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MODELLING THE RELATIONSHIP BETWEEN CO_2 EMISSION AND ECONOMIC GROWTH IN NIGERIA: DOES ENVIRONMENTAL KUZNET CURVE HYPOTHESIS HOLD?

ABUBAKAR SADIQ SALISU; ABUBAKAR ABDULLAHI; MUSA MUNKAILAL; & BILYAMINU ABDULLAHI
Department OF General Studies (Economics Unit) Gombe state Polytechnic Bajoga

Abstract
This study examines the relationship between carbon dioxide emission (CO_2) and economic growth in Nigeria for the period (1981-2018) with the objective of checking the validity of environmental kuznet curve (EKC) hypothesis using annual time series data. The study employs econometrics techniques of Augmented Dickey-Fuller (ADF) unit root test, Johansen co-integration and error correction methodology while E-views econometrics package was used as a tool of analysis. The results from the analysis reveal that all the variables are integrated of the first order I (1). the Johnsen co-integration indicates that real GDP per capita which is a proxy for economic growth is statistically significant and negatively affects CO_2 in the long run while GDPSQ shows a positive statistically significant effect on CO_2 and capital formation has negative long run influence on carbon emission. The vector error correction model revealed a 27 percent speed of convergence to long run equilibrium and the results short run dynamics shows statistically effects of GDP, GDPSQ and CAP. U-shaped relationship between economic growth and carbon emission was obtained from the study and therefore environmental kuznet curve hypothesis does not hold in Nigeria for the periods under study. Arising from the foregoing it is recommended that policies that discourage importation of carbon intensive product should be formulated and implemented and that productive activities of multinational and local companies that contributes to emission should be checked so that economic growth can be achieve with minimal emission.

Keywords: *CO2 Emission, Economic growth, Environmental quality, Environmental Kuznet Curve and Johansen CO-integration.*

Introduction.

Carbon dioxide is one of the major greenhouse gases emission considered to be a key driver of global warming and environmental degradation. According to Nunez (2019) carbon dioxide is the primary greenhouse responsible for about three-quarters of emissions. Carbon dioxide enter atmosphere through of burning fossil fuel (coal, natural gas and oil), solid waste, trees and other biological materials and also as result of certain chemical reactions e.g. manufacture of cement. Most global economic production depends on energy produced from burning fossil fuels, thus an attempt to propel the engine of growth through productive ventures produces greenhouse gases causing earth to warm. A report released by united states environmental protection agency (USEPA, 2020) global carbon emissions from fossil fuel have significantly increased since 1900, since 1970, CO2 emission have increased by about 90%, with emission from fossil fuel combustion and industrial process contributing about 78% of the total greenhouse gas emission.

Economic activities in Nigeria in the last 50 years have been the major source of carbon dioxide emission and concentration of greenhouse gases which in turn result in to climate change (Ejuvbekpokpo, 2014). Oil is the engine of growth and key driver of Nigeria economy and it exploration is believed to be a major emitter of carbon dioxide which eventually lead to deterioration of the environment. The oil and gas industry has emerged as the world's second largest air emission producer. Each year the industry emits over 150 billion cubic meters of environmentally damaging air emissions through venting, flaring or fugitive leaks and is also responsible for 300 million tons of carbon dioxide emission released in to the atmosphere (IPIECA/OGP,2002.24). oil is not the only contributor of carbon emission in Nigeria, other economic activities like agriculture, mining, manufacturing and other sectors that drive growth also have their fair share. For instance, agriculture (including land use change) is one of the major contributor to Nigeria's total emission accounting for emissions

equivalent to an estimated 156 million tons of carbon dioxide, and 45% of the national total(FAO,2012)

Environmental kuznet curve (EKC) hypothesis has become a popular research tool among economist and environmental experts for modelling the nexus of ambient pollution concentrations and economic growth(Stern,2015). Inspired by Simon Kuznet (1955) who explained the relationship between income inequality and economic growth with an inverted U-shape curve in their path breaking study about the potential impact of NAFTA Grossman and Krueger (1991) studied the relationship between air quality and economic growth in the context of liberalisation of trade(NAFTA) between the united states and Mexico. they supported that trade liberalisation affect environment by expanding the scale of economic activities as well as modifying it composition and bringing out a change in production method. Environmental kuznet curve (EKC) assumes an inverted U-shaped relationship between development process and pollution, that is environmental pollution increase with rising per capita income at the first phase of development process, however the pollution level began to fall beyond a threshold income level reached at later stage of development.

