ENVIRONMENTAL SUSTAINABILITY AND ECONOMIC GROWTH: EVIDENCE FROM NIGERIA

OBORO EMMANUEL DAVID
Edwin Clark University Kiagbodo, Delta State, Nigeria
oborodavid@edwinclarkuniversity.edu.ng

Abstract

Climate change's long-term effects are linked to current and upcoming risks to sustainable development. The nation's infrastructure, business community, and governmental sector must all adjust to the changing environment in order to reduce these dangers. In order to test the environmental Kuznets curve (EKC) hypothesis using the ECM test for Nigeria, this paper examines the relationships between CO2 emissions and their major determinants, including economic growth, trade openness, industrialization, Renewable electricity and Foreign direct investment from 1980 to 2023. Results show that the GDP per capita and its square have a strong positive and negative impact on CO2 emissions, respectively. Our analysis also revealed an inverted U-shaped relationship between economic growth and CO2 emissions. .That trade openness, and industrialization positively affect CO2 emissions, but long-term CO2 emissions are found to be reduced by renewable electricity and foreign direct investment.

Keywords: GDP per capita, CO2 emission, EKC hypothesis, Sustainable development, Nigeria.

JEL Classification: O20, O21,O25

1. INTRODUCTION

Environmental sustainability refers to the long-term preservation of priceless environmental resources in a changing human environment (Rosen , 2017, Zhang et al., 2018). It is debatable whose definition and metrics of sustainability work best. Economists frequently emphasize an approach to accounting that places a strong emphasis on capital stock maintenance. The depletion of natural resources and the question of whether current resource consumption rates can be maintained into the long future are major concerns for some in the environmental profession (Ebert, Udo and Heinz Welsch 2004 and Esty, Daniel C., Mark A. Levy, et al.2003).

While the definition of "green growth" is widely accepted, different institutions have given it different meanings. "Fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being depends," according to the OECD's definition of "green growth" (Mentes, 2023). "Green growth" is defined by

the World Bank as "growth that is resilient in accounting for natural hazards and the role of environmental management and natural capital in preventing physical disasters, clean in that it minimizes pollution and environmental impacts, and efficient in its use of natural resources." Additionally, this progress must be inclusive. (World Bank, 2012).

Previous economic research raises the topic of how important nature and the environment are to the economy. For instance, Ricardo thought that the availability of low-quality land was the reason for declining returns in agricultural production. According to Malthus, the amount of food available per person decreased as population increased on unproductive ground. Marx argues that the capitalist system cannot last. Since the early 1990s, the EKC hypothesis has dominated the literature when it comes to understanding the connection between environmental degradation and economic growth. According to the EKC theory, the link between environmental deterioration and economic activity is an inverted U. Early economic expansion is marked by high levels of pollution and degradation, but beyond a certain threshold of per capita wealth (Malthus. 1986; Ricardo, 1951; Marx, 1976).

Even though the EKC argues that the relationship between economic activity and environmental degradation has an inverted U-shape, there has been empirical evidence to the contrary. Many studies have supported the EKC, but some have not. Further, several studies have found mixed results (supporting the EKC hypothesis for some countries/pollutants but not for other countries/pollutants). (Yusuf, 2023).

Rehman et al. (2021a) state that one of the most significant environmental problems the world is currently experiencing is climate change , which is believed to be mostly caused by greenhouse gas emissions, primarily carbon dioxide (CO2) emissions. 2019 was the second-hottest year on record, according to UN Secretary-General António Guterres during his opening remarks at the news conference for the WMO State of the Climate 2019 Report. According to the World Meteorological Organization's (WMO) seminal State of the Global Climate report, the average global temperature in 2020 was around 1.2°C higher than preindustrial levels. In order to lessen the risk of runaway climate change, the Paris Agreement calls for reducing global temperature to far below 2°C, and ideally 1.5°C, over preindustrial levels. Global emissions must peak as soon as is practical and then quickly decline, falling by 45% from 2010 levels by 2030, in order to reach net zero emissions by 2050. In 2021, Bertram et al. The world is far from achieving this goal at the rate at which nationally defined contributions are occurring now. The combined worldwide greenhouse gas emissions of developed countries and economies in transition fell by 6.5 percent between 2000 and 2018. In the meantime, emissions from emerging nations rose by 43.2% between 2000 and 2013. The improvement in GDP and increased industrialization are the main causes of the growth.

In light of this, this study investigates, with particular reference to Nigeria, the relationship between economic growth and CO2 emissions as well as the impact of economic growth on the environment. There aren't many empirical studies that highlight the connections between Nigeria's environment and economic growth. This calls for an empirical investigation into whether the EKC applies to Nigeria.

The current work adds the following to the body of prior literature. First off, to the best of our knowledge, this study is the first to examine the viability of the EKC hypothesis for specific variables for Nigeria and a chosen long-term dataset time range (spanning the years 1980–2023). Second, previous research on Nigeria mostly focused on the relationship between CO2 emissions, a measure of pollution, and energy consumption and economic growth. However, the new work also considers characteristics related to trade openness and financial development that are crucial for developing nations like Nigeria..

Lastly, policymakers are expected to find the research findings helpful in developing environmental policies that focus on low-carbon growth plans. The Nigerian low-carbon turning point can be determined `using the EKC hypothesis. The current paper is expected to close the gap in previous research concerning the perspectives of trade openness and financial development as well as the validity of the EKC hypothesis for the case of Nigeria.

The remaining portion of the current investigation is as follows: The next section looks at the empirical articles in the literature. The third section includes a summary of the empirical findings and the methods utilized in this study. A discussion of the implications for policy brings the final section to a close.

2. LITERATURE REVIEW

2.1. CONCEPTS OF ECONOMIC GROWTH

Early economic growth is represented by a lack of ecologically friendly technologies and little to no understanding of environmental problems. The quality of the environment gets better with increased income per capita up to a point, after which it gets worse with greater affluence. This relationship can be shown using the inverted U-shaped curve. It is named after Kuznets's discovery and is known as the EKC (1955).

