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ECONOMIC GROWTH AND CARBON DIOXIDE EMISSION IN NIGERIA

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Abstract

Environmental degradation measured by CO_2 emissions is a significant challenge to sustainable economic development. Owing to the significant impact of the empirical relationship between economic growth and CO_2 emissions, this study examined the relationship between economic growth and carbon dioxide emission with a view to testing the validity or otherwise of the Environmental Kuznets Curve (EKC) in Nigeria. Using Autoregressive Distributed Lags (ARDL) approach, the study employed data on trade openness, electricity consumption, population and the square of GDP as control variables in the analysis for the period 1970 to 2018. The result showed that electricity consumption and trade openness have a negative and significant relationship with CO_2 emission, while population growth has a positive but insignificant impact on CO_2 emission. This insignificant impact of population growth can be linked to the lower income of the populace. However, the estimated coefficient of the square of income is negative, while that of its level is

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positive and thus supports the existence of EKC in Nigeria. Increasing the degree of openness to international trade along with appropriate trade policies will contribute to the Nigerian economy as openness leads to the reduction of pollutants in the environment. Adoption of mixed energy consumption, especially through hydroelectricity and solar system, will drastically reduce the rate of carbon emission in Nigeria regarding the fact that Nigeria is well endowed with these resources.

Keywords: Carbon dioxide emission; Economic growth; Renewable energy; EKC hypothesis; Autoregressive Distributed Lags.

INTRODUCTION

Human beings and the environment are inseparable, and the relationships are very intimate and dynamic. It is from the land, air, and water (the physical environment) that resources for human needs are derived. As human beings affect the quality of the environment, so the environment affects the quality of people's lives. Human well-being is inextricably linked to the continued availability of natural means of support, and this implies that any threat to the security of these resources constitutes a direct threat to human survival and development (Henderson & Loreau, 2019). Access to modern energy is assumed to be a precondition for the attainment of the Sustainable Development Goals (SDGs). Ekpo and Bassey (2016) argued that the positive multiplier effect of regular power supply cannot be overemphasized. Meanwhile, the higher the energy consumption, the higher the carbon emission resulting from consumption because fossil fuel (Oil & Gas) constitutes almost 75 % of Nigeria's energy consumption, while renewable energy plays a smaller role.

Climate change and environmental degradation are two of the key development-related challenges facing sustainable global output growth. The need to preserve environmental quality has therefore been at the forefront of both national and international development discourses over the last three decades in the pursuit of global sustainable development. Global warming and air pollution have been described as some of the main causes of climate change, while CO_2 emissions have generally been identified in the literature as a significant contributor to the twin problems of global warming and air pollution (Abokyi *et al.*, 2019). The objective of this study was to examine the relationship between economic growth and carbon dioxide emission with a view to testing the validity or otherwise of EKC in Nigeria.

The world economy relies very much on different energy sources, especially petroleum products and biomass, as a catalyst for economic growth. As a result, the associated emissions and climate change have generated considerable environmental concerns among policymakers and other stakeholders in the energy sector. The search for clean energy and energy-efficient appliances continues to be a priority for stakeholders in sustainable development. This has necessitated researches to examine output-energy-emission linkages and establish an optimization system to reduce costs and emission rates (Adewuyi & Awodumi, 2017). Since the major driver of the Nigerian economy is crude oil production[1], it is significant to note that GDP growth will have an effect on the level of carbon emitted which will, in turn, have an implication on the welfare of the citizens. This study, therefore, investigated the relationship between carbon emission and economic growth with the aim of advocating a green growth that will reduce the adverse environmental effects through the recommendation of appropriate policies.

Background of the Study

The global objective of the environmental effort is sustainable development. The concept of sustainable development implies a development that meets the need of the present without compromising the ability of future generations to meet their needs. This is a kind of development that incorporates five elements in terms of people, planet, prosperity, peace and partnership. Sustainable development is becoming a global issue that now needs to move from theoretical engagement to a practical organizational structure. Environmentally friendly practices and strategies should therefore be an integral part of planning and decision-makers ' interests.