Despites the efforts of researchers to establish an exact relationship existing between carbon dioxide emission and economic growth in an attempt to validate or invalidate the existence of environmental kuznet curve (EKC) hypothesis in various countries at different point in time, there is still no complete convergence about their findings. Some found the relationship to have inverted U-shape and support the EKC while others have found the relationship to have U-shape and contradict the EKC hypothesis. For instance, Lu, Li and Wang (2016), Twerefou, Poku and Bekoe (2016), Aruga (2019) studied the relationship and found the result to support EKC hypothesis while Akpan and Akpan (2012), Alege and Philip (2013), Nulambeh and Wusiman (2020) found their findings to contradict EKC hypothesis.

This research work majorly seeks to examine the relation between carbon emission and economic growth in Nigeria between the periods 1981 to 2018 in an attempt to check the existence or otherwise of environmental kuznet curve. Accordingly, the paper is structured as follows. Following

this introduction section, section two provide literature review, section three dwells on methodology, section four contain results and discussion and finally section five dwell on conclusion and recommendations.

Theoretical framework of the environmental kuznet curve (EKC)

The central idea of environmental kuznet curve hypothesis (EKC) is that economic growth at an initial stage worsen the environmental quality, but after a certain point along the economic growth path the environmental situation will begin to improve.

Kuznet (1955) in his original work hypothesized that income inequality first increase, then reaches a turning point and decline thereafter during the transition of an economy from a low-income to a high-income country. Therefore, an inverted U-shaped relationship is assumed between income inequality and economic growth.

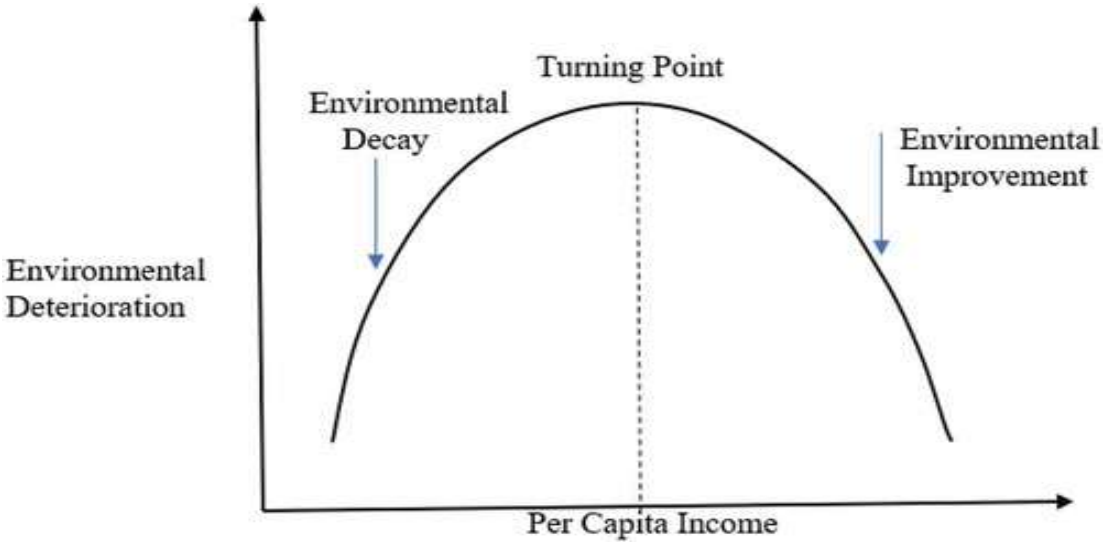
Based on the wisdom of original kuznet curve, the EKC hypothesis posits that further growth of the economy is likely to improve environmental performance of a country after it surpass an adequate level of growth. According to (Dietz et al, 2012) an attempt by countries to propel the growth of their economies exerts a lots of pressure on their environments at the initial stages, but eventually they will reach a turning point beyond which further growth decrease pressure on the environment. This implies that environmental pollution is a U-shaped function of the income per capita. The effect of economic growth on the environment may change from positive to negative as long as countries achieve higher income level at which people demand and afford more efficient infrastructure and cleaner habitats (Panayotou,2003). If EKC hypothesis is true, then economic growth will be a solution rather than a threat to environmental pollution problems, although even with the general acceptance of EKC by countries there is still doubt about co-existence of economic growth and environmental improvements. For instance, Ginevicious et al (2017) opined that sustainable development is an oxymoron because humanity has been facing severe environmental problems and natural habitat has been damaged beyond repair since the last four decades.