The Environmental Kuznets Curve theory provides a graphic representation of the correlation between environmental quality and economic development. This theory states that environmental degradation increases in the early phases of economic growth but decreases once per capita income reaches a certain level. According to the notion, societal preferences and market forces may produce better environmental results as the economy grows.

The Kuznets curve represents a theory proposed by economist Simon Kuznets in the 1950s and 1960s. According to this theory, when an economy develops, market forces lead economic disparity to increase and then decrease. The Kuznets curve appeared to reflect experience when it was initially proposed. However, since the 1970s, inequality has worsened in the US and other wealthy countries, debunking the theory.

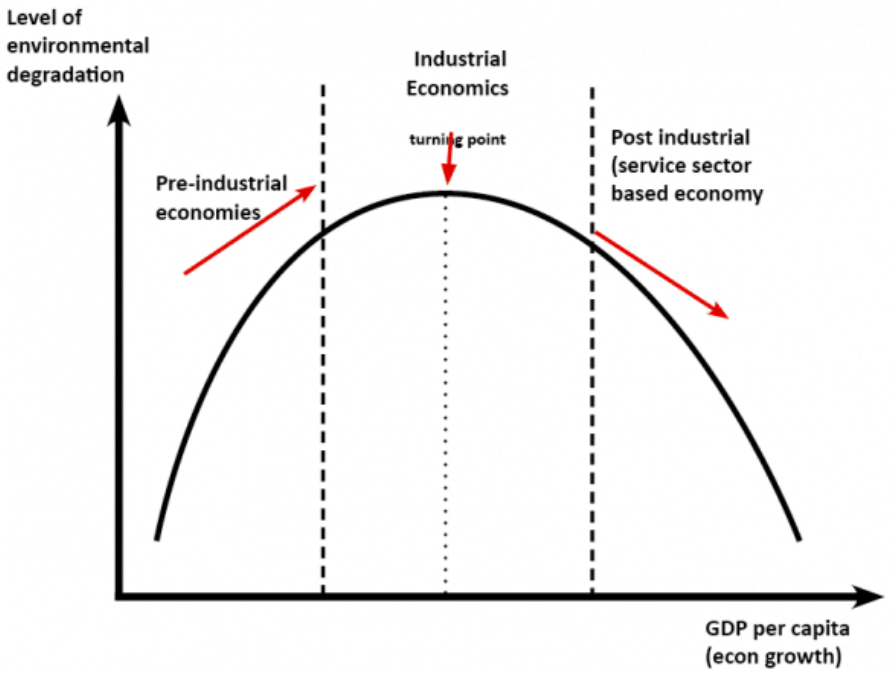


Figure 1: *Diagram of Kuznets Curve*
Source: *Pettinger, T. (2019)*

2.2. CAUSES OF ENVIRONMENTAL KUZNETS CURVE

1. Empirical evidence of falling pollution levels with economic growth. Research in the US showed that while car use increased in response to higher economic growth, levels of air pollution, particularly Sulphur dioxide, decreased due to regulation.

2. Spare income with growth. People who experience higher rates of economic growth have more discretionary income after meeting their basic needs, which makes them more willing to pay higher prices in exchange for improved environmental standards.

3. Living standards as opposed to real GDP. Traditional economic theory focuses on increasing real GDP and rates of economic growth. However, there is growing awareness that the relationship between economic growth and living standards can be weak.

4. Advancements in technology. Better productivity and technology are the main engines of long-term economic growth. Increased productivity results in increased output while utilizing fewer raw materials. For instance, since the 1950s, fuel efficiency has greatly increased because to advancements in automotive technology. Many cars from the 1950s had extremely low miles per gallon. Automobile manufacturers have started to develop hybrid technology and have made significant progress in cutting fuel usage in recent years.

5. Renewable and solar energy. The development of solar technology is an excellent illustration of how better technology has decreased the possibility of environmental harm. The price of solar energy has dropped dramatically in recent years, which bodes well for sustainable technologies

6. The decline in industry. Economic development initially causes a transition from agriculture to manufacture. More environmental deterioration results from this. But there is a third movement from the industrial to the service sectors due to higher productivity and rising real earnings. Industrialization has decreased as a percentage of the economy in a country like the United Kingdom. Compared to manufacturing, the service sector often has less of an influence on the environment. 7. The function of laws and regulations. The size of the government as a percentage of GDP often increases with economic growth and progress. In an effort to address environmental externalities that negatively impact people's health and way of living, the government can impose taxes and regulations.

8. Declining income's marginal usefulness. Growing wealth has a decreasing effect on marginal utility. The yield on your initial £10,000 each year is pretty substantial. However, the gain is quite little if income increases from £90,000 to £100,000 in contrast. It doesn't matter how wealthy you are if you have to live with environmental deterioration (traffic jams, pollution, poor health). As a result, a logical person will start to emphasize raising other facets of living standards more when they observe their income rising (Pettinger, 2019).

2.3. CRITICISMS OF KUZNETS ENVIRONMENTAL CURVE

1. The empirical data is conflicting. Pollution is not guaranteed to decrease with economic progress.

2. There are other variables that contribute to pollution, not just income. For instance, the efficiency of governmental regulations, the growth of the economy, and the population density.

