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AN ECONOMETRIC ANALYSIS OF THE MACROECONOMIC DETERMINANTS OF CARBON DIOXIDE EMISSIONS IN NIGERIA

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DECLARATION

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ABSTRACT

Global concern for climate change as a result of incessant environmental damaging impacts of greenhouse gas emission is still surging high. Many researchers have examined the linear relationship of carbon emission with economic growth for decades now, yet, little or no studies critically examined the macroeconomic determinants of carbon dioxide emissions. Thus, this study focused on an econometric analysis of the macroeconomic determinants of CO2 emission in Nigeria, covering the periods between 1981 and 2016 using both linear and non-linear Autoregressive Distributed Lag (ARDL & NARDL) models. The time series data used were sourced from the database of the World Bank Development Indicators, 2016 and Central Bank of Nigeria Statistical Bulletin, 2017 edition. The main macroeconomic variables driving CO2 emissions in Nigeria include: Energy Consumption (EC), Financial Development (FD), Per capita GDP (GDP), share of Manufacturing output in GDP (MAN), Population density (PO) and Trade Openness (TO). The time series properties of the data were examined using the Augmented Dickey Fuller (ADF) unit root tests for stationarity, and it was found that all the variables were first differenced stationary, I (1), except FD and PO that were stationary at the level form. Interesting finding from ARDL estimations revealed that in the long run, a percentage increase in EC, MAN, GDP^2, and PO would cause a decrease of about 1.03, 1.14, 36.40, and 0.46 percentages respectively in carbon emission in Nigeria, while a percentage increase in GDP, GDP^3, FD, and TO would potentially cause an increase of about 0.001, 23.93, 0.002 and 0.001 percentages in total carbon emission in Nigeria. Also, the finding from environment-economic relationship, refutes the validity of EKC and found N-shaped relationship in Nigeria. However, from the NARDL model estimation, positive and negative changes in GDP, EC, and MAN are likely going to exhibit asymmetric relationship with carbon emission in Nigeria. Overall changes in GDP Per capita showed strong magnitudes of impacts on CO2 emission, and GDP Per capita bi-directionally granger caused energy consumption, which reversely caused increase in CO2 emission. Trend analysis revealed that emission fell on average from 0.64 metric tons between 2005 and 2010 to 0.52 metric tons between 2011 and 2016. Based on these findings, the study therefore recommends among others a concerted efforts of Ministry of finance in partnership with the ministry of environment in strengthening green bond issuance made as commitment to reduce emission in a bid to fulfil the Nationally Determined contributions in the Paris Agreement (2016) and give subsidies and incentives to encourage the competitiveness of renewable energy technologies. Also, the study encourages government to initiate carbon tax for polluting industries and increase energy supply to stimulate capacity industrial production to promote economic activities which will in turn increase GDP per capita which is still very low to reach EKC threshold level of income, since increase in energy use, responded negatively to CO2 emission in the long run.

RÉSUMÉ

L'inquiétude mondiale concernant le changement climatique en raison des impacts environnementaux incessants des émissions de gaz à effet de serre continue de monter en flèche. De nombreux chercheurs ont examiné la relation linéaire entre les émissions de carbone et la croissance économique depuis des décennies, mais peu ou pas d'études ont examiné de manière critique les déterminants macroéconomiques des émissions de dioxyde de carbone. Ainsi, cette étude a porté sur une analyse économétrique des déterminants macroéconomiques des émissions de CO2 au Nigéria, couvrant les périodes comprises entre 1981 et 2016 en utilisant à la fois des modèles linéaires et non linéaires de retard en distribution autorégressive (ARDL et NARDL). Les séries chronologiques utilisées proviennent de la base de données des indicateurs de développement de la Banque mondiale, 2016 et du bulletin statistique de la Banque centrale du Nigéria, édition 2017. Les principales variables macroéconomiques à l'origine des émissions de CO2 au Nigéria sont les suivantes: consommation d'énergie (CE), développement financier (PIB), PIB par habitant (PIB), part de la production manufacturière dans le PIB (MAN), densité de la population et ouverture commerciale (TO).). Les propriétés des séries chronologiques des données ont été examinées en utilisant les tests de racine unitaire de Dickey Fuller (ADF) augmentés pour la stationnarité, et il a été constaté que toutes les variables étaient d'abord stationnaires, I (1), sauf FD et PO stationnaires au forme de niveau. Des résultats intéressants des estimations de l'ARDL ont révélé qu'à long terme, une augmentation en pourcentage de l'EC, de l'HOM, du PIB2 et de l'OP entraînerait une diminution d'environ 1,03%, 1,14, 36,40 et 0,46% des émissions de carbone au Nigéria. Dans GDP, GDP3, FD et TO provoqueraient potentiellement une augmentation d'environ 0,001, 23,93, 0,002 et 0,001% des émissions totales de carbone au Nigeria. En outre, la découverte de la relation environnement-économie réfute la validité de l'EKC et a trouvé une relation en forme de N au Nigeria. Cependant, d'après les estimations du modèle NARDL, les changements positifs et négatifs du PIB, de la CE et de la MAN vont probablement présenter une relation asymétrique avec les émissions de carbone au Nigeria. Variations globales du PIB Par habitant, les impacts sur les émissions de CO2 ont été très importants et le PIB Par habitant bi-directionnel, le granger a entraîné une consommation d'énergie qui a entraîné une augmentation des émissions de CO2. L'analyse des tendances a révélé que les émissions ont chuté en moyenne de 0,64 tonne entre 2005 et 2010 à 0,52 tonne entre 2011 et 2016. Sur la base de ces constatations, l'étude recommande donc entre autres des efforts concertés du ministère des finances en partenariat avec le ministère de l'environnement. dans le renforcement de l'émission d'obligations vertes comme engagement à réduire les émissions afin de remplir les contributions déterminées au niveau national dans l'accord de Paris (2016) et d'accorder des subventions et des incitations pour encourager la compétitivité des technologies d'énergie renouvelable. En outre, l'étude encourage le gouvernement à instaurer une taxe sur le carbone pour les industries polluantes et à augmenter l'approvisionnement énergétique afin de stimuler la production industrielle afin de promouvoir des activités économiques qui augmenteront encore le PIB par habitant. aux émissions de CO2 à long terme.

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TABLE OF CONTENTS

ABBREVIATION AND ACRONYMS

ARDL	Autoregressive Distributive Lag
ADF	Augmented Dickey Fuller
CFE	Composite Factor Emission
DFID	Department for International Development
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
FAO	Food and Agricultural Organization
GHG	Green House Gas
GDP	Gross Domestic Product
LCDs	Less Developed Countries
NARDL	Nonlinear Autoregressive Distributive Lag
NDCs	Nationally Determined Contributions
NBS	Nigeria Bureau of Statistics
NAFTA	North America Free Trade Agreement
SBC	Schwarz Bayesian Criteria
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UECM	Unrestricted Equilibrium Correction Model
VECM	Vector Error Correction Model
WDI	World Development Index

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background

Climate change has become a threat to sustainable development over the last decades in every country and all sectors across the world (IPCC, 2016). International organizations around the world continuously attempt to reduce the adverse impacts of global warming. One such attempt is the Kyoto Protocol agreement, titled the United Nations Framework Convention on Climate Change (UNFCCC), made in 1997 as an attempt to reduce the adverse impacts of global warming. Among the variety of polluting substances, CO_2 is a major one and represents 58.8 percent of greenhouse gas emissions (World Bank, 2007).

This global problem has attracted the attention of many researchers and scholars to study the established interactions between climate change and threats associated with greenhouse gas emission (US National Academic Press, 2008). This study is therefore concerned with the relationship between energy consumption, macroeconomic variables and carbon dioxide emission which have been discovered as the major threats to climate change. Carbon dioxide emissions are produced in our daily lives through burning of fossil fuels to meet essential needs such as electricity, heating and transportation and have been identified to be a major component of greenhouse gas emissions (Nkongolo et al., 2008). Various researchers have stated that CO2 emission is known to contribute significantly to global warming which account for rising global temperatures and eventually cause sea level to rise (Guy and Levine, 2001; Joseph et al., 2011; Shu et al., 2010). As mentioned by Azam and Farooq (2005), the increase of CO2 in the atmosphere also threaten to alter global warming as well as local climate condition, affect forests, crop yields and water supplies. This fact was also collaborated by Blasing et al. (2004) when they emphasized that anthropogenic emissions of carbon dioxide when compared with global warming potentials constitute by far, the largest part of the emission of greenhouse gases.

This devastating phenomenon occurs due to increase in temperature of atmosphere by enormous gas flaring in Nigeria, burning of fossil fuels by industries and transports, burning of fossil fuels by businesses and households with fossil fuel generators, gas fired power plants and deforestation through increased pressure on biomass and fuel woods for cooking among rural dwellers. In Nigeria today, vast quantities of fossil fuels have been used as an energy source to power the economy and fuel woods have been largely used by urban and rural dwellers for cooking and heating.

In response to this scenario, this study seeks to examine the macroeconomic influencing factors and historical linkage between global warming and climate change (Liao, 2013). This linkage is similarly related to the relationship between energy consumption, carbon dioxide emissions and macroeconomic variables in which it is reported that if energy consumption has increased extremely, then carbon dioxide emissions would increase intensely (Macknick, 2009), (Mardiana and Riffat, 2013). Macroeconomic impacts to climate change cannot be undermined, if oil price is low for decades, it will be a disincentive to develop renewable energy and decarbonize the global economy (IIASA, World Bank, 2016). If the world is really serious about meeting the level of tight carbon budgets that are required for $2°c$ or lower, then strong climate policy signals that put a sizeable price on carbon will be needed (David M, 2016).

According to (IPCC, 2007), a high population growth rate generally represents more greenhouse gas emission. This has posed great challenges to human life and the environment. This scenario significantly contributes to a large percentage of carbon dioxide emissions in Nigeria. Heckscher –Ohin-Samuelson in his factor endowment model and international trade theory posits that countries specialize in production of goods in which they possess comparative advantage. Due to greater trade openness, there is pollution generated from movement of goods from country to another or to further process them. Many studies on the determinants of carbon dioxide emissions have focussed on whether the relationship between economic development and carbon dioxide emission with extended consideration whether Environmental Kuznets Curve relationship holds. This theory suggests that there is an inverted U- shaped relationship between per capita income and environmental pollution. This implies that environmental pollution increases at the early stage of economic growth and that it eventually decreases after income exceeds a threshold level. This leads from a basic agrarian society through a highly polluting industrial phase and then to a clean economy that delivers sustainable development. This study will investigate the relevance of this theory in Nigeria in a bid to provide much needed viable information on the issues of climate change threat to the climate policy makers now that Nigeria is among the 10 developing countries supported by the United Nations Framework Convention on Climate Change (NEED,2010)

It was reported that concentrations of carbon dioxide emissions in the atmosphere continued to grow to approximately 390 ppm or 39% above pre industrial levels in 2010 with global average temperature increase by $0.76°c$ (0.57 to $0.95°c$) between 1850 to 1899 and 2001 to 2005 (IPCC, 2007). Therefore, it was observed that the coordination of macroeconomic factors and carbon dioxide emissions forms an important issue as one of the environmental challenges that will have a significant impact on the country's future. This paper is concerned with empirically accounting the threat of carbon dioxide emissions, energy consumption and macroeconomic variables in Nigeria in order to recommend suitable technologies, mitigation and adaptation policies that will help Nigeria withstand the adverse effects of climate change.

1.1.1 Trends of Carbon Dioxide Emissions and its Determinants

1.1.1.1. Per capita Income and Carbon Dioxide Emission Trend

It has been shown that CO2 emission is caused by various factors such as income, energy consumption per capita, population, financial development, and trade openness among others. The growth rate of these determinants and the quantum of CO2 emission (measured in metric tons) are critically examined to chart the basic stylized facts surrounding the dynamics of GHG emission in Nigeria.

