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Impact of Environmental Degradation on Economic Growth: Testing the Environmental Kuznets Curve in Nigeria

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ABSTRACT

Looking at the contribution of economic activity in the country, it is seen to add robustness to growth and development, but in contrast give birth to greenhouse gases (GHGs), such as CO_2 CO_2 which is also called carbon dioxid, CH_4 which is also called methane, and N_2O represent nitrous oxide. The factors influencing Greenhouse gas emissions include rising of population, upward movement of per capita output and consumption, infrastructural development made about infrastructures, human character, and innovation. However, if mitigation efforts are not enough, climate change would most likely lead to a slowdown the upward movement. Thus, the study examined the relationship between economic growth and environmental degradation using the Autoregressive Distributed Lag model and examined the impact of environmental degradation on economic growth in Nigeria from 1990 to 2022 using that lens. Based on the estimated ARDL regression result, environmental degradation as determined by carbon dioxide emissions (kt) and economic growth are negatively correlated. The negative indication indicated that economic growth will decline by roughly -0.455% and -0.893% over the medium and long terms, respectively, as carbon emissions rise. The findings indicated that there is validity to Nigeria's Environmental Kuznets Curve, which demonstrates how environmental deterioration impedes economic progress. Similarly, a positive indication indicating a one-period lag in carbon emissions showed that, in the short term, economic growth increases by around 0.948% in tandem with rising carbon emissions. Thus, the paper illustrated an inverse U-shaped interaction between environmental degradation and economic growth, with healthy economy initially related with increased emissions. However, the majority of the control variable estimates deviate from theoretical expectations. On the other hand, a positive and statistically significant one-period lagged coefficient of trade openness suggests that trade openness looks to support and encourage economic growth in the short run. Similarly, during the period under consideration in Nigeria, the short-run economic growth is positively and strongly correlated with the one-period lagged coefficient of gross fixed capital formation. The report suggested boosting energy efficiency in the world's energy mix in order to lower greenhouse gas emissions, which are the main contributors to climate change. Therefore, in order to prevent the development of closed-form relationships that could result in a slowdown in economic growth, Nigerian government agencies that are responsible for implementing national and international environmental rules should proceed with caution.

INTRODUCTION

The global economy has risen significantly over the past century due to a number of factors, including globalization, industry booms, innovation, significant technology developments, unfettered international trade at all levels and in all sectors, and the overall state of the economy. But the growth in the economy has come at the expense of the environment, causing pollution to increase and environmental deterioration to worsen (Abbasi *et al.*, 2021).

In contrast, the globe Economic Forum (WEF) claims that environmental hazards represent the five most likely long-term global risks and that they account for four of the top five challenges facing the globe now (WEF, 2021). It's believed that environmental issues brought on by environmental deterioration pose the greatest danger to the SDGs (sustainable development objectives). This is accurate given that environmental risks affect all businesses, people, and society (SRI, 2021). There is no worldwide immunization against this risk, and no one can be immune to it (WEF, 2021). These risks have been mostly attributed to carbon dioxide emissions, the main cause of climate change.

While looking at the activities in economy plays an important role development and progress, but also brought about a rise in the emissions of greenhouse gases (GHGs), such as methane (CH4), carbon dioxide (CO_2), and nitrous oxide (N2O). Mohammed *et al.* (2020) and Mohammed *et al.* (2021) claimed that these greenhouse gases have transformed the environment, exacerbated climate change, and reduced the health ecosystems. A few factors that influence greenhouse gas emissions are per capita consumption, population increase and output growth, infrastructure decisions, human behavior, innovation, and advanced technology (Bekun *et al.*, 2021; Fatai *et al.*, 2021 and Cai, *et al.*, 2018). If we don't take strong enough actions to address climate change, our economy health and opportunities for social and human

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development are likely to suffer. (Yusuf *et al.*, 2020).

The growing concerns about environmental degradation and climate change have received a lot of attention in the literature and policy debates. The majority of the focus in the economics literature has been on the relationship between environmental degradation and economic health within the procedure of the Environmental Kuznets Curve idea. The EKC hypothesis has dominated the research regarding the relationship between economic growth and environmental degradation since the early 1990s. The relationship between environmental degradation and economic activity is an inverted U, according to the EKC theory. High levels of pollution and environmental degradation are typical of early economic growth; however, this pattern reverses once a certain per capita income is reached, and at high income levels, economic growth is linked to environmental improvements (Halkos & Managi, 2017; Halkos & Managi, 2016 and Grossman & Krueger, 1991).