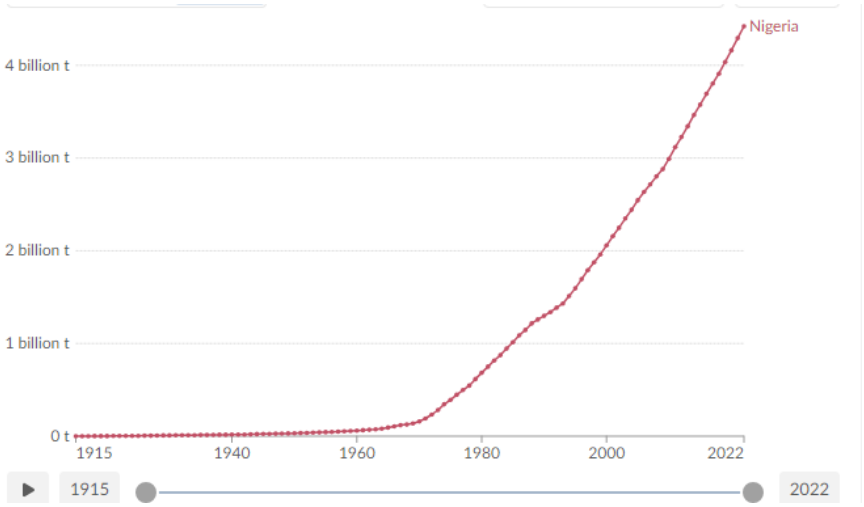
3. Environmental contamination worldwide. Even if the industrial sector has shrunk and the service sector has expanded in many affluent economies, these economies continue to import commodities from developing nations. They are exporting environmental devastation in that sense. While pollution in the US and the UK may be declining, environmental deterioration is increasing in the nations that export to the US and the UK. Deforestation serves as one illustration. Richer nations typically halt the deforestation process, although they continue to import meat. Richer nations often halt the deforestation process, but they continue to import furniture and livestock from nations that are turning their forests into farms.

4. Resource consumption increases with growth. A few economists contend that with industrialization, there has been some lessening of environmental deterioration. Nonetheless, certain resources will unavoidably continue to be exploited more extensively if the economy grows. Long-term environmental deterioration levels may not necessarily continue to decline.

5. The highest GDP countries also have the biggest CO2 emissions. In the US, for instance, CO2 emissions per person are 17.564 tons. In contrast, Ethiopia has 0.075 tons per person. From 1,500 million tons in 1981 to 8,000 million tons in 2009, China's CO2 emissions rose.

2.4. NIGERIA: CO2 COUNTRY PROFILE

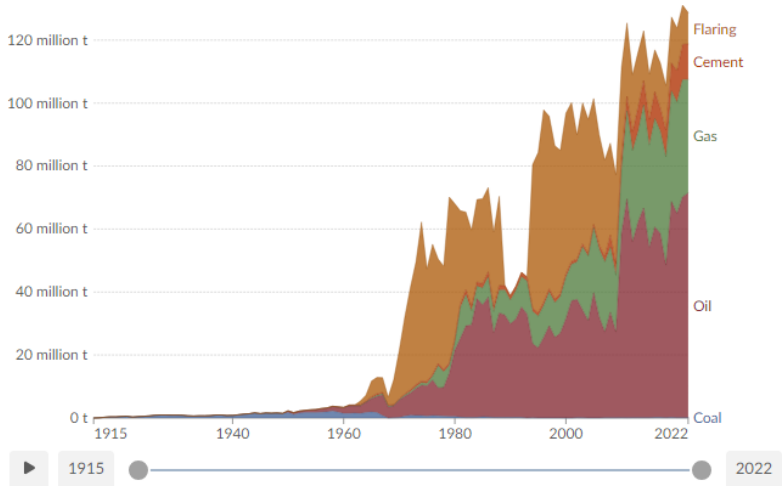
This is an overview of how Nigeria is doing in reducing CO2 and other greenhouse gas emissions. As Africa's largest economy, Nigeria's wide range of livelihoods, agricultural practices, and commodities are threatened by climate change. Rising sea levels increase vulnerability to flooding and waterborne disease. Additionally, drought and rising temperature hinder agricultural production and fishing, reducing food security and negatively impacting health and nutrition. The Nigeria Energy Transition Plan outlines Nigeria's commitment to carbon neutrality by 2060 across 5 key sectors: power, cooking, oil and gas, transport and industry (USAID, 2023).



Data source: Global Carbon Budget (2023) – Learn more about this data
OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

***Figure 2**: Cumulative CO_2 emissions*

This shared chart shows cumulative CO2 emissions – the sum of emissions produced since 1751 to the given year. This allows us to understand how much of the total CO2 emissions to date have been emitted by a given country. (Ritchie and Roser, 2024)



Data source: Global Carbon Budget (2023) – OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

***Figure 3**: CO_2 emissions by fuel or industry type, Nigeria*

CO2 emissions are dominated by the burning of fossil fuels for energy production, and industrial production of materials such as cement.

What is the contribution of each fuel source to the country's CO2 emissions?

This interactive chart shows the breakdown of annual CO2 emissions by source: either coal, oil, gas, cement production or gas flaring. This breakdown is strongly influenced by the energy mix of a given country, and changes as a country shifts to or from a given energy source.

Data source: World Bank (2023); Global Carbon Budget (2023); Population based on various sources (2023) – OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY
Note: GDP figures are adjusted for inflation.

***Figure 4**: Change in per capita CO_2 emissions and GDP, Nigeria. Consumption-based emissions include those from fossil fuels and industry. Land-used change emissions are not included*

To reduce emissions and achieve increasing prosperity at the same time, we have to decouple economic growth from CO_2 emissions. Several countries have achieved this in recent years.

The chart here shows whether this country has achieved this by showing the change in GDP per capita, and annual per capita CO2 emissions over time.

We show both production-based and consumption-based emissions (for countries where this data is available). This allows us to see whether the import of production from other countries- or the export to other countries- has affected this change in emissions (SAID, 2023).

2.5. EMPIRICAL REVIEW

Kuznets' groundbreaking research from 1955 demonstrated the connection between rising economic growth and rising income inequality. The Environmental Kuznets Curve (EKC) theory was further developed by Grossman and Krueger (1991) to examine the environmental impact of the North American Free Trade Agreement between the United States and Mexico. The EKC was further refined by Shafik and Bandyopadhyay (1992) from both cross-country and individual country viewpoints. According to Beckerman (1992), pollution rises in the early phases of development but later exhibits an inverse relationship where pollution falls as economic activity rises. In their critique of the EKC theory, Stern et al. (1996) proposed an inverted U-shaped relationship between per capita income and environmental degradation, which would eventually result in less environmental effect as economic growth increases.