Energy is an indispensable part of human lives, and it is strongly correlated with the environment. Imagine what it would be like if lives were disconnected from electricity, oil and gas. Human beings could hardly have cooked food. Walking would have become the option in the absence of cars, planes, trains, and buses as modes of mobility. But to think from an ecological point of view, no energy means, no supply of electricity, which translates into less energy consumption from fossil fuels. Also, no vehicle is equivalent to the absence of pollution of the air. From a logical viewpoint, a negative correlation between energy and environmental protection can be presumed. Although energy development has improved our lives, eco-pollution has worsened. Therefore, from the above discussion, it can be concluded that man, energy and the environment are in daily interaction in our modern society as depicted in the form of a simple Venn diagram below:

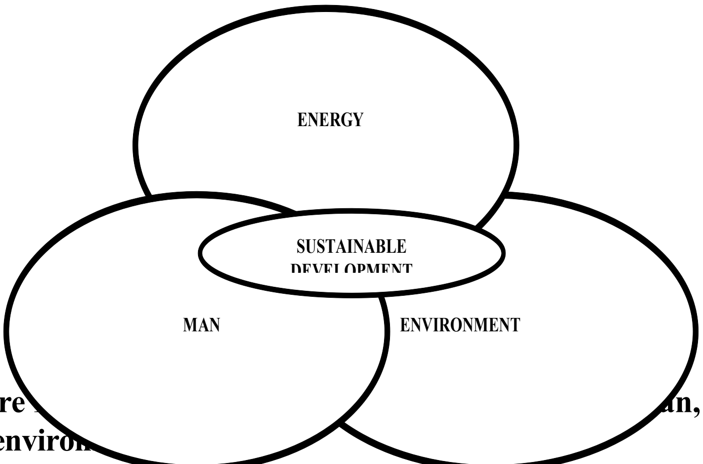

Figure n, energy and enviro

From the Venn diagram, interaction is such that, when a man makes a concentrated effort to meet his various needs using limited energy resources, it has a negative impact on the environment. Sustainable development can be seen as an area at the center of Figure 1 where all the three sets of constraints (insatiable human needs, limited fossil energy and environmental pollution) are met. Achieving prosperity through sustainable development would entail some major changes in human behaviour (such as environmental awareness) and patterns of energy consumption (such as the implementation of renewable energy technology). It will often be – and should be – the responsibility of investors or stakeholders to accomplish this desirable impact in society with a view to engendering harmony among human beings, energy, and the environment.

The growing economic activities in recent years are prone to environmental degradation, resulting in climate change and global warming which affect the quality of life. In a developing nation like Nigeria, the growth and environmental relationship could be more harmful due to the production and consumption structure. However, in developing countries, including Nigeria, environmental education and awareness campaign is not much regarded. The manifestations of environmental degradation in Nigeria are at three levels: water problems, forest degradation and solid waste management.

Literature Review and Theoretical Framework

The Environmental Kuznets Curve (EKC) hypothesis advocates a reversed U-shaped association between different pollutants and per capita income. The EKC postulates that speedy growth certainly results in environmental degradation due to a glut use of natural resources and emission of pollutants (Rani and Kumar, 2019). A sizeable literature on EKC reveals that environmental stress moves more rapidly than income growth at the initial phases of development and comes down to economic growth relatively at higher income levels.

The EKC hypothesis is becoming an important issue among researchers and policymakers who examine policies on the environment. Therefore, many studies were carried out to investigate the EKC hypothesis (Mikayilov *et al.*, 2018; Ameyaw *et al.*, 2019; Kong & Khan, 2019; Zhang & Meng, 2019; Jian *et al.*, 2019; Fang *et al.*, 2019). Most of these studies used CO_2 emissions as an indicator of pollution. The GDP per capita is also used as a determinant of pollution in these studies, especially in emerging and developing economies.

Many studies (Adewuyi & Awodumi, 2017; Mardani *et al*., 2019; Canh *et al*., 2019; Egbetokun *et al.*, 2019) extended the literature by exploring the association between energy consumption, carbon emissions, and economic growth simultaneously. Olubusoye and Musa (2020) empirically investigated the relationship between energy consumption, carbon emissions, and economic growth with a view to testing the presence of EKC. The study showed that the presence of an inverted U-shape relationship exists when long-run income elasticity is smaller than short-run income elasticity, implying that as income increases over time, CO_2 emissions reduce hypothesis in 20 African countries, using the income elasticity approach.

Also, Mensah *et al.* (2019) tested the causal link between economic growth, fossil fuel energy consumption, carbon emissions and oil price with a sample of 22 African countries using the Pool Mean Group panel ARDL and panel econometric methods. They found out that there exists a causal relationship among the variables. Ssali *et al*. (2019) explored the nexus between environmental contamination, economic growth, energy use, and foreign direct investment in six selected sub-Saharan African nations by applying Panel unit root. Their findings revealed that there is a confirmation of bidirectional causality between energy use and CO_2 in the short-run and one-way causality running from energy use to CO_2 in the long run.