Figure 1 shows a six-year average trend of percentage change income (GDP) per capita and carbon emission in metric tons in Nigeria between 1981 and 2016. It could be seen from figure 1 that as GDP per capita rises between 1981 and 1982, carbon emission also rises in proportion to GDP per capita. However, carbon emission declined in proportion with decline in GDP per capita between 2011 and 2016. This period reflects economic recession in Nigeria. Hence, this trend shows the extent at which GDP per capita determines carbon dioxide emissions in Nigeria. Emission rates marginally declined from 0.84 metric tons as the highest to 0.56 tons between 1987 and 1992, and further to 0.4 tons between 1993 and 1998. These trends however increased to 0.65 tons between 1999 and 2004, declined to 0.64 and 0.52 tons between 2005 and 2010 and between 2011 and 2016 respectively.

On the other hand, however, the rates of change of per capita GDP which measures the welfare of standard of living of Nigeria were below the quantum of emission from 1981 to 1998. However, from 1999 to 2004, income level surged sporadically to 2.71 per cent and gradually declined to 1.62 and 0.39 per cents in 2005-2010 and 2011-2016 respectively. In the recent times, especially between 20011-2016, the amounts of emissions generated were more than the level of changes in welfare (income per capita). By implication, the rate at which CO2 is emitted is becoming alarming in Nigeria.

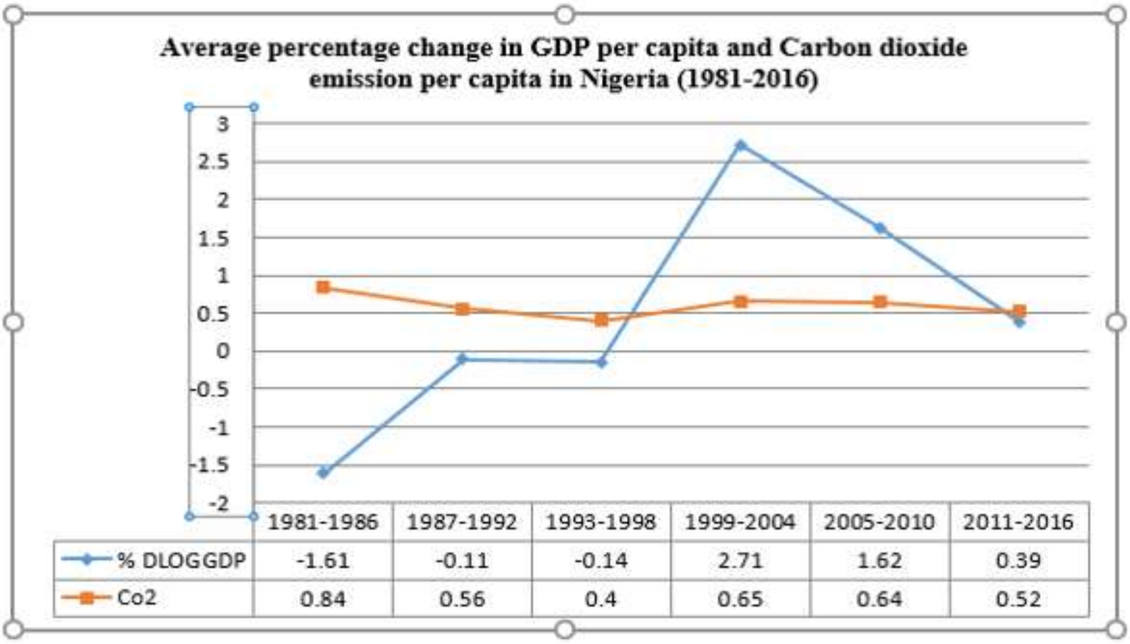


Fig. 1.1: Annual percentage change in income per capita and CO2 emission in Nigeria (1981-2016)

Source: Computed by the author using underlying data from WDI, 2017. It is variously hypothesized that the rate of population growth is a determinant of the level of emission of carbon dioxide. To visually verify this, average trend of the rate of population growth in Nigeria and carbon dioxide emission is shown in figure 2. From the chart, it could be deduced that the rate of population was fairly constant over the years with an aggregate of 2.54 for the six periods shown in the graph. However, the amount of emission of carbon dioxide was constantly less than the rate of population growth in Nigeria. By implication, it is the few number of the population, especially the rural labour force and core industrial sector that may be responsible for consistent GHG emission in Nigeria.

Specifically, the chart above reveals that the highest rate of emission was within the period of structural adjustment programme (SAP) of 1986 in Nigeria. These could mean that there has been greater awareness of the consequences of GHG emission by Nigerian, hence the change in attitude towards reducing the level of emission by clean energy access would have been embraced. This could also mean that the level of poverty may be worsening and that people are no longer able to engage in diverse activities that could cause more GHG to be emitted. Many industries that highly emit GHG have been relocated from Nigeria where they can have access to constant power supply.

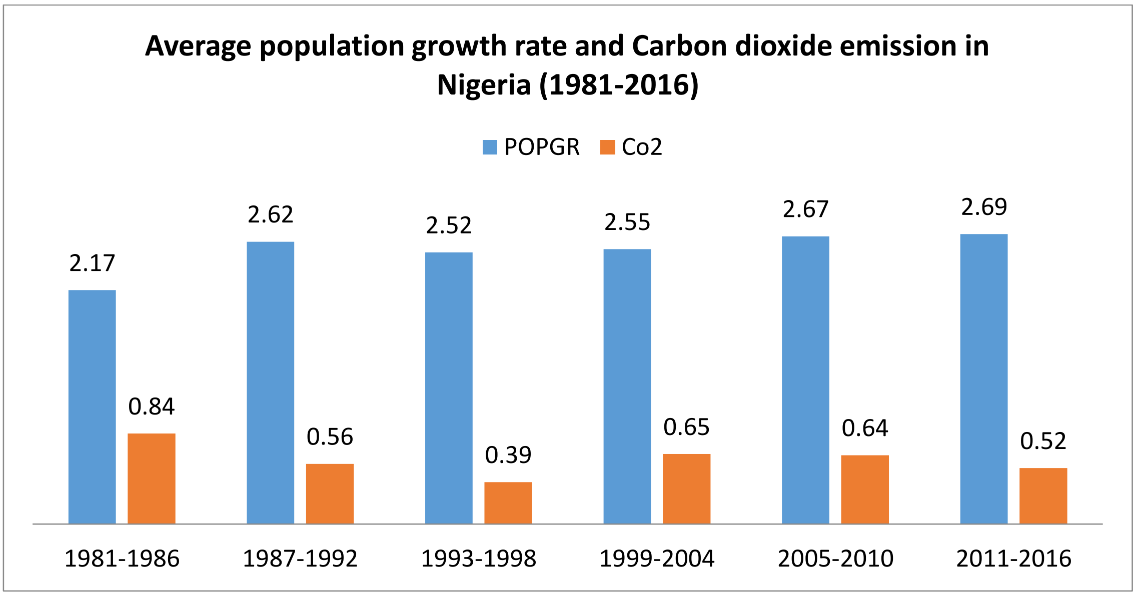


Fig. 1.2: Average population growth rate and co2 emission in Nigeria (1981-2016)
Source: Computed by the author using underlying data from WDI, 2017.

1.1.1.3. Trend of Trade Openness and Carbon Dioxide Emission

Trade, especially international trade is usually considered as an engine room for economic growth. Thus, trade openness, measured here by the ratio of the sum of import and export to GDP is a viable opened economy macroeconomic variable. Consequently, it is hypothetically believed that industrial output contributes to increase in trade openness. Overall, increases in industrial activities are believed to cause environmental pollution. Thus, GHG emission is not unrelated to trade openness. The seemingly existing connection is that more trade is a function of increased industrial output productivity, and such industrial operations result into emission. Therefore, trade openness is causally related to Carbon Dioxide emission.

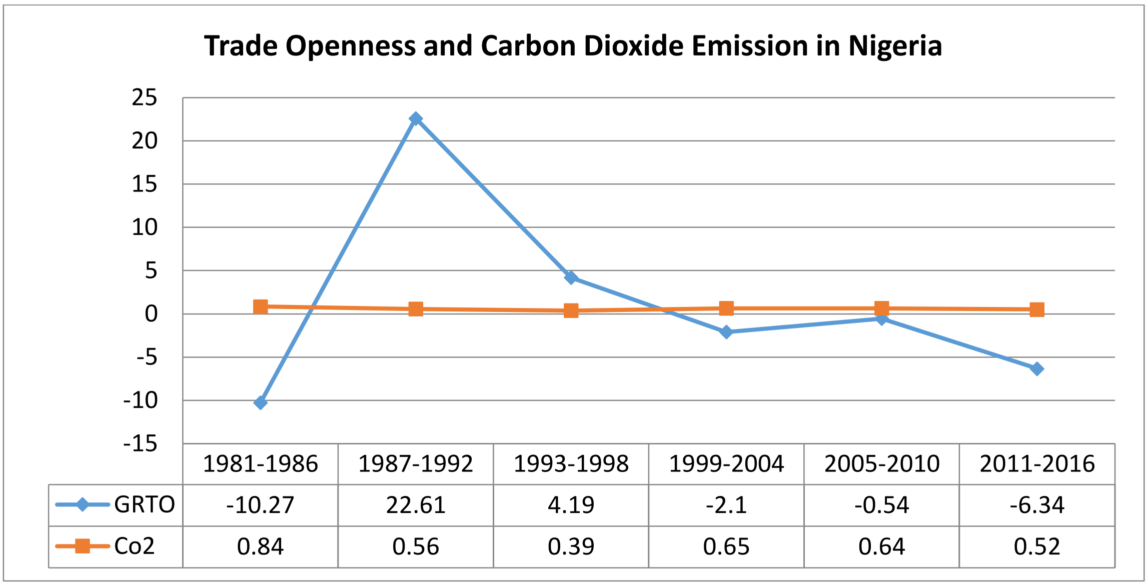


Fig. 1.3: Average growth rate of Trade Openness and Carbon Dioxide Emission in Nigeria (1981-2016)

Source: Computed by the author using underlying data from WDI, 2017.

Figure 1.3 indicates that three intriguing episodes. The first is the SAP era where the level of trade openness was below the tons of carbon dioxide emission. This period could be characterized by the emerging or developing stages of many industries in Nigeria with low level of technological breakthrough in production, hence the low level of the associated quantum of emissions. The second episode is the period between 1987 and 1998 where the rate of trade openness outpaced that of emission rate in the economy of Nigeria. Basically, the production possibility curve of the economy at this time could be said to be efficient in such a way that there was efficiency and sustainable production mix that still guaranteed environmental sustainability. However, the third episode, from 1999 to 2016 (democratization era) could be said to be worse than the previous eras. Here, the growth rate of trade openness decreased while carbon dioxide emission constantly grows. This could be connected with the fact that improved capital intensive model of industrial production in the modern era may calls for more pollution or emission of GHG. Unfortunately, firms may profit more from pollution because the policy instrument such as heavy pollution tax that could serve as a deterrent to emission appears to be lacking among the policy makers in Nigeria. If this trend continuous, our yearning for environmental sustainability would be a mere dream.

1.1.1.4. Trend of Financial Development and Carbon Emissions

Finance, is said to be the life-wire of all economic agents (household, firms and the government). Indeed, its availability or deepening affords agents more margin of increasing relevant economic choices. By implication, GHG emission is believed to be causally related the level of financial development (FD). The ratio of bank credit to the private sector is used here as a measure of financial development. Here, the conceivable connection between financial development and carbon dioxide emission is that more finance is capable of giving agents opportunity to expand economic activities which indirectly leads to increase in emission.

