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ECONOMIC GROWTH AND CARBON EMISSION: ANALYZING THE VALIDITY OF ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS IN NIGERIA

Jennifer Uvbi Omodamwen

Department of Banking and Finance, Faculty of Management Sciences,
University of Benin, Benin City, Edo State, Nigeria

Felix Eromosele Obainoke

Department of Banking and Finance, National Institute of Construction
Technology and Management, Uromi, Edo State, Nigeria

Abstract

This study investigates the relationship between economic growth (EGTR) and carbon emission (CE) in Nigeria for a period ranging from 1982-2022 in the often-cited environmental pollution emission-growth relationship encapsulated in the environmental Kuznets curve (EKC). An index of carbon emission intensity was regressed on economic growth rate- measured by GDP growth rate, along with three other mitigating explanatory variables of trade openness, human capital investment and electricity consumption. Employing the ECM Auto Regressive Distributed Lag (ADL) estimation technique, the result shows no evidence and validation of the environmental Kuznets curve (EKC) in Nigeria. Economic growth (EGTR) activities increase carbon emission (CE) in Nigeria both in the short run and long run period while electricity consumption significantly reduced carbon emission (CE) in the long run in Nigeria. From the findings, the study concludes that industrial based production technology is still very prevailing in Nigeria economy without reducing carbon emission (CE) for environmental sustainability development. The study therefore recommends that strong institutional framework, and implement effective policy, rules and regulations that will support sustainable development should be enacted. The implementation of these measures will eventually lead to greater environmental responsibility and sustainability strategies in Nigeria, and eventually, the entire ECOWAS sub-region.

Keywords: ARDL, ECM Economic growth, Carbon emission, Environmental Kuznets Curve (EKC)

1. Introduction

The economic growth and development in most countries of the world has been the aftermath of the effective use of energy system. On the other hand, carbon emissions, released by the burning of fossil fuels, have brought about negative externalities across the globe. This is due to energy usage; especially fossil fuel alongside manufacturing and construction activities has shown a negative impact on the environment in the form of environmental degradation, poor health outcome, and reduced life expectancy, including aquatic life (Matthew et al., 2020; Mesagan & Ekundayo, 2015).

Over the years, the world economy has more than tripled as a result of industrial development that has

brought about greater energy consumption and greater carbon emissions resulting from consumption. In actual fact, the effect of global warming and an emerging paradigm shift to green economy has encouraged researchers to study the relationship between carbon dioxide (CO₂) emissions and economic growth. Economic growth is responsible for the rise of standard of living of most countries all around the world and has also given rise to the CO₂ emissions and natural resources reductions (Mardoni et. al. 2019). The emission of CO₂ is a major cause of global warming (Mohammed, Ismat, Jeroen & Guido, 2012; Omojolaibi, 2010).

Economic growth is one macroeconomic goal that cannot be compromised in any developing economy,

like Nigeria. An attempt to achieve economic growth in a country spurs consumption of energy in various sectors of the economy. It is instructive to state that between the years 2000 and 2020, transport alone emitted an average of 47.76% of CO₂ gas in Nigeria (International Energy Agency, 2021). Consumption of fossil fuel has been found to be a critical source of CO₂ emission, orchestrating climate change globally and, unfortunately, Nigeria has been identified as one of the top producers and consumers of fossil fuel (Alege, Adediran & Ogundipe, 2016). It is essential to state that the consumption of fossil fuel deteriorates the quality of the environment and involves human health implications in the economy. In the same vein, the degradation of the environment increases budgetary allocation in terms of healthcare financing (Balan, 2016). Consequently, in achieving sustainable economic growth, extensive use of energy cannot be avoided, as one needs to conduct manufacturing, agricultural activities, to provide services, and to account for other sectors of the economy. The nexus amid carbon dioxide emissions and economic growth has been the subject of considerable academic research over the past few decades. According to the Environmental Kuznets Curve (EKC) hypothesis, as output increases, carbon dioxide emissions increase as well until some threshold level of output was reached after which these emissions begin to decline. The main reason for studying carbon emissions is that they play a focal role in the current debate on the environment protection and sustainable development. Economic growth is also closely linked to energy consumption since higher level of energy consumption leads to higher economic growth. However, it is also likely that more efficient use of energy resources requires a higher level of economic growth.