This study is based on the context of the Environmental Kuznets Curve (EKC) hypothesis which states that there is an inverted U-shape relationship between environmental pollution and income per capita. The hypothesis implies that environmental degradation or other forms of pollution in the early stages of economic development increase and reduces in the subsequent stages. In fact, the study by Grossman and Krueger (1991) was the pioneer study, and since then, a series of studies like those of Beckerman (1992), Stern (2004), Richmond and Kaufman (2006), Galeotti *et al.* (2009), Fodha & Zaghdoud, (2010), and Omojolabi (2010) have confirmed the validity of EKC.

Methodology of the Study

This study used the Autoregressive Distributed Lags (ARDL) approach to evaluate the relationship between economic growth and CO_2 emissions in Nigeria. This method was appropriate for the investigation for two reasons. To begin with, the ARDL approach may simultaneously analyse both the short-run and long-run effects of independent variables on the dependent variable, allowing the researcher to distinguish between the two, which is critical in econometrics study. Second, for small samples, such as ours with yearly time series, the ARDL technique trumps the other alternatives. Pesaran and Shin (1999) used the ARDL framework to show that OLS estimators of short-run parameters are consistent and ARDL-based estimators of long-run coefficients are super consistent in small sample sizes.

Typically, the standard EKC model is in the following form.

$$\left(\frac{E}{P}\right)_{it} = \alpha_{it} + y_{it} + \beta_1\left(\frac{GDP}{P}\right)_t + \beta_2\left(\frac{GDP}{P}\right)_t^2 + \theta X_t + \mu_t \qquad (1)$$

Where E is the environmental pollution captured by CO_2 emission, P is population size[2]. Therefore, $\left(\frac{E}{P}\right)$ is the per capita CO_2 emission, $\left(\frac{GDP}{P}\right)$ is GDP per capita, X_t implies the series that may affect environmental quality at a time and μ_t is the error term. The theoretical expectation is that if β_1>0 and β_2 = 0, then there is linear relationship between growth and environmental quality, while the relationship is monotonically increasing. However, if >0 and <0, there will be an inverted U-shaped. From the specifications, the turning point income per capita for which per capita emissions is at their maximum levels is derived as below:

$$\frac{(GDP)}{P}_{max} = \frac{-\beta}{\beta^2} \qquad (2)$$

Where and are the parameters estimates for the levels and square of per capita respectively.

To that effect, this study included population as a variable to proxy for demographic changes. It also comprised trade openness as a controlling variable. Based on the suggestion that carbon dioxide emission (CO_2) in Nigeria depends on energy consumption, electricity consumption (ELEC) is a proxy for energy. Gross domestic per capita, (GDPP) was used as the proxy for economic growth. All data used were sourced from the World Bank Development Indicators (WDI). The variables were represented in a functional form as equation one. However, to capture the general objective of testing the applicability of EKC in Nigeria, the square of GDP per capita was included in the model as specified in equation 3.

$$CO_2 = f(ELEC, GDP, GDP^2, OPEN, POP) \quad (3)$$

The study converted the linear specification of the model into log-log specification. It is noted that log-log specification provides more reasonable and efficient results as compared to the simple linear functional form of the model (Cameron, 1994; Ehrlich 1975, 1996). In addition, the logarithmic form of variables gives direct elasticity for interpretations. To that effect, the estimable equation is specified in log-linear form in equation 4.

$$LCO_2 = \beta_1 + \beta_{ELEC}\,LELEC + \beta_{GDP}\,LGDP + \beta_{GDP^2}\,LGDP^2 + \beta_{TR}LOPEN + \beta_{POP}\,LPOP + \mu_t \quad (4)$$

Where LCO_2=log of CO_2 emission, LELEC = log of electricity consumption, LGDP = log of the income, $LGDP^2$ = log of the square of income, LOPEN = log of trade openness and stands for the residual error term. It is hypothesized that economic activity is positively stimulated by an increase in energy use leading to an increase in environmental pollutants or carbon emissions, while electricity has been a proxy for energy in this study as part of the gap relative to other studies. Therefore, the following apriori expectation is established: . The EKC hypothesis suggests that and the expected sign of , negative if the production of pollution-intensive items decreases due to environmental protection laws and importation such items from other countries where environmental policies are flexible. Frankel and Rose (2005) posited that foreign investors come with modern technology and innovative managerial skills from their home country for the advantage of host countries. This results in the use of energy-efficient approaches which increase welfare. Moreover, trade openness increases the demand for environmental quality and cleaner products because it offers a set of available varieties to consumers. On the other hand, Grossman and Krueger (1995) and Halicioglu (2009) argued that the sign of OPEN is positive if dirty industries of developing economies are busy and produce a heavy share of CO_2 emissions with production.

