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Assessing the Moderating Effect of Institutional Quality on Economic Growth - Carbon Emission Nexus in Nigeria[1]

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Research Department

Assessing the Moderating Effect of Institutional Quality on Economic Growth - Carbon Emission Nexus in Nigeria

Anne C. Maduka, Stephen O. Ogwu & Chukwunonso S. Ekesiobi

Abstract

This study explores the relationship between economic growth and carbon dioxide and the moderating effect of institutional quality in Nigeria from 1990 to 2020, by employing long run and short run dynamic ARDL regression, quartile regression and granger causality test for the estimation. Utilizing CO2 per capita emissions, GDP per capita– a proxy for economic growth, capital stock (CAPSTK) – proxy for capital investment in Nigeria and Control of Corruption and Regulatory Quality (COC and RGQ) which represent the effective environmental regulations and laws put in place for the control and prevention of environmental degradation, the study found a significant cointegration between CO2 emissions and economic growth (lnGDP) in Nigeria. Furthermore, an N-shaped nexus exist between CO2 emissions and economic growth in the long run and short run instead of the inverted U-shape curve postulated by the EKC hypothesis. This was confirmed by both ARDL and quartile regression results. Similarly, InCAPSTK contributed significantly to the growth of CO2 emissions in Nigeria both in the long run and short run, although, the short run did so at 10% significant level. Contrary to expectations, control of corruption (COC), contributes significantly to CO2 emissions in the long run but when it interacts with income (InGDP×COC), it significantly contributes to the reduction of CO2 emissions. More so, Regulatory quality (RGQ) had no significant impact on CO2 emissions in Nigeria either in the long run or short run, even when it interacts with InGDP. This finding is further supported by the quartile regression outcomes and granger causality. The study therefore concludes that CO2 emissions - economic growth nexus in Nigeria assumes an N-shape both in the long run and short run. Based on the results, the study recommends that Government should pursue industrialization policy with sophisticated method of production that will bring about rapid economic progress and at the same time support environmental sustainability.

KEYWORDS: Regulatory Quality, Control of Corruption, Carbon Emission, Economic Growth, Quartile Regression, Environmental Sustainability

JEL: O44; Q5; C5

1. Introduction

The threat posed by climate change has intensified interest in the study of economic growth and carbon emissions (CO2). While hydrocarbon fuel reliance and continued carbon emissions have significant effects on the ecosystem and global rising temperatures, sustainable development guarantees the existence of humanity (Ouédraogo, *et al*., 2021). According to Ekundayo (2015), a precondition for the attainment of sustainable development as contained in the 2030 global development agenda is for countries to transit to eco-friendly growth and engender an emission-free environment. Polluting growth activities directly affects humans, causing illnesses such as cancer, inflammation, and heart disease (Pope and Dockery, 2006), and environmental quality (Ben Amar, 2021). The writings by Kuznets (1955) and Grossman and Krueger (1991) fostered the creation of the environmental Kuznets curve (EKC) concept, an inverted U-shaped association between environmental pollution and economic growth, providing an interesting examination within emerging economic research. Correspondingly, a large body of studies on the subject matter has accumulated in recent decades, emphasizing the importance of a country's degree of economic growth with environmental quality. The EKC hypothesis also suggests that environmental quality initially deteriorates when the economy expands, but after reaching a specific income threshold, it improves as income rises.

The influence of economic growth on environmental degradation cannot be overstated (Mobosi et al. 2017), as increased production leads to swelled pollution. Changes in climate conditions have greater effects on Africa (Dimnwobi, et al, 2021), placing the continent as the most vulnerable to global warming. Recent studies have proved that most of the environmental degradation witnessed in African countries have been debilitating, emanating from the production and consumption of energy commodities and a general increase in economic activity (Ogwu, 2021). Among the countries in Sub-Saharan Africa, Nigeria is of significant interest. The country has the highest economy in Africa, is the largest black nation on earth with over 200 million persons and the largest producer of crude oil in Africa, as well as the world's 25th largest economy by nominal GDP and PPP (Whiting, 2019).With abundant oil resources serving as the major economic backbone, the Nigerian economy has experienced considerable petrodollar revenues and economic prosperity since its independence. From 2011 to 2021, Nigeria grew her GDP annually at an average rate of 2.63 percent, with a peak of 6.88 percent in Q1 of 2011, recording strong figures through the 2008/2009 global economic turmoil in the process, and a low of -6.10 percent in Q2 of 2020 partly due to the COVID-19 induced economic recession. Interestingly, the National Bureau of Statistics GDP report of 2021 states that the Nigerian economy increased by 3.4 percent in 2021 (N72.39 trillion in real value), the strongest rate of GDP growth in 7 years.

However, Nigeria's environmental pollution levels have been alarming on the heels of a rise in 'dirty growth' (Maduka et al. 2021). A World Bank (2021) report states that, although Nigeria alongside six other countries contributes 40 percent of global oil supply, these countries are equally responsible for about two-thirds (65%) of gas flaring in the world for the past nine years successively. This makes the country one of the single largest sources of emissions in the world (Maduka et al. 2021; Kankara, 2013), and puts at risk, the attainment of the Zero Routine Flaring by 2030 initiative inaugurated by the World Bank and the United Nations in 2015 and backed by several energy corporations, governments, and organizations (IEA, 2021). As a result, according to the WHO (2018) and Dada and Ajide (2021), 94 percent of Nigerians are vulnerable to high levels of pollution. The amount of pollution in the country surpasses the SSA average of 72%, while the cost of air pollution impairment is roughly 1% of post-GNP.

Recent economic literature opines that sustainable development is tractable to economic growth accompanied by structural and institutional improvements. As an economy grows, adjustments in output structure from primary production to processing and manufacturing under eco-friendly circumstances become more necessary to ensure sustainable development (Adewuyi and Adeleke, 2016). In a natural resource-dependent economy like Nigeria, good governance and quality institutions are also required to support the fair, transparent, and equal allocation of resources and opportunities. Surprisingly, despite commitments to the global sustainability agenda, the Paris accord and local environmental efforts like the Ogonioil spill clean-up and the national policy to end gas flaring, there has been little action with hazardous consequences for the economy and environment (Mobosi et al. 2017). This scenario is largely due to weak institutions, as no tangible abatement measures have been implemented despite the increasing environmental degradation (Alege and Ogundipe, 2013; Adewuyi and Adeleke, 2016). Quality institutions are however critical to attaining sustainable economic prosperity, especially for a resource-rich country like Nigeria, which is plagued by bad governance, including corruption and abuse of power, as well as a disregard for the rule of law (Okoye, et al., 2018;Mobosi et al. 2017;Adewuyi and Adeleke, 2016).