Real evidence has contradicted the EKC's assertion that there is an inverse U-shaped relationship between environmental degradation and economic activity. Both inside and outside of Nigeria, numerous research has backed the EKC (Grossman & Krueger, 1995; Sisay & Balázs, 2019; Hammed *et al.* 2020; Maneejuk *et al.*, 2020; Abdulkarim, 2023; Acheampong & Opoku, 2023 and Mohammed *et al.*, 2024), but some have not (Aye & Edoja, 2017; Adu & Denkyirah, 2018; and Raihan *et al.* (2022). While several research, including Yan *et al.* (2022), Cetin (2018), and Sica (2014), uncovered contradictory findings about the EKC hypothesis's underlying assumptions for some nations. Thus, the study examines the relationship between environmental degradation and economic growth as well as how environmental deterioration propels economic growth in Nigeria. Furthermore, because there are so few empirical studies that particularly address the relationships between environmental sustainability and economic growth in Nigeria, a detailed research of whether the country falls into the Environmental Kuznets Curve is necessary.

There are several ways that environmental degradation can affect economic growth. Understanding these connections can help policymakers create comprehensive policies that balance environmental sustainability with economic development. Identifying how environmental degradation impacts economic health is essential. This includes recognizing that the effects can be both direct and indirect, allowing for more effective strategies to be developed. Trade openness, for instance, can have a significant impact on an economy since it can promote know-how and boost competitiveness in both domestic and international markets due to its productivity and competitive advantage (Chang *et al.*, 2009). According to the majority of research that have been published recently, trade openness has a significant role in explaining economic growth (Gershon *et al.*, 2024; Acheampong & Opoku, 2023 and Mesagan, 2015).

In a similar vein, foreign direct investment is thought to be an important channel via which environmental deterioration may influence economic expansion. According to the Pollution Haven Hypothesis (Eskeland & Harrison, 2003; Javorcik and Wei, 2003; Levinson, 2020), developing nations are more likely to have polluted or degraded environments because of their open economies. According to this theory, polluting companies in advanced nations with tight environmental rules will transfer to developing countries through foreign direct investment because of the lax environmental restrictions in developing countries. Thus, developing nations turn into pollution havens. As a result, developing nations will import pollution from developed nations. Empirically, Opoku *et al.* (2022) demonstrated that environmental deterioration is a major factor in deciding foreign direct investment entry into emerging nations. Environmental impacts can also result from capital investment through foreign direct investment in nations with lax regulatory frameworks. Consequently, it is sometimes recommended that developing nations use gross fixed capital formation as a stand-in for capital investment in order to boost their long-term development rates. Accordingly, capital investment through inflows of foreign direct investment is a major factor driving economic growth (Gershon *et al.*, 2024; Acheampong & Opoku, 2023 and Mesagan, 2015). According to the ways that environmental deterioration can impact economic growth, the following questions are attempted to be addressed in this paper:

Research Questions

The following research questions guided the paper:

i. How does carbon dioxide emissions impact on economic growth?

ii. What impact does trade openness have on economic growth in Nigeria?

iii. To what extent does foreign direct investment affect economic growth in Nigeria?

iv. What is the impact of gross fixed capital formation on economic growth in Nigeria?

The rest of this paper is divided into five sections. The next section provides a summary of the literature, which is divided into theoretical interpretations, empirical reviews, and the concepts of economic health or growth and carbon emissions. The economic framework and the empirical discoveries upon which data are presented in sections three and four while in addition to section five, conclusions and recommendations was concluded.

MATERIALS AND METHODS

Conceptual Review

In the words of Palmer (2012) who is a researcher expanded on the concept of economic growth as the broadening of a nation's production capacity in all areas, which extend to economic production of more goods and services for the nation and beyound. An increase in Real Gross Domestic Product (RGDP) signifies a rise in national production, income, and expenditure, indicating economic growth. This upward movement reflects an

expansion in the economy. The Gross Domestic Product (GDP) serves as a measure of this economic expansion, while the GDP growth rate illustrates the pace at which the economy is developing. (Picardo, 2020).

Employment growth, lower taxes for public spending, debt reduction, longer life expectancies, higher investment, and advancements in R&D are all advantages of economic growth. Slow economic growth, on the other hand, has negative effects on public services. These effects include inadequate health and educational facilities, low rates of savings and investment, high rates of poverty and unemployment, a rise in the national debt, and lower tax revenue than anticipated (Picardo, 2020).