Based on equation (4), the Autoregressive Distributed Lags (ARDL) that will be estimated are formulated below in order to find the links among the variables under investigation

$$lnCO_2 = \alpha_1 + \alpha_{co2}\ lnCO_{2_{t-1}} + \alpha_{elec}\ lnELEC_{t-1} + \alpha_{GDP}\ lnGDP_{t-1} + \alpha_{GDP^2}\ lnGDP^2_{t-1} + \alpha_{OPEN}\, lnOPEN\alpha_{t-1}$$
$$+$$
$$\alpha_{POP}\ lnPOP_{t-1} + \sum_{i=1}^{p}\varphi_{CO2}\Delta\ lnCO_{2t-i} + \sum_{j=0}^{q}\varphi_{elec}\Delta\ lnELEC_{t-j} + \sum_{k=0}^{m}\varphi_{GDP}\Delta\ lnGDP_{t-K} + \sum_{l=0}^{n}\varphi_{GDP^2}\Delta\ lnGDP^2_{t-l} + \sum_{n=0}^{0}\varphi_{open}\Delta\ lnOPEN_{t-n} + \sum_{g=0}^{v}\varphi_{pop}\Delta\ lnPOP_{t-g}$$
$$+\gamma ECT_{t-1} + \mu_t \quad (5)$$

Where is the intercept, α_{co2}, α_{elec}, α_{GDP} , α_{GDP^2}, α_{OPEN}, and α_{POP} are the long-run parameters of the series under consideration respectively while φ_{CO2}, φ_{elec} , φ_{GDP}, φ_{GDP^2} , φ_{open}, and φ_{pop} are short run parameters. The term is the error term which is not expected to auto-correlate.

Equation 5 is an unrestricted model implying the general specification of the ARDL model. However, the determination of whether short-run or long-run specification of the ARDL model depends on the outcome of the co-integration test. Thus, the ARDL bounds testing approach to co-integrating is a necessary criterion, and it depends upon the tabulated values by (Pesaran, et al., 2001) to make a decision about co-integration among the variables. To that effect, the null hypothesis of co-integration and the alternative hypothesis of co-integration among the variables are;

$H_o = \alpha_{ELE} = \alpha_{GDP} = \alpha_{GDP^2} = \alpha_{OPEN} = \alpha_{POP} = 0$; this implies that the variables are not cointegrated.

$$H_1 = \alpha_{ELE} \neq \alpha_{GDP} \neq \alpha_{GDP^2} \neq \alpha_{OPEN} \neq \alpha_{POP} \neq$$

From the outcome of the bound test, the F-statistics value is compared with the values of the lower critical bound and that of the upper critical bound in line with Pesaran (1997) and Pesaran *et al*. (2001). Co-integration exists among the variables if the calculated value of F-statistics is more than the upper critical bound. If the lower critical bound is more than the computed F-statistics, then there is no co-integration. However, if the calculated F-statistics is between lower and upper critical bounds, then the decision about co-integration is inconclusive. In such conditions, the focus will be on the significance of the lagged error correction term (ECT) for co-integration to investigate the long-run relationship among variables. If the outcome shows the existence of long-run co-integration among the variables, equation 5 is used to investigate the long-run coefficient of ARDL as below:

$$lnCO_2 = \alpha_1 + \alpha_{CO2}\ lnCO_{2_{t-1}} + \alpha_{ELE}\ lnELEC_{t-1} + \alpha_{GDP}\ lnGDP_{t-1} + \alpha_{GDP^2}\ lnGDP^2_{t-1} + \alpha_{OPE} lnOPEN\alpha_{t-1}$$
$$+\alpha_{POP}\ lnPOP + \eta_t \qquad (6)$$

While the remaining part of equation 5 with summation and change signs represents the short-run ARDL model, as below:

$$lnCO_2 = \alpha_1 +$$
$$\sum_{i=1}^{p} \alpha_j \Delta\ lnCO_{2t-1} + \sum_{j=0}^{q} \alpha_j \Delta\ lnELEC_{t-j} + \sum_{k=0}^{m} \alpha_j \Delta\ lnGDP_{t-K} + \sum_{l=0}^{n} \alpha_j \Delta\ lnGDP^2_{t-1} +$$
$$\sum_{l=0}^{0} \alpha_m \Delta\ lnOPEN_{t-n} + \sum_{i=1}^{q} \alpha_j \Delta\ lnPOP_{t-j}$$
$$+ \gamma ECT_{t-1} + \mu_t \qquad (7)$$

The difference between the long-run and the short-run ARDL model is the addition of the Error Correction Model (ECM) to the short-run form that is differenced.