In the light of the background information, the contributions of this study are fivefold. First, the study makes a modest contribution to the EKC discourse that is largely mixed, while some studies back the EKC's existence (Lv and Li, 2021; Le and Ozturk, 2020; Le and Nguyen, 2020; Elsalih *et al.* 2020; Godil et al., 2020) other findings do not (Adams et al., 2020; Acheampong et al., 2020; Olubusoye and Musa, 2020).Our research further contributes to the extant literature by reassessing and reinterpreting the EKC hypothesis because Nigeria is still on the road to sustainable development since the EKC professes that environmental degradation is high at the inception of development. Second, we contend and present empirical evidence that rises in economic growth alone does not contribute to environmental quality improvement, but rather the institutional factors that facilitate economic growth. This improves on the inconsistent findings of existing studies on the link between economic growth and environmental pollution. The goal of this research is to investigate the moderating influence of institutional quality on the impact of economic expansion on ecological pollution. This study varies from previous studies on institutional quality and CO2 emissions (Ulucak, 2020; Wawrzyniak & Dory, 2020; Sarkodie and Adams, 2018) given the adoption of regulatory quality and corruption control as indicators of institutional quality. Third, given the prevalence of pervasive corruption, weak institutions, and regulatory fragility that have become synonymous with Nigeria (Okoye, et al., 2018; Mobosi et al. 2017; Adewuyi and Adeleke, 2016), this study is particularly pertinent and timely. As a result, neglecting these two factors may result in an understatement of the real environmental damage attributable to emissions, threatening to put Nigeria's initiatives and strategies for safeguarding the environment off course. Fourth, Nigeria is a developing nation with a fast-rising population and a continuously growing economy. Economic development is expected to continue along the same path into the future, with repercussions for the ecology. The results of the study will present pragmatic and evidence-based solutions to enable the country to achieve the Sustainable Development Goals (SDGs), the Paris Accord pact, and the Zero Routine Flaring by 2030 goal. Five, apart from adopting the ARDL dynamic regression by Pesaran, Smith and Shin (1991) as observed in the literature, the quantile regression model proposed by Koenker and Basset (1978) will be employed to validate the outcome of the ARDL model, alongside the Granger causality technique and other supporting tests.

Thus, the goal of this study is to verify the EKC validity for Nigeria and determine whether the level of institutional quality moderates the influence of economic growth on environmental pollution. The subsequent sections of this paper are arranged as follows: section two is the empirical evidence, section three is the methodology, section four is the result presentation and discussion, while section five is the conclusion and recommendation.

2. Empirical Evidence

Many studies have examined the relationship between economic growth and carbon dioxide emissions. This empirical exploration reviews and elicits information on the EKC along with the growth-CO2 nexus on the one hand, and the role of institutional quality on the other. Following the first strand under the EKC, Le and Ozturk (2020) studied the influence of economic growth on carbon emissions for 47 Emerging Markets and Developing Economies (EMDEs), confirming the existence of the EKC.

Similarly, Le and Nguyen (2020) examined the effect of economic prosperity on environmental pollution for 95 nations using the panel corrected standard errors (PSCE) and discovered the presence of the EKC. This result agrees with Elsalih*et al.* (2020) that employed a dynamic two-step SYS-GMM estimator to evaluate the impact of economic expansion on environmental deterioration in 28 oil-producing nations. In addition, Godil et al. (2020) applied a quartile autoregressive distributive lag method for Pakistan and discovered the occurrence of the EKC. For 39 developing nations, Haldar and Sethi (2020) studied the impact of economic expansion on environmental pollution and established identical conclusions. Sarkodie and Adams (2018) validated the presence of the environmental Kuznets curve in the instance of South Africa, while Lv and Li (2021) employed the spatial econometric framework to examine the impact of economic development on environmental pollution for 97 nations and concluded that the EKC exists. Egbetokun et al. (2020) evaluated the impact of economic growth on CO2 emissions in Nigeria and confirmed the validity of the EKC.

Additional research, contrary to the ones described previously, reported no evidence of the presence of the EKC. Lise (2006), for instance, looked at the relationship between carbon dioxide and income in Turkey. The study found a linear relationship between the variables, rather than a quadratic relationship, concluding that the relationship does not support the EKC hypothesis. Omojolaibi (2010) conducted a study on environmental quality and economic growth in some selected West African countries, including Nigeria, assessing the existence of an EKC in those countries. The pooled OLS results showed a consonance with EKC, while the fixed effects results were at variance with the applicability of EKC in West Africa. Akpan and Chuku (2011) examined economic growth and environmental degradation in Nigeria, using the Autoregressive Distributed Lag (ARDL) from 1960 to 2008. The outcome did not back the existence of the EKC hypothesis. Equally, Akpan and Abang (2015) found that the relationship between economic growth and environmental quality has an N – shaped curve instead of a U – shaped curve from panel data from 47 countries. Adams et al. (2020) analysed the effect of economic expansion on environmental contamination in 19 Sub-Saharan African nations. The EKC was shown to be invalid. Likewise, in a study of 83 economies, Acheampong et al. (2020) investigated the impact of economic growth on environmental pollution and established the absence of the EKC. Olubusoye and Musa (2020) investigated the relationship between carbon emissions and economic growth in Africa. The EKC hypothesis was investigated using the ARDL model, Mean Group (MG), and Pooled Mean Group (PMG) models for 43 African countries divided into three income groups from 1980 to 2016. Only 21% of the nations in the sample accepted the EKC hypothesis, whereas 70% of the countries in the whole sample rejected it. According to the study, increased economic expansion will result in higher emissions in the majority of African countries.

Likewise, in terms of the relationship dynamics between CO2 emission and economic growth, Coondoo and Dinda, (2002) studied the causal relationship between carbon dioxide (CO_2) and growth of income in a panel study representing 88 countries of America, Europe, Asia and Africa using Granger Causality tests. The findings reveal that causality goes from emissions to income in industrialized countries in North America, Eastern Europe, and Western Europe. But for the group of countries like Japan, Oceania, Central and South America, causation runs from income to emission. However, for the country groups of Asia and Africa, the causality is found to be bidirectional. Similarly, Richmond and Kaufmann (2006)applied a panel study to determine the existence of a turning point in the relationship between economic development and carbon emissions in OECD and non-OECD countries, using variables like; a ratio of fuel mix supplied by energy suppliers, income and CO2 emission. The results showed a negative nexus between economic development and carbon emissions for OECD countries and a positive relationship for non-OECD countries. In another development, Soytas and Sari (2009) used the Granger causality test to study energy consumption, economic growth and carbon emissions for Turkey, controlling for gross fixed capital formation and labour. The results showed that unidirectional causality runs from carbon emission to energy consumption without feedback. Also, Kasperowicz (2015) studied the economic growth impact of carbon emissions in Poland using the ECM technique for the period 1995 to 2012. Employing variables like gross domestic product (GDP), carbon dioxide emissions (CO_2), energy consumption, capital stock and total employment, the results found that there is a significant relationship between economic growth and CO_2 emissions. The results differ from that of Richmond and Kaufman (2006) which was not significant. Menyah and Rufael (2010) studied the long run and causal relationship between energy consumption, pollutant emissions and economic growth in South Africa from 1965 to 2006. Adopting the ARDL bound test for long-run relationships and the ECM technique for short-run dynamics, the result found unidirectional causality running from emissions to economic growth. Furthermore, in another related study, Menyah and Rufael (2010) identified a unidirectional causality going from nuclear energy to CO2 without feedback in a work examining the relationship between CO2 emissions, nuclear energy, renewable energy, and economic growth in the United States from 1960 to 2007. The findings also revealed no link between renewable energy and CO2. For the period 2002–2012, Zaidi and Ferhi (2019) investigated the causal link between energy consumption, economic growth, and CO2 emissions in a dynamic simultaneous equation model. Using variables of the study including GDP, a proxy for energy use, and CO2 emissions, they found a bidirectional nexus between energy use and electricity use.

In Nigeria, some studies have focused on the relationship between economic growth and CO_2 emissions. Mesagan (2015) used the ECM technique to determine the relationship between economic growth and carbon emission. Findings reveal that economic growth has a favourable influence on carbon emissions in the initial period, but a negative impact in the lagged period, also, capital investment and trade openness have a positive effect on carbon emissions. Ayadi (2014) discovered that economic expansion and foreign direct investment into Nigeria contributed significantly to pollution, although trade is helpful in both the long and short term. Olubusoye and Musa (2020) applied data spanning to 2016 conducted a panel study which at most could only produce a short-run country-specific result.