From figure 4, average trend of the growth rate of financial development was plotted against the observed level of emission for the selected periods. It can be seen that the periods, between 1993 and 1998 and between 205 and 2010 recorded the highest average values of approximately 40% and 41% growth respectively in the level of financial development. The corresponding levels of emission of carbon dioxide for these periods were 0.39 and 0.64 metric tons of CO2 emission respectively. It can be deduced further from the chart that there is an unstable trend of financial development over the selected periods.

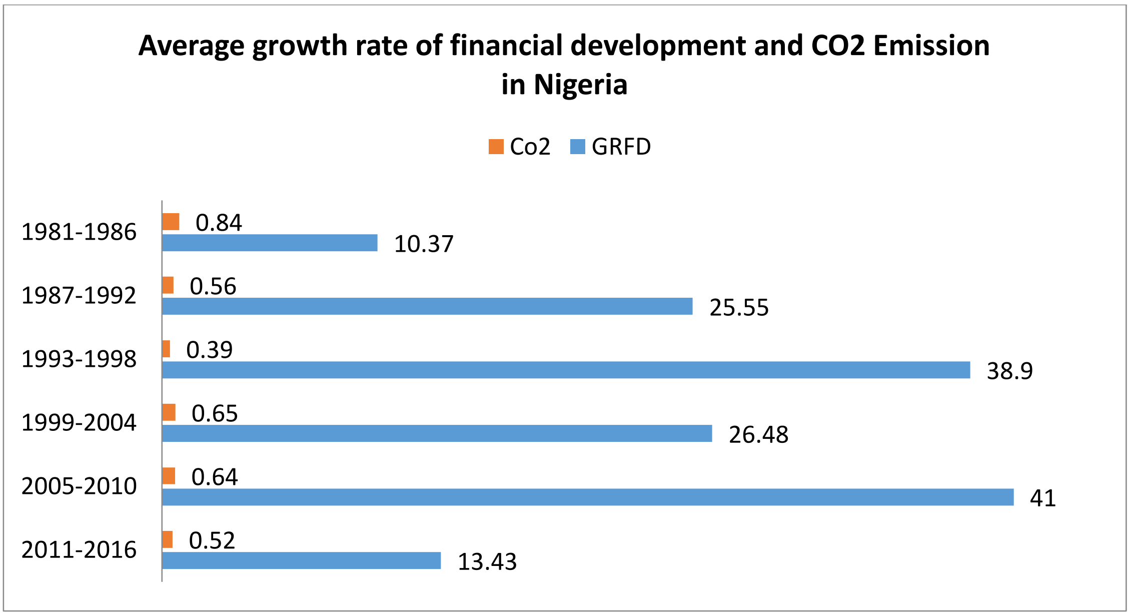


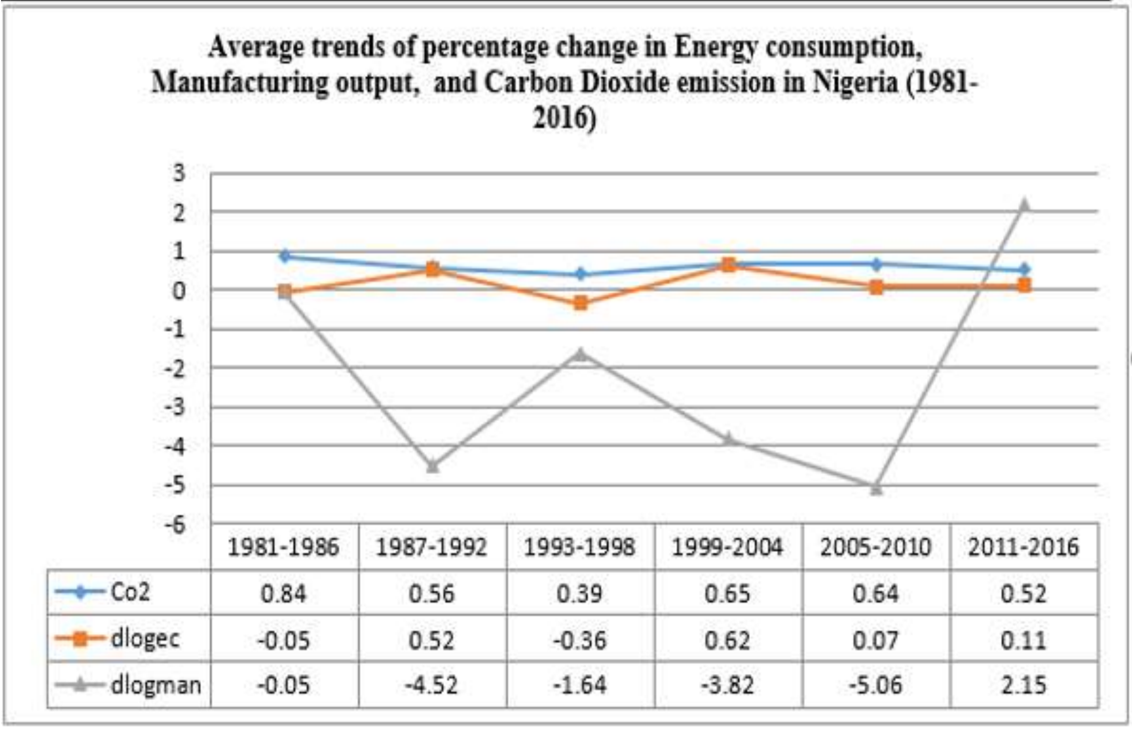
Fig. 1.4: Average growth rate of Financial Development and CO2 Emission in Nigeria (1981-2016). Source: Computed by the author using underlying data from WDI, 2017.

As deduced from the chart, during the period of SAP, however, FD was at the lowest magnitude (10.37%), however the rate of CO_2 emission at that time was the highest with 0.84 metric tons of carbon emission. This could be as a result of various intervening variables; however, emphasis on renewable energies that could mitigate pollution or emissions might have been little then. Much policy emphasis on renewable energy sources that would help reduce emission is necessary.

1.2.1.5. Trend of Manufacturing sector performance, Energy use per capita and Carbon Emissions in metric tons.

In the modern economy, there is hardly increase in industrial productivity without intensive use of energy and this is believed to generate more carbon emission in Nigeria like any other emerging and industrializing world. This implies that manufacturing sector productivity has potential effects on many macroeconomic variables and so it can cause increase in carbon emission.

The trends in figure 5 showcases that the level of percentage changes in energy consumption and manufacturing sector output is below the level of carbon emission generated. Thus, this could imply that as little as the quantum of productivity from manufacturing sector and energy consumption per capita could be, higher rates of carbon dioxide are emitted constantly in Nigeria. Between 1987 and 1992 and between 1999 and 2004, the level of carbon emission and changes in energy consumption were marginally the same at 0.56 tons and 0.52 per cent, and 0.65 tons and 0.62 per cent respectively. There was improvement within the last decade however between 2011 and 2016 where output of the manufacturing sector was 2.15 per cent and emission rate at 0.52 tons' energy consumption per capita at 0.11. That is higher productivity and energy use per capita did not proportionally cause emission. This could mean that the level of emission is decreasing as a result of few cement industries, petroleum refining and petrochemical industries currently operating in Nigeria as these industries cause greater level of carbon dioxide emission. In the case of decreased level of energy consumption per capita between 2010 and 2016, the level of emissions remains constant with no significant difference at 0.65 and 0.64 metric tons between 1999 and 2004 and between 2005 and 2010 but falls with significant difference at 0.52 metric tons between 2011 and 2010. This could imply that a significant shift from inefficient energy use and intensive fossil energy use to renewable energy is receiving wider acceptance in Nigeria. Therefore, further increase in energy use could result in significant fall in carbon dioxide emissions in Nigeria. This is a very interesting discovery in this trend. Therefore, it could be great for Nigerian government to gear more efforts towards promoting clean energy access through favourable policies that could serve as incentives for renewable energy technologies.



	1981-1986	1987-1992	1993-1998	1999-2004	2005-2010	2011-2016
Co2	0.84	0.56	0.39	0.65	0.64	0.52
dlogec	-0.05	0.52	-0.36	0.62	0.07	0.11
dlogman	-0.05	-4.52	-1.64	-3.82	-5.06	2.15

Fig.1.5: Average trends of percentage change in Energy consumption, Manufacturing and CO2 Emission in Nigeria (1981-2016)

Source: Computed by the author using underlying data from WDI, 2017.

1.2 Problem Statement

Nigeria's first National Communication under UNFCCC (2003), asserts that the emissions of GHG in Nigeria is generally low based on available data. However, this is expected to rise in the future as a result of increasing population growth rate and other macroeconomic influencing factors which are expected to lead to increase in energy consumption. The abundance of oil and gas supplies in the country has played a significant role in accounting for Nigeria's heavy reliance on energy. The country consumes a very considerable amount of liquefied petroleum gas, motor spirits, kerosene, diesel oil, fuel oil, and gas oil, all of which significantly contribute to climate change problems in particular and environmental problems in general. According to UNFCCC (2003), Nigeria consumed about 19 million metric tons of oil equivalent of commercial energy in 1990, and the level of consumption has been increasing since this period. Also, Nigeria possesses one of the least energy-efficient economies in the world with energy consumption per capita at 138 kg of oil equivalent with an energy intensity of 0.476 in 1990. Gas flaring and inefficient energy use play significant roles in Nigeria's GHG emissions. Yet, despite the growing momentum, there is still little agreement on the best set of actions required to reduce dependence on fossil fuels and greenhouse gas emissions in Nigeria. According to Jiang and Li (2017), the increase in greenhouse gases poses a threat to an economy, as they have led to the massive decline in agricultural output and threats to health and ecosystems. The Department For International Development,(2009), predicts that climate change could result to between 6% and 30% loss in Nigeria's GDP by 2050. This figure is estimated between USD100 to 460 Billion. By 2020, if no adaptation is implemented, between 2 to 11% of the Nigerian GDP could be potentially lost (Department for international Development, 2009). It has been observed that about 45.8 billion KW of heat are released into the atmosphere of Niger Delta from flaring 1.8 billion ft^3 of gas every year which has raised temperature and rendered large areas uninhabitable (Adegbulugbe, et al.., 2007). The Department for International Development (2009) predicts a possible sea level rise from 1990 levels to 0.3 by 2020 and 1m by 2050 and a rise in temperature of up to $3.2°c$ by 2050. Odjugo (2010) posits that a 1m rise in sea level could result in loss of 75% of the Niger Delta, a coastal region of Nigeria. And if the current trend is not reversed, Nigeria may face the risk of temperature increase between $2.5°c\ and\ 4.5°c$ by the year 2100.

As a source of energy, wood is widely used in Nigeria in both rural and urban areas for cooking and heating. The overall effect is that the country witnesses a high rate of deforestation, about 3.5% annually in 1980–1990. Annual deforestation of the woodlands in northern Nigeria runs to about 92,000 hectares, while the whole country consumes about 50 to 55 million cubic metres of wood annually. According to Food and Agriculture Organization (FAO), the remaining forest area in Nigeria will likely disappear by 2020 if the current rate of forest depletion continues unabated. This means that the major sink for carbon dioxide emissions could soon disappear in the country.

In 2016, Nigeria showed its commitment to the global effort to reduce the impact of climate change by signing the Paris Agreement. Nigeria is committed to reducing greenhouse gas emissions unconditionally by 20% and conditionally by 45%, which is in line with Nigeria's Nationally Determined Contributions (NDCs). In partnership with the Ministry of Finance, the Ministry of Environment is finalising preparations for a green bond issuance during the first half of the year. The green bond issuance is aimed at attracting investments for low carbon infrastructure development relevant to the targets set in the NDCs in priority projects in renewable energy, transport and afforestation.