Environmental degradation occurs when human activities result in harmful or unhealthy conditions for the environment. This can lead to the destruction of ecosystems, depletion of natural resources, contamination of the air and water, degradation of soil, and the extinction of plant and animal species. This process diminishes the quality and integrity of essential resources like soil, water, and air, ultimately impacting the overall health of biological ecosystems. Air, water, and soil are especially vulnerable to damage from excessive use and harmful human actions. In this context, carbon dioxide (CO_2) emissions serve as a metric for environmental degradation, helping to assess whether economic growth can mitigate environmental decline under the Environmental Kuznets Curve (EKC) hypothesis in Nigeria. Greenhouse gas emissions, particularly CO_2, are considered major contributors to global warming and environmental degradation, primarily resulting from the burning of fossil fuels and cement production. Among them are carbon dioxide emissions from gas flaring and the consumption of solid, liquid, and gas fuels (Climate Watch Historical GHG Emissions, 2023).

Emissions of carbon dioxide, which are mostly leftovers from the production and use of energy, make up the majority of greenhouse gases linked to global warming. Emissions of anthropogenic carbon dioxide are mostly caused by burning fossil fuels and producing cement. When fossil fuels are burned, they produce varying amounts of carbon dioxide at the same energy level. For example, coal releases almost twice as much carbon dioxide as natural gas, while oil releases roughly 50% more. For every metric ton of cement produced, the cement manufacturing process emits almost half a metric ton of carbon dioxide. Emissions from land use, such as deforestation, are not included in the data on carbon dioxide emissions, which include gasses from the burning of fossil fuels and the manufacturing of cement. The kt (kiloton) unit of measurement is used. Elemental carbon is a common unit of measurement and reporting for carbon dioxide emissions. They were multiplied by 3.667, which is the ratio of carbon mass to carbon dioxide mass, to get the actual mass of carbon dioxide.

Empirical Review

Gershon *et al.* (2024) while studying the interactive effect of energy consumption and economic growth on carbon emissions for seventeen selected African countries using static panel estimation techniques using annual data from 2000 to 2017 found that while upward movement of energy consumption has an inverse or negative impact on carbon emissions, it has a beneficial impact on economic growth. In contrast energy used has a greater effect on economic broadening than it does on the environment. The report made the case for giving economic broadening and energy efficiency as the most important in order to significantly lessen the damaging impact of energy use on the environment.

Using the environmental Kuznets curve (EKC), Mohammed *et al.* (2024) evaluated the effects of policies, GDP, population structure, energy consumption, and carbon dioxide (CO_2) emissions on the environment within the EU. The discovery demonstrated from 1990 to 2019, the European Union-27's energy consumption went up by þ1.18 million tonnes of oil equivalent (Mtoe) annually ($p < 0.05$), but CO_2 emissions decreased by twenty-four point two, five million tonnes (Mt) annually. Latvia had the lowest yearly CO_2 emissions (0.087 Mt CO_2), whereas Germany had the biggest decrease (7.52 Mt CO_2). The empirical environmental Kuznets curve study showed an inverted U-shaped relationship between gross domestic product and CO_2 emissions in the European Union -27. Most importantly, a 1% rise in gross domestic product leads to a 0.705% rise in carbon emissions, but with time, a 1% rise in GDP2 results in a 0.062% reduction in environmental pollution ($p < 0.01$). These findings suggested that economic development in the EU has progressed to the point where economic growth directly affects environmental benefits which further provided insight into how well environmental policies in the twenty-seven member states of the EU prevent degradation and encourage green growth overall.

The question of whether environmental degradation is linked to economic growth is investigated by Acheampong and Opoku (2023). In a global study involving 140 countries from 1980 to 2021, researchers used the two-step dynamic system generalized method of moments to control for endogeneity. The results showed that environmental degradation negatively impacts economic growth. Additionally, the research uncovered an inverse U-shaped relationship between emissions and economic growth, indicating that initially, as the economy grows, emissions increase, but after a certain point, further growth leads to a decrease in emissions. Conversely, when looking at ecological footprint measures of environmental deterioration, the relationship with economic growth followed a U-shaped pattern, suggesting that after reaching a certain level of economic growth, environmental impact increases again. The research recommended reducing greenhouse gas emissions by boosting energy efficiency in the world's energy mix.

Abubakar and Abdullahi (2022) explored the impact of carbon dioxide emissions on economic growth and examined whether the relationship between CO_2 emissions and economic health is influenced by

financial development in Nigeria, the most populous country in Africa, from 1980 to 2020. They employed the Autoregressive Distributed Lag (ARDL) estimation method to conduct their analysis. The results of the cointegration boundary test revealed a long-term relationship among CO_2 emissions, financial institutions, economic health, and energy consumption. Their empirical findings indicated that CO_2 emissions do not have a direct long-term effect on economic growth. However, there was clear evidence that CO_2 emissions and financial development together contribute to economic growth over the long term. This suggests that CO_2 emissions impact economic health significantly when financial development is present. To moderate CO_2 emissions from productive activities while maintaining efficient productivity across major sectors, the study recommended that the government adopt clean modern technologies for production and phase out the use of fossil fuels such as oil and gas.