So far literature remains scanty on country-specific study as regards to causal effects between gaseous carbon emissions and the economic growth process of Nigeria which is an obvious study gap. Thus the current study fills this gap by extending empirical investigation to Nigeria using a dynamic model with latest data to examine the relationship between carbon emissions and economic growth in Nigeria. Therefore the main

objective of this Study is to examine the relationship between carbon emissions and economic growth in Nigeria.

2. Literature Review

Economic growth and carbon emissions have been examined severally by different researchers with mixed results. This study examined previous empirical works from different research studies, for instance, Natufe and Evbayiro-Osagie (2023) examined the relationship between carbon emissions and Nigeria's economic growth from 1985 to 2021. The study adopted ARDL approach in analyzing the data. The findings revealed that Gross fixed capital formation had a significant positive influence on GDP in the short-run but a significant negative influence on GDP in the long-run. While nitrous oxide ((N₂O)) emissions and carbon dioxide (CO₂) emissions has positive and negative impacts on GDP in the short-term and long-term, respectively. The study therefore recommended that the Nigerian government should both conceptualize and implement favourable policies and incentives (granting of tax credits to carbon-neutral corporations) from the government as a foundational catalyst for the development of green infrastructure

Onofrei, Vatamanu and Cigu, (2022) explored the dynamics of the relationship between economic growth and CO₂ emissions in the 27 EU member states in a panel setting for the period 2000–2017. They employed Dynamic Ordinary Least Squares (DOLS), unit root tests and cointegration techniques for the study. The result show that the status of economic growth does not automatically diminish climate vulnerability in EU countries, only the correct type of growth does, the study therefore recommended that EU policymakers should be aware of the energy cost pressure and to achieve economic growth in relationship with appropriate tools in terms of climate risk management. Osabohien, Aderemi, Akindele and Jolayemi (2021) examined how energy consumption impacts on life expectancy in Nigeria for the period 1980-2017. The autoregressive distributed lag (ARDL) model was applied in the study. The finding implied that, on average, carbon emissions could reduce life expectancy

by 0.35%. Based on this finding, the study concludes by recommending that the Nigerian government should embark on the alternative use of energy that emits lesser carbon.

Osadume and Edih (2021) investigated the impact of economic growth on carbon emissions on selected West African countries between 1980 and 2019. The study selected six-sample countries in West Africa and used secondary data obtained through the World Bank Group online database covering the period 1980–2019, employing panel econometric methods of statistical analysis. The outcome indicated that the independent variable showed a positively significant impact on the dependent variable for the pooled samples in the short-run, with significant cointegration.

Olubusoye and Musa (2020) in their study employed the ARDL model, Mean Group (MG), and the Pooled Mean Group (PMG) model to examine the Environmental Kuznets Curve (EKC) hypothesis in 43 African countries pooled into 3 income groups from 1980–2016. Result show that carbon emissions increase as economic growth increases in 79% of the countries while economic growth will lead to lower carbon emissions in only a few countries (21%). They recommended that the countries should take all possible policy actions such as the massive deployment of renewable energy, carbon tax policy, and the carbon emissions trading scheme to curtail growth in carbon emission.

Afolayan and Aderemi (2019) utilised Dynamic Ordinary Least Square and Granger causality approach to evaluate the impact of environmental quality on health effects in Nigeria, from 1980 to 2016. The study argued that emissions of CO₂ had an insignificant negative impact on mortality rate.

Omri (2017) examined the nexus between CO₂ emissions, energy consumption and economic growth using simultaneous-equations models with panel data of 14 MENA countries over the period 1990-2011. Their empirical results show that there exists bidirectional

causal relationship between energy consumption and economic growth.