In relation to carbon emissions, it has been widely acclaimed by environmentalist that carbon emissions are pro-cyclical to output. As Nigeria expand its industrial base for increased output, increase in carbon emission will still persist. That is, there is the tendency for emissions to rise beyond their trend during periods of economic expansion and similarly fall during periods of economic recession (Doda, 2014). In addition, these emissions are considered to be much more volatile than output. However, little empirical attention has been given to establishing these stylised facts especially for developing countries and Nigeria in particular for the determinants of carbon emissions especially in the area of the macroeconomic effects of real shocks for effective policy development for adaptation and mitigation measures given that significant changes in macroeconomic variables could lead to fluctuations in carbon dioxide emissions. Therefore, the coordination of macroeconomic variables and carbon dioxide emissions through effective policies forms an important issue as one of the environmental challenges that will have a significant impact on Nigeria's sustainable future.

1.3 Research questions

i. Is there any short run and long run relationship between macroeconomic variables and carbon dioxide emission?

ii. Does Environmental Kuznets Theory (EKC) holds in Nigeria?

iii Is there short run and long run asymmetric effects of macroeconomic variables on carbon dioxide emissions in Nigeria?

iv. What is the direction of the causal relationship between macroeconomic variables and carbon dioxide emissions?

v. What are the suitable policies for tackling carbon dioxide emissions in Nigeria?

1.4 Research Hypotheses

$\boldsymbol{HO_1}$ **:** There is no short run and long run statistical impact of macroeconomic variables on carbon emissions

$\boldsymbol{HO_2}$**:** There is no Validity of Environmental Kuznets theory in Nigeria

$\boldsymbol{HO_3}$**:** There is no long run and short run asymmetric effects of macroeconomic variables on carbon dioxide emissions in Nigeria.

$\boldsymbol{HO_4}$**:** There is no causal relationship between the macroeconomic variables and carbon dioxide emissions.

1.5 Aim and Research Objective

The broad objective of this study is to empirically identify the macroeconomic determinants of carbon dioxide emission in Nigeria. Hence, the specific objectives are to:

i. Identify the short run and long run determinants of carbon dioxide emission in Nigeria.

ii Investigate the validity of Environmental Kuznets Curve (EKC) in Nigeria.

iii. Establish whether there is asymmetric relationship among some selected determinants of carbon dioxide emissions in Nigeria.

iv. Empirically determine the direction of causal relationship between macroeconomic variables and carbon dioxide emissions in Nigeria.

1.6 Significance of the study.

Most studies on climate change have focused mainly on the developed countries with less attention on the developing countries. This neglects the fact that African countries will be the most vulnerable to climate change effects due to her climate sensitive economy and low adaptation and mitigation technologies. Few studies on African context have over concentrated on output- energy nexus and output-environmental pollution nexus (Onoja et al., 2014; Kajally and Adedeji, 2016; Omojolaibi, 2010; Essien, 2010; and Ozoemena, 2017 among others). However, this study adopts the disaggregated level of carbon emissions. These studies over time have suffered omission of relevant macroeconomic variables (Ang, 2007), Soytas et al... (2007). This might have been the reason EKC has not been found in Nigeria. The existing literatures reveal that findings from the previous studies over time are not conclusive to present policies recommendations that can be applied in all countries. Though few studies like (Ozoemena, 2017), (Essien (2010), (Omojolaibi, 2010), (Akpan, Usenobong et.al.. 2011), included some macroeconomic variables but have omitted some key emission induced macroeconomic variables like

Financial development and energy use per capita. Lack of inclusion of financial development and energy use per capita in the case of Nigeria may lead to key macroeconomic variable bias which may result in negative consequential impacts on the findings. Moreover, most studies have employed wrong methodology to examine the relationship among macroeconomic variables and carbon dioxide emissions in Nigeria during the beginning of the debate on this study. Moreover, no studies have examined the short run and long run asymmetric relationship among macroeconomic variables and carbon dioxide emissions which is capable of causing differential changes in the short run and the long run in Nigeria. In response to this, this study seeks to fill these observed gaps by employing Non- Linear Autoregressive Distributed Lag in order to account for the short run and long run asymmetric behaviour of macroeconomic variables on carbon dioxide emissions and to ascertain the validity of EKC hypothesis in Nigeria. The empirical findings from this study will serve as an important policy document for the policy makers, planners, institutions and the Nigerian government now that Nigeria has showed its commitment to the global effort to reduce the impact of climate change by signing the Paris Agreement (UN, 2016). Nigeria is committed to reducing greenhouse gas emissions unconditionally by 20% and conditionally by 45%, which is in line with Nigeria's Nationally Determined Contributions (NDCs). In partnership with the Ministry of Finance, the Ministry of Environment was finalising preparations for a green bond issuance during the first half of the year, 2016. The green bond issuance is aimed at attracting investments for low carbon infrastructure development relevant to the targets set in the NDCs in priority projects in renewable energy, transport and afforestation. Therefore, there is no doubt that the empirical findings from this study will guide the government, Ministry of Finance, Ministry of Environment and the concerned agencies on First, inform decision makers on the determinants of CO_2 emissions. Second, provides policy recommendations that could assist in tackling the emissions, while maintaining long-run economic growth and averting the potential loss in GDP in the future. Equally, the empirical findings could further provide a hint on how CO_2 emissions responded to its determinants over the period covered. It is however noteworthy that the coordination of macroeconomic variables and carbon dioxide emissions through effective policies forms an important issue as one of the environmental challenges that would have a significant impact on Nigeria's future which this project seeks to solve.

1.7 Scope of the Study

The study employs time series data over a period of 35 years ranging from 1981 to 2016.The study is limited to carbon dioxide emissions and macroeconomic influencing factors. This period of observation is selected because of the availability of data to carry out the study.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

The global concern for the threat of climate change which is becoming a great challenge all over the world everywhere around the world today, more and more studies for the safety of the environment are being conducted. Although the literature includes some studies about environmental issues, the specific relationship between carbon emissions and macroeconomic relationships still remains limited. Most of the existing studies on this topic concentrate more on the nexus between economic growth and the environmental degradation with causality analysis. However, this study will go beyond looking at the literature on economic growth – pollution relationship and examine the literature on macroeconomic determinants of carbon dioxide emissions and their causal relationships. Chapter two critically reviews the existing theoretical and empirical literature on the EKC and the determinants of carbon dioxide emissions as well as in relation to the fundamental macroeconomic theories underlying the study. This chapter is divided into three sections: Section 2.1 introduces the chapter, Section 2.2 discusses the theoretical literature review with reference to broad environmental Kuznets theory in relation to emissions while section 2.3 presents the empirical literature review, highlighting the theoretical concerns situating the study, including the key macroeconomic influencing factors on Carbon dioxide emissions, Section 2.4 highlights the dynamic nature of causal relationship among carbon dioxide emissions and macroeconomic variables while section 2.5 provides the summary of chapter 2.

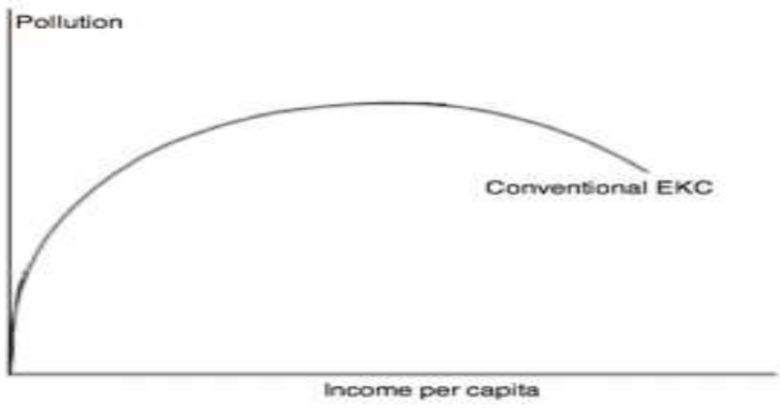
2.2 Theoretical Literature Review

2.2.1 The Environmental Kuznets Curve theory

Environmental Kuznets Curve (EKC) was proposed by Simeon Kuznets and named after Kuznets (1955). This theory states that environmental pollution is a quadratic function of income. EKC suggests that there exists U- shaped relationship between environmental pollution and income per capita in every country. This specifically implies that environmental pollution increases in early stage of economic growth and eventually decreases after income exceeds a threshold level. The relevance of this theory was first tested by Grossman and Krueger (1995) and the same inverted U – shaped relationship was found. The relationship between economic development and environmental pollution has been the topic of a burgeoning literature since the work of Grossman and Kruger (1991). These authors have investigated the environmental impacts of the North American Free Trade Agreement (NAFTA) and discovered that the relationship between the total discharge of various environmental pollutants and economic growth exhibits an inverted U-shaped curve. Later, this curve has been coined as the Environmental Kuznets Curve (EKC) and many studies have tested the validity of this relationship. The basic idea of the EKC hypothesis is that environmental degradation increases with income up to a threshold income level beyond which air quality improves as income continues to grow. This growth in income will empower many people to access clean energy for consumption and productive uses.

According to Stern (2003), in the early phases of economic growth, environmental pollution tends to increase but once a certain income per capita is reached (this varies with different environmental indicators) the tendency is reversed and so environmental pollution decreases as income levels rise. Thus, the EKC implies that the environment suffers during the initial phase of economic development but tends to improve in later phases. Environmental indicators are, therefore, represented by a traditional inverted U-shaped curve of environmental degradation versus income per capita with a quadratic function shown in Figure 1 below (Stern 2003).

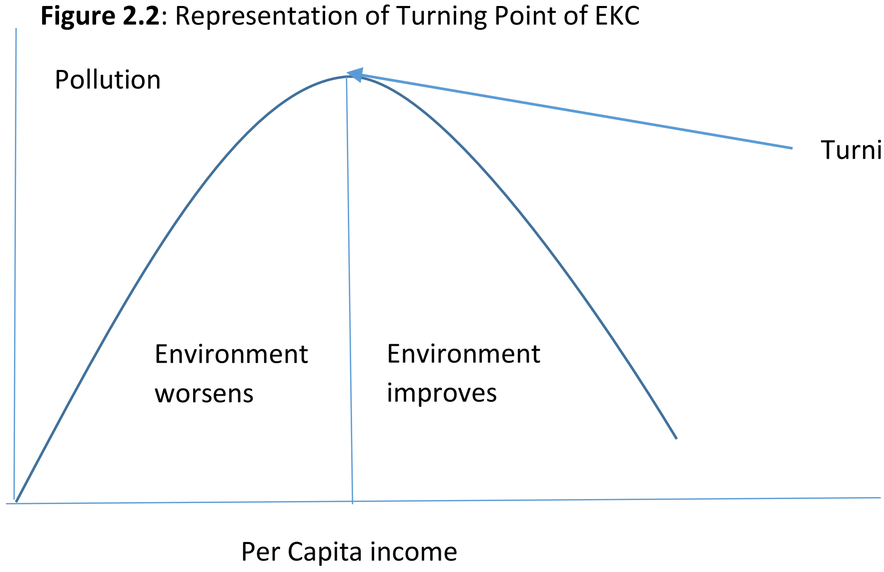
Figure 2.1: Representation of the quadratic EKC



Dasgupta et al (2002)

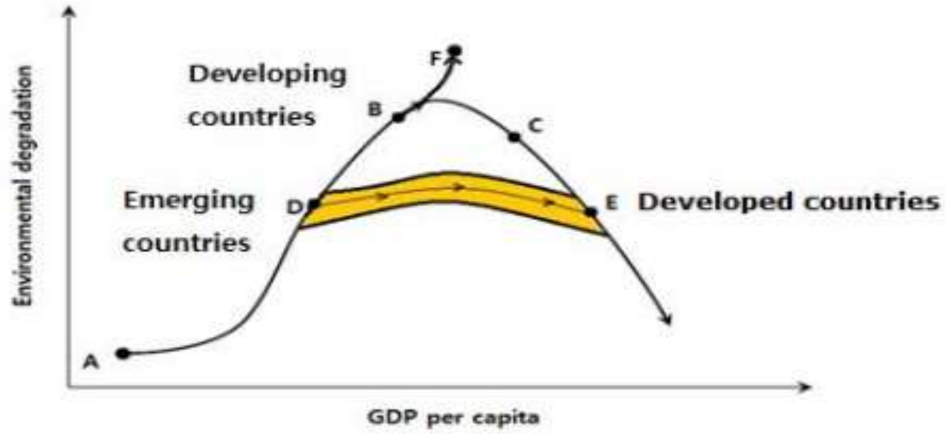
The environmental Kuznets curve concept was made popular by the World Bank's world development report (WDI, 1992) where it posits the idea that the higher the economic activities, the higher the environmental degradation is formed on the static assumptions about technology, environmental investments and taste. As an economy grows, the need and demand for improved environmental quality will equally grow, together with the resources available for investment. In backing this argument, Beckerman (1992) opined that there is a confirm proof that, although the growth of an economy usually leads to increase in pollution in the economy at the early stages of the growth, at the end, the best and possibly the only way to achieve a nice environment in most countries is just for a country to become rich. The figure below shows the initial growth level of a country, the environment worsens as a result of rapid increase in pollution but after a turning point level of per capita income, environment improves. After that threshold, the country has become wealthy to access clean technologies for productive uses. These environmental friendly technologies will lead to continuous decrease in pollution and thereby resulting to improvement in the environmental quality of the country as shown in figure 2 below.