Concerning works involving institutional quality and the environment, the following studies are reviewed. According to Teng et al. (2021), academics, policymakers, and administrators devote little consideration to the effects of institutional quality on environmental contamination. However, there have been several noteworthy instances. For instance, Danish and Ulucak (2020) employed the FMOLS, DOLS, and DK regression approaches to assess the association between both institutional quality and environmental pollution in 18 Asia-Pacific nations. The study discovered that institutional quality does help the environment. Sarkodie and Adams (2018) employed different evaluation approaches for South African data, including the ARDL methodology, to explore the impact of institutional quality on CO2 emissions. They observed that institutional quality could aid in lessening CO2 emissions. Joshi and Beck (2018) examined the association between democracy (political freedom and economic freedom) and carbon dioxide emissions in a sample of OECD and non-OECD countries using the Arellano-Bover / Blundell-Bond Generalized Method of Moments (GMM) technique. Findings reveal the relationship of both political and economic freedoms have a positive and significant relationship with emission in OECD and non-OECD countries. Examining a group of 93 developing and emerging economies, Wawrzyniak&Doryń (2020) applied a GMM estimation to analyse how institutional quality modifies the nexus between economic growth and CO2 emission. Although the study found that government efficacy influences the economic growth-emissions link, it did not establish that corruption control has a moderating function in influencing the economic growth-carbon emission nexus.

3.1 Methodology and Data Sources

The study tests the nexus between carbon dioxide emissions and economic growth and the moderating effect of institutional quality in Nigeria. The Autoregressive distributed Lag (ARDL) and the quantile regression are adopted for the analysis, thereafter, the causality tests will be conducted to further support the regression results. Annual data on GDP per capita (GDP), CO2 Emissions per capita (CO2), Gross Fixed Capital Formation (CAPSTK), Control of Corruption (COC) and Regulatory Quality (RGQ) which are measures of Institutional Quality were sourced from the World Bank Development Indicator (WDI).

3.2 Theoretical Framework

In the long run, the link between economic growth and carbon dioxide, according to the EKC hypothesis, takes the shape of an inverted U. It claims that once per capita income reaches a particular level, economic growth will be accompanied by improvements in environmental quality. This suggests that after a certain threshold of economic growth, the resulting environmental degradation following the increased economic activities will begin to decrease. Three effects emanate from such relationship, namely;

1. Scale effect: According to the scale effect, as production increases, more inputs are required, resulting in higher emissions of pollutants such as carbon dioxide, gas, and methane, among others. As a result, economic growth has a negative relationship with the environment in the short run, according to the hypothesis (Jordan, Kuik and tol, 2017).

2. Composition Effect: The composition effect, according to Jordan et al. (2017), implies that as the economy grows, its structure may alter as more people participate in cleaner or dirtier activities. The composition effect, on the other hand, is thought to have an uncertain impact on environmental standards.

3. Technique Effect: This implies that variations in income per head can lead to shifts in civic environmental priorities. Such an increase, for example, may lead to a desire for more stringent environmental rules, which in turn can impact production methods, leading them toward the adoption of less polluting technologies (Grossman and Krueger, 1995; Panayotou, 1997).

The EKC hypothesis claims that economic expansion is the solution to environmental concerns based on these effects. In other words, economic expansion leads to environmental betterment. As economic growth is sustained, environmental degradation fizzles away. Higher-income growth will lead to a more advanced production process that is less harmful to the environment (Roca et al, 2001; Perman and Stern, 2003). To put it another way, as a country grows wealthier, current environmental issues will be handled through legislative changes that both protect the environment and support economic development (Roca et al, 2001, Perman and Stern, 2003).

Since the EKC illustrates the nexus between income and the environment, this study can then express the conventional functional hypothesis to be:

$$E_t = F(Y, Y^2, Y^3) \quad (1)$$

Where $E_t$the environmental factor is at a time (t) and Y is the measure of income (GDP). By extension,

$E_t = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_3 Y_t^3 + \beta_4 Z_t \, \omega_t$
(2)

In equation (2) $E_t$is the amount of carbon emission in the country, Y_t is the income (GDP) used to measure economic growth in the early stage of growth (pre-industrial stage), Y_t^2 indicating advancement in economic growth (industrial economy or turning point in growth), it is at this point that emissions stop increasing, and then Y_t^3 is the stage of economic growth where emissions begin to decline (service-oriented economy), and Z_t represents other variables that influence emission (Mishra, 2020). β_1, $\beta_2$and β_3 are coefficients of the different levels of income, β_4 is the coefficient of the other variable (s) that impact emission and ω_t measures the error in the model. The differences in functional forms are expressed by the different values of coefficients of the income terms. According to Alvarez-Herranz and Lorente (2016) cited in Allard et al. (2018), the EKC can adopt any shape based on the sign of the parameters of the different levels of income. Firstly,β_1=β_2=$\beta_3 = 0$, indicates that there is either a flat pattern or absence of any form of relationship between environmental degradation and income. But if $\beta_1 > 0$ and β_2=$\beta_3 = 0$, then a monotonically positive relationship exists between environmental degradations and income, indicating that environmental degradations rise with an increase in income. Similarly, if $\beta_1 < 0$ and β_2=$\beta_3 = 0$, then a negative monotonic relationship exists between environmental degradation and income such that increasing income will lead to a decline in environmental degradation. However, if $\beta_1 > 0$ and$\beta_2 < 0 \; and \; \beta_3 = 0$, then the classical inverted U-shaped EKC exists. But a U-shaped relationship exists between environmental degradations and income if $\beta_1 < 0$ and$\beta_2 > 0 \; and \; \beta_3 = 0$. Furthermore, if $\beta_1 > 0 (positive)$and $\beta_2 < 0$ (negative) and $\beta_3 > 0$ (positive) then an N-shaped nexus exist between environmental degradation and income. Contrarily, the relationship will assume that of an opposite N-shaped if $\beta_1 < 0$ and$\beta_2 > 0 \; and \; \beta_3 < 0$.

Zhang (2021) among others, who found the existence of an N-shaped nexus between pollution and income in China, identified three stages in the growth of income that gave birth to N-shaped nexus. They are the scale effect, where the government pays attention to the growth of income, employment, and production while neglecting the environmental and conservation policies; the compositional and technical effects, where the government now focuses on reducing the pollution level; and the technological obsolescence effects, where the technological effects that take the form of innovations have reached its maximum limit, thereby leading to scale effects outweighing the technical effects, and bringing about further deteriorations in the environment with the increase in income.