Work by Odusanya, Adegboyega and Kuku (2014) assessed the nexus between real per capita health expenditure and per capita CO₂ emissions in Nigeria, over the time frame encompassing years 1960-2011. According to the study, both short-run and long-run estimates proved that increase in CO₂ emission would lead to a significant rise in health expenditures

Omojolaibi (2010) conducted a study on environmental quality and economic growth in some selected West African countries to conduct an assessment of the environmental Kuznets curve. The pooled OLS results showed a consonance with EKC, while the fixed effects results were at variance with the applicability of environmental Kuznets curve in West Africa. The study suggested that the countries should formulate policy to ensure efficiency in energy use and reduction in carbon emissions.

Friedl and Getzner (2003) explore the relationship between economic development and carbon dioxide (CO₂) emissions for a small open and industrialized country, Austria to test whether an Environmental Kuznets Curve relationship also holds for a single country which is in contrast to backlog of existing literatures which extensively concentrated on panel or cross-section data for a set of countries. It was found that N-shaped relationship between GDP and CO₂ emissions is found to fit the data most appropriately for the period 1960 to 1999, and a structural break is identified in the mid-seventies due to the oil price shock. It further concludes that emission projections derived from this single country specification support the widely held opinion that significant policy changes are asked for when implementing the Kyoto Protocol in order to bring about a downturn in future carbon emissions.

3. Methodology

3.1 Research Design

Quantitative research method is employed for this study. The ex-post factor research design is adopted, since the data cannot be manipulated, as they are to be

used as reported. Geographically, the study is limited to Nigeria.

3.2 Data and Sources

The data used in this study are secondary data sourced from the World Bank Development Indicators (WBDI) database for the period 1982-2022.

3.3 Theoretical Framework and Model Specification

This study is premise on the EKC theory. Recall that the basic premise of the EKC is that pollution intensity increases as income level (economic growth) increases but falls subsequently as income crosses given thresholds. In order to capture this diminishing rate of pollution following increase in per capita income, depicting an inverted U-shaped relationship, the positive relationship is expected between real economic growth rate and pollution in the short run and negative relationship between economic growth and pollution in the long run. In functional form, model (1) is captured as:

$$CE = f(EGTR, TOP, HCIVT, ELEC).....(1)$$

$$CE_t = \alpha_0 + \alpha_1 EGTR_t + \alpha_2 TOP_t + \alpha_3 HCIVT_t + \alpha_4 ELEC_t + \varepsilon_{it}.....(2)$$

Eq. (2) is the long run model while Eq. (3) is the short run model.

Where:

CE = Carbon emission (Proxied by CO₂ emissions metric tons per capita)

EGTR = Economic growth (

TOP = Trade openness (TOP =)

HCIVT = Human Capital Investment (Proxied by government expenditure on primary school children)

ELEC = Electricity consumption (Proxied total electricity consumption)

Δ = The difference operator

β_0 = Constant (Intercept)

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ = Coefficients

ε_t = Error term

Ecm(-1) = Error correction term

ct = Error term

t = Respective variables at current time t

A priori expectation as derived from theoretical literature is expressed as;

$\alpha_1 < 0$ while $\alpha_2, \alpha_3, \alpha_4 < 0$ in Eq. (2)

$\beta_0 > 0$, and $\beta_2 > 0$ while $\beta_1, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7 < 0$ in Eq. (3)

Thus, the EKC is validated, by comparing the elasticity coefficient of EGTR to that of CE in the short and long run. That is, $\alpha_1 < 0$ in the long run and $\beta_2 > 0$ in the short run. On this premise, the EKC hypothesis is adjudged to hold.

3.4 Method of Data Analysis

The study adopted descriptive statistics to summarize the variables' properties in a more convenient form (mean, median, standard deviation, Jarque-Bera statistics); correlation technique to examine the direction and strength of relationship between variables of interest. Akaike Information Criteria (AIC) is used to determine the optimal lag for the model. Augmented Dickey Fuller unit root test is employed to ascertain the variable's fluctuation consistency with respect to their mean. All variables were stationary at first difference. The Engle and Granger two stage co-integration technique is used to establish the existence of long run relationship among variables. This technique is informed because of the single model underlying this study.