Figure 2.2: Representation of Turning Point of EKC



The theory underpinning the EKC can be further described considering the figure 3 below. Munasinghe (2008), Pointed out the usefulness of Tunnel effect which may enable developing countries to attain their target economic growth while maintaining a lower level of emissions. From the figure below, suppose that developing countries lie on point B, then these countries can move to point C by accessing and using clean technologies through developing and implementing sustainable development policies. But it is difficult for global pollutant to follow this pathway but a lower rate of increase than from B to F would be expected. A significant impact will be seen if the developed countries could support the emerging, developing and newly industrialized countries through financial support as well as transfer their environment-friendly technologies to these countries, the poorer countries may be able to shift from point D to point E which is the basic concept of the tunnel.

Figure 2.3: Representation of Tunnel effect of EKC



Source: Munasinghe (2008)

A thorough survey of theoretical and empirical studies dealing with the EKC is provided by Dinda (2004) and Stern (2004). Dinda (2004) reviewed EKC literature and pointed out that previous studies` results are not consistent with the negative relation between environmental degradation and economic growth in the initial stages of development. In addition, the literature does not confirm the consensus about the level of income needed for a turning point, after which the 'cleanness' of the environment is very significant. At very low levels of economic growth, low levels of pollution are emitted because people tend to rely primarily on subsistence activity that has little impact on the environment (Stern, 2004). As the countries become industrialized, they tend to use dirtier or cheaper technologies, which emit large amounts of pollution. Initially, the amount of CO2 emitted increases rapidly as poor countries develop. When a certain level of economic growth is reached, people start to value the environment more and choose to use affordable, cleaner, and effective technologies.

The impact of per capita GDP on CO2 emissions is theoretically ambiguous. This impact is decomposed into three effects: scale effect, technique effect and composition effect (Copeland & Taylor, 2004). The scale effect refers to the fact that increases in GDP require more inputs and therefore more emissions. The technique effect refers to the invention of new environmental friendly technologies in production which in turn leads to the reduction of pollutants. The composition effect stems from changes in production of an economy caused by specialization as well as the transition from agriculture or basic industries to high-tech services. The overall impact of GDP on the environment depends on which effect is stronger and dominates the others.

The majority of literature on the determinants of the CO_2 emissions focused on the relationship between economic growth and carbon dioxide emission with an extended consideration whether the EKC relationship holds. The pioneering studies claimed that the relationship of the shape of several emissions and Gross Domestic Product (GDP) per capita assume an inverted U-curve (Holtz-eakin and Selden, 1995) and (Roberts and Grimes, 1997). This study kindles an interesting empirical issue which prompted many works such as Grossman and Krueger (1991), Solow (1991), Beckerman (1992), Common &Barbier (1996). However, Gossman and Krueger (1995) claimed that the turning point of the EKC for several pollutants have a tendency to occur before countries reaches a GDP of US$ 8,000 per capita. Grossman and Krueger (1985) used panel data to examine a sample of 42 countries and estimated that this turning point is equivalent to per capita real income around 8000 USD. This far put away developing countries like Nigeria from this relationship. A strong empirical evidence of EKC justifies a lenient environmental policy scenario while the absence of such evidence supports the pursuits of economic growth trajectory that is constrained by environmental degradation.

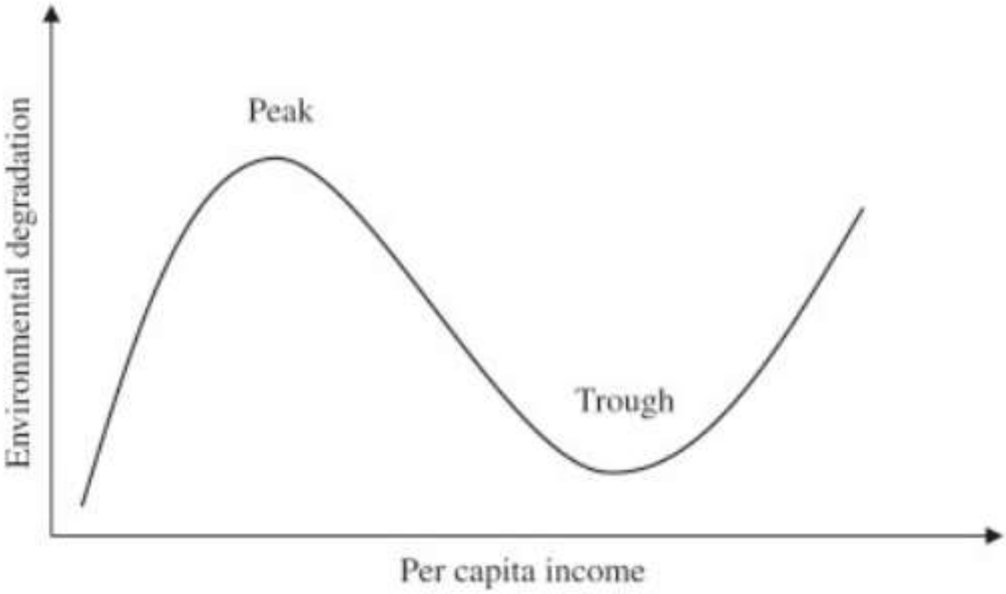
Studies on African countries such as KEHO (2015) in a paper titled “an econometric analysis of the long run determinants of CO2 emissions in Ivory Coast, Western Africa” supports the notion of environmental Kuznets curve. The results further outlined that per capita income share of industrial GDP and trade openness derives the CO2 emissions, while the effects of trade openness on CO2 emissions relies on the structure of the economy and rises as the country engages in industrialisation. Also, the literature outlined the complementary relation of trade openness and industrialisation in worsening environmental quality in Ivory Coast. Also, a study by Boopen and Vinesh (2011) on the relationship between CO2 emissions and economic growth in Mauritania, suggested that the carbon dioxide emissions trajectory is diligently associated with the GDP time path, but the estimates of the data in the study failed to establish the inverted U-shaped EKC. However, the analysis concludes that economic and human activities are the main causes of emissions.

Arrow et al.., (1995) theoretically criticized EKC. The researcher argued that a major drawback of EKC is the fact that income is an exogenous variable. In order words, Grossman and Krueger (1995) do not account for the effects of increased carbon emissions on income. Arrow et al., (1995) claimed that pollution negatively influences production and may slow down economic growth. Rezai et al.., (2009) applied Keynes Ramsey growth model and argued that it is socially beneficial for present and near future generation to scarify their own consumption to mitigate global warming for the benefit of generation yet to come. Mendelson (2009) argued in support that the long term consequences of climate change have given impression that the greenhouse gas emission threaten long term economic growth. Sari and Soytas (2009) provides conflicting results for five OPEC countries Algeria, Indonesia, Nigeria, Saudi Arabia and Venezuela by incorporating labour and capital in production function, energy consumption and carbon dioxide emission. It is argued that higher economic growth rate pursued by developing countries is achievable only in association with the consumption of large quantity of commercial energy which leads to environmental degradation. Stern (2004) argued that many studies on EKC are statistically weak, lack necessary diagnosis tests, and have questionable methodology that is often inappropriate given the feature of data. Literature has confirmed that most of these studies are suffering from the problem of relevant macroeconomic variables. For example, Ang (2007) for France and (Soytas et al..,2007) for United States. The argument over time has shown that the results from this study has proved inconclusive to make policy recommendation that could be applied across countries due to lack of appropriate methodology, macroeconomic variable variable bias, poor diagnostic tests and lack of a definite threshold income for emission reduction by EKC. Therefore, based on the foregoing, the literature asserts that emission decreases when a country per capital income reaches a threshold. At that point, the country has started sourcing for alternative clean energy for productive uses.

2.3 Empirical Literature Review

Many empirical studies posit a nonlinear quadratic relationship according to the environmental Kuznets hypothesis (Ang, 2007; Halicioglu, 2009; Ozturk and Acaravci, 2013). According to Martinez-Zarzoso and Bengochea-Morancho (2004), after examining the findings and methodologies of many authors, opines that Pollution-CO2 relationship is better represented by a cubic model. Hence, many authors including Fodha and Zaghdoud (2010), Akbostanci et al. (2009) and several others have made use of the cubic regression model in order to test for the presence of the EKC for CO2 emissions. The cubic model suggests that environmental degradation indicators will first rise, and then fall (or stabilize) as income per capita increases and then rise once again. Several authors specifically chose to use the cubic form in order to test for the presence of an EKC. The N-shaped curve of income per capita with a cubic function of logarithm of income is shown in Figure 4 below. This figure demonstrates that environmental degradation indicators first rise with income, then fall and then rise once again, thus creating an N-shaped curve as shown in figure 4 below.

Figure 2.4: Representation of Cubic form of EKC



Miah et al (2010)

2.3.1 Empirical Findings on EKC

Jayantha k et al. (2012) tested for the EKC for India and China for the period 1971-2007 employing Autoregressive Distributed Lag (ARDL) methodology and the error correction term for the long run and short run relationships between growth, trade, as well as energy use and endogenously determined structural breaks. The findings revealed that that there is an existence of EKC for both India and China. The study examined the short run and long run elasticities of EKC. Stationarity test of the time series was first carried out for the possibility of co-integration. For the panel of 43 countries, the study revealed that EKC is only present for the Middle East and South Asia. As for the individual country tests, the study found evidence of an EKC for 15 out of 43 countries: Jordan, Iraq, Kuwait, Yemen, Qatar, the UAE, Argentina, Mexico, Venezuela, Algeria, Kenya, Niger, Congo, Ghana and South Africa. However, these authors do not provide a detailed description of the shapes of the EKCs, simply confirming the presence of an EKC for a certain number of countries.

Fodha and Zaghdoud (2010) examined the relationship between the levels of GDP and CO2 as well as GDP and SO2 in Tunisia for the period of 1961- 2004. They tested the presence of the EKC for each pollutant in Tunisia using Vector Autoregression (VAR) Model. The study found that there is co-integration between the variables for both relationships between GDP and CO2 as well as GDP and SO2 in Tunisia and found an N-shaped relationship when looking at the signs of the parameters in the regression. However, solving the roots of the model produced two turning points which are very low in terms of CO2 emissions and close to each other occurring at $600 and $765 per capita. The study plotted the predicted emissions per capita against the level of GDP per capita and found that CO2 relation seems to take a monotonically increasing curve. For the case of SO2, they found an inverse N-shaped relationship. When the roots of the model were solved, it was found that the first turning point was too low, lying outside of the dataset. Once the predicted emissions per capita was plotted against the level of GDP per capita, the result showed an inverted U-shaped curve. Therefore, the presence of an EKC for SO2 emissions with a turning point of $1200 was found.