Empirical Analysis

Unit Root Test

One important preliminary test for time series analysis is the unit root test. For this study, two forms of unit root test were carried out: Augmented Dickey Fuller (ADF) and Phillips-Perron. Augmented Dickey Fuller (ADF) was used because of its wide acceptance in the literature (Joshi, 2021). However, because the test has limitations associated with the large small test, the Phillips-Perron test was used as an alternative method (Hamilton, 1994). The results obtained are presented in Table 1

Table 1: Summary of Unit Root Tests

Augmented Dickey-Fuller			**Phillips-Perron**		**Conclusion**
Series	**Levels**	**First Difference**	**Levels**	**First Difference**	
CO_2	-2.314075 (0.1718)	-7.056856 (0.0000)*	-2.532809 (0.1143)	-7.077444 (0.0000)*	I (1)
ELEC	-2.329703 (0.1673)	-6.536420 (0.0000)*	-2.538251 (0.1132)	-9.419564 (0.0000)*	I (1)
GDPP	-0.797969 (0.8104)	-3.643066 (0.0383)**	-0.897019 (0.7808)	-5.323941 (0.0001)*	I (1)
OPEN	-2.553788 (0.1096)	-7.863623 (0.0000)*	-2.714093 (0.0791)	-7.831525 (0.0000)*	I (1)
POP	-2.682629 (0.0848)	-6.282915 (0.0000)*	-2.814964 (0.0637)	-2.575456 (0.1052)	I (1)
$GDPP^2$	-0.783396 (0.8145)	-3.623127 (0.0400)**	-0.947610 (0.7642)	-5.342402 (0.0001)*	I (1)

Source: Author's computation from e-views
Note: p-values of t-stat in brackets. **&* indicate significance at 5% & 1 % respectively.

The results of both tests showed that all the series (variables) were stationary in the first difference. Applying the ADF test, CO_2 emission, ELEC, OPEN, and POP were significant at 1%, while GDP and the square of GDP were significant at 5%. On the other hand, all the series, except POP, were significant at 1% using the Philip Perron test, while the POP was only significant at 1% for the ADF test. Conclusively, all the variables were I (1); that is, they were significant in the first difference.

Co-integration Test

Considering the possibility of the long-run relationship between variables in time series (Gujarati & Porter, 2009), it is necessary to conduct co-integration tests when conducting time series analysis. The usual co-integration tests found in the econometric literature are the Johansen and bounds tests. The selection of an appropriate co-integration test depends on the nature of the stationary of the variables that are involved in the empirical model. While the Johansen test is suitable only when preliminary unit root tests reveal that all variables in the model are stationary at first difference (I(1)), the bounds test is right when unit root tests show a mixture of variables that are stationary at levels (I(o) and those that are stationary at the first difference (I(1).

Regarding the fact that all the variables are I(1) from the unit test result in Table 1, this study adopted the bounds tests approach developed by Pesaran *et al*. (2001). A Summary of the bound test conducted is presented in Table 2.

Table 2: Summary of Bounds Test of Co-integration

Critical Values	Lower bound	Upper bound
10%	2.08	3
5%	2.39	3.38
2.4%	2.7	3.73
1%	3.06	4.15
F-Statistic: 3.33, **Degrees of Freedom:** 5		

Source: Author's computation from e-views

The decision rule for the bound test is that the null hypothesis of no long-run relationship be rejected if the value of the F-statistic of the test is more than that of the upper bound at the given level of significance. If, on the other hand, the calculated F-statistic is less than the lower bound at the given level of significance, the null hypothesis is accepted that there is no long-run relationship (that is, no co-integration) among the variables in the model. If, however, the F-statistic falls within the lower and upper bounds, the judgment of the test is inconclusive. Considering the upper and lower bounds tabulated for five (5) degrees of freedom, it can be observed that the computed F-statistic of the test (3.33) exceeds the value of the upper bound at a 10% level of significance. This result shows that there is co-integration among the series in the model. However, since the value of computed F-statistics is higher than both lower and upper bound at a 10% level of significance as indicated in Table 2, it implies that there is a long-run relationship among series in the model and thus a long-run ARDL model is specified.