The ECM technique is employed to establish the short run and long-run effect of explanatory variables on dependent variable. The probability value in the short and long run result were used to test the significance of the effect. Finally, the Breusch-Godfrey higher order serial-correlation test is used to ascertain the absence of serial correlation in the model in addition to the Durbin Watson (DW) statistics test.

4. Results and Discussions

Table 1: Summary Statistics

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J-Bera	Prob.
EGTR	3.119268	4.200000	15.33000	-13.13	5.342099	-0.865177	4.805233	10.68219	0.470091
CE	0.696098	0.670000	0.930000	0.460000	0.107886	0.177557	2.566396	0.536619	0.764671
ELEC	106.5129	97j.07000	156.8000	50.90000	29.41425	0.171085	1.702581	3.075643	0.214849
TOP	32.57098	33.72000	53.28000	9.140000	12.36033	-0.36218	2.271478	1.803043	0.405952
HCIVT	92.88268	92.09000	113.0800	78.66000	8.482877	0.780906	3.059021	4.173015	0.124120

Source: Author's computation (2024); from E-view 10.0 output

Table 1 presents the summary statistics for the variables. The descriptive statistics shows that the ratio of mean to median for TOP and HCIVT is approximately one. This shows symmetrical distribution pattern of these variables from their mean and it is not wide apart. There were periods of rapid annual increase in all the variables' activities as show by the corresponding maximum values that are higher than their mean values. Also, there was period of sharp year on year decrease in the variables as shown by their corresponding minimum values. The Std. Dev. value of

5.34 for EGTR is higher than its mean value, which shows there was high degree of swing or movement in EGTR during the studied period. It further shows the high level of growth variability over the period. Other variables experience low swing as indicated by the Std. Dev. values that are less than their corresponding mean values. The J-Bera statistics that considers Skewness and Kurtosis in its estimation shows that all the variables are normally distributed since their corresponding probability values are < 0.05 .

Table 2: Correlation Matrix

Correlation t-Statistic Probability	EGTR	CE	ELEC	TOP	HCIVT
EGTR	1.000000				

CE	-0.366418**	1.000000			
	-2.459324	-----			
	0.0185	-----			
ELEC	0.313737	-0.624334*	1.000000		
	2.063475	-4.991268	-----		
	0.0458	0.0000	-----		
TOP	0.496710	-0.325601**	0.171771	1.000000	
	3.574022	-2.150569	1.088893	-----	
	0.0010	0.0378	0.2829	-----	
HCIVT	-0.321658	0.406507*	-0.321176	-0.395502	1.000000
	-2.121500	2.778569	-2.117955	-2.689171	-----
	0.0403	0.0084	0.0406	0.0105	-----

Source: Author's computation (2024); from E-view 10.0 output

The correlation matrix in table 2 shows the strength and direction of relationship between the explanatory variables and dependent variable. EGTR, ELEC and

TOP have significant inverse nexus with CE. This implies that forward movement in these variables decreases CE in the opposite direction. Only HCIVT has

a significant positive relationship with CE and increases among variables is not up to 0.80. This suggests absence of multi-colinearity problem in the Model.

Table 3: Optimal Lag Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-518.6476	NA	641186.1	27.56040	27.77587	27.63706
1	-424.7727	158.1051	17315.20	23.93540	25.22824*	24.39538*
2	-397.0101	39.45205*	16087.56*	23.79001	26.16020	24.63330
3	-368.7507	32.72150	16452.82	23.61846*	27.06601	24.84507

* indicates lag order selected by the criterion; LR: Sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

Source: Author's computation (2024); from E-view 10.0 output

The AIC is employed to determine the optimal lag selection for the model. In table 3 the AIC selected three lag as the optimal lag for the model.