The idea is predicated on an economic model in which trade has an impartial effect on environmental deterioration and there is no feedback from production possibilities to environmental quality. When these presumptions are broken, it becomes difficult to determine the EKC parameters. After evaluating a large number of research, they also noted econometric problems with estimating the EKC. According to the conclusions derived from EKC estimations, if per capita income is normally distributed globally and the median value is substantially lower than the mean income, then additional increases in per capita income will result in a decrease in air pollution.

The origin of the EKC hypothesis discussion is the growth-related policies and controversy. Scholars assume that a higher income level raises environmental degradation. In fact, higher income level may decline environmental degradation (Beckerman, 1992), and thus, economic growth is mandatory for the improvement of environmental quality (Bhagwati, 1993). So, the economic growth might be an influential way for reducing the environmental degradation in developing countries (Panayotou, 1993). There are disagreement among the scholar that which growth is eventually beneficial for the improvement of environment quality, like the current environmental regulation, by lowering economic growth may essentially be declining environmental quality (Bartlett, 1994). Since, in the recent years, the development path raises the conflicts about the connection between the environmental protection and globalization, a stage based connection between the

economic growth and environmental degradation (Htike, M. et al., 2021). Sinha A, et al (2018) conducted the survey of empirical literature on EKC estimation for CO2 from 1991–2017. They considered studies conducted on both single and the group of countries context and hypothesized that the shape of the EKC is an inverted U-shaped which shows the link between CO 2 and economic growth. However, the study failed to confirm the validity of the EKC hypothesis..

Research largely supports the negative U-shaped correlation between CO2 and economic growth. Salari et al. (2021) evaluate the state-level correlation between CO2 emissions, GDP per capita growth, energy consumption in the US from 1997 to 2016 using data from recent studies. The results demonstrate a negative U-shaped link concerning GDP and CO2 emissions, offering sufficient proof to back the EKC theory across state lines. Similarly, considering that CO2 emissions and economic growth are positively associated and that CO2 emissions are negatively impacted by the square of economic growth, Al-Zgool et al. (2020) show that Bahrain profits from the EKC hypothesis.

While the World Bank's (1992) and Grossman and Krueger's (1995) initial findings about the EKC appear to have gained traction in the last ten years, Harbaugh, Levinson, and Wilson (2002) contend that data changes, an extension of the GDP per capita lag-structure, and the inclusion of more country-specific covariates suggest that the pollution-income relationship is not as strong as previously believed.

The connection between competitiveness and environmental regulation is another closely linked topic. According to popular belief, the expense of environmental regulations hinders competitiveness in global markets and inhibits the rise of productivity. The opposing viewpoint, known as the "Porter hypothesis," contends that stringent environmental regulations in the form of financial incentives can spur innovation that could ultimately boost a firm's competitiveness and possibly offset the short-term private costs of the regulations (Porter and van der Linde 1995).

Studies conducted empirically (e.g., Kalt 1998; Tobey 1990; Jaffe et al. 1995) on the relationship between environmental regulation and competitiveness—which is reflected in changes in trade and investment patterns—have not found any evidence to support the idea that regulations increase competitiveness or a significant negative effect on it. The ability of the available data to quantify the level of regulation is limited. However, there are other plausible explanations for these inconclusive results, such as the fact that compliance costs represent a small portion of total production costs, that stringency differentials are negligible, and that investments are made using the most recent technological advancements even in cases where they are not mandated by national environmental regulations.

Studies of differences in sustainability reporting between developing and developed countries show regional differences in the content, type, and extent of reporting (Dawkins and Ngunjiri, 2008; Vilar and Simão, 2015; Ali et al., 2017; Bhatia and Makkar, 2019; Sharma, 2019). Evaluation of content shows that reports from developing countries mainly address social performance, employees,

and consumers, whereas reports from developed countries mainly address environmental performance (Bashtovaya, 2014). The main topic of sustainability reports in developed countries is management and reduction of environmental pollution, with these reports also emphasizing the support of groups within society (Sharma, 2019). By contrast, reports from developing countries mainly address investments in programs that positively affect living standards, such as investing in education or providing food and water. For example, CSR programs in developing countries focus on social areas through philanthropy, whereas programs in developed countries prioritize environmental issues (Khojastehpour and Jamali, 2021). Sustainability reports from developing countries place little emphasis on the area of human resources, such as equal opportunities for employees or the welfare of employees, whereas reports from developed countries did not prioritize community issues, such as donations/charities and community awareness programs (Bhatia and Makkar, 2019). Companies in both developed and developing countries assigned the highest importance to reporting on Customers and Products, such as product innovations or responsible marketing and communication. These findings indicate that sustainability reporting by companies is directed more at customers than at employees, as customers are regarded as the more important interest group.

Subsequent studies focused on the causes of differences in sustainability reporting by companies in developed and developing countries. Institutional factors (Welford, 2005; Bashtovaya, 2014), as well as political and economic conditions (Welford, 2005) have been reported responsible for these differences. Companies in developing countries, adapt to government programs and try to use sustainability activities to solve local social and economic issues (Sharma, 2019). Companies in developing countries may try to use their CSR programs to eliminate institutional gaps caused by corrupt governments or governments with insufficient resources (Visser, 2009). By contrast, companies operating in developed countries do not deal with issues such as lack of basic healthcare and education, regarding provision of these services to be the responsibility of their governments, thereby enabling them to invest in other areas as part of their CSR programs (Bhatia and Makkar, 2019).