Some studies support the literature that per capita income (Economic growth), Energy Consumption, financial development, trade openness, population and manufacturing can have a significant impact on CO_2 emissions.

First, financial development is the indication of an efficient stock market and financial intermediation, which gives a platform for listed companies to lower their cost of capital with increasing financial channels, disseminating operating risks and optimizing assets and liability structure. This eventually encourages new installations and investments in new projects that can have a considerable impact on increase in energy consumption which will eventually increases CO_2 emissions. Moreover, the presence of an efficient financial system leads to more consumer-loan activities, which indeed makes consumers to buy more energy-consuming products and causes more CO_2 emissions. These arguments are empirically supported by Jensen (1996) and Zhang (2011). Jensen (2011) argues that financial development encourages CO_2 emissions as it increases manufacturing production. Employing VECM and variance decomposition approach, Zhang (2011) finds that financial development significantly increases CO_2 emissions and thereby environmental degradation in China.

However, a number of studies reveal a positive relationship between financial development and environmental quality. For instance, Lanoie et al. (1998) argue that an efficient financial market provides incentives to its companies or firms to comply with environmental regulations that help to mitigate environmental degradation. Kumbaroglu et al. (2008) also support Lanoie et al. (1998) findings by concluding that financial development helps to significantly reduce CO_2 emissions in Turkey by using advanced greener technology in the energy sector. Tamazian et al. (2009) investigate the effect of economic and financial development on CO_2 emissions in some of the most emerging economies, including Brazil, Russia, India and China (BRIC) nations. Using panel data over the period 1992–2004, the authors find that both factors are essential for CO_2 reductions. Tamazian and Rao (2010) also inspect the impact of financial, institutional and economic development on CO_2 emissions for 24 transitional economies during 1993 to 2004. Using a GMM model, the study reports that financial development helps lower CO_2 emissions by promoting investment in energy efficient sector. However, the authors point out that financial liberalization may be harmful for environmental quality if it is not accomplished within a strong institutional framework. Following the ARDL bound testing procedure; Jalil and Feridun (2011) also present the similar findings using Chinese aggregate data over the period 1953–2006. The ARDL bounds testing approach suggests that the Environmental Kuznets curve (EKC) exists between industrial output and environment. All of these studies argue that industrialization requires more equipment and machineries to carry out the production of goods and services, which will then consume more energy and releases higher CO_2 emissions than the traditional agricultural or manufacturing activities.

Abbasi and Riaz (2016) used an augmented VAR model to study the long run relationship between CO2 emissions and financial development in Pakistan. The findings of the study suggest that per capita CO2 emissions were co-integrated with financial development indicators and per capita GDP. Adding to that, the estimated long run model for the full analysed sample showed that only GDP per capita had statistically significant impact on CO2 emissions. In return, this caused emissions to increase with the standards of living. Sordosky (2010), studied the impact of financial development on energy consumption in emerging economies. The research was based on a panel data set on 22 emerging countries covering the period between 1990 and 2006. The results show a positive and statistically significant relationship between financial development and energy consumption. Hence, effective financial intermediation encourages the customers to take bigger loans and pollute more through automobiles that increase CO2 emissions. Some other researchers viewed that the issue differently and argue that the development of the financial sector enhances research and development together in building energy efficient technologies and in consequence reduces CO2 emission. This is the stand of Frankel and Romer (1999). This is in line with the view of Bello and Abimbola (2010), and Wang and Jin (2007) who found that a boost in FDI led to lower CO2 emissions. Also, this engaged companies to adopt more energy efficiency strategies and attracted more investors. Interestingly, some other findings suggest the exactly opposite of the earlier stream. In fact, Ren et al. (2014), and Lau et al. (2014) arrived at the same conclusion. The former analysed the CO2 emissions in various industrial sectors of China. They concluded that FDI led to an increase of CO2 emissions in the industrial zones. This is due to a lack of knowledge and awareness of efficient resource utilization. The latter focused on Malaysia and investigated the presence of EKC for Malaysia in presence of FDI. The results suggested that in the long run, FDI was the cause of an increase of CO2 emissions. As for private sector credit, it was found by Shahbaz et al. (2013), in their analysis of financial development impact on CO2 emissions for Malaysia, that it decreases the impact on CO2 emissions

Secondly, trade openness also has a considerable impact on energy consumption. The impact of trade on pollution depends on differences in factor endowments and environmental policies. Trade may reduce or increase energy consumption depending upon whether the country has comparative advantage in cleaner or dirty industries. Trade liberalization may be viewed as a way to transfer dirty industries to countries where environmental regulations are laxer. On the other hand, trade may allow access to energy-efficient technologies and better environmental management practices and thus contribute to significant reduction in CO2 emissions (Grossman & Krueger, 1991; Goldemberg, 1998; Keller, 2004). An increase in exports and imports of goods and services requires more economic activities, such as production, processing and transportation. These activities will intensify energy consumption and CO_2 emissions. There is an extensive amount of literature, such as Jena and Grote (2008), Ghani (2012) and Sadorsky (2011, 2012), who claims that trade openness increases energy consumption. However, only a few studies examine the link between trade openness and CO_2 emissions, with the pioneering study by Grossman and Krueger (1991). However, all of these earlier studies fail to find conclusive evidence of the relationships between trade and environmental quality. Halicioglu's study (2009), which uses Turkish data, is probably the first to reveal that trade is one important determinant of CO_2 emissions. Hossain (2011) also finds a positive relationship between trade openness and CO_2 emissions in newly industrialized countries. Moreover, Ozturk and Acaravci (2013) also found that foreign trade increases CO_2 emissions in Turkey for the 1960-2007. A recent study by Ren et al. (2014) examines the impact of international trade on CO_2 emissions in China for the period 2000-2010. Based on the two-step GMM estimation, the study argues that China's trade surplus is one of the important reasons for the rapidly increasing CO_2 emissions. Sharma (2011) investigated the determinants of CO2 emissions for a global panel of 69 countries using a dynamic panel data model. He found that trade openness; per capita GDP and energy consumption have positive effects on CO2 emissions. Managi, Hibiki, and Tsurumi (2009) used the technique of instrumental variables to depict the relationships between trade openness and the environment quality in OECD and non-OECD countries. They found that beneficial effect of trade on the environment varies depending on the pollutant and the country. Trade has improved the environment quality in OECD countries. However, it has had a detrimental effect on sulphur dioxide and carbon dioxide emissions in non-OECD countries. Aka (2008) examined the impacts of trade openness and economic growth on air pollution for Sub-Saharan Africa considered as a whole during the period 1961-2003. He used the bounds test approach and found that economic growth contributes to the degradation of air quality, while trade intensity is beneficial to the environment. They carried out the empirical analysis using the bounds test to cointegration. Their results provide evidence that income growth and energy consumption are main factors increasing CO2 emission in the long-run in all the countries. Energy consumption has a positive and significant effect on CO2 emissions. Results also indicated an inverted U-shaped for only Japan and Korea. In all the other countries, the long run relationship between economic growth and CO2 emissions follows an N-shaped trajectory and the estimated tuning points are out of the sample data size. With respect to trade openness and population density, the results are mixed. Increased trade openness contributes to worsening environmental conditions in Mexico, Nigeria and South Africa. For Brazil, China, Egypt, Japan and Mexico, increasing population density leads to more environmental degradation in the long run. In the cases of South Korea, Nigeria, and South Africa, population density has a positive but statistically insignificant impact on CO2 emissions.

The econometric analysis of factors influencing trade openness, economic growth and urbanisation as reasons for greenhouse gas emission in Africa which was carried out by Onoja et al., (2014) confirmed the existence of the EKC hypothesis in the continent. The findings further revealed that the GDP growth rate and trade openness serve as the major long-run and short-run determinants of greenhouse gas emissions. Hence, recommending African countries to take immediate positive policy measures that will enhance green economy on the continent.

Thirdly, Per Capita GDP, the study developed by Friedl and Getzer (2003) indicates an N-shaped nexus between GDP per capita and Co2 emissions. However, Richmond and Kaufmann (2006) discovered a non- causal link among GDP and CO2 emissions

He and Richard (2010) investigated the relationship between per capita CO2 emissions and per capita GDP for Canada between 1948 and 2004. They found little evidence in favor of the EKC. Iwata, Okada, and Samreth (2010), Jalil and Mahmud (2009) and Ang (2007) found evidence supporting the EKC for CO2 emissions in France and China. A positive link between trade and carbon dioxide emissions was found by Halicioglu (2009) for Turkey. Akbostanci, Türüt-Asik and Tunç (2009) tested for the existence of EKC in Turkey using cointegration techniques and both time series and provincial panel data for the periods 1968 to 2003 and 1992 to 2001. They found a monotonically increasing relationship between CO2 emissions and income in the times series analysis, which suggests that the EKC hypothesis does not hold for CO2 emissions. He and Richard (2010) investigated the relationship between per capita CO2 emissions and per capita GDP for Canada between 1948 and 2004. They found little evidence in favor of the EKC. Iwata, Okada, and Samreth (2010), Jalil and Mahmud (2009) and Ang (2007) found evidence supporting the EKC for CO2 emissions in France and China.

Tucker's (1995) analysis of the relationship between CO_2 emissions and per capita income in 137 countries in 21 years span concluded that there was a positive relationship between them, and that as per capita incomes accelerate across countries, emissions increased. He posited that, an increased demand in environmental protection is as a result of higher income levels. Therefore, any successful implementation of emission reduction proposals must assure that incomes will not be adversely affected, particularly the less developed countries (LCDs). Van Den Bergh, and Opschoor (1998) conducted a research of economic growth and emissions in line with the EKC. They argued that the estimation of the panel data of countries is determined by the Inverted-U relationship between income and emissions. They based their arguments on the insights from intensity of use analysis in resource economics, which they used an alternate growth model to estimate for the emissions of the three pollutants (CO_2, NOx, and SO_2) in four different countries (Netherlands, UK, USA and Western Germany). They finally concluded that the time patterns of the above emissions link positively with economic growth, and that reduction in emission could have been attained as a result of structural and technological changes in the economy. The studies by Holtz-eakin and Selden (1995) on the relationship between the CO_2 emissions and economic growth, stated that estimations derived from the global panel data they obtained exposed that, as GDP per capita increases there will be a marginal propensity to emit carbon dioxide. Also, its growth will continue at 1.8 percent annually for the foreseeable future, which is not functional to the average growth in emissions. Instead, output and population will grow most rapidly in lower-income countries with high marginal propensity to emit due to the distributional effect of policies for emission reduction.

Studies on African countries such as KEHO (2015) an econometric analysis on the long run determinants of CO_2 emissions in Ivory Coast, Western Africa, supports the notion of environmental Kuznets curve. The results further outlined that per capita income, share of industrial GDP and trade openness derives the CO_2 emissions, while the effects of trade openness on CO_2 emissions relies on the structure of the economy and rises as the country engages industrialisation. Also, the literature outlined the complementary relation of trade openness and industrialisation in worsening environmental quality in Ivory Coast. Also, a study by Boopen and Vinesh (2011) on the relationship between CO_2 emissions and economic growth in Mauritania, suggested that the carbon dioxide emissions trajectory is diligently associated with the GDP time path, but the estimates of the data in the study failed to establish the inverted U-shaped EKC. However, the analysis concludes that economic and human activities are having increasingly negative environmental effects than the desired economic prosperity of the Mauritanian economy. In a related study on the factors causing CO_2 emissions in Southern Africa and what actions to be taken, by the Centre for Environmental Economics and Policy in Africa concludes that the main driving force behind CO_2 emissions is income per capita. But, the study states that, there is no evidence of the linkage between the variables to depict an existence of the EKC among the six countries covered by the study. However, the study resolved to suggesting policies to curb the environmental problems by establishing robust measures in reducing carbon emissions by switching to less polluting energy mix. The econometric analysis of factors influencing trade openness, economic growth and urbanisation as reasons for greenhouse gas emission in Africa abound. A study by Onoja et al., (2014) confirmed the existence of the EKC hypothesis in the continent. The findings further revealed that the GDP growth rate and trade openness serve as the major long-run and short-run determinants of greenhouse gas emissions. Hence, recommending African countries to take immediate positive policy measures that will enhance green economy on the continent.