Essentially there are three stages at which economic growth influence the environment differently, these are the preindustrial phase, industrial

phase and post-industrial phase. At the early stage of industrial development (preindustrial) period, economic growth leads to an increase in environmental deterioration but beyond a critical point of income per capita that reaches a turning point in the industrial stage which is the second stage of development, the trend start reversing (Ginevicious et al, 2017). According to Dinda (2004) the intensity of agricultural activities and resources extraction as well as industrial take off at the preindustrial and industrial phases the resources depletion and waste generation accelerates. Pollution usually increases monotonically when a country become more industrialized and start manufacturing goods(Urheim,2009). At the early stage of industrial development environment suffers because of weak environmental regulations as people are not rich enough to pay for environmental pollution abatement strategies. Therefore, at low-level income there is hardly fund set aside for environmental protection because of pervasive poverty, ineffective tax collection and low level of environmental awareness (Panayotou,2003). In this respect, increased pollution is considered acceptable side effect of economic growth (Arrow et al, 1994). In the case of developing countries however, there seems to be a trade-off between economic growth and environmental quality because slowing economic growth in the interest of protecting the environment is at the bottom of their priority list (Urheim, 2009).

However, in the later stage (post-industrial phase), environmental quality will start to improve with the increasing level of income. As pointed out by (Dietz et al, 2012, Hervieux and Darne, 2015) in the post-industrial phase of development, with a rising income level people attach more importance to environmental amenities and regulatory institutions become stronger and more effective in tackling environmental hazards which result in to less pollution. According to (stern, 2004) there is a shift from more resources intensive extractive and heavy industrial sectors toward a service and lighter manufacturing which reduce emission per unit of output in the post-industrial stage of development. At the final phase of development economic growth lead to environmental quality because of increased demand for environmental quality and structural changes toward information based industries and more efficient

technologies(panayotou,2003). The effect of economic growth on environmental quality is presented in the figure (1) below.
A typical EKC diagram.



Environmental kuznet curve hypothesis implies that environmental problems created by economic growth are automatically resolved in a later stage of economic development, thus U-shaped relationship between economic growth and environment is proposed. Therefore, existence of inverted U-shaped relationship is a validation of the hypothesis.

Empirical literature.

There abounds a research work on the relationship between carbon emission and economic growth in a view to check the existence of environmental kuznet curve or otherwise. As stated by Mitic (2019) The first studies that empirically studied and tested the existence of inverted U-shape EKC between income and environmental pollution are Grossman and Krueger (1991), Shafik and Bandyophadyay (1992). Theoretically the relationship has been a subject of controversy. Previous studies conducted hardly come to a unanimous conclusion on the existence of inverted U-shape EKC.

Nulambeh and Wusiman (2020) investigated the association between financial development, trade openness, economic growth and environmental quality in Cameroon 1980-2016. In order to examine the relevance of environmental kuznet curve in Cameroon the study employed

econometrics tools of unit root test, Johansen co-integration, vector error correction model as well as granger causality. The result obtained from the study revealed that GDP influence CO_2 negatively while GDP square negatively and all the variables are statistically significant. The results also indicated that GDP and GDP square granger causes CO_2 unit-directionally without feedback. The study therefore found U-shape relationship and concludes that Environmental kuznet curve hypothesis does not hold in Cameroon and recommended that Government should focus on implementation of policies that raises growth with minimal carbon emission.

Alege and Philip (2013) studied the relationship between environmental quality and economic growth in Nigeria using fractional co-integration analysis over the period 1970-2011. The main objective of the study is to examine the effect of growth on environmental performance by controlling for the role of institutional quality, trade openness and population density. The study failed to attain a reasonable turning point and hence nonexistence of of environmental kuznet curve hypothesis in Nigeria. the paper recommended the need to restrict importation of emission intensive products, check the activities of multinationals which invest in producing high carbon emitting goods.

Alabdulrarazag and Alrajhi (2016) studied the validity of environmental kuznet curves in Saudi Arabia using annual data spanning from 1971 to 3013 using ARDL bound testing and granger causality within VECM framework to explore short run and long run causality direction. The result of the ARDL revealed a long run equilibrium relationship among carbon dioxide emission, economic growth, energy consumption and population density. The result showed short run and long run positive significant impact of economic growth on carbon emission. The study therefore found evidence of environmental kuznet curve hypothesis in Saudi Arabia. The study recommended that policies should be formulated and implemented to reduce emission level and consumption of renewable energy should be encouraged.