According to research by Ayeche et al. (2016), Selden and Song (1994), Grossman and Krueger (1991), and others, there is a negative relationship between environmental quality and economic growth in every economy. Using panel data broken down by country, Grossman and Krueger (1995) assessed the relationship between per capita income and a number of environmental indices. It shows first that production activities necessitate more natural resources, which raise CO2 emissions and worsen environmental conditions. Secondly, the shift in the economy from agriculture to industrialization, or the structural change, also contributes to an increase in ED. Third, increased R&D spending would be helpful in implementing cutting-edge technology in manufacturing processes, which boosts economic growth and improves environmental sustainability. On the other hand, it might be brought on by an increase in river basin contamination, oxygen depletion, and urban air pollution. According to Akbostanci et al. (2009), there was no U-shaped connection between income and pollution in Turkey. The study uses conventional parametric

regression models to determine the link between CO2, SO2, and PM 10 emissions and economic growth.

Saboori et al. (2012) also witnessed that income and ED did not support the EKC hypothesis in Indonesia. In this study, existence of EKC is tested through auto regressive distributed lag econometric models, while CO 2 emission, economic growth, energy consumption and foreign trade related factors were undertaken. Popa (2012) established a link between social factors, HD, economic welfare and economic environment using robust empirical models in European economies. It considered real GDP as dependent variable, and population at risk of poverty, unemployment rate (UNR), life expectancy rate and expected years of schooling as explanatory variables. It provided significant association between per capita GDP and social factors, while economic growth was negatively impacted due to incidence of poverty and lack of employment opportunities.

3. METHODOLOGY

The present study examines the validity of the EKC curve as delineated in the theoretical framework section. To capture the connection between these variables, a quadratic relationship between per capita real GDP and per capita CO2 emission is required (Ang, 2007). The World Bank World Development Indicators database is the source of data. Income growth is measured through GDP growth, while environmental pollution is measured by CO2 emission per capita in kilotons.

3.1. MODEL SPECIFICATION

To test the EKC hypothesis in the case of Nigeria, this study used the theoretical and empirical findings to develop the following model:

$$\mathrm{CO2\ E} = \mathrm{f\ (GDPp, GDPp2, TRDE, INDUST, RENW, FDI)} \quad 1$$

The econometric transformation of Equ . 1 is thus expressed:

$$CO2 = \beta 0 + \beta 1 GDPpt + \beta 2 DPp2t + \beta 3\mathrm{TRDEt} + \beta 4\mathrm{INDUSTt} + \beta 5\mathrm{RENWt} + \beta 6\mathrm{FDIt} + \varepsilon t$$

Where

$CO2$= the natural logarithm of carbon dioxide emissions
GDPp = Gross Domestic Product Per Capita.
GDPp2= Gross Domestic Product Per Capita.
TRDE =Trade
INDUST = Industrialization.
RENW= Renewable electricity
FDI = Foreign direct investment

Based on the equation (3) the parameters must satisfy the following sign restriction: $\beta 1, \beta 3, \beta 4 > 0;\ \beta 2, \beta 5, \beta 6, < 0$

We expected a negative sign for a squared value because an increase in the square term of GDP will lead to a decrease in CO2 emissions; this shows that further

increases in GDP decrease the level of CO2 emissions, and it is proved by the occurrence of the EKC hypothesis. The EKC hypothesis is said to exist when we find economic growth and the square term of GDP are significantly positively and negatively related to CO2 emissions. This implies that at an initial stage, economic growth increases environmental degradation until a certain level where further economic growth reduces environmental degradation. The situation above indicates that environmental quality is associated with the cost of economic growth.

3.2. DATA AND VARIABLE DESCRIPTION

Variables definition, notations, and the source of data reported in Table 1.

Table 1:.*Brief description of dependent and independent variables*

Variable	**Measurement /Proxy variables**	**Source**	Expected sign
CO_2E)	CO2 emissions (metric tons per capita)	World Bank, WDI (2023)	
GDPp	Gross Domestic Product Per Capita proxied for Economic Development	World Bank, WDI (2023)	+
GDPp2	Squared GDPPCit Gross Domestic Product (GDP per capita, current US $)	calculated from GDPp	-
TRDE	Trade is a country's the total trade as the percentage of GDP	World Bank, WDI (2023)	+
INDUST	Industry value added (% of GDP)	World Bank, WDI (2023)	+
RENW	Renewable electricity output (% of total electricity output)	World Bank, WDI (2023)	-
FDI	Financial development proxied by FDI, net inflows (% of GDP)	World Bank, WDI (2023)	-

Source: Author's computation

4. EMPIRICAL RESULTS

This section presents the econometric results and their interpretation along with the theoretical and empirical support of the study: i.e., the descriptive statistics, the unit root test using the Augmented Dickey-Fuller ADF test, the co-integration test using Johansson co integration test and the long-run and short-run dynamics results.

In time series analysis, testing the stationarity of the variables is vital to avoid spurious results. Besides, testing the co-integration of the variables to determine the long-run relationship among the variables is essential.

4.1. DESCRIPTIVE STATISTICS OF THE VARIABLES

Table 2: *Descriptive statistics of the variables relating to Nigeria*

	LogCO_2 E	**LogGDPp**	**LogGDPp2**	**LogTRDE**	**LogINDUST**	**Log RENW**	**Log FDI**
Mean	−3.15	7.58	50.76	3.66	17.26	17.26	4.53
Median	−2.37	6.12	37.47	3.69	17.88	17.88	4.51
Max.	2.55	11.09	91.27	4.24	22.62	22.62	6.42
Min.	−5.638	6.037	72.65	3.11	4.4	4.4	2.38
Std Dev.	1.067	0.87	12.14	0.24	3.24	3.24	1.144

Skewness	1.449	1.38	1.75	0.001	−1.29	−1.29	0.000
Kurtosis	5.09	4.89	5.95	2.48	5.24	5.24	1.78
Prob.	0.000	0.0000	0.0000	0.202	0.000	0.000	0.000

Source: Author's computation using E-view

Table 2 shows the descriptive statistics of the variables relating to Nigeria. The mean of LogCO_2 emissions is −3.15, and the range is between −5.638 and 2.55, showing that the variation is not large. Similarly, the mean values of our target variables (LogGDPp and LogGDPp 2) have a small variation in their range. For example, the mean values of LogGDPp and LogGDPp2 are 7.58 and 51, respectively. Further, the value of the range of LogGDPp is between 6 and 11, and the range of LogGDPp2 is between 72.65 and 91.27. Generally, the ranges of our dependent and independent variables show low variation.