Table 3: Error Correction Mechanism (ECM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq(-1)*	-0.4322	0.0823	-5.2459	0.0000

Source: Author's computation from e-views

The error correction term (ECM) is negative, less than one, and its P-value of 0.0000 is significant at a 5% significant level. The coefficient has the correct a priori sign and size. Its p-value also indicates that significant adjustments toward long-run equilibrium occur in the model. The value of -0.432210 per cent of disequilibrium in CO_2 emission is corrected each year as a result of changes in the specified exogenous variables. This implies that the short-run equilibrium adjusts by about 43.2% of the long-run equilibrium per year. That is, the speed of adjustment is 43.2% per annum.

Table 4: Estimated ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SHORT RUN				
D(LNGDPP)	48.27704	8.962682	5.386451	0.0000
D(LNOPEN)	-0.079367	0.063441	-1.251029	0.2197
D(LNOPEN(-1))	-0.158956	0.063509	-2.502879	0.0174
D(LNOPEN(-2))	-0.238733	0.061504	-3.881588	0.0005
D(LNOPEN(-3))	-0.189588	0.062966	-3.010981	0.0050
LONG RUN				
LNGDPP	107.8811	44.60553	2.418560	0.0213
LNSGDP	-4.290511	1.779928	-2.410496	0.0217
LNELEC	-0.521673	0.215575	-2.419916	0.0212
LNOPEN	-0.234038	0.181772	-1.287535	0.2069
LNPOP	1.157348	1.505496	0.768748	0.4475
C	-676.3723	279.0995	-2.423409	0.0210
R-squared: 0.527221; Adjusted R-squared: 0.466609; F-stat: 18.35163 p.>F: 0.000				

Source: Author's computation from e-views

Table 4 contained the short-run and long-run estimates of all the explanatory variables, including the coefficient of determination (R-squared). For the short-run results, the findings showed that GDP per capita has a positive relationship with CO_2 emissions in Nigeria in the short run. This is because the coefficient of GDPP is positive with a value of 48.3% approximately. Therefore, a 1% change in GDP per capita leads to 48.3% increase in carbon dioxide (CO_2) emission in Nigeria. This is in line with the economic theory adopted by this study. The degree of trade openness has a negative coefficient and signifies a negative relationship between CO_2 emission and the level of international trade in Nigeria. That is, a 1% increase in trade openness leads to 0.079% decrease in CO_2 emission in Nigeria. However, it is statistically insignificant with a P-value of 0.2197. The negative relationship can be attributed to the fact that the country is heavily import-dependent and thus importing energy-efficient products. The emissions from the production of those goods apparently happened overseas where they are produced.

For the long-run estimate, there is a positive and long-run relationship between per capita GDP and CO_2 emission. The result shows that a 1% increase in GDPP leads to a 107.9% approximately increase in CO_2 emission in Nigeria, while it is statistically significant by the p-value of 0.0213. However, the square of GDPP (GDP^2) has a negative coefficient, and it is significant at the p-value of 0.0217; the value indicates a negative relationship between the square of GDPP and CO_2 emission which implies that a 1% increase in GDP^2 leads to approximately 4.3% decrease in CO_2 emission in Nigeria. This is quite in line with the a priori expectation of the economic theory. The square of GDP per capita is used to capture the threshold for the level of income. Thus, the negative coefficient of GDP^2 as indicated by the findings support the claim that EKC holds in Nigeria. This is because the signs for the coefficient of GDP and GDP^2 support the theory, and they are statistically significant at 5%.

Electricity consumption has a long-run negative impact on CO_2 emissions in Nigeria. From the table above, the coefficient of ELEC is negative, and it implies that a 1% increase in electricity consumption leads to approximately 53% decrease in CO_2 emission in Nigeria; this is statistically significant with the p-value of 0.0212 at 5%. It can be attributed to the fact that the major source of electricity supply in Nigeria is hydro which does not produce carbon. The long-run effect of international trade on CO_2 emission is also negative. Its coefficient of -0.234038 implies that a 1% increase in international trade leads to a 0.2% decrease in CO_2 emission, which is statistically insignificant with the p-value of 0.2069. This can be attributed to the high consumption of imported goods which their production with emissions is carried out by foreign countries. The long-run impact of population on carbon dioxide emission in Nigeria is positive but statistically insignificant with a p-value of 0.4475. The coefficient value of 1.157348 implies that a 1% increase in population leads to a 1.2% increase in CO_2 emissions in Nigeria. This is in line with the a priori expectation of the economic theory. The value of lagged ECM is significant and shows that the deviation in CO_2 emission away from the equilibrium is corrected by 43.2 % within a year.