Razah and Shah (2018) examined the impact of trade, economic growth and renewable energy on environmental degradation in G7 countries using data from 1991-2016. The study employed panel unit root test, co-

integrational as dynamic ordinary least squares well as fixed effect regression models. The result revealed that all variables are co-integrated in the long run and all the variables have significant effect on carbon emission and conclude that environmental kuznet curve hypothesis holds in G7 in the period under study. The study recommended sustaining the level of economic growth with a minimal emission.

Aruga (2019) investigated energy –environmental kuznet curve hypothesis among the 19 Asia Pacific countries. The study also tested energy-environmental kuznet curve hypothesis for the low, middle and high income groups of the region by applying panel unit root and co-integration. The result of the study revealed that environmental kuznet curve hypothesis hold for the whole Asian-Pacific region. The study recommended that developed countries need to support the developing nations to achieve economic growth along energy-environmental kuznet curve.

Akpan and Akpan (2012) applied vector error correction framework to examine the long run and causal relationships between electricity consumption, carbon emission and economic growth in Nigeria using annual time series data for 1970 to 2008. Findings of the study showed that in the long run economic growth is associated with increase carbon emission while an increase in electricity consumption leads to increase in carbon emission. No support was obtained for the hypothesized environmental kuznet curve. The paper recommended that efficient planning and increase investment in electricity infrastructure be put in placer to propel the growth of Nigerian economy with renewable energy.

Lu, Li and Wang (2016) investigated the existence of environmental kuznet curve hypothesis in Croatia for the period 1991Q1-2011Q1 by applying autoregressive distributed lag (ARDL) and vector error correction model (VECM). The results of the study show the existence of inverted U-shape relation between economic growth and carbon emission in the long run and conclude the existence of environmental kuznet curve hypothesis in Croatia. The result of VECM granger causality revealed bi-directional causality from economic growth to co2 in the short run and uni-directional causality from economic growth to co2 in the long run. The paper recommended that Croatian Government growth and development to

tackle carbon emission by removing dirty and less efficient techniques in production.

Twerefou, Poku and Bekoe (2016) investigated environmental kuznet curve hypothesis for carbon dioxide emission in Ghana using annual time series data spanning from 1970-2010 using ARDL bound testing approach. The result found a U- shaped relationship between carbon emission and per capita income which indicates absence of environmental kuznet curve hypothesis in Ghana for the periods under study. The study concludes that further increase in per capita income is associated with increase carbon emission. The study recommended the use of cleaner technologies and products and implementation of low carbon development strategy which integrate development and climate change mitigation action.

Onafowara and Owoye (2014) examined the long run relationship between economic growth, energy consumption, population density, trade openness and carbon emission in Brazil, China, Egypt, Japan, Mexico, Nigeria, south Korea and south Africa and found the Environmental kuznet curve hypothesis to hold for only two countries including Japan and South Korea, whereas N-shaped trajectory was found for the other six countries.

Killic and Balan (2016) studied the relationship among carbon dioxide emission, income, energy consumption, trade openness, financial development and institutional quality based on environmental kuznet curve hypothesis in 151 countries for the period 1996-2010 using pooled ordinary least squares method. The result supported cubic specification of environmental kuznet curve hypothesis which assume a cubic polynomial inverted U-shaped relationship between income and environmental degradation. The study recommended the use of clean energy to mitigate the effect growth has on the environment.

Methodology.

Sources and types of Data.

This research work made use of secondary annual time series data which are obtained from world bank development indicators (2020) and international energy agency. The data include real Gross Domestic product per capita in US dollars which serve as a proxy for economic growth,

carbon dioxide emission measured in metric tons as well as capital formation. All data are from 1971 to 2018.

Model specification.