4.2. UNIT ROOT AND CO-INTEGRATION TESTS

Before we checked the presence of a long-run relationship (co-integration) between the variables, we determined the order of integration of each variable in the model by unit root tests: the tests by the Augmented Dickey-Fuller ADF test. Following the unit root test, this study used Johansson co integration test to confirm the existence of a long-run relationship among the variables.

Table 3 *Unit root test*

Variables	**Difference**	**ADF statistic**	**Critical Value (5%)**	**Order of Integration**	**Remark**
CO^2E	CO^2E	-3.025841	-5.337582	I(0)	Non-Stationary
	D(CO^2E)	-6.531722	-5.337582	I(1)	Stationary
GDPp	GDPp	-8.253361	--5.337582	I(0)	Stationary
GDPp2	GDPp2	-3.552772	-5.337582	I(0)	Non-Stationary
TRDE	TRDE	-2.248753	-5.337582	I(0)	Non-Stationary
	D(TRDE)	-6.206373	-5.337582	I(1)	Stationary
INDUST	INDUST	-7.505882	-5.337582	I(0)	Stationary
RENW	RENW	-3.516749	-5.337582	I(0)	Non-Stationary
	D(RENW)	-8.463865	-5.337582	I(1)	Stationary
FDI	FDI	-6.253361	--5.337582	I(0)	Stationary

Source: Author's computation using E-view

The results in table 3 shows that industrialization, financial development, GDP Per Capita and its square are stationary at level, while trade and Renewable Energy are stationary at first differencing. Following Harris (1995) and Gujarrati (2003) cointegration, both 1 (0) and 1 (1) variables could be carried forward to test for cointegration.

4.3. COINTEGRATION TEST

The Johansen Fisher Cointegration test was employed to examine the long-run relationship for the variables.

Table 4: *Cointegration Test*

Hypothesized No. of CE(s)	**Eigenvalue**	**Likelihood Ratio**	**5% Critical Value**	**1% Critical Value**
None **	0.569521	350.6138	175.00	168.36
At most 1 **	0.921821	177.6227	124.24	133.57

At most 2 **	0.627129	102.6525	94.15	103.18
At most 3 *	0.637214	70.03953	68.52	75.05
At most 4	0.273629	526.2427	64.25	64.57
At most 5	0.272855	17.25512	39.88	45.75
At most 6	0.282632	9.022551	17.23	30.09
At most 7	0.015402	0.501281	5.86	7.52

*(**) indicates four cointegrating equations at the 5% significant level.

Source: Author's computation using E-view

4.4. THE ESTIMATION RESULTS

The outcomes of relationship between the independent variables and CO2 emissions are displayed in Table 5. The GDP per capita and its square, our target variables, have a strong positive and negative impact on CO2 emissions, respectively. Our analysis reveals an inverted U-shaped relationship between economic growth and CO2 emissions. This is in line with previous findings of the literature (Selden and Song, 1994; Andersson and Karpestam, 2013). In summary, CO2 emissions begin to decline once a nation achieves a certain degree of economic growth.

The result shows that there is a significant and positive correlation between carbon dioxide emissions and global trade. More precisely, increased environmental pollution is as result of a higher trade-to-GDP ratio. The CO2 produced by industry as a percentage of the whole economy is higher, as indicated by its coefficient. The literature by authors like Weber et al. (2008), Chebbi et al. (2009), Sharma (2019), and Leitao and Shahbaz (2013) are in line with these findings. This outcome is consistent with OECD (2017) results, which highlight the detrimental effects of international trade on the environment due to the exchange and transportation of commodities, as well as the relocation of industry to regions with laxer environmental regulations. The findings refute the pollution heaven theory, which holds that businesses export pollutants to developing nations, and instead show that foreign direct investment (FDI) proxied for financial development reduces pollution.

Table 5: *Estimation method using the ECM approach*

Variables	Coefficients	Std error	t-statistic	Prob.
C	-12.266512	5.73751	-.6052753	0.0023
GDPp	0. 546	1.7232	2.30567	0.0269
GDPp2	−0.7213	0.51525	3.7381	0.010
TRDE	2.091	0.347	4.1294	0.002
INDUST	5.253	0.729	3.6417	0.016
RENW	−0.021	0.010	-0.8381	0.166
FDI	−0.624	0.345	-3.0451	0.4082
R-squire	0.681278			
Mean Dep Var	12.06666			
Adj R-squire	0.631265			
S.D. Dep Var	0.925235			
DW	1.431324			
Sum-squired resid	2.822051			
F-stat	45.13109			
S.E. of Reg.	0.311125			
Log Likelihood				
Prob.(F-stat)	0.000000			

Source: Computed by the authors using Eview

5. CONCLUSION AND RECOMMENDATIONS

Researchers, academics, and policymakers are very concerned about achieving fast and sustainable economic growth without negatively impacting the environment. The EKC hypothesis is a well-known theory that explains the connection between environmental degradation and economic activity. Therefore, the main goal of this work was to use the ECM estimate technique to investigate the EKC hypothesis in the case of Nigeria during the years 1980–2023. The usual EKC hypotheses were confirmed by the regression findings, which showed a negative per capita squared GDP and a positive and significant per capita GDP. While energy from industrialization, as predicted, caused environmental pollution, the creation of renewable energy was also found to play a positive influence.
In order to lower air pollution, this article recommends that environmentalist decision-makers concentrate on renewable energy. Furthermore, the production and trading of fossil fuels are two of the main causes of global CO2 emissions. Thus, it is crucial for scientists to use biofuel or renewable energy sources and reduce long-distance trading. Lastly, financial development can stimulate the adoption of environmentally friendly technologies.