The R-squared is 53 per cent, which shows that the independent variables are capable of explaining 53 per cent of the behaviour of the dependent variable, while the adjusted R-squared is 47 per cent, which shows that the independent variables are capable of explaining 47 per cent of the dependent variable.

Post–Estimation Test

To check the validity of our findings, several post-estimation tests were carried out in this study. These estimations were the serial correlation test, the heteroscedasticity test, the normality test and the stability test, using the cusum test and the cusum of square test.

Table 5: Serial Correlation

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.539839	**Prob. F (4,29)**	0.7077
Obs*R-squared	3.118518	**Prob. Chi-Square(4)**	0.5382

Source: Author's computation from e-views

Table 5 above shows the serial correlation result. The result shows that at a 5% significance level, the null hypothesis is not rejected since the P-value of 0.7077 is greater than 0.05. This implies that there is no serial correlation or there is no evidence of autocorrelation in the disturbance of the white noise or error term. This is to say that the model does not violate any of the CLRM rules.

Table 6: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.748697	**Prob. F (11,33)**	0.6856
Heteroskedasticity Test: ARCH			
F-statistic	0.497671	**Prob. F (4,36)**	0.7375
Obs*R-squared	2.148370	**Prob. Chi-Square (4)**	0.7085

Source: Author's computation from e-views

The results of the different heteroscedasticity tests carried out in this study are presented in Table 6. The results show that both the Breusch-Pagan-Godfrey test and the ARCH test indicate that there is no presence of heteroscedasticity because their P-values are greater than 0.05. To that effect, there was no reason to reject the null hypothesis of no heteroscedasticity.

Table 7: Normality Test

Normality Test	
Jarque-Bera statistics	0.649153
Probability	0.722833

Source: Author's computation from e-views

Table 7 shows the result of the Normality test. It indicates that the null hypothesis of Normal distribution is not rejected because the P-value of 0.722833 is greater than the 0.05 level of significance. This implies that the variables in the model are normally distributed.

Test of Model Stability

The stability of the estimated ARDL model is tested with the aid of the CUSUM and CUSUMSQ tests for parameter stability which were first introduced by Brown *et al.* (1975). These tests are based on the analysis of the scaled recursive residuals and have a significant advantage over the Chow (1960) tests of not requiring prior knowledge of the point at which the hypothesized structural break takes place. The result of the CUSUM test is presented in Figure 2. The decision rule is to reject this hypothesis provided the CUSUM line lies within the upper 5 per cent and lower 5 per cent significance bounds for all the periods. In Figure 2, it can be seen that the blue CUSUM line is indeed within the upper 5 per cent and lower 5 per cent bounds for all the periods under analysis. The conclusion, therefore, is that the coefficients estimated in the regression model are stable over the 1970 - 2018 period.

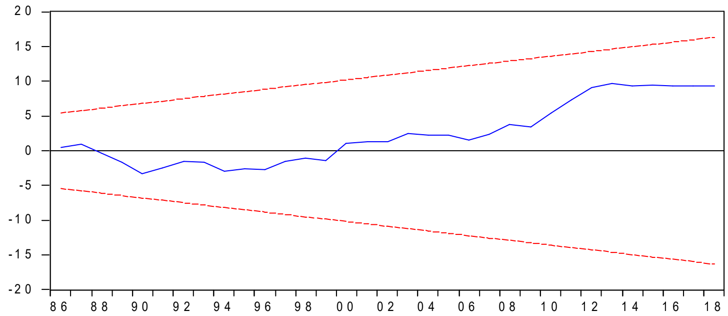

Figure 2: CUSUM Test of Parameter Stability

Figure 3 presents the result of the CUSUMSQ test of coefficient stability. The CUSUMSQ test is similar to the CUSUM test in that its decision rule involves observing the CUSUMSQ line to determine if it lies within the upper 5 per cent and lower 5 per cent lines for the periods under focus. Since the CUSUMSQ line is within the upper and lower bounds for the 1970 – 2018 periods, the conclusion is that the estimated coefficients of the ARDL model are stable over time.