In order to test the presence of environmental kuznet curve hypothesis in Nigeria, the functional relationship of the model for the study is expressed as

$CO_2 = F$ (GDP, GDPSQ, CAP) …… (1)

Where CO_2 is carbon dioxide in metric tons, GDP is real gross domestic product per capita in US dollars which is a surrogate for economic growth, GDPSQ is gross domestic product per capita square, CAP is capital formation which is a control variable that affect carbon dioxide emission. The short run and long run relationship between economic growth and carbon dioxide emission can be specified in the model below.

$$\Delta CO_{2} = \alpha_0 + \sum^{n}_{t=1} \beta_{it}\Delta GDP_{t-1} + \sum^{n}_{t=1}\beta_{2t}\Delta GDPSQ_{t-1} + \sum^{n}_{t=1}\Delta\beta_{3t}CAP_{t-1} + \lambda EC_{t-1} + \varepsilon_t \ldots\ldots (2)$$

Where

Δ is the first difference operator

α_0 is the parameter of slope coefficient

$\beta_1 - \beta_3$ are the confidents of each exogenous variables

λ is the coefficient of error correction term

ε is the white noise error term.

If $\beta_1 = \beta_2 = 0$ it will show level relationship, if $\beta_1 > 0$ and $\beta_2 = 0$ or $\beta_1 < 0$ and $\beta_2 = 0$ there will be monotonically decreasing and increasing linear relationship respectively. But when $\beta_1 < 0$ and $\beta_2 > 0$ there will be U-Shape relationship and environmental kuznet curve hypothesis will not hold. Finally, if $\beta_1 > 0$ and $\beta_2 < 0$ then there will be inverted U-Shape relationship and environmental kuznet curve hypothesis (EKC) will hold. The turning point of real income will be $-\beta_1/2\beta_2$.

Results and Discussion

Unit Root Test. Economic theory requires that the variables be stationary before the application of standard econometric techniques in order to avoid getting misleading results (spurious regression). The unit root test for all the variables were carried out using Augmented-Dickey Fuller (ADF)

methodology. The results of the stationarity test are presented in the table **4.1** below

Table 4.1. summary of unit root test using the ADF criteria.

Variable	Order of integration	ADF	Decision
D(Co_2)	1st Difference	-5.734955	I(1)
D(GDP)	1st Difference	-10.06780	I(1)
D(GDPSQ)	1st Difference	-3.245701	I(1)
D(CAP)	1st Difference	-4.659043	I(1)

Source: authors computation using E-Views 9.0, 2020

The above results of the augmented Dickey- Fuller test indicate that all the variables employed in the model are not stationary at level but became stationary after the first difference. the critical value is -2.948404 at 0.05 significance level which is less than ADF statistics of all the variables. Therefore, the variables are all I (1).

Lag order selection criterion.

After identifying the level of stationarity, then there is need to test for the long run relationship of the variables, before that there is need to determine optimal lag length. The table **4.2** below depict the optimal lag structure to be use in the estimation of co-integration and error correction model.

Table 4.2. Result of lag order selection criteria

VAR Lag Order Selection Criteria						
Endogenous variables: CO2 GDP GDPSQ CAP						
Exogenous variables: C						
Date: 12/20/20 Time: 10:42						
Sample: 1 38						
Included observations: 33						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-859.3489	NA	6.23e+17	52.32418	52.50557	52.38521
1	-750.4460	184.8049	2.25e+15	46.69370	47.60067*	46.99887

2	-737.0086	19.54532	2.76e+15	46.84901	48.48156	47.39831
3	-703.2661	40.90006*	1.07e+15	45.77370	48.13183	46.56714
4	-680.2696	22.29962	9.01e+14*	45.34967*	48.43338	46.38725*
5	-666.4024	10.08524	1.67e+15	45.47893	49.28822	46.76064
* 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 using E-Views 9.0, 2020.

The result indicates that most of the selection criterion such as Akaike information criterion (AIC), final prediction error (FPE), Hannan-Quin information criteria (HQ), selected the optimal lag length of **4** at **5**% level of significance. Hence the lag length of **4** will be used in the estimation of Johansen co-integration and error correction model.

Johansen co-integration Test Result.

Johansen co-integration is applied to check for existence of long run relationship among CO_2 emission, economic growth proxied by real gross domestic product per capita and it square as well as capital formation in Nigeria. The result of the co-integration is presented in table **4.3** below.

Table 4.3. results of Johansen co-integration test.