REFERENCES

Abdulmalik M. Yusuf, A. M., Abubakar, A. B. & Mamman, S. O. (2023).Relationship between greenhouse gas emission, energy consumption, and economic growth: evidence from some selected oil-producing African countries. *Environmental Science and Pollution Research. Volume 30, pages 49536–49550, (2023).*

Akbostanci, E., Türüt-Asik, S. and Tunc, G.I. (2009) The Relationship between Income and Environment in Turkey: Is There an Environmental Kuznets Curve? *Energy Policy*, 37, 861-867. https://doi.org/10.1016/j.enpol.2008.09.088

Albert A. Bartlett, A. A. (1994). Reflections on Sustainability, Population Growth, and the Environment. *Population and Environment*. Vol. 16(1) (Sep., 1994), 5-35 (31 pages)

Ali, S. H. (2017). Mineral supply for sustainable development requires resource governance. *Nature* 543, 367–372 (2017)

Ang, J. B. (2007): CO2 emissions, energy consumption, and output in France. *Energy Policy*, 5, 4772-4778.

Ayeche, M.B. *et al.(2016).* Causal linkage between economic growth, financial development, trade openness and $C0_2$ emissions in European countries. *American Journal of Environmental Engineering*. p-ISSN: 2166-4633 e-ISSN: 2166-465X. 2016; 6(4): 110-122

Baltagi, H. B. (2005), Econometric Analysis of panel Data. John Wiley and Sons, Third Edition. Environmental Sustainability Index (ESI), Various Years, New Haven, Conn.: *Yale Center for Environmental Law & Policy.*

Bashtovaya, V. (2014). CSR reporting in the United States and Russia. *Social Responsibility Journal, 10*(1), 68–84.

Bertram, R. M., Blasé, K. A. and Fixsen, D. L. (2015). Improving Programs and Outcomes: Implementation Frameworks and Organization Change. Research on Social Work Practice 25(4):477-487.

BhagwatiT, J. (1993). he Case for Free Trade. Scientific American.269(5), 42-49 (6 pages)

Bhatia, A. and Makkar, B. (2020), CSR disclosure in developing and developed countries: a comparative study, *Journal of Global Responsibility*, 11(1), 1-26. https://doi.org/10.1108/JGR-04-2019-0043

Chebbi H., Olarreaga M. and Zitouna H. (2009): Trade openness and CO2 emissions in Tunisia. ERF 16th Annual Conference, November 7-9, 2009.

Dawkins, C. and Ngunjiri, F. W. (2008). Corporate Social Responsibility Reporting in South Africa: A Descriptive and Comparative Analysis. *International Journal of Business Communication (IJBC)*. 45(3).

Dinda, S. (2004): Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics*, 49, 431– 455

Ebert, Udo and Heinz Welsch (2004).Meaningful Environmental Indices: A Social Choice Approach. *Journal of Environmental Economics and Management 47: 270-283*

Environmental Law & Policy (2006), Environmental Sustainabilty Index (ESI) (2005). 2005 Environmental Sustainability Index Report.New Haven, Conn.York: *Oxford University Press.*

Esty, D.C., M.A. Levy et al. (2005). The 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship". New Haven: *Yale Center for Environmental Law and Policy*

Esty, Daniel C., Mark A. Levy, et al. (2003). *Environmental Sustainability in the Arab World. The Arab World Competitiveness Report 2002-2003* (P. Cornelius, ed.). New York: Oxford University Press

Fabrizi, A., Gentile, M. Guarini, G. & Meliciani, V. (2024). The impact of environmental regulation on innovation and international competitiveness. *Journal of Evolutionary Economics*.

Gazi , M. A. I. et al (2022). Dynamic Nexus between macroeconomic factors and CO2 emissions: Evidence from oil-producing countries. Sec. *Environmental Economics and Management*. Volume 10

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement. *National Bureau of economic research. doi: https://www.nber.org/papers/w3914*

Grossman, G. M., and Krueger, A. B. (1995). Economic Growth and the Environment. *Q. J. Econ.* 110 (2), 353–377. doi:10.2307/2118443

Grossman, G.M. and Krueger, A.B., 1995, Economic growth and the environment. *Quarterly Journal of Economics 110(2), 353–377. doi: 10.2307/2118443*

Harbaugh, W. T.; Levinson, A. & Wilson, D. M., (2002). Reexamining The Empirical Evidence For An Environmental Kuznets Curve, *The Review of Economics and Statistics*, MIT Press, 84(3), pages 541-551.

Htike,M. M. Anil Shrestha, A & Kakinaka, M. (2021).Investigating whether the environmental Kuznets curve hypothesis holds for sectoral CO2 emissions: evidence from developed and developing countries. *Environment, Development and Sustainability*. 24, 12712–12739, (2022)

Jaffe, A. B., S. R. Peterson, P. R. Portney, and R. N. Stavins. 1995. Environmental regulation and the competitiveness of US manufacturing: What does the evidence tell us? *Journal of Economic Literature* 331: 132–63.

Jeetoo, j. and Chinyanga, E. R. (2023). A spatial econometric analysis of the environment Kuznets curve and pollution haven hypothesis in Sub-Saharan Africa. *Environ Sci Pollut Res Int. 2023; 30(20): 58169–58188. Published online 2023 Mar 28. doi: 10.1007/s11356-023-26306-9*

Karl Marx, *Capital*, vol. 1 (London: Penguin, 1976), 637.