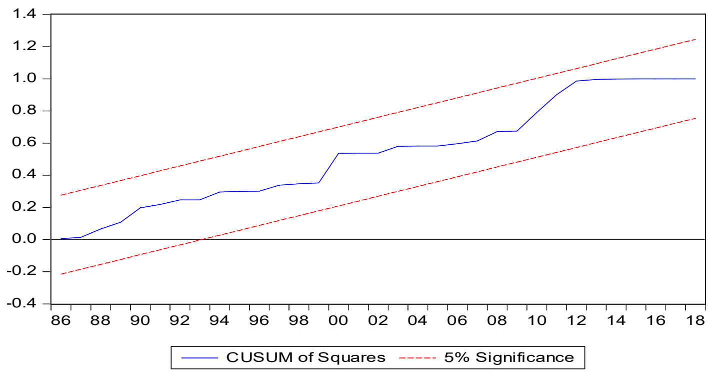

Figure 3: CUSUMSQ Test of Parameter Stability

Discussions of Results

The result of the estimated ARDL regression shows that the per capita GDP in both the short run and the long run has positive and significant impact on CO_2 emission in Nigeria, while the square of GDP per capita has only a long-run negative relationship with CO_2 emission; this is in line with a priori expectation of the economic theory because the signs of GDPP and $GDPP^2$ support the existence of EKC in Nigeria. It can also be observed that only per capita GDP and trade openness show the short-run impact on CO_2 emission. The findings revealed that international trade has a negative relationship with CO_2 emission in Nigeria. The negative coefficient of trade openness implies that it reduces the emission in Nigeria. This can be attributed to the fact that the impact of trade openness depends on the nature of commodities imported. To that effect, it signifies that most of the products that are imported to Nigeria are energy-efficient products, and their production is done by the exporting countries. The trade openness is statistically insignificant in the current period, but it impacts significantly on CO_2 emissions in the previous lags within the short run.

In the long run, the finding shows that there is a negative relationship between electricity and CO_2 emission. Electricity consumption significantly affects CO_2 emission in Nigeria. However, the negative coefficient can be attributed to the gradual adoption of mixed energy consumption. As people's income rises, they tend to demand a cleaner environment by adopting less emit energy appliances, such as the solar system for generating electricity. Thus, the gradual awareness of the use of gas and the solar system of electricity to complement the available hydropower could be responsible for such a negative coefficient of electricity in the result.

The result reveals that thepopulation has a long-run positive relationship with CO_2 emission in Nigeria, and this corresponds with the a priori expectation. However, it has an insignificant impact on CO_2 emission; a 1% increase in population leads to 1.5% increase in CO_2 emission. This can be attributed to income distribution as well as poverty level. People might not have adequate resources to consume a substantial amount of energy.

For instance, according to the Nigeria National Bureau of Statistics (2012), 65% of the population was poor in 2010 and might not have enough resources to consume a substantial amount of energy. Therefore, consumption is low and CO_2 emission is also low. Thus, growth in population will not have a positive impact on CO_2 emissions in Nigeria which is in line with the findings of Ali *et al.* (2016).

5. Conclusion and Policy implications

This study investigated the existence of inverted U-shaped income-environmental degradation commonly known as environmental degradation for Nigeria over the period 1970 to 2018. To limit the problem of omitted variable bias, the study included the square of income variable and other explanatory variables like trade openness and electricity consumption in Nigeria. The CO_2 emission was used as the dependent variable. The unit root test was conducted and found all the variables to be stationary at first difference. The ARDL bound test approach to co-integration was adopted in the study to check for the existence of a long-run relationship among the series in the model. This technique was adopted on the basis of its superiority over the traditional technique. The unit root test revealed that none of the variables was integrated beyond order one, and this paved way for the adoption of ARDL. However, the co-integration test result showed that there was co-integration among the series.

The overarching recommendation of this study shows that Nigeria should look beyond the existence of EKC induced notion. There is a need for a paradigm shift from the current means of production that incorporates carbon dioxide emission in order to achieve sustainable development. There should be the pursuance of ecological means of economic growth. Given the fact that Nigeria is being endowed with abundant alternative sources of energy that are free of pollution emissions, it is evident that these resources are yet to be exploited to derive a higher level of growth feasible.

Economic growth and industrial sector expansion in Nigeria put great pressure on the environment, and Nigeria is struggling to enhance economic growth which mainly depends on non-renewable energy resources that negatively affect the environment. From the results obtained, there are several policy implications for Nigeria that must be taken into consideration. First, the government has to implement more energy conservation policies as this will not harm economic growth. Second, Nigeria has to adopt more strict environmental regulations to control pollutants emitted from the burning of nonrenewable sources of energy, and then environmental quality will improve without negatively affecting economic growth. Third, Nigeria has to alternate gradually to more environment-friendly sources of energy; that is, renewable energy resources instead of depending on fossil fuels.

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