Date: 12/20/20 Time: 13:00				
Sample (adjusted): 6 38				
Included observations: 33 after adjustments				
Trend assumption: Linear deterministic trend				
Series: CO2 GDP GDPSQ CAP				
Lags interval (in first differences): 1 to 4				
Unrestricted Co-integration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**

None *	0.678477	70.66356	47.85613	0.0001
At most 1 *	0.480000	33.21891	29.79707	0.0194
At most 2	0.269070	11.63932	15.49471	0.1751
At most 3	0.038509	1.295900	3.841466	0.2550
Trace test indicates 2 co-integrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Co-integration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.678477	37.44465	27.58434	0.0020
At most 1 *	0.480000	21.57960	21.13162	0.0432
At most 2	0.269070	10.34342	14.26460	0.1904
At most 3	0.038509	1.295900	3.841466	0.2550
Max-eigenvalue test indicates 2 co-integrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
MacKinnon-Haug-Michelis (1999) p-values **Source: authors computations using E-Views 9.0,2020				

The result of the Johansen co-integration test in table 4.3 above reveals the existence of long run relationship among CO_2 emission and economic growth, economic growth squared and capital formation in Nigeria in the period under study. Both the trace test and maximum Eigen Value reveals the presence of two co-integrating vectors. The results of the co-integrating can also be expressed as

$$CO_2 = 0.457184GDP - 0.000152GDPSQ + 2.034598CAP$$
$$(0.28068) \quad (8.4E\text{-}05) \quad (0.3001)$$
$$[1.628551] \quad [1.81280] \quad [6.78170]$$

From the foregoing long run results, economic growth proxied by real gross domestic product per capita is statistically significant and negatively affects carbon emission, thus one-unit increase in gross domestic product per capita will lead to a 0.457184-unit decrease in carbon emission in the period under study. The result reveals that economic growth squared is

also significant but positively affects carbon emission where one-unit increase in economic growth squared results in to 0.000152 increase in carbon emission. The result of capital formation suggest that it is statistically significant and negatively influence carbon emission where one-unit increase in capital formation leads to 2.0346 decrease in carbon emission.

So our long run results show the situation as $\beta_1<0$, $\beta_2>0$ this implies that environmental kuznet curve hypothesis with an inverted U-shape does not hold in Nigeria instead a U- shape relationship does exist in the case of Nigeria. This finding is in consonance with the results from the studies by Alege and Philip (2013), Nulambeh and Wusiman (2020).

The error correction model.

Since the long run association exist between carbon emission, economic growth and capital formation, the speed of adjustment in the long run equilibrium relation was established with the use of error correction test. This estimate shows the speed at which the system reverts back to equilibrium from the state of equilibria. The result of the error correction and short run dynamics is presented in the table **4.4** below.

Table 4.4 Error correction and short run Dynamics.
Dependent Variable: CO_2

Variables	Coefficients	Standard Error	t-Statistics	Prob.
C	2.9502*	0.7239	4.0751	0.0010
D(GDP(-1))	0.4158*	0.0702	5.9172	0.0000
D(GDP(-2))	0.3448*	0.0801	4.3053	0.0006
D(GDP(-3))	0.2046*	0.0563	3.6365	0.0024
D(GDP(-4))	0.0870	0.0444	1.9581	0.0691
D(GDPSQ(-1))	-0.0001*	2.12E-5	-5.9842	0.0000
D(GDPSQ(-2))	-0.0001*	2.42E-5	-4.4744	0.0004
D(GDPSQ(-3))	-6.81E-5*	1.74E-5	3.9087	0.0014
D(GDPSQ(-4))	-3.04E-5*	1.33E-5	-2.2772	0.0379
D(CAP(-1))	0.2347	0.1611	1.4570	0.1657
D(CAP(-2))	0.1169	0.1376	0.8499	0.4088
D(CAP(-3))	-0.5919*	0.1589	-3.7239	0.0020

D(CAP(-4))	-0.0662	0.1269	-0.5219	0.6093
ECM(-1)	-0.2714*	0.0529	-5.1374	0.0001
R-Square		0.7964		
Adjusted R-Square		0.5657		
F-Statistics		3.4519		
Prob. (F- statistics)		0.010		
Durbin-Watson		2.8633		

(*) indicates significant at 5%.
Source: authors computation using E-Views 9.0, 2020.

According to the result in the table above the coefficient of error correction term is appropriately signed and statistically significant at 5% percent level of significance, with the speed of convergence to equilibrium of about 27 percent. This result indicates that about 27 percent disequilibrium in the previous year's shock converges back to the equilibrium in the current year.

The short run dynamics are captured by individual parameters of the independent variables. From the results in table 4.4 above, all the lagged values of GDP are statistically significant and positively influence e carbon emission except GDP lag 4. All the coefficients of GDPSQ have negative and significant effect on carbon emission in the short run. The result also reveals that all the lagged values of capital formation are insignificant except CAP lag 3 which has negative and significant effect on the carbon emission.