Katircioglu, S. (2017)Investigating the Role of Oil Prices in the conventional EKC model: Evidence from Turkey. *Asian Economic and Financial Review***.** *Vol 7, Issue 5, May2017*

Khojastehpour, M. and Jamali, D. (2021), Institutional complexity of host country and corporate social responsibility: developing vs developed countries, *Social Responsibility Journa*l, 17(5), 593-612. https://doi.org/10.1108/SRJ-04-2019-0138

Leitão, N. and Shahbaz, M. (2013). Carbon Dioxide Emissions, Urbanization And Globalization: A Dynamic Panel Data. *Economic Research Guardian*, 2013, 3(1), 22-32

Malthus, Th.R. 1986. The Works of Thomas Robert Malthus. 8 vols. Ed by E. A. Wrigleyand D. Souden. London: Pickering.

Mente, M. (2023). Sustainable development economy and the development of green economy in the European Union. *Energy, Sustainability and Society volume 13, Article number: 32 (2023)*

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. ILO Working Papers from International Labour Organization

Pettinger, T. (2019). *Environmental Kuznets curve*. https://www.economicshelp.org/blog/14337/environment/environmental-kuznets-curve/

Pooja Yadav (2022). Explained: What Is The Environmental Performance Index And Why India Has Rejected The Report. https://www.indiatimes.com /explainers/news/what-is-the-environmental-performance-index-and-why-is-india-rejecting-the-report-574129.html

Popp, D. (2012). *The role of technological change in green growth*: The World Bank

Porter, M. E., and C. van der Linde. 1995a. Green and competitive: ending the stalemate. *Harvard Business Review* 735, 120–34.

Rehman N., Mahmood A., Ibtasam M, Murtaza S.A., Iqbal, N. and Molnár (2021) The Psychology of Resistance to Change: The Antidotal Effect of Organizational Justice, Support and Leader-Member Exchange. *Frontiers in Psychology*. 12, 67-95

Ricardo, D. 1951-73. The Works and Correspondence of David Ricardo. 11 vols. Ed. byP. Sraffa with the collaboration of M.H. Dobb, Cambridge: Cambridge University Press.[1928] 1951. Notes on Mr Malthus. In Ricardo 1951-1973. II.

Ritchie, H. and Roser, M (2024). *Nigeria: CO2 Country Profile*. Retrieved from https://ourworldindata.org/co2/country/nigeria?country=~NGA

Rosen, M. A. (2017). Sustainable Development: A Vital Quest. *European Journal of Sustainable Development Research, 1(1), 2.* https://doi.org/10.20897/ejosdr.201702

Roy, Esha (11 June 2022). Explained: What is the environment index, and why has India questioned it?. *The Indian Expres*

Saboori, B, et al. (2012). An Empirical Analysis of the Environmental Kuznets Curve for CO2 Emissions in Indonesia: The Role of Energy Consumption and Foreign Trade. *International Journal of Economics and Finance*, 4(2)

Salari, M., Javid, R. J., and Noghanibehambari, H. (2021). The nexus between CO2 emissions, energy consumption, and economic growth in the U.S. Econ. *Anal. Policy* 69, 182–194. doi:10.1016/j.eap.2020.12.007

Selden, T.M. and Song, D., 1994, Environmental quality and development: Is there a Kuznets curve for air pollution? *Journal of Environmental Economics and Management 27(2), 147–162. doi: 10.1006/jeem.1994.1031*

Shafik, N. and Bandyopadhyay, S., (1992) Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence, Background Paper for the World Development Report (Washington, DC: The World Bank).

Sharma, S. (2019). Descriptive Research Designs. https://www.researchgate.net/publication/333220662_Descriptive_Research_Designs

Sinha A, Shahbaz M, Sengupta T (2018) Renewable energy policies and co ntradictions in causality: a case of Next 11 countries. *J Clean Prod*, 197, 73–84

Song, T., Zheng, T., and Tong, L. (2008). An empirical test of the environmental Kuznets curve in China: A panel cointegration approach. *China Economic Review 19, 381–392. doi: 10.1016/j.chieco.2007.10.001*

Stern D.I. (2004): The Rise and fall of the Environmental Kuznets Curve. *World Development*, 32(8), 1419–1439.

Tobey, J. A. (1990). The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test, Kyklos Wiley Blackwell, 43(20), 191-209, May.

USAID (2023). Nigeria: Climate Change Country Profile (November 2023). Retrieved from https://reliefweb.int/report/nigeria/nigeria-climate-change-country-profile-november-2023

Vilar, V.H.; Simão, J. (**2015**,) CSR Disclosure on the Web: Major Themes in the Banking Sector. *Int. J. Soc. Econ. 42*, 296–318.]

Visser, L. (2009). Motivational Communication. In: Handbook of Improving Performance in the Workplace. (R. Watkins and D. Leigh, eds.). ISPI & Pfeiffer-Publishers.

Weber JM, et al. (2008) Control of replication initiation by the Sum1/Rfm1/Hst1 histone deacetylase. *BMC Mol Biol* 9:100

Welford, R (2004). Corporate Social Responsibility in Europe, North America and Asia: 2004 Survey Results. *The Journal of Corporate Citizenship*.17, 33-52

World Bank (1992), *World Development Report 1992: Development and the Environment,* Oxford University Press, New York.

World Bank (2009). *World Development Indicators CD-ROM 2009*, Washington, DC.

World Bank' (2012). World Bank's 'green growth' approach denounced (Bretton Woods Project). Bretton Woods Project / July 2012. https://whygreeneconomy.org/information/world-banks-green-growth-approach-denounced-bretton-woods-project/

Yale Center for Environmental Law & Policy (2005), Environmental Sustainabilty Index (ESI) in 2003. 2003 Environmental Sustainability Index Report.New Haven, Conn. Yale Center

Zhang, Y., Zhao, W., Li, B., & Li, H. (2018). Understanding the Sustainability of Fuel from the Viewpoint of Energy. *European Journal of Sustainable Development Research, 2(1), 09. https://doi.org/10.20897/ejosdr/76935*