Wolde (2015) studied the relationship between economic growth and environmental degradation in Ethiopia by questioning the existence of environmental Kuznets Curve. Wolde (2015) applied a time series data from Ethiopia ranging between the period of 1969 and 2010 in a Vector error correction model. His finding indicates the existence of the EKC hypothesis in Ethiopia and therefore argued that to sustain the current trend in pollution abatement, the country has to sustain the existing environmental friendly economic policy.

Busayo (2016) studied the relationship between fossil fuel consumption, the environment and economic growth in Nigeria by using data between 1970 and 2013. Applying the VECM technique, Busayo (2016) found that fossil fuel consumption and CO2 emissions impact significantly on economic growth. Also the study found the existence of an N-shaped relationship between environmental pollution and economic growth thereby disputing the presence of the EKC hypothesis for Nigeria. It therefore recommended that government should formulate economic growth policies in tandem with emission regulations to combat environmental degradation.

Ojewumi (2015) investigated the validity of Environmental Kuznets Curve (EKC) hypothesis in Sub-Saharan African countries, using panel data analysis for the period 1980 - 2012. The study estimated the impact of growth on environmental degradation of the sub-saharan African economies in a panel data study using data obtained from WDI. The results of the empirical analysis support the validity of the EKC hypothesis for solid emission (CSF) and composite factor of emission (CFE). The findings also show that SSA countries need to harmonize a well-coordinated environmental and economic policy mix that would ensure greater output but at the same time protect their environment from degradation and pollution.

Oshin and Ogundipe (2015) estimated the existing linkage between economic growth and environmental pollution in West Africa to ensure if the Environmental Kuznet Curve hypothesis exists in the West African sub region which was ranked one of the poorest regions of the world. The study adopted a static panel data regression methodology for all the nations that make up the membership of the Economic Community of West African States (1980-2012). Employing GDP per capita, literacy rate, population density, trade openness and a measure of institutional quality, the available result from their estimation procedure re-established the existence of the EKC hypothesis in the studied economies.

Fourthly, Population, Shi's (2003) empirical assessment and forecasting of the population’s impact on carbon dioxide emissions on a data for 93 countries from the period of 1075 to 1996, varied with the earlier researchers like Dietz and Rosa (1997), whose assumptions are that there is a unitary elasticity of emissions with respect to population change, i.e. that a 1% rise in population results the same percentage increase in emissions. Shi stated that in the last two decades’ population change is greater than proportionally associated with growth in the CO_2 emissions, and that the developing countries suffer more than the developed countries in terms of the impacts. This pronouncement suggests that the impact of population growth is obvious and that it is one of the deriving factors behind the rapid increase in the global CO_2 emissions. For Brazil, China, Egypt, Japan and Mexico, increasing population density leads to more environmental degradation in the long run. In the cases of South Korea, Nigeria, and South Africa, population density has a positive but statistically insignificant impact on CO2 emissions. Some studies have examined the channels through which population growth contributes to increases in CO2 emissions. The study carried out by Birdsall (1992) suggested two channels through which population growth contributes to CO2 emissions. The first channel is through its effect on energy consumption where a large population could result in increased demand for energy for power which leads to an increase in CO2 emissions. The second channel is through its effect on deforestation where increasing population tend to destroy the forests and engage in combustion of fossil fuels contributing to the release of CO2 emissions. Population has also been found to contribute to CO2 emissions through its effect on production and consumption activities (Satterthwaite, 2009).

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Fifthly, Manufacturing: Indonesian Ministry of Industry (2013) has argued that there are eight manufacturing sectors as the highest contributors of CO2 emission to the green-house gas effect which are cement, steel, pulp and papers, petrochemical, fertilizer, ceramic, textiles, and food and beverage sectors in which these sectors use energy more than 6000 TOE [5]. Therefore, these eight sectors were determined as sectors to be the highest priority to be reduced. However, not only the highest contributor sectors to be the target of policy action, but also the most sensitive sectors of CO2 emission due to the increase of income. Generally, the identification of key sector of CO2emission can help the policy maker to mitigate climate change policy by intervening on the key sector of CO2 emission in manufacturing. The objective of this paper is to identify the most elastic sectors of CO2 emission in manufacturing due to the increase of income or value added. In Spain, Alcantara and Padilla (2006) found that the productive sectors that deserve more attention are electricity and gas, land transport, manufacture of basic metals, manufacture of non-metallic mineral products, manufacture of chemicals, manufacture of coke, refined petroleum products and nuclear fuel, wholesale and retail trade, and agriculture. These sectors become the key sectors of CO2 emission. In Brazil, Imori and Guilhoto (2010) also found that the key sectors cover machinery industries, electric equipment, transportation equipment, textiles and construction sectors.

Sixthly, Energy Consumption: Studies by Ang (2008), Hossain (2011), Sharma (2011), confirm that energy consumption has a positive impact on carbon dioxide emissions as the energy is used in the production processes, which involve the burning of fossil fuels.

Chindo et al (2015) examined the relationships among the energy used, carbon dioxide emissions and GDP in Nigeria. The study employing ARDL method to co-integration, the outcomes showed there exists a long-run association energy consumption, carbon dioxide emissions and GDP. Thus, both the short and long-run carbon dioxide emissions have been found to have a substantial and positive effect on gross domestic product, while energy consumption reveals a significant and negative influence on GDP in short-run. Ali et al. (2016) examine the dynamic influence of urbanization, growth, energy consumption, plus trade openness on CO2 emissions in Nigeria grounded on Autoregressive Distributed Lags Approach (ARDL) for the period of 1971-2011, the outcome reveals that urbanization does not have the significant effect on CO2 emissions in Nigeria through growth, and energy consumption has a positive and significant effects on CO2 emissions.

2.4 Dynamic Causal relationship between Carbon Dioxide Emissions and Macroeconomic Variables.

Some studies have focused on the nature of relationship between the macroeconomic variables and carbon dioxide emissions. Population and Co2 emissions have been examined employing different methodologies with large proportion of results showing positive relationship between population growth and CO2 emissions (Shi, 2003, Cole and Neumayer, 2004) and (Hossain, 2012, Mohammed et al..,2011). Soytas and Sari (2009) found unidirectional causality running from energy consumption to pollution emissions in the long run while Haliciglu (2009) found bidirectional causality in the long run and short run between economic growth and pollution emission. Zhang and Chang (2007) found unidirectional causality running from economic growth to energy consumption to pollution emission in the long run while Ang (2007) found unidirectional causality from economic growth to energy consumption and pollution emission in the long run.

Ozturk and Acaravci (2010), and Ang (2007) studies confirms the presence on the long-run relationship. Abbasi and Riaz (2016) used an augmented VAR model to study the long run relationship between CO2 emissions and financial development in Pakistan. The findings of the study suggest that per capita CO2 emissions were cointegrated with financial development indicators and per capita GDP. Adding to that, the estimated long run model for the full analysed sample showed that only GDP per capita had statistically significant impact on CO2 emissions. In returns this caused increase in emissions.

Sari and Soytas (2009) investigated the relationship between carbon emissions, income, energy and total employment in five selected OPEC countries (including two MENA countries: Algeria and Saudi Arabia) for the period 1971–2002. They mainly focus on the link between energy use and income. Employing the autoregressive distributed lag (ARDL) approach, they find that there is a cointegrating relationship between the variables in Saudi Arabia and conclude that none of the countries needs to sacrifice economic growth to decrease their emission levels. Halicioglu (2009), applying ARDL approach of cointegration in a log linear quadratic equation between per capita CO2 emission, per capita energy use, per capita real income, square of per capita real income and openness ratio, finds that there is a short-and long-run bi-directional causality between carbon emission and income in Turkey

Jalil and Mahmud (2009) examine the long-run relationship between carbon emissions and energy consumption, income and foreign trade in the case of China using time series data for the period 1975-2005. They employ the autoregressive distributed lag methodology to test for the existence of an EKC in the long-run. Their empirical results suggest the existence of a robust long-run relationship between the variables. Their results also confirm the existence of an EKC for carbon dioxide emissions. They conclude that carbon dioxide emissions are mainly determined by income and energy consumption in the long-run.

Asumadu-Sarkodie and Owusu (2016) examined the causal nexus between carbon dioxide emissions, energy consumption, population growth and GDP in Ghana by employing a data spanning between 1971 and 2013 by comparing VECM and ARDL model. Their study found evidence of a bidirectional causality running from energy consumption to GDP and a unidirectional causality running from carbon dioxide emissions to GDP, population and energy use. In addition, evidence from their study shows that a 1% increase in population will increase carbon dioxide emissions by 1.72%. However, Asumadu-Sarkodie and Owusu (2016) further examined the causal nexus between carbon dioxide emissions, energy consumption, population and GDP in Ghana by employing a data spanning between 1980 and 2012 using VECM technique. Their study found evidence of a long-run equilibrium relationship between carbon dioxide emissions, energy consumption, population and GDP and bidirectional causality between carbon dioxide emissions and energy consumption.

Ang (2007) uses panel data on France between 1960 and 2000 and applies a cointegration method and error correction model to test the dynamic causality between economic development, energy consumption and pollution. The researcher finds a long-run relationship between the three variables. Furthermore, a short-run unidirectional causal relationship is found from energy consumption to economic growth. Another valuable paper within this group of research is the study on the United States by Soytas, Sari and Ewing (2007). The researchers employ a Granger causality test and find that energy consumption granger-causes carbon dioxide emissions, however, income does not. This result suggests that economic growth may not be the main solution to the current global environmental challenge.

Yang (2000) considers the causal relationship between different types of energy consumption and GDP in Taiwan between 1954 and 199, using different types of energy consumption; he found a bi-directional causality between energy and GDP. This result contradicts with Cheng and Lai (1997) who found that that there is a uni-directional causal relationship from GDP to energy use in Taiwan. Soytas and Sari (2003) discovered bidirectional causality in Argentina, causality running from energy consumption in Italy and Korea, and from energy consumption to GDP in Turkey, France, Germany and Japan. Paul and Bhattacharya (2004) found bidirectional causality between energy consumption and economic growth in India.