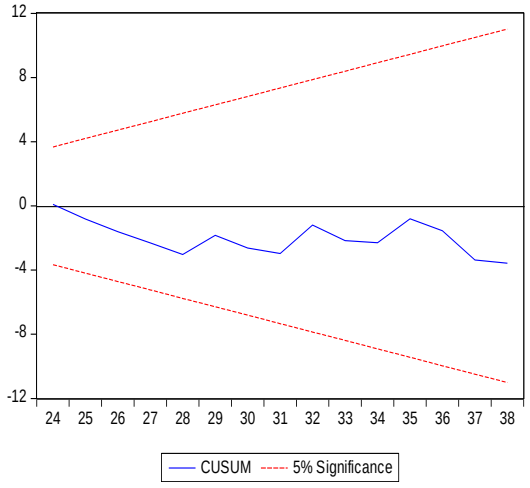
The **R-square** value shows that more than **79%** of the variation or movement in dependent variable (carbon emission) are explained by the movement of the explanatory variables (economic growth, economic growth square and capital formation). The remaining percentage of little above **20%** of variation in carbon emission will be attributed to other exogenous factor not considered in the model or not related with the included explanatory variables under consideration in this study. **The adjusted R-square** of more than **50%** compliments the high explanatory power of the R-square and therefore re-affirms the validity of the result.

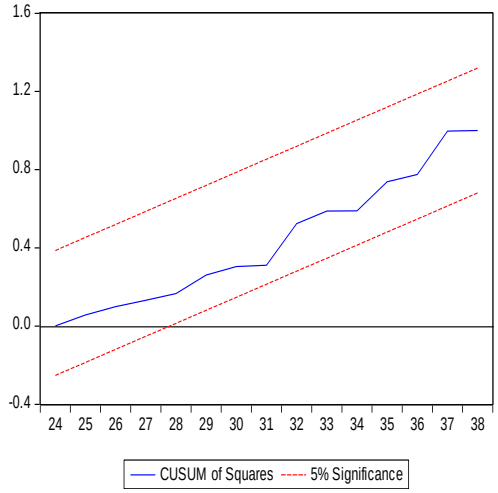
Durbin-Watson (DW) statistics: The Durbin Watson statistics at **5%** level of significance is **2.8633** this implies that there is no evidence of positive first order serial correlation among the explanatory variables.

F-Test: if the p-value of F-statistics is lower than 0.05 then the null hypothesis that all the variables are statistically insignificant at 5% level is rejected. Based on the result from table 4.4 above, the p-value for our F-statistics is 0.010 which is far less than the 5%. this means that carbon emission in Nigeria is significantly affected, positively and negatively by the individual as well as combined movement of the explanatory variables under consideration in this study.

Model stability Test.

Following the procedures provided by Brown, Durbin and Evans (1975), this study investigated the stability of the parameters in the CO_2 model using the plots of cumulative sum of residual (CUSUM) and cumulative sum of the squares of recursive residuals ($CUSUM_{SQ}$). the results of the two test are presented in figures 2(A) and 2(B) respectively. The existence of parameters instability is established if the CUSUM and $CUSUM_{SQ}$ go outside the bonds represented by the two critical (dotted) lines.





2(A)

2(B)

From the figures above, both the CUSUM and $CUSUM_{SQ}$ stays within the 5% critical line implying stability throughout the sample period. Thus the findings of the study are robust for policy analysis and formulation.

Conclusion.

This research work undertakes a comprehensive analysis of the relationship between carbon emission (CO_2) and economic growth in Nigeria in order to check for the existence of environmental kuznet curve (EKC) hypothesis in Nigeria using annual time series data from 1981-2018. Carbon dioxide emission in metric tons, capital formation as well as Gross Domestic Product per capita at constant US dollars were sourced international energy agency and world bank development indicators respectively. Augmented Dickey-Fuller (ADF) unit root test, Johansen co-integration as well as vector error correction model (VECM). The findings of the study reveal a long run relationship where economic growth proxied by GDP per capita has a statistically significant negative effect on carbon emission and GDP square have a statistically significant positive relationship with carbon emission. The result also shows that capital formation which is a control variable has a statistically significant negative effect on carbon emission. While the short run result also indicated that most of the lagged values of GDP, GDPSQ AND CAP have statistically significant influence on CO2. Based on the results of the study an inverted U-shape relationship between carbon emission and economic growth does not exist in Nigeria rather it is U-shaped relation, hence environmental Kuznet curve (EKC) hypothesis does not hold in Nigeria for the periods under study.