3.3 Estimation Technique

3.3.1 ARDL Regression

The use of the ARDL model is possible if a long-run relationship exists among the variables. It is justified since it removes the constraint in the event of variables being stationary at both I(0) and I(1). Similarly, the ARDL model is a potent solution to spurious regression resulting from missing or omitted variables (Engle and Granger, 1987; Yule, 1926; Simon, 1954). Its application in this study is to account for both the long run and short-run relationship between economic growth and carbon emission. To ascertain the existence of Cointegration in our model that will guarantee the use of the ARDL, the Bound F-statistic test proposed by Pesaran, et al, 1991 will be used. All the variables for the study are changed to their log form in order reduce skewness. The ARDL model is thus stated as:

$$\begin{aligned}\Delta CO2_t = {} & \beta_0 + \beta_1 CO2_{t-1} + \beta_2 InGDP_{t-1} + \beta_3 InGDP^2_{t-1} + \beta_4 InGDP^3_{t-1} + \beta_5 InCAPSTK_{t-1} \\ & + \beta_6 COC_{t-1} + \beta_7 InGDP\ X\ COC_{t-1} + \beta_8 RGQ_{t-1} + \beta_9 InGDP\ X\ RGQ_{t-1} \\ & + \sum_{i=1}^{\rho} \alpha_1 \Delta CO2_{t-i} \\ & + \sum_{j=0}^{q} \alpha_2 \Delta InGDP_{t-j} + \sum_{k=0}^{r} \alpha_3 \Delta\, InGDP^2_{t-k} + \sum_{l=0}^{s} \alpha_4 \Delta\, InGDP^3_{t-l} \\ & + \sum_{m=0}^{u} \alpha_5 \Delta InCAPSTK_{t-m} + \sum_{n=0}^{v} \alpha_6 \Delta COC_{t-n} + \sum_{h}^{w} \alpha_7 \Delta\, InGDP\ X\ COC_{t-h} \\ & + \sum_{i}^{y} \alpha_8\, \Delta RGQ_{t-i} + \sum_{g}^{z} \alpha_9\, InGDP\ X\ RGQ_{t-g} + \mu_t \end{aligned} \quad (1)$$

Where ΔCO2 represents the first difference in carbon emissions,InGDP, $InGDP^2$, $lnGDP^3$represents the three stages of economic growth, lnCAPSTK represents the country's capital stock, which represents capital investment, and COC and RGQ are the control of corruption and regulatory quality respectively, which represents effective environmental laws aimed at controlling and preventing environmental degradation, $InGDP\ X\ COC$, represent the interaction of economic growth with control of corruption and $InGDP\ X\ RGQ$ represent the interaction of economic growth with regulatory quality in Nigeria. The short-run maximum lags of the variables are p, q, r, s, u, v, w, and z, while the information criteria will be used to determine the optimal lags. Carbon emission CO2, economic growth (GDP), capital stock (CAPSTK), and institutional quality (COC and RGQ) have long-run impacts of β_1, β_2, β_3 and β_4, respectively, while β_o is the constant term and α_1, α_2, α_3, α_4, α_5, α_6, α_7, α_8 and α_9 are the short-run impacts of these variables. Capital stock and Institutional quality are control variables. The elasticity of the income coefficients for the short and long runs can be understood as the elasticity of income, whereas $\mu_t$represents the idiosyncratic variable (error term). GDP per capita and capital stock are logged. Furthermore, to capture the error in our co-integrating equation, we state the necessary ECM equation as follow:

$$\begin{aligned}\Delta CO2_t = {} & \beta_0 + \beta_1 CO2_{t-1} + \beta_2 InGDP_{t-1} + \beta_3 InGDP_{t-1}^2 + \beta_4 InGDP_{t-1}^3 + \beta_5 InCAPSTK_{t-1} \\ & + \beta_6 COC_{t-1} + \beta_7 InGDP\ X\ COC_{t-1} + \beta_8 RGQ_{t-1} + \beta_9 InGDP\ X\ RGQ_{t-1} \\ & + \sum_{i=1}^{\rho} \alpha_1 \Delta CO2_{t-i} \\ & + \sum_{j=0}^{q} \alpha_2 \Delta InGDP_{t-j} + \sum_{k=0}^{r} \alpha_3 \Delta\ InGDP_{t-k}^2 + \sum_{l=0}^{s} \alpha_4 \Delta\ InGDP_{t-l}^3 \\ & + \sum_{m=0}^{u} \alpha_5 \Delta InCAPSTK_{t-m} + \sum_{n=0}^{v} \alpha_6 \Delta COC_{t-n} + \sum_{h}^{w} \alpha_7 \Delta\ InGDP\ X\ COC_{t-h} \\ & + \sum_{i}^{y} \alpha_8\ \Delta RGQ_{t-i} + \sum_{g}^{z} \alpha_9\ InGDP\ X\ RGQ_{t-g} + \theta ECM_{t-1} \\ & + \mu_t \qquad (2)\end{aligned}$$

Here, while other variables remain as previously defined,θrepresents the error correctioncoefficients indicating the speed of adjustment in the longrun.

3.3.2 Quantile Regression

The Quantile regression in this study is used to authenticate the output of the ARDL. According to Allard, et al. (2018), the unequal variations that result from statistical data can cause the relationship between variables to change at different points in the dependent variable's conditional distribution. Based on this, estimation methods that are built on the mean values could give incorrect results. Thus, the use of the quantile regression becomes ideal as it presents a more valid picture of the relationship that exists among variables. Furthermore, the quantile regression can be used to capture the heterogeneity among the various income and market groups (Allard, et al., 2018). The general specification of the quartile regression model is stated below:

$$Y_i = X_i' \delta_\rho + \epsilon_{\rho i} \qquad (3)$$

Where Y_i denotes the dependent variable, X_i' is a vector of explanatory variables$K \times 1$. Similarly, $\delta_\rho$and $\epsilon_{\rho i}$ are used to represent the unknown vector of estimated regression parameter $K \times 1$for the values of ρ ranging between 0 to 1 and unidentified disturbance (error term), respectively. By transforming equation (3) we can obtain the quantile conditional process as follow:

$$\varphi_\rho\left(\frac{Y_i}{X_i}\right) = X_i'\delta_\rho \quad (4)$$

According to Rehman, Ma and Ozturk (2021), the functional form of the vector δ_ρ can be measured by decreasing the corresponding value ofρ. Furthermore, since the quantile regression can follow either the generalized moment techniques or the basic linear algorithm programming, it is possible to put the number of weighted error conditions to minimal by restriction. The goal is to allow the error conditions to vary while weighing the positive and negative residuals in the chosen quantile. Thus, the interactions between the interest variables can be stated as follow:

$$\Delta CO2_t = \beta_0^\rho + \beta_1^\rho CO2_{t-1} + \beta_2^\rho InGDP_{t-1} + \beta_3^\rho InGDP_{t-1}^2 + \beta_4^\rho InGDP_{t-1}^3 + \beta_5^\rho InCAPSTK_{t-1} + \beta_6^\rho COC_{t-1} + \beta_7^\rho InGDP\ X\ COC_{t-1} + \beta_8^\rho RGQ_{t-1} + \beta_9^\rho InGDP\ X\ RGQ_{t-1} + \mu_t$$
(5)

Where all the variables and terms remain as earlier defined, we proceed to estimate the coefficients of the quantile process which will range between the 1st to 9thquantile.