Nwani C (2017) examined the causal relationship between crude oil price, energy consumption, carbon dioxide emissions and financial development using ARDL bounds testing approach to cointegration and found cointegration between the variables in the presence of structural break in the series. The long-run effect of energy consumption on CO_2 emissions in the oil-dependent economy is found to be positive and statistically significant. The long-run and short-run causal effects of crude oil price on energy consumption and CO_2 emissions in the economy are found positive and statistically significant, suggesting that higher crude oil prices create economic conditions that generate more energy consumption and CO_2 emissions in the Ecuadorean economy. The direction of causality among the variables examined using Toda-Yamamoto Granger causality test procedure suggests that a unidirectional causality runs from crude oil price to energy consumption and economic growth, and bidirectional causality between energy consumption and CO_2 emissions. A unidirectional causality that flows from CO_2 emissions to economic growth through financial development is also observed in the economy

2.5 Summary of the literature review

From the literature, it could be realised that most of the studies were done on developed economies while there are few specific studies that use macroeconomic variables like oil price and financial development in developing countries. Lack of attention to the study on the cases of developing countries will have a negative consequential impact on the adaptation and mitigation to climate change effects. Literature have confirmed that Africa will be the most vulnerable to the adverse effects of climate change as most of its economy is climate sensitive. Beckerman (1992) opined that there is a confirm proof that, although the growth of an economy usually leads to increase in pollution in the economy at the early stages of the growth, at the end, the best and possibly the only way to achieve a nice environment in most countries is just for a country to become rich. From the literature, EKC gave a condition that environmental degradation will begin to fall at a threshold income above 8000 USD which theoretically puts almost all developing countries out of the relationship. However, EKC was criticized for failing to provide the exact income level at which environmental degradation falls. Having looked at the literature so far, emissions are majorly induced by human activities which can be attributed to macroeconomic variables. From the foregoing, it could be seen that some studies have lacked appropriate methodology and omission of key induced macroeconomic variables over time in this debate. This study seeks to consider the overlooked relevant macroeconomic variables in Nigeria context by including financial development and oil price. Over time, many studies in this field have favoured EKC by nature of only quadratic form of model specification without reference to inclusion of cubic term. Cubic formulation by contrast allows for both inverted U- shaped EKC and monotonically rising N- income relationship (Ozoemena et al… (2017). Stern (2004) observed lack of necessary diagnostic tests from the previous studies. These weaknesses have resulted to inconclusive findings over time which has made policies recommendations over time inappropriate to be applied across countries. Arrow et al.., (1995) theoretically criticized EKC. The researcher argued that a major drawback of EKC is the fact that income is an exogenous variable. In order words, Grossman and Krueger (1995) do not account for the effects of increased carbon emissions on income. Arrow et al., (1995) claimed that pollution negatively influences production and may slow down economic growth Therefore, appropriate methodology, emission induced macroeconomic variables and necessary diagnostic tests should be added in the debate which this study will adop

CHAPTER THREE:

METHODOLOGY

3.1 Introduction

This chapter discusses the methodology adopted for the study. It is divided into sections: Section 3.1 is the introduction, 3.2 is the preference of the study area 3.3 gives overview of the theoretical framework, Section 3.4 highlights the model specifications, section 3.5 elaborates the Causality analysis, section 3.6 presents the estimation technique while section 3.7 shows the data sources and the key variables.

3.2 Preference of the study area

My choice of Nigeria as my study area cannot be overemphasized. Nigeria is the most populous country in Africa with population of over 186 million people. Equally, the country has the fastest growing population in Africa with 2.6% annual growth rate in 2016. The country is ranked 44th emitter in the list of over 200 World's countries. However, with the pace at which the country's population is growing coupled with increase in macroeconomic activities such as energy consumption, trade, the nature of financial development and oil price, the concern for CO2 emissions, which accompany it, equally grows. As such, it is likely that the country's per capita emissions will continue to rise due to the fast population growth and macroeconomic activities. This will expectedly increase the cumulative CO_2 emissions significantly. Therefore, Nigeria is expected to devise sustainable ways of addressing CO_2 emissions by evaluating the determinants of emissions and the way forward for abatement which motivates the choice of this country in this study.

Climate change is not just an environmental issue any longer; it has become a development issue when looking at its potential impact on the economic activities. It poses a serious threat to sustainable development of many developing countries, particularly Nigeria. Literature confirm that Africa is going to be the most vulnerable to the adverse effects of climate change due to its climate sensitive economy with low income and technology for mitigation and adaptation. For instance, it is projected that climate change may result in a loss of 6% to 30% in Nigeria's GDP by 2050, which translates to US$100 billion to US$460 billion if no adaptation measures are taken (Department of international organization, 2009). That study further predicted that the country may suffer a loss of 2% to 11% in GDP by 2020 if the current trend is maintained.

Nevertheless, the evidence of climate change is already manifesting in the North, West, South and Eastern part of Nigeria with variation in rainfall, increase in temperature, sea level rise etc. This is posing hardship presently in Nigeria as rivers are drying up; crops are dying off because of shortage of rainfall and rain falling at unexpected time.

The significance of this study cannot be overemphasized. First, it should help to inform decision makers on the determinants of CO_2 emissions. Second, it provides policy recommendations that could assist in tackling the emissions, while maintaining long-run economic growth and averting the potential loss in GDP in the future. Equally, the empirical findings could further provide a hint on how CO_2 emissions responded to its determinants over the studied period.

3.3 Theoretical Framework

This study follows the studies by Ozoemena et.al (2017), Essien (2010) and Ang (2007) to fill the relevant macroeconomic variables and methodology bias suffered by Environmental Kuznets Curve theory (Kuznets,1955) and other related studies which might have made findings from this study over time inconclusive for policy recommendations across countries. EKC relationship states that at the country's early stage of growth, environmental pollution increases and that it eventually decreases after income exceeds a threshold level. This theory specifically describes a process of development that leads to a basic agrarian society with limited environmental impact through a highly polluting industrial phase and then to a clean economy that delivers sustainable services. This argument was supported by Stern (2003), in his view that in later stages of development, the economy shifts to lower resource intensive services and fewer manufacturing that will likely result to decreased level of emissions. The environmental Kuznets curve concept was made popular by the World Bank's World Development Report (WDI, 1992), where it posits the idea that the higher the economic activities, the higher the environmental degradation is formed on the static assumptions about technology, environmental investments and taste. As an economy grows, the need and demand for improved environmental quality through pollution abatement will equally grow together with the resources available for investment. In backing this argument, Beckerman (1992) opined that there is a confirm proof that, although the growth of an economy usually leads to increase in pollution in the economy at the early stages of the growth, but at the end, the best and possibly the only way to achieve a nice environment in most countries is just for a country to become rich.

In view of the forgoing arguments, following the reduced form equation by Grossman and Krueger (1995), which extended the model developed by Kuznets, (1955) to examine the relationship between environmental pollution and macroeconomic variables conforms to testing the EKC hypothesis. Kuznets propounded that environmental pollution is a quadratic function of per capita income thus.

$y_{i_t} = \beta_{i_i} + T_i + \propto_1 x_{i_t} + \propto_2 {x_{i_t}}^2 + \mu_{it}$ …………………………………...equation 3.1

Some researchers estimate this equation without the cubic term. This makes it more favourable to EKC. The cubic formulation below in contrasts allows for both monotonically rising environmental N – income relationship and inverted U shaped EKC which depicts the asymmetric nature of carbon dioxide emissions (Ozoemena et al. (2017). According to a study by Martinez-Zarzoso and Bengochea-Morancho (2004), the cubic model best represents the relationship between CO2 emissions per capita and GDP per capita. However, in many cases, the addition of the third variable ${x_{i_t}}^3$ may lead to collinearity problems, thus making the quadratic equation more suitable. In this study, investigation begins by using the cubic equation if there is no presence of collinearity, and the quadratic relationships if the variables are perfectly collinear. Since these two models have been used in many studies, they are employed in this research to analyse the relationships among carbon dioxide and its macroeconomic determinants.

$y_{i_t} = \beta_i + T_i + \propto_1 x_{i_t} + \propto_2 {x_{i_t}}^2 + \propto_3 {x_{i_t}}^3 + \propto_i z^1 y_{it} + \mu_{it}$ …….................. equation 3.2

Where y is environmental pollution indicator, β is a country specific effect, T is time specific effect, X is per capita income, i and t subscripts denote the country and time. Z is the vector of emission induced macroeconomic variables which according to theory can influence the quality of the environment.

3.4 Model Specification

Literature has confirmed that most of these studies are suffering from the problem of relevant macroeconomic variables (see for example, Ang, 2007 for France and Soytas et al., 2007for United States). As consumption of energy increases, economic growth increases with increase in pollution coupled with other macroeconomic variables. This model is specified to solve the problem of macroeconomic variables and methodology bias suffered in the previous literatures, using the approach adopted by Ozoemena et al… (2017), Essien, (2010) and Ang (2007) but deviates from the models by including financial development and energy use per capita as key emission induced macroeconomic variables. The concept of economics of scale posits that as a country grows, all macroeconomic activities in the economy will increase in equal proportion to the amount of economic growth especially at the early stage of growth. However, according to Stern (2003), in the later stages of growth, the economy shifts to lower resource intensive services and fewer manufacturing that will likely result to decreased level of emissions resulting in clean environment. This study adopts EKC approach of methodology because it is one of the few models that actually reveals how technically specified measurement of environmental quality may vary or reverse as the future of the economy changes. The cubic model of CO2 emissions can be represented by the following equation according to Fodha and Zaghdoud (2010) in order to account for the relationships among carbon dioxide emission, Per capita income, energy consumption, trade openness, Population, Financial development and share of manufacturing in GDP.

$CO_2 = f(GDP_t, (GDP)^2, (GDP)^3, EC, TO, POP, FD, MAN)$………………..............5.3

Econometrically, the model is specified thus:

$CO_{2_t} = \propto_0 + \propto_1 GDP_t + \propto_2 (GDP_t)^2 + \propto_3 (GDP_t)^3 + \propto_4 EC_t + \propto_4 TO_t + \propto_5 pop_t + \propto_5 FD_t + \propto_5 MAN_t + \mu_t$……...5.4

Where $CO_2 =$ carbon dioxide emission in metric ton, GDP is real per capita income, EC is the energy consumption in metric ton per capita, POP is the population density, TO is the trade openness (The sum of export and import divided by GDP), FD is the financial development (credit to private sector), MAN is the share of manufacturing in GDP and μ_t is error term which is not correlated with carbon emission. The EKC hypothesis is known to be an indicator of the long-run relationship between economic growth and carbon dioxide emissions, expressed as a logarithmic cubic function of income. According to Cameron, (1994) and Ehrlich, (1996), log linear variables yield direct elasticities that make it easier for interpretation; therefore, equation 5.4 is put in log linear form thus:

$InCO_{2_t} = \propto_0 + \propto_1 InGDP_t + \propto_2 In(GDP_t)^2 + \propto_3 In(GDP_t)^3 + \propto_4 InEC_t + \propto_4 InTO_t + \propto_5 Inpop_t + \propto_5 InFD_t + \propto_5 InMAN_t + \mu_t$………………..…………...5.5

Where all the variables have been already defined and In is the natural log of variables.

The environment – economic relationship can take many different forms thus:

i. If $\propto_1 = \propto_2 = \propto_3 = 0$, No relationship.

ii. If $\propto_1 > 0$, $\propto_2 = \propto_3 = 0$, a monotonic increasing relationship exists.

iii. If $\propto_1 > 0$, $\propto_2 = \propto_3 = 0$, a monotonic decreasing relationship exists.

iv. If $\propto_1 > 0$, $\propto_2 < 0$, $\propto_3 = 0$, an inverted U – Shaped relationship is observed suggesting EKC is observed.

v. If $\propto_1 < 0$, $\propto_2 > 0$, $\propto_3 = 0$, a U shaped relationship suggesting the existence of EKC

vi If $\propto_1 > 0$, $\propto_2 < 0$, $\propto_3 > 0$, an N – Shaped relationship is observed suggesting no EKC.

vii. If $\propto_1 < 0$, $\propto_2 > 0$, $\propto_3 < 0$, an inverse N – Shaped relationship is observed

viii. If $\propto_1 > 0$, $\propto_2 > 0$, $\propto_3 < 0$, a Polynomial inverted U shaped relationship exists

ix. If $\propto_1 < 0$, $\propto_2 < 0$, $\propto_3 > 0$, a cubic Polynomial U shaped relationship exists

Therefore the existence of EKC is only possible If $\propto_1 > 0$, $\propto_2 < 0$, and , $\propto_3 = 0$, where $\propto_1 > 0$ denotes increase in environmental pollution. With increase in income resulting