Recommendations.

On the basis of the findings of the study, the following recommendations were advanced.

- Institutional framework should be strengthened to ensure appropriate abatement strategies and adoption of cleaner technologies in order to mitigate the rising emission associated with early development stages
- Policies that discourage importation of carbon intensive products should be formulated and implemented
- The productive activities of multinationals and local companies that contribute to carbon emission should be monitored so that a reasonable economic growth can be achieved with a minimal emission.

References.

Akpan, G.E and Akpan, U.F (2012). Electricity consumption, carbon emission and economic growth in Nigeria. *International journal of energy economics and policy.* 2(4) 115-131

Alabdulrazag, B. and Alrajhi, A. (2016). The validity of environmental kuznet curve hypothesis in the kingdom of Saudi Arabia: ARDL bound testing Approach to Co-integration. *International review of management and business Research* vol.3(4) 34-53.

Allege, P.O and Ogundipe, A.A. (2013). Environmental quality and economic growth in Nigeria: A fractional co-integration analysis. *International journal of development and sustainability*, Vol 2, No2 56-71.

Arrow, K., Bolin, B., Costanzo, R., Dasgupta, B., Folke, C., Holling, C. S, (1994). *Economic growth carrying capacity and environmental science.268(5210) 20-521*

Aruga, K. (2019). Environmental kuznet curve hypothesis for Asia-Pacific region*. Economic and Business aspect of sustainability. 11(8) 2395*

Brown, R.I, Durbin, J and Evans, M (1975). techniques for testing the constancy of regression relationships over time. *journal of the royal statistical society,*37, 149-163.

Diezt, T., Rose, E., and York, R. (2012). Environmentally efficient wellbeing: is there environmental kuznet curve*. Applied Geography* 32, 1-28

Dinda, S. (2004). Environmental kuznet curve hypothesis*: a survey. Ecological economics* 49, 431-455

Ejurbekpokpo, S.A(2014). Impact of carbon emission on economic growth in Nigeria. Asian journal of basic and applied sciences, vol 1, NO1, 15-24

Food and agriculture organization (2012). Opportunities for low carbon development in Nigeria, volume 2, agriculture and land use.

Ginevicious, R., Lapinskien, G. AND Peleckis, K. (2017). The evolution of environmental kuznet curve concept: *the review of research. Panoeconomicus* 64(1) 93-112

Grossman, G.M and Krueger, A.B. (1991, Environmental impact of north American Free trade agreement (No. w3914), *National bureau of economic research*

Hervieus, M.S. and Darne, O. (2015). Environmental kuznet curve and ecological footprint. A time series analysis. economics Bulletin 35(1) 814-826.

Killic, C and Balan, F (2016). Is there environmental kuznet inverted U-shape curve? *Panoeconomicus, 65(00) 6-18.*

Lu, J., Li, HZ and Wang, J (2016). Modelling CO2 emission and economic growth in Croatia: is there any environmental kuznet curve*? international journal of energy and economic research*. 123, 164-172

Mitic, P. (2019). A literature survey of environmental kuznet curve. Economics analysis. 19.52.12, 109-127

Ndembanteh, AN and Wusiman, N. (2020). An empirical analysis of environmental kuznet curve: the case of Cameroon. *Journal of social sciences Mus Alpasian university*, 8(IIB) 23-31.

Onafowara, O.A and Owoye, O. (2014). Bound testing approach to analysis of environmental kuznet curve hypothesis*. Energy economics*,44 47-62

Panayotou, T. (2003). Empirical test and policy analysis of environmental degradation at different stages of economic development. (No. 99297783402676). *International labour organization*.

Raza, S.A and Shah, N. (2018*). Environmental science and pollution research*. vol4 26965-26977.

References.

Stern, D.I. (2004). The rise and fall of environmental kuznet curve. World development 32(8) 1419-1439

Twerefou, D.K, Poku, F, A. and Bekoe, W (2016). An empirical examination of environmental Kuznet Curve hypothesis for carbon dioxide emission in Ghana: ARDL approach. *Environmental and socio- economic studies. 4, 4, 1-12.*

Urheim, M. (2009). Economic growth and environment: friends or foes. The environmental kuznet curve for co2. University of Oslo, master's thesis in environmental and development economics.