4. Result Presentation and Discussions

Table 1: Descriptive Statistics

	CO2	InGDP	InGDP^2	InGDP^3	InCAPSTK	COC	InGDPXCOC	RGQ	InGDPXRGQ
Mean	0.666417	11.66652	138.3421	1664.261	14.86480	-1.176498	-13.64478	-0.921344	-10.64965
Median	0.654964	12.02279	144.5474	1737.863	14.80287	-1.172974	-13.78646	-0.907262	-10.12364
Maximum	0.862605	13.52555	182.9404	2474.369	16.78849	-0.891883	-10.34105	-0.659629	-8.200535
Minimum	0.481063	8.555482	73.19628	626.2294	14.65394	-1.431231	-16.75480	-1.351967	-15.96011
Std. Dev.	0.080902	1.519469	34.26189	587.7880	0.365866	0.123662	1.750183	0.170664	1.958414
Skewness	0.442992	-0.552084	-0.392413	-0.248299	4.893926	-0.187057	0.166137	-0.821965	-0.939694
Kurtosis	3.234609	2.126978	1.903585	1.749386	26.34081	2.936723	2.120890	3.362898	3.296862
Jarque-Bera	1.085012	2.559251	2.348353	2.338750	827.4360	0.185954	1.140852	3.660845	4.676127
Probability	0.581290	0.278141	0.309073	0.310561	0.000000	0.911214	0.565285	0.160346	0.096514
Sum	20.65892	361.6622	4288.604	51592.08	460.8089	-36.47144	-422.9881	-28.56166	-330.1393
Sum Sq. Dev.	0.196353	69.26363	35216.30	10364842	4.015727	0.458767	91.89425	0.873789	115.0616
Observations	31	31	31	31	31	31	31	31	31

Source: Author's computation

Figure 1 presents the outcome of the descriptive statistics which from all indications looks good and normal. While InGDP, InGDP^2, InGDP^3, COC, RGQ and InGDP×RGQ are negatively skewed, the rest of the variables are positively skewed. A look at the mean, maximum, and minimum values on a comparative basis indicates that the effectiveness of control of corruption (COC) and regulatory quality (RGQ) which are institutional quality measures, is on the decline. Similarly, InGDP and CO2 are on the increase but emissions tend to increase more rapidly than income.

Figure 1: Scattered plot for CO2 per Capita and In**GDP per Capita in Nigeria**

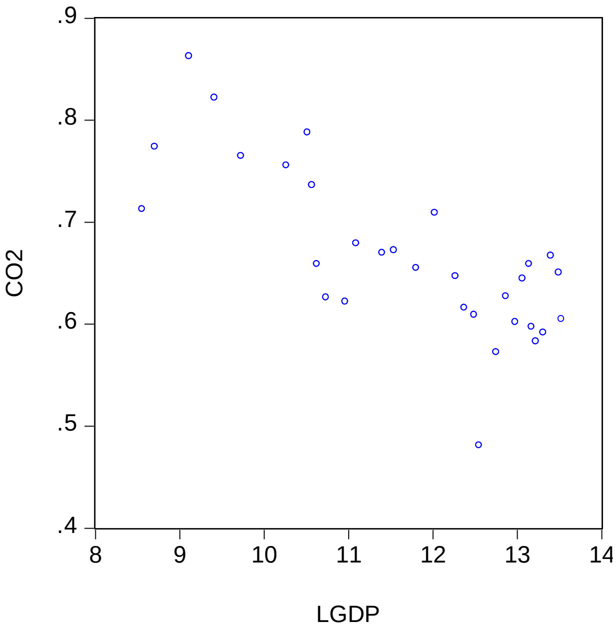
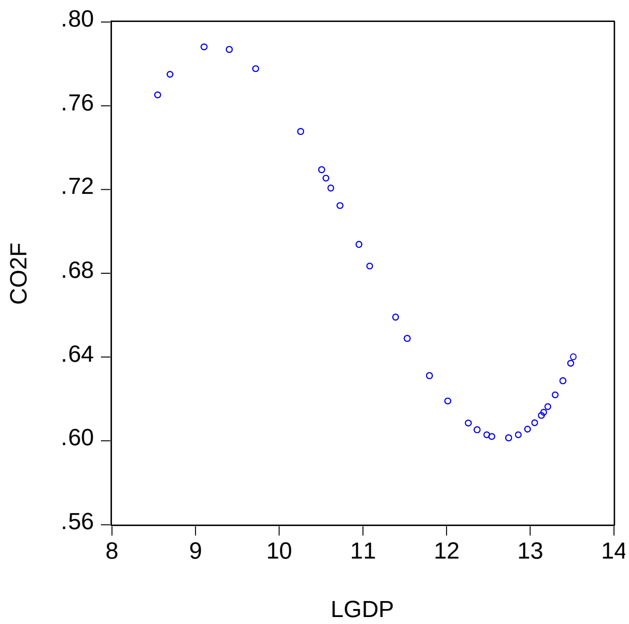


Figure 2: Scattered plot for fitted CO2 per capita and In**GDP per capita in Nigeria**



Figures 1 and 2 are the scattered plots showing the relationship between CO2 per capita and lGDP per capita in Nigeria. Figure 1 reveals that the relationship between CO2 per capita and InGDP per capita in Nigeria takes the form of an N-shaped curve. This is further clarified by figure 2, which is the fitted figure. Figure 1 gives us an insight to the manner in which CO2 emissions respond asymmetrically to the changes in InGDP which in turn could be attributed to the income (InGDP) response to the variations in macroeconomic variables in Nigeria. This is valid looking at the fact that Nigeria within the period considered in this study has remained oil dependent i.e, crude oil has been the major export product for the country and the key contributor to the GDP. It is noteworthy, that even though the prices of crude oil are exogenously determined by the OPEC body, this has not significantly impacted on Nigeria's crude oil production or CO2 emissions.

Table 2: Stationarity Results

Variable	ADF (constant only)		PP (constant only)	
	Level	First Difference	Level	First Difference
InGDP	-2.7722*	-2.2094	-4.7739***	-2.7992*
$InGDP^2$	-2.5840*	-2.2869	-3.5152**	-3.2612**
$InGDP^3$	-2.1522	-2.4713	-2.2719	-3.7586***
CO2	-1.7713	-5.3902***	-1.7167	-6.7192***
InCAPSTK	-1.4852	-3.6312**	-1.3394	-3.7342***
COC	-2.3086	-6.7221***	-2.4164	-6.7229***
InGDP×COC	-2.5078	-6.3826***	-2.4677	-6.3835***
RGQ	-2.9761**	-8.6056***	-3.0523**	-8.7327***
lGDP×RGQ	-3.1540**	-8.4439***	-3.1849**	-8.5466***

NB: *, **, *** implies significant at 10%, 5% and 1% level of significance

Source: Author's Computation

The results in table 2 show that within the framework of ADF unit root testing, all the variables are integrated of order I(1) except the three levels of InGDP which shows the presence of unit root. Similarly, within the framework of Philip Perron (PP) unit root testing, all the variables are integrated of order I(1) except InGDP which is integrated of order I(0). This implies that the use of ARDL bound test Cointegration is justified, since the Pesaran, Shin and Smith (2001) approach of modelling the ARDL permit the use of variables that are jointly integrated. It also implies that we should reject the null hypothesis which says that the variables have unit roots and accept the alternative of no unit-roots.

Table 3: ARDL Bound Test Results with Intercept and Trend

Test Statistic	5% critical value		1% critical value	
F – Statistic	Lower Bound 1(0)	Upper Bound 1(1)	Lower Bound 1(0)	Upper Bound 1(1)
5.698420***	2.04	2.08	2.5	3.68

NB: ***implies significant at both 1%.

Source: Author's Computation.

The results in table 3 show the ARDL bound test for Cointegration. The results indicate evidence of Cointegration among the variables. This is validated by the value of the F- statistic for the joint significance of the variables which is greater than the upper bound at both 1% and 5% levels of significance. The results of the test conclude that there is a long-run relationship among variables of interest. Ideally, the Cointegration test of the ARDL is built on the proposition that the long run relationship between the predicted variable and predictive variables is singular (Orji, et al., 2021; Pesaran, Shin and Smith, 2001). The Bound F-test has two outstanding features. Firstly, in checking for the joint significance of the ARDL it converts all the variables of the model into dependent variable and secondly, it is highly influenced by the number of lags it is subjected to (Orji, et al., 2021). Hence, this study adopted the lag of 2 whereas; the optimum lag was decided by Akaike Information Criterion (AIC).