Table 4: Stationarity Test

Variables	ADF Stat.	Order	Remark
EGTR	-11.92301*	I(1)	Stationary
CE	-9.734614*	I(1)	"
ELEC	-8.551009*	I(1)	"
TOP	-7.983801*	I(1)	"
HCIVT	-4.702501*	I(1)	"
Critical Values			
1%	-4.234972	1 st Diff.	
5%	-3.540328	"	
10%	-3.202445	"	

S = Stationary, * & ** = Stationary at 1% and 5% Significance Level

Akaike Information Criterion (AIC) Max. lag 3 process

Source: Author's computation (2024); from E-view 10.0 output

Table 4 shows the summary of ADF statistics. All variables are stationary at first difference and integrated of the same order I(1) at 5% confidence level. Thus, the

hypothesis of there is unit root in the observations is rejected at 5% level of confidence.

Table 5: Engle and Granger Two Stage Co-integration

Variables	ADF Stat.	Critical Value	Prob.	Remark
Resid. (ECM)	-5.416263*	-2.624057	0.0000	Co-integration exist

*= Significant at 1% level.

Source: Author's computation (2024).

Table 5 shows the summary co-integrating relationship among variables in the model. The ADF stat. absolute value of 5.416263 is greater than the ADF critical value. This implies that co-integration relationship exists

between variables of interest. Any variables that deviate in the short run will adjust to long run equilibrium; because all co-integrated variables embodied an error correction element.

Table 6: Parsimonious ECM Short Run and Long Run Result

Short Run Result: Dependent Variable = ΔCE			
Variables	Coefficient	t-stat	Prob.
C	-2.82E-05	-0.002468	0.9980
D(EGTR(-1))	0.005587*	2.658760	0.0120
D(ELEC(-1))	-0.001400	-1.488896	0.1460
D(TOP(-1))	2.99E-05	0.024467	0.9806
D(HCIVT(-1))	0.002477	1.130431	0.2664
ECM(-1)	-0.753870*	4.845983	0.00000
R-squared	0.495394	Prob(F-statistic)	0.000268
Adjusted R ²	0.418938	D.W. Stat.	2.011358
F-statistic	6.479504*		
Long Run General Least Square (GLS) Result: Dependent Variable = CE			
Variables	Coefficient	t-stat	Prob.
C	0.771703	3.294887	0.0023
EGTR	0.002164	0.657134	0.5155
ELEC	-0.001613**	-2.516118	0.0168
TOP	-0.002209	-1.557165	0.1287
HCIVT	0.001658	0.797439	0.4307
AR(1)	0.348807	1.895926	0.0665
R-squared	0.522206	Prob(F-statistic)	0.000084
Adjusted R ²	0.451942	D.W. Stat.	2.030075
F-statistic	7.432069*		
* & ** = 1% & 5% Level of Significance			

Source: Author's computation (2024).

The ARDL model estimated for variables of interest is shown in table 6. The Error Correction Term (ECT) value of -0.75 approximately is significant, high and correctly signed. This indicates that shocks to Carbon Emission (CE) emanating from within the model in previous year are corrected within the same year the shocks occurred. That is, there is huge correction, as the model adjusts partially to correct shock at the speed of 75%. After adjusted for degree of freedom, the model explained 42% total systematic variation in CE by all the explanatory variables taken together in the short run as indicated by the adjusted R² coefficient of 0.42 approximately. And, 45% total systematic variation in CE in the long run is accounted for, by all the variables

taken together in the long run; as indicated by adjusted R² coefficient of 0.45. The model has a fairly good fit of the regression line as approximately 58% and 55% of variation in CE was not accounted for but captured by the error term in both short and long run. All the explanatory variables have significant relationship with CE both in the short run and long run, as revealed by the F-statistics values of 6.48 and 7.43 approximately that are significant at 5% confidence level in both short and long run periods. Only EGTR passed the significant test in the short run and ELEC passed the significant test in the long run period as indicated by their corresponding probability value that is < 5%.