Using the Environmental Kuznets Curve (EKC) theory as a foundation, Maneejuk *et al.* (2020) investigated the connection between economic progress and environmental degradation. The Environmental Kuznets Curve (EKC) hypothesis utilizes CO_2 emissions as a measure of environmental degradation to explore whether economic growth can potentially reduce environmental harm. Eight major global economic groups, comprising forty-four countries globally, were studied. The relationship between environmental conditions and economic growth was analyzed using the kink regression model, which helps identify the turning point in this correlation. The findings validated the EKC hypothesis within three major international economic communities: The European Union (EU), the Organization for Economic Co-operation and Development (OECD), and the Group of Seven (G7). The study recommended that in addition to enhancing environmental quality, authorities should carefully design and implement specific measures to support economic growth in order to achieve sustainable development.

To evaluate the usability of the environmental Kuznets curve (EKC) theory in Nigeria, Hammed *et al.* (2020) examined the relationship between environmental deterioration, energy use, and economic growth. The non-linear autoregressive distributed lag (ARDL) method is employed. The findings validated the EKC theory's application in Nigeria, where GDP growth first deteriorates environmental quality before subsequently improving it. Moreover, it is found that energy usage deteriorates environmental quality since, in Nigeria, every 1% increase in energy use results in a 0.002% rise in CO_2. The report recommended using newer, lower-emission technologies since meeting the country's energy demands is necessary for sustainable growth.

Using the Pooled Mean Group (PMG) method, Sisay and Balázs (2019) examined the EKC hypothesis for 12 East African nations from 1990 to 2013. The results showed that the relationship between per capita income and CO_2 emissions, a proxy for environmental degradation, expands the basic inverted U-shaped curve association between economic activity and environmental degradation in a bell-shaped manner. As a result, one may argue that economic activity in East African countries does not produce greenhouse gas emissions. Thus, contemporary industrial methods, technical improvement, and environmental conservation legislation are required to make East African countries' economic expansion efficient in minimizing CO_2 emissions.

Cetin (2018) examined the effectiveness of renewable energy sources in lowering CO_2 emissions for both developed and developing nations between 1990 and 2011 using a pooled mean group (PMG) estimator. The empirical findings of the study show that while emerging markets do not support the EKC hypothesis, established markets do. The long-run elasticity results of the per capita statistics may also indicate that developed and emerging markets have different CO_2 emissions. The study's findings did, however, indicate that using renewable energy sources will eventually be essential to reducing CO_2 emissions for both panel groups.

Mesagan (2015) focused on the interaction of Nigeria's economic health increase and carbon emissions from 1970 to 2013. The study used an error correction model, and the discovering unambiguously illustrated that economic health increase has a progressive impact on carbon emissions during the initial period and an inverse impact during the lagged term. It also revealed that capital investment and trade openness have a progressive effect on Nigeria's carbon emissions. The study further advised that while reducing gross domestic product (in an effort to reduce carbon emissions) may prevent the nation's economic wellbeing, it is more workable to look for strategies to motivate green growth in the state.

Theoretical Framework

This paper's theoretical framework is based on EKC which means Environmental Kuznets Curve, which connect CO_2 emissions to economic health. Simon Kuznets (1955) researched on the relationship between economic health and earnings inequality and first agreed on the EKC hypothesis. Kuznets (1955) came to the finalization that early economic health is connected to an increase in income disparity up to a certain point, above which inequality is reduced by ongoing economic health (Saba, 2023).

Growth in the early part is linked to increasing emissions. However, increased productivity becomes environmentally maintenance when economies of scale, money, and innovation increase. As a result, an inverse or negative U-shaped relationship was seen between economic health and environmental deterioration. The environmental Kuznets curve (EKC) hypothesis has gained worldwide recognition based on these findings.

On a general note, there is a direct correlation between pollution and economic health. The connections between these 2 (two), however, can be reduced by a number

of measures, such as switching to ecologically friendly technology and improving technological advancements that ensure overall gains in economic production and, more especially, in the reduction of environmental hazard. Notwithstanding the fear surrounding the possibility of limitless substitution or technological advancement, there might be hindrances on the degree to which these linkages can be further loosened in the future.

As employed by David Stern in 2003, the functional relationship can be expressed as:

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

Equation (1) written as thus explicitly below:

$$\ln(E/P)_t = \alpha + \gamma_t + \beta_1 In(GDP/P)_t + \beta_2 (In(GDP/P))^2_t + \varepsilon_t \quad (2)$$

where ln stands for natural logarithms, P is the population, and E is the amount of carbon emissions. The number of years is indicated by the subscript "t" on the RHS, while the first two terms are intercept parameters. 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.