Table: 4 Normalised Short Run and Long run Coefficients

Dependent variable -CO2

	PANEL A SHORT RUN				PANEL B LONG RUN	
Variable	Coefficient	Std. Error		Variable	Coefficient	Std. Error
ΔCO2(-1)	-0.826161***	0.200950		InGDP	7.937128***	2.609109
Δ InGDP	14.03196**	5.335862		InGDP^2	-0.796046***	0.243441
Δ InGDP2	-1.401982**	0.495220		InGDP^3	0.024729***	0.007503
ΔInGDP3	0.045612**	0.015275		InCAPSTK	0.780546*	0.381012
ΔInCAPSTK	0.644857**	0.290629		COC	4.914986**	1.950065
ΔCOC	2.133835	1.309837		InGDP×COC	-0.415104**	0.159583
ΔInGDPXCOC	-0.167859	0.108929		RGQ	-2.110325	1.845243
ΔRGQ	-1.743469	1.380528		InGDP×RGQ	0.171004	0.153981
ΔInGDPXRGQ	0.147218	0.115427		C	-24.42258**	10.07780
ECM(-1)	-0.826161***	0.078451				

R^2	0.94
Adjusted R^2	0.86
F – Statistic	11.949(0.0000)
DW	2.51
ARCH	0.0383(0.8464)
LM Test	2.4586(0.1310)
Reset	0.4777(0.6415)
Normality	3.4670(0.1766)

*Note: ***, **,* implies significance at 1%, 5% and 10%, respectively.*

Source: Author's Computation

In table 4, the results of the normalised Short run and long run coefficients are presented. The results from the short run indicate that the lag of CO2 emissions have negative significant effect on the current CO2 emissions. The implication of this result is that previous emissions will offer the policy makers in the country clue on the need to regulate current emissions. Contrarily, this outcome will be an indicator to new investor especially in the mining sector that the country has an effective emission regulatory framework thus, giving them the notion that they too do not have the freedom to pollute due to strict emission control. This is because uncontrolled emissions, serves as an incentive for more pollution and as such the intending investor would have to consider the burden of emission control. Furthermore, the variable of interest which is InGDP, representing the initial stage of economic growth in Nigeria, has a positive relationship with CO2 emissions. This relationship with CO2 emissions is statistically significant. Its coefficient is 7.937128, which implies that 1 unit increase in GDP will increase CO2 emissions by 794%, if all other explanatory variables are kept constant. This result confirms the existence of scale effects in Nigeria's economic growth at this level. This means that no attention was given to environmental control measures at the kick-off growth (Zhang, 2021). Similarly, $InGDP^2$ which is used the capture the second stage of economic growth has negative relationship with CO2 emissions. This relationship according to the coefficient value (-0.796046) is highly statistically significant with the potential of reducing CO2 emissions by 80% with every 1 unit increase in $InGDP^2$. This validates the presence of compositional or technological effects, which is characterized by effective environmental regulations (Zhang, 2021). Furthermore, $InGDP^3$ which is used as a representation of the advance level in economic growth has positive relationship with CO2 emissions and this relationship is statistically significant, according to the coefficient value (0.024729). The short run income assumed a similar trend as the long run. The initial growth result suggests that 1 unit increase in the initial GDP will increase CO2 emissions by 14.03196. Because this effect is statistically significant, it only point to the existence of Scale effects resulting from economic growth without environmental regulations. Similarly, the $InGDP^2$ which depicts the second level of economic growth has negative relationship with CO2 emission in Nigeria. This relationship is shown to be statistically significant and has the potential to reduce emissions by 1403% as shown by the coefficient value (-1.401982). The major factor responsible for this relationship between environmental degradation and economic growth at this level is technological effects. The third level of economic growth which is depicted as $InGDP^3$ has positive link with CO2 emissions. Because this link is statistically significant, it portends that 1 unit increase in growth at this level will amount corresponding 5% increase in CO2 emissions as indicated by the coefficient value (0.045612). This is brought about by technological obsolescence. The conclusion shows that, while GDP has a positive association with CO2 emissions in both the short and long term, and this relationship is statistical significant. This is an evidence of technological obsolescence effects. This suggests that technological effects have reached it maximum limit thus, scale effects now out crowds technological effects resulting in environmental deteriorations. The overall results from the different levels of economic growth suggest that growth of the Nigerian economy could accurately predict CO_2 emissions in the country. Also, the results vividly suggest that the economic growth – carbon dioxide nexus in Nigeria does not follow the pattern of the Environmental Kuznet Curve hypothesis and as predicted by Nayaran and Nayaran (2010) but conform with the findings of Akpan and Chukwu (2011) and Akpan and Abang (2015) . According to this result, rather than the U-shaped curve as posited by the EKC theory what is obtainable in Nigeria is an N-shaped curve. It is noteworthy, that the initial level of income in the long run and short run maintained a high coefficient values, this is a perfect demonstration of how the Nigerian economy worked within the study period. This is valid, for between the 1990 until recently, the oil sector have remained the main sector contributing significantly to the GDP of Nigeria while the other sectors were gradually abandoned. Thus, this has given room for the high and significant emissions of CO_2 in the country.

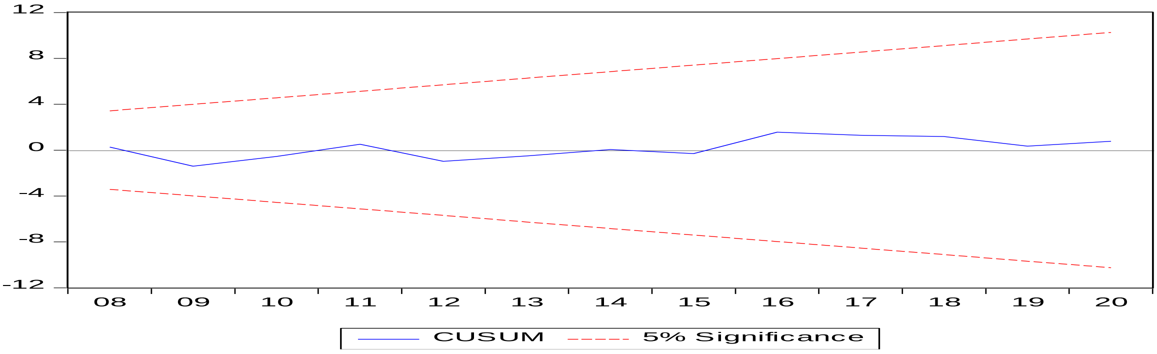
Furthermore, the long run InCAPSTK is positive as its coefficient (0.780546) suggests and statically insignificant but the short run scenario shows positive significance at 5%. This result suggests that one unit increase in InCAPSTK will increase CO_2 emissions by 64% and implies that the marginal effect of CAPSTK on CO_2 emissions supports the view that capital investment in Nigeria does not have pollution abatement equipment with which to regulate and eliminate pollutants produced in the process of manufacturing. Consequently, as capital investment increases in Nigeria, carbon emission also increases. This implies that increase in capital investment will increase CO_2 emissions through increase activities of business sector, such as dumping of waste, emissions from power generating plants of the business sector, transport sector emission, etc. This is a possible sign of technological obsolescence. More so, in view of the long run and short run outcome on comparative basis, a major reality is brought to light. The reality is that right from the 2008/2009 global financial crisis which was hard on the country's financial market with varying impact both on investment and employment; and with rising security threats in some regions of the country, there has been drastic drop in capital investment especially from abroad. This has tremendously impacted on the overall output and possibly on environmental outcome in the country as amplified by the insignificant long run result.