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.568541	Prob. F (2,31)	0.5721
Obs*R-squared	1.379906	Prob. Chi-Square(2)	0.5016

Source: *Author's computation (2024).*

The serial correlation problem that was in the long run result were corrected by Cochrane-OrcuttAR(1). Convergence was achieved after 7 iterations with 40 observations included after adjustment. The GLS result is shown in table 6. The Durbin-Watson statistics value of 2.030075 can be approximated to 2.0 which may show the absence of serial correlation in the model. The Breusch-Godfrey higher order serial correlation test is further used to ascertain this position as shown in table 7. The F-statistics values in table 7 are not significant at 5% confidence level as indicated by their corresponding probability values. This implies that both the D.W. statistics and Breusch-Godfrey test unanimously confirmed the absence of serial correlation in the model. This implies that the models can be used for policy recommendation without re-specification.

4.1 Discussions of Findings

The cause and effect relationship in table 6 shows that all the explanatory variables have different degree of effect on CE, although in different magnitude. Holding other factors constant, the average value of CE is -2.82E-05 in the short run, and 0.772 in the long run. EGTR has significant positive effect on CE in the long run. Comparing the short and the long run elasticity coefficient of EGTR effect on CE; did not conform to the EKC proposition of destroy now and build latter in Nigeria. This finding is in tandem with that of Granados and Carpintero (2012) that did not confirm EKC hypothesis. However, the finding is contrary to that of Apergis and Ozturk (2015), Omiri (2017), Osabuohien et.al. (2021) that confirmed the EKC hypothesis in their study. ELEC has negative effect on CE both in the short run and long run. However, only the long run effect is significant. This implies that ELEC only reduces CE significantly in the long run as an alternative source of energy consumption in line with *A priori* expectation. TOP and HCIVT have insignificant positive effect on CE in the short run and the effect of TOP in the long run became negative but remain insignificant, while that of

HCIVT remain positive and insignificant. Top conform to *A priori* expectation. HCIVT failed to conform to *A priori* expectation, which may be due to lack of technical know-how in renewable energy technology in emerging economy including Nigeria; and large proportion of labour still engage in industrial production with low level technology and less shift to service base production. Invariably, with increased TOP activities, the rate of environmental pollution is decreased insignificantly; given less dominance credence to the late stage of the EKC hypothesis in the long run. Kohler (2013) found similar result in their study. Increase in HCIVT activities insignificantly promotes environmental pollution. This finding is contrary to that of Ayadi (2014) who report that TOP significantly reduces environmental pollution.

Scale effect (positive nexus between EGTR and CE) is detected in the short run; however turning point was not detected in the long run. Only ELEC is the significant conduit that reduces CE in the long run. This implies that Nigeria toll the line of destroy now and repair latter but she is yet to reach the turning point and this might still take several decades (Van Alstine & Neumayer 2010).

5. Conclusion and Recommendations

This study investigates the link between economic growth (EGTR) and Carbon Emission (CE) in Nigeria over the period 1982-2022 in the often-cited environment pollution emission-growth relationship encapsulated in the environmental Kuznets curve (EKC). An index of carbon emission intensity was regressed on economic growth rate-measured by GDP growth rate, along with three other mitigating explanatory variables of trade openness, human capital investment and electricity consumption. Employing the ECM, ARDL estimation techniques, the results show no evidence and validation of the environmental Kuznets curve (EKC) in Nigeria. EGTR activities increase CE both in the short

and long run period while electricity consumption significantly reduced CE in the long run. From the findings, the study concludes that industrial based production technology is still very prevailing in Nigeria economy without reducing CE for environmental sustainability development.

Based on the foregoing findings, it is recommended that strong policy measures, regulations and strategies should

be implemented to curtain environmental pollution in the form of carbon emission and greenhouse gases. In this regard, strong institutional framework and implement effective policy, rules and regulations that will support sustainable development should be enacted. The implementation of these measures will eventually lead to greater environmental responsibility and sustainability strategies in Nigeria, and eventually, the entire ECOWAS sub-region.

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