However, in order to facilitate empirical modeling in this research, GDP per capita will be used to represent the dependent variable, output growth (GDP), and carbon emissions (CO_2) will be used to represent environmental degradation. This will make it possible for the study to demonstrate how environmental degradation affects Nigeria's economic growth. Equation (2) functional form is written below as:

$GDPPC = f(CO_2)$ (3)

Where GDPPC stands for gross domestic product per capita as a measure of economic growth and CO_2 stands for carbon emissions as a proxy for environmental degradation.

Explicitly, equation (3) can be written as:

$GDPPC = \alpha + \beta\ (CO_2) + \varepsilon$ (4)

METHODOLOGY

The ex-post facto design is the chosen research design for this work. An empirically based study design that establishes the cause-and-effect link between the independent and dependent variables is called the ex-post facto design. The incapacity of the researcher to alter the data being studied is what distinguishes this method.

Model Specification

The model used in this paper is based on the Environmental Kuznets Curve (EKC) theoretical framework and a modified version of the model of Abubakar and Abdullahi (2022), who examined how carbon dioxide emissions affected economic growth and whether or not that relationship depended on Nigeria's financial development between 1980 and 2020. Abubakar and Abdullahi (2022) model is of the form:

$GDP = f(EM, FD, EC + \mu)$ (5)

Where, GDP represents economic growth, EM is CO_2 emissions, FD represents financial development, EC represents energy consumption, and μ is the error term. For the purposes of this work, equation 5 is expanded and adjusted to take into account three indices of economic growth: capital investment, which is measured by gross fixed capital formation, trade openness, and foreign direct investment. For the purposes of this work, equation 5 is expanded and adjusted to take into account three indices of economic growth: capital investment, which is measured by gross fixed capital formation, trade openness, and foreign direct investment. The changes or modifications and extensions are written below:

$GDPPC_t = \beta_0 + \beta_1 CO2_t + \beta_2 TOP_t + \beta_3 FDI + \beta_4 GFCF + \varepsilon_t$ (6)

We take the log of the dependent and explanatory variables to guarantee consistency across all the variables.

$\ln GDPPC_t = \beta_0 + \beta_1 \ln CO2_t + \beta_2 \ln TOP_t + \beta_3 \ln FDI + \beta_4 \ln GFCF + \varepsilon_t$ (7)

Where, In: Natural logarithm, β_0 is the intercept, β_1 to β_2 are slope parameters. Economic growth is represented using GDP per capita (constant 2015 US$). Environmental degradation is measured with carbon dioxide emissions (kt), which serves as the main indicator of environmental degradation in the literature (Opoku *et al.*, 2022; Pal and Mitra, 2017; Sadorsky, 2009; Zheng *et al.*, 2019). TOP represents trade openness, FDI is foreign direct investment, gross capital formation as proxy for capital investment (GFCF), and ε_t is the error term. Trade openness, foreign direct investment, and gross fixed capital formation served as control variables in this analysis. These control variables were employed with the support of research by Mesagan (2015), Acheampong and Opoku (2023), and Gershon *et al.* (2024). Moreover, it is expected that all of the control variables will have positive coefficients. However, it is anticipated that either a positive or negative effect on economic growth will result from environmental degradation as measured by carbon dioxide emissions.

However, equation (7) was converted into an ARDL Model result as follows in order to investigate the impact of environmental degradation on economic growth in Nigeria using the Autoregressive Distributed Lag Technique (ARDL):

$$\Delta InGDPPC_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} InGDPPC_{t-i} + \sum_{j=0}^{n} \beta_{2i} \Delta InC02_{t-j} + \sum_{k=0}^{o} \beta_{3i} \Delta InTOP_{t-k} + \sum_{l=0}^{p} \beta_{4i} \Delta InFDI_{t-l}$$

$$+ \sum_{l=0}^{q} \beta_{5i} \Delta InGFCF_{t-l} + \beta_6 InGDPPC_{t-1} + \beta_7 InC02_{t-1} + \beta_8 InTOP_{t-1} + \beta_9 InFDI_{t-1} + \beta_{10} InGFCF_{t-1} + \varepsilon_t \quad (8)$$

The bounds test is conducted by testing the null hypothesis (H0) against the alternative hypothesis (H1) using the following equations: H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$ and H_1: $\beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5$

The bounds test results based on the computed F-Statistic are similar to those of Pesaran *et al.* (2001), who rejected the null hypothesis of no cointegration and concluded that cointegration between the series is present if the

F-Statistic is greater than the upper bound I (1) in each case.

Furthermore, after a long-run linear relationship (cointegration) between the variables has been confirmed, the short-run coefficients are computed using the short run / Error Correction Model provided in Equation 9.

$$\Delta InGDPPC_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \Delta InGDPPC_{t-i} + \sum_{j=0}^{n} \beta_{2i} \Delta InC02_{t-j} + \sum_{k=0}^{o} \beta_{3i} \Delta InTOP_{t-k} + \sum_{l=0}^{p} \beta_{4i} \Delta InFDI_{t-l}$$

$$+ \sum_{l=0}^{q} \beta_{5i} \Delta InGFCF_{t-l} + ECT_{t-1} + \varepsilon_t \quad \text{----------} \quad (9)$$

ECT_{t-1} = lagged Error correction term. The ECT records the output evolution process that agents employ in response to the previous period of prediction errors. The variables utilized in the paper are listed in Table 1.

Because of its many advantages, the Autoregressive Distributed Lag Technique (ARDL) is chosen above other methods for predicting long-term linkages between variables. One advantage is that it can be applied whether or not the underlying independent variables are I(0), I(1), or mutually co-integrated (Pesaran *et al.* 2001). Its superiority over the Engle and Granger co-integration tests in small sample sizes is its second advantage (Allege & Ogundipe, 2013; Johansen, 1991; Philips & Hansen, 1990). The third advantage of employing the ARDL approach is the capacity to estimate an unconstrained conditional error-correction model (UECM) by treating each variable as a dependent variable in turn.

Table 1: Description of Variables

Variable	Description	Sources
Environmental Degradation	The degradation of the environment is gauged by terrestrial CO2 emissions, which come from burning fossil fuels as a result of both industrial processes and human activities. In the analysis, the variable "metric tons per capita" is considered independent.	WDI, 2023
Economic Growth	In this study, economic growth is measured using real GDP per capita (constant 2015 US$), which is the total value of goods and services produced by a country divided by its population. This variable is considered a dependent variable in the study.	WDI, 2023
Trade Openness	Trade openness measured with trade (% of GDP). This served as control variable	WDI, 2023
Foreign direct investment	An investment made by a business or individual from one country into business ventures located in another. The measurement unit is Net Inflows (% of GDP).	WDI, 2023
Gross Fixed Capital Formation	This is a proxy for capital investment and served as control variable.	WDI, 2023

Source: Researchers' Compilation, 2024

RESULTS AND DISCUSSIONS

Descriptive Statistics

Table 2 presents the descriptive statistics for the paper.

The summary data in Table 2 demonstrate that all the variables have positive mean values, with GDPPC and C02 having the highest and lowest mean values, respectively. Also, each variable's standard deviation offers a more accurate and comprehensive representation of dispersion than an outlier, which has the potential to greatly exaggerate the range of data. CO_2 exhibits the least departure from the mean, while GDPPC exhibits the largest. The probability values of the Jarque–Bera statistics, with the exception of FDI, suggest that the residual is normal and that the null hypothesis is not rejected.

Table 2: Descriptive Statistics

	GDPPC	CO_2	TOP	FDI	GFCF
Mean	1632.967	0.678296	35.71788	1.578278	28.46303
Std. Dev.	812.5669	0.122238	9.550595	1.211996	11.24335
Skewness	-0.015194	0.364401	-0.096016	1.798286	0.360175
Kurtosis	1.833415	1.840752	2.333943	6.754132	2.069240
Jarque-Bera	1.872535	2.578137	0.660700	37.16465	1.904676
Probability	0.392088	0.275527	0.718672	0.000000	0.385838
Observations	**33**	**33**	**33**	**33**	**33**

Source: Authors Computation, 2024 (Eviews-12)

Unit Root Test

Time series data often show tendencies that can be handled with differencing, mostly for the purpose of figuring out how stationar the data is. An important stage in time series analysis is the Augmented Dickey-Fuller (ADF) unit root test, the results of which are displayed in Table 3 and which determines if the series is stationary

Table 3: Unit Root Test Result

Variable	ADF Test Statistics		
	ADF	**Critical Value**	**Order of Integration**
GDPPC	-4.583012	-4.284580*	I(1)
C02	-5.714705	-4.284580*	I(1)
TOP	-5.593623	-4.296729*	I(1)
FDI	-3.930156	-3.562882**	I(0)
GFCF	-4.835999	-4.284580*	I(1)

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

The result of the Augmented Dickey-Fuller (ADF) unit root test indicate that the variables are integrated in a mixed-order fashion, with FDI being integrated at the level and the other variables being integrated at first order. I (0) and I (1) are hence the integration order.

Cointegration Test

Table 4 presents the analysis of cointegration, using the ARDL bounds technique.