Moving further, control of corruption (COC) which is one of the measures of the quality of institution in Nigeria is statistically significant in the long run while regulatory quality (RGQ) is insignificant, although the RGQ correspond with economic expectation in terms of relationship with CO_2 emissions in Nigeria, whereas, control of corruption which is expected to decrease the level of emissions ended up increasing emissions. This is an indication that efforts to control corruption in Nigeria are not yielding significant result as shown by the long run result. However, when COC it is allowed to interact with income it significantly reduced CO_2 emissions by 42%. This is not true for environmental Regulatory Quality (RGQ) which is insignificant even when it is allowed to interact with income. This portends that the existence of corruption in Nigeria is majorly due to the high level of poverty thus, the control of corruption in Nigeria can only yield significant result when poverty is drastically reduced. When this is achieved, COC will then enable the successful implementation of environmental laws in Nigeria. In addition to this, its insignificant effect on CO2 emissions indicates that Nigeria may have put in place some environmental laws, but there may be no adherence to the laws due to problem of enforcement, indiscipline, and corruption in Nigeria's institutions (Ladan, 2007). This outcome brings to mind the reality that Nigeria's per capita income does not imply what it seems to portray, owing to the growing income inequality. In reality the larger portion of the country's income is distributed among the ruling political class with those capitalist classes having close affinity with this ruling political class. This income gap have continued to widen and thus, breeding corruption. As a result, the prevailing decay in the country's institutions is corruption brought about by poverty. Poverty has further strengthened the bane of corruption in Nigeria making the existing institutions ineffective. In many occasions, members of these institutions set up by the government has been indicted with corrupt practices and bribery and when investigated it was confirmed to be true. The rest of the short run results are generally insignificant, this is also the case with the rest of the long run variables.

The constant term (C) has negative and significant effect on CO2 emissions. This suggest that there are variables that contribute to CO2 emissions in the country which were not included in the model, variables like foreign direct investment (FDI), trade openness and future energy use which may likely be environmentally friendly. Therefore, the long run results suggest the existence of an N-shaped curve rather than the U-shaped curve proposed by the EKC hypothesis. Similarly, the coefficient of the error correction mechanism (ECM (-1)) which has negative sign and significant at 1% suggests that the result conforms to a priori expectation. Its value of-0.826161 indicates the speed of adjustment to long run equilibrium. In other words, about 83% of the disequilibrium will be corrected in the next period. Its negative sign shows that a convergence from short run to long run equilibrium is possible. It can be concluded that there is rapid speed of adjustment towards long run equilibrium. Finally, the diagnostic tests indicate that the model is correctly specified, meeting all of the tested statistics' conditions of non-autocorrelation, good fit, normal distribution of residuals, no misspecification errors, and the absence of Heteroscedasticity. The F – statistic is robustly significant at 1%, suggesting that the independent variables have reasonably joint effect on the dependent variables. This outcome is further validated by the outcome of the cusum and cusum squared test presented as figures 3 A & B below.

It is interesting to note that the long run and short run results confirm that the economic growth- carbon dioxide relationship in Nigeria is not consistent with the EKC hypothesis. This happened because the long run and short run coefficient of the various levels of InGDP, though significant, suggest that instead of the U-shaped curve postulated by the EKC hypothesis, an N – shaped nexus exists between GDP and the emissions of CO2. Thus, the study rejects EKC hypothesis in Nigeria as proposed by Mobosi et al. (2017), Adewuyi and Adeleke (2016) and Narayan and Narayan (2010). The result is in line with that of (Akpan and Chuku, 2011; Akpan and Abang, 2015).

Figure 3A and 3B: Result of Stability Test (Cusum and Cusum Squared)



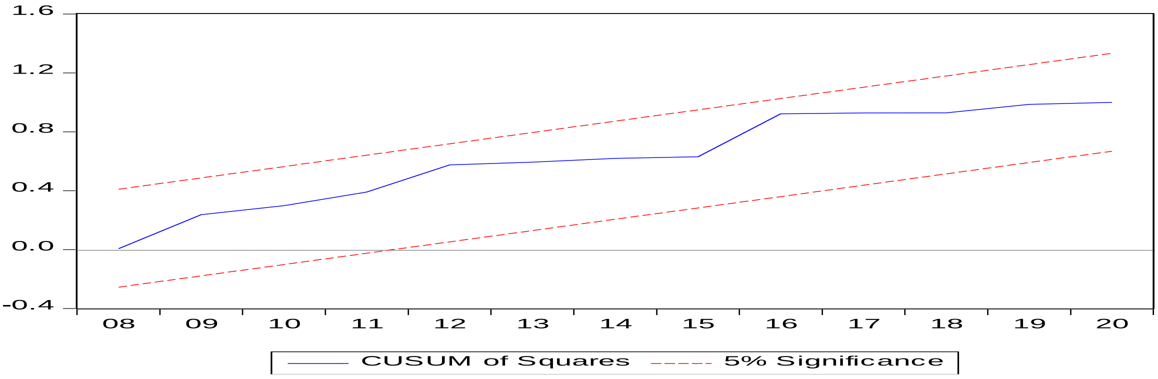


Table 5: Results of the Quantile Regression

Explanatory Variables	10th	20th	30th	40th	50th	60th	70th	80th	90th
InGDP	4.634***	4.819***	5.133***	4.177***	3.262***	3.702***	3.013**	3.97***	3.014***
$InGDP^2$	-0.468***	-0.477***	-0.506***	-0.420***	-0.332***	-0.369***	-0.323***	-0.394***	-0.291***
$InGDP^3$	0.014***	0.014***	0.015***	0.012***	0.010***	0.011***	0.009***	0.012***	0.009***
InCAPSTK	-0.013	-0.019	-0.019	-0.015	-0.005	-0.019	-0.018	-0.020	-0.040
COC	3.458**	3.742**	4.161***	4.259***	4.747***	4.314***	4.590***	2.569*	-2.150
InGDP×COC	-0.301**	-0.310**	-0.342***	-0.347***	-0.382***	-0.344***	-0.374***	-0.215*	0.154
RGQ	-1.465	-1.220	-1.507	-1.878	-2.238*	-2.369*	-0.265	0.664	3.522**
InGDP×RGQ	0.106	0.092	0.115	0.146	0.175*	0.184*	0.013	-0.055	-0.279**
Constant	-13.101**	-13.531**	-14.544***	-11.130***	-8.003**	-9.757**	-5.723	-10.393**	-8.513*

(***), (**), (*) indicate significance at 1%, 5% and 10%, respectively.

Source: Author's computation

The quantile regression result in table 5 above, confirmed the findings from the ARDL regression. It shows that in all the quantiles, InGDP, $InGDP^2$ and $InGDP^3$ are all significant at a 5% level of significance, with the impact aligning with the results of the ARDL regression. Similarly, the lCAPSTK is insignificant at all quantiles thus, closely conforming to the long-run outcome of the ARDL regression. According to the quantile regression, COC and InGDP×COC are both statistically significant from the 10th up to the 70thquantile, this result agrees with the ARDL long run result but contrasts with the short-run outcome. Furthermore, the quantile regression results indicate that at all the quantiles; regulatory quality (RGQ) in Nigeria has no significant impact on CO2 emissions. This is also true when the regulatory quality is interacted with economic growth (RGQ×InGDP), confirming the result from the short run and long run ARDL.