The Table unequivocally demonstrates that the null hypothesis (H0: No cointegration) is rejected at 5%, where

Table 4: Result of ARDL Bounds Test for Cointegration

Null Hypothesis: No Long-run Relationships Exist		
Test Statistic	**Value**	**K**
F-Statistic	4.899666	4
Critical Value Bounds		
Significance	**Lower Bound**	**Upper Bound**
5%	2.56	3.49

Source: Researcher's Computations based on E-Views 12

the F-statistic is greater than the critical values at both the top and lower bounds. This indicates that the variables have a lasting relationship. As a result, it can convincingly support the notion that the analysis's variables are related over the long term.

Autoregressive Distributed Lag Estimates

Given the cointregration of the dependent variable with the regressors and the mixed-order of integration obtained from the unit root analysis, Table 5 presents the results of the Linear ARDL estimate.

Table 5: ARDL Regression Results

Co-integrating Estimates (ECM Estimates)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
DLOG(CO2)	-0.455485	0.506049	-0.900081	0.3944
DLOG(CO2(-1))	0.947917	0.510096	1.858313	0.1002
DLOG(TOP)	-0.017559	0.176442	-0.099518	0.9232
DLOG(TOP(-1))	0.525079	0.164458	3.192786	0.0127
DLOG(FDI)	-0.195061	0.054162	-3.601467	0.0070
DLOG(FDI(-1))	-0.845424	0.167632	-5.043343	0.0010
DLOG(GFCF)	-0.237726	0.383215	-0.620348	0.5523
DLOG(GFCF(-1))	1.121922	0.402690	2.786070	0.0237
CointEq(-1)*	-0.951930	0.137727	-6.911710	0.0001
R-squared	0.869433			
Adjusted R-squared	0.718779			
Durbin-Watson stat	1.917854			

Long Run				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LOG(CO2)	-0.893197	1.103891	-0.809135	0.4418
LOG(TOP)	-0.722653	0.511378	-1.413149	0.1953
LOG(FDI)	0.758438	0.277434	2.733764	0.0257
LOG(GFCF)	-0.706332	0.536579	-1.316362	0.2245
C	11.66561	2.825789	4.128267	0.0033

Source: Researcher's Computation Using EViews-12 (2024)

In accordance with the estimated ARDL regression result, environmental degradation in Nigeria, as determined by carbon dioxide emissions (kt), has a negative relationship with economic growth. The negative sign indicates that, both in the short and long terms, respectively, economic growth declines by about -0.455% and -0.893% ceteris paribus as the level of carbon emissions rises.

The EKC hypothesis—which holds that degradation of the environment impedes economic progress in Nigeria—is impliedly confirmed by these findings. Previous studies (Grossman & Krueger, 1995; Sisay & Balázs, 2019; Hammed *et al.* 2020; Maneejuk *et al.* 2020; Acheampong & Opoku, 2023 and Mohammed *et al.* 2024) have demonstrated that environmental degradation, as measured by carbon dioxide emissions, has a negative impact on economic growth.

Most estimates of the control variables, however, differ from the literature. In contrast to previous studies, trade openness and foreign direct investment are expected to favorably influence economic growth, as found by Mesagan (2015) and Acheampong and Opoku (2023). In contrast, trade openness appears to have a positive and statistically significant one-period lagged coefficient in the short term, indicating that trade openness influences economic growth. This result is in line with the research conducted by Mesagan (2015) and Acheampong and Opoku (2023). In contrast, there was a positive and significant correlation between economic growth and the short-run, one-period delayed coefficient of gross fixed capital production in Nigeria during the study period.

More precisely, in the medium and long terms, respectively, a percentage increase in carbon emissions will result in a decrease in economic growth of roughly -0.455% and -0.893%. These results suggest that the EKC theory—which holds that environmental deterioration impedes economic progress in Nigeria—is validated there. Previous studies have shown that environmental degradation, as assessed by carbon dioxide emissions, has a negative effect on economic growth (Acheampong & Opoku, 2023; Mohammed *et al.*, 2024, among others).

It has been discovered that trade openness and economic growth in Nigeria are negatively correlated, both in the short and long terms. This is contrary to theoretical assumptions, since one would expect trade openness to positively affect economic growth.

Economic growth will contract by -0.018% in the near term for every percentage point increase in trade openness. On the other hand, trade openness hinders economic growth in the long run. Most of these findings go counter to the findings of Mesagan (2015) and Acheampong and Opoku (2023), who discovered a positive relationship between trade openness and economic growth. Conversely, a positive, statistically significant, and short-run period-lag coefficient of trade openness suggests that, over the studied time, trade openness expansion promotes economic growth. This result is in line with the research conducted by Mesagan (2015) and Acheampong and Opoku (2023).

Additionally, Table 5's findings showed that foreign direct investment considerably impedes economic growth in the near run. Therefore, there will be a short-term decline in economic growth of -0.195% for every percentage point rise in foreign direct investment. Nevertheless, there is a robust and favorable relationship between foreign direct investment and economic growth. This is in line with theoretical expectations.

Likewise, gross fixed capital creation, which is a proxy for capital investment, is expected to have adverse effects on Nigeria's economic growth both in the short and long run. Specifically, Nigeria's economic growth will fall by -0.2375% and -0.706% in the short and long terms, respectively, for every 1% rise in gross fixed capital creation. Capital investment is not a substantial contributing factor to Nigeria's economic growth, according to the statistically insignificant influence of gross fixed capital formation on economic growth. This conclusion might have something to do with Nigeria's extremely low level of capital investment.

Post-Estimation Test Results

To evaluate the validity of the findings and the model's stability and applicability, the study ran a few diagnostic tests. The results shown in Table 6 indicates that the model did not exhibit serial correlation or heteroskedasticity during the research period. The residuals are homoscedastic, according to the heteroscedasticity tests. According to the findings of the diagnostic tests for heteroscedasticity and serial correlation, the data appears to be quite well-behaved. Additionally, the residues' normal distribution is indicated by the fact that the p-value for the normality test for the research period is greater than 0.05. As a result, the residuals have a uniform distribution. Consequently, the null hypothesis regarding the normal distribution was not rejected.

Table 6: Diagnostic Test Results

Test	**Null Hypothesis**	**T-Statistic**	**Prob**
Jarque-Bera	There is a normal distribution	0.614	0.74
Breusch-Godfrey LM	No serial correlation	0.151	0.86
Heteroskedasticity: Breusch-Pagan-Godfrey	No conditional heteroscedasticity	2.381	0.10

Source: Researcher's Computations based on E-Views 12

Stability Test Result

The stability test in Figure 1 demonstrated the stability of the economic growth model during the inquiry period because the chart plots at the 5% significant level fall within the crucial constraints.

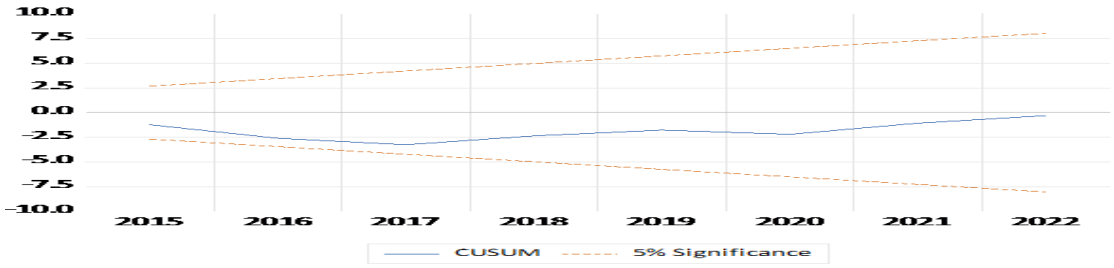

Figure 1: Stability Tests Result

Source: Researcher's Plot using E-Views 12

CONCLUSION

The study examined the connection between environmental deterioration and economic growth, and using the Autoregressive Distributed Lag (ARDL) technique, it evaluated the impact of environmental degradation on economic growth in Nigeria from 1990 to 2022. The regression analysis showed a negative correlation between economic growth and environmental degradation. These results suggest that the EKC theory—which holds that environmental degradation impedes economic progress in Nigeria—is validated here. Furthermore, a one-period lag in positive sign for carbon emissions indicated that, in the short run, economic growth increases by roughly 0.948% ceteris paribus as carbon emissions rise. This outcome is also in line with theoretical hypotheses that growth is initially associated with increasing emissions. However, when economies of scale, money, and innovation improve, increased productivity turns into environmentally sustainable progress. As a result, the study showed that there is an inverse U-shaped association between economic expansion and environmental degradation. Many people agree that this result represents the Kuznets inverted U-shaped curve.

This article has shown that carbon emissions and economic growth in Nigeria are negatively correlated. Therefore, in order to lower greenhouse gases—the main contributors to climate change—it is imperative to increase energy efficiency in the world's energy mix. Thus, it is important to exercise caution while implementing both national and international environmental policies so as not to foster closed-form connections that might impede economic progress. Furthermore, the positive correlation that exhibited a one-period lag between carbon emissions and economic growth implied that some degree of environmental deterioration is necessary in order to stimulate economic growth. Therefore, policymakers need to be cautious in the fight against environmental pollution because most instruments and strategies meant to lower greenhouse gas emissions also have the potential to change patterns of production and consumption and impede economic growth. Therefore, planning for mitigation, restoration, and sustainable practices should serve as the foundation for policies that support economic growth, particularly in the early phases of development.

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