Table 6: Pairwise Granger Causality Test at lag 1

S/N	Null Hypothesis:	F-Statistic	Prob.	Remarks
1	InGDP →CO2 CO2 →InGDP	8.45443 0.01644	0.0072 0.8989	Rejected Accepted
2	$InGDP^2$→CO2 CO2→$InGDP^2$	7.11578 0.02224	0.0128 0.8826	Rejected Accepted
3	$InGDP^3$→ CO2 CO2 →$InGDP^3$	5.93765 0.22929	0.0217 0.6359	Rejected Accepted
4	COC →CO2 CO2 →COC	2.24957 0.21584	0.1453 0.6460	Accepted Accepted
5	InCAPSTK →CO2 CO2 →InCAPSTK	9.13377 9.40819	0.0054 0.0049	Rejected Rejected
6	InGDPXCOC →CO2 CO2 →InGDPXCOC	0.43582 1.71710	0.5147 0.2011	Accepted Rejected
7	InGDPXRGQ →CO2 CO2 →InGDPXRGQ	0.25811 0.03640	0.6155 0.8501	Accepted Accepted
8	RGQ →CO2 CO2 →RGQ	0.51339 1.45139	0.4798 0.2388	Accepted Accepted

Note: Rejecting the null hypothesis indicates that one variable actually granger cause the other, whereas, accepting the null hypothesis confirms that there is no causation between variables at either1%, 5% or 10% level of significance. This is used to indicate the direction of causality.

The causation results in table 6 indicate that there is causality going from InGDP, $InGDP^2$ and $InGDP^3$to CO2 emissions in Nigeria. Thus, the null hypothesis that the three levels of Economic growth used to examine the existence of EKC does not granger cause CO2 emissions is rejected. This further buttresses that the EKC hypothesis apply to the economic growth – carbon emissions relationship in Nigeria .Institutional quality variables (COC and RGQ) do not have any causal effect on CO2 emission, meaning that environmental laws are not vigorously pursued in Nigeria. Similarly, when the institutional quality variables interact with LGDP, the null hypothesis is rejected. However, the null hypothesis that

CAPSTK does not causeCO2 emissions is rejected. The study instead concludes that increased capital investment will increase CO2 emissions due to increased business activities of both local and foreign investors. Altogether, this result strengthens the ARDL dynamic results which show that an increase in GDP does not affectCO2 emissions in Nigeria. This supports the findings of the study that GDP has a positive relationship with CO2 emissions, implying that the level of production activities are significant enough to cause CO2 emissions. The emissions observed in the country are caused by the overall economic activities in the country, most especially from fossil fuel production and combustion, agricultural production, household and commercial activities and low waste management (Ogwu, 2021; Ekesiobi et al., 2017).

5. Conclusion and Recommendations

This study examined the relationship between economic growth and carbon dioxide emissions in Nigeria, bearing in mind the moderating influence of institutional quality. To determine this relationship, the ARDL regression analysis was employed on CO2 emissions, GDP, capital stock (CAPSTK), and institutional quality (COC and RGQ). Furthermore, the quantile regression and Granger causality test were used to corroborate the findings from the ARDL regression. The study found that the three levels of GDP identified to have a significant effect on CO2 emissions. The nature of these relationships supports the existence of an N-shaped curve rather than the U-shaped curve proposed by the EKC hypothesis. Also, CAPSTK was found to stimulate CO2 emissions in the short and long run, but more in the long run. This outcome could be attributed to the worsening security situation in the country which is depleting the country's capital stock (CAPSTK) by scaring away investors, but the long-run outcome gives hope that investment will significantly improve once normalcy is restored. Furthermore, control of corruption (COC) which is a measure of institutional quality has a significant impact on CO2 emissions in the long run, this is also true when COC interact with income (InGDP). However, regulatory quality (RGQ) has an insignificant impact on CO2 emissions in the long run and short run even when interacted with income. The result for InGDP×COC implied that corruption control in Nigeria can only reduce CO2 emissions if poverty is reduced. This infers that there is no effective policy targeted at pollution reduction and control in Nigeria without addressing poverty levels.

The study, therefore, recommends as follows; since economic progress is likely to raise carbon emissions, restricting growth to minimize environmental degradation does not augur well for the economy, especially given the risk of denying the majority of Nigerians of the gains of development. While the pursuit of environmental sustainability is imperative, it should not come at a huge cost to the economy. To provide the best quality of life, government economic growth policies should be structured to be environmentally sustainable, inclusive, and equitable. From our findings, economic growth-centred policies will not be sufficient to mitigate environmental pollution, beckoning for a multifaceted approach. Therefore, further recommendations include the effective management of the capital stock in the economy through the adoption of green industrialisation investments, to decouple manufacturing and production away from harmful environmental externalities by optimizing the use of renewable energy, sustainable supplies, and clean technology. Foreign direct investment and financial sector policies, in general, have to be geared towards promoting rapid economic progress in the country and at the same time reinforcing environmental sustainability. Institutional development is also a prerequisite for the furtherance of environmental quality, as the presence of a potent judicial process, an effective and equitable allotment of capital, as well as the enforcement of rules and regulations, fosters economic growth by resulting in a curtailment in carbon emissions. To enhance regulatory control, the government must intensify its efforts to make institutions more proactive and capable of enforcing environmental laws and regulations, so that economic growth does not undermine environmental quality.

Also, the independence of the different tiers (federal, state and local) and arms (executive, legislature and judiciary) of government need to be guaranteed for improved regulatory control, to ensure equal power sharing and delineation of responsibilities, so they can work in sync (horizontally and vertically) devoid of undue interference. Tougher environmental laws should be imposed on polluting industries and sanction violators with carbon taxes, fines, and other penalties to compensate for the societal cost of pollution. A good place to start should be the recent Petroleum Industry Act to checkmate gas flaring and other harmful crude oil-related pollution. Also, the National Environmental Standard and Regulation Enforcement Agency (NESREA) needs to be revitalised to deliver on its core mandate which is to "ensure a cleaner and healthier environment for Nigerians". It is also imperative for anti-corruption efforts in the country to be bolstered to tackle the menace of bribery and corruption. As a result, the Independent Corrupt Practices and other Related Offences Commission (ICPC) and the Economic and Financial Crimes Commission (EFCC) should take renewed and concerted strides in the battle against corruption, by instigating legal action against corrupt offenders and warding off future diversion and abuse of public resources designated for financing economic expansion programmes.

To conclude, future carbon emission abatement is a real concern for present environmental preservation and sustainable development initiatives. While this research makes a modest attempt to provide policy insights into the Growth-Pollution-Institutional Quality debate, it is far from exhaustive. Another limitation of this work stems from the data period hence, the study could not capture the period when oil began to overshadow the other sectors of the economy in terms of contribution to GDP. Other measures of institutional quality such as rule of law, government effectiveness, and political stability have been reckoned as key players in the growth of the Nigerian economy, most especially, the issues relating to the disturbance of peace in some regions of the country which frequently interrupt economic activities in these regions. As a result, there are intrinsic constraints that provide an impetus for additional research investigations. Examining findings across nations and regions to draw parallels in respect to nationality, culture, faith, dialect, and system of government will be beneficial. Cross-country comparisons of advanced and budding economies, which differ in many other ways, might be another area of research. Research in this area also should be continuous with the availability of new data, theories and methodology. These actions would further pave the way to achieve decarbonisation and mitigate climate change for the welfare of the present and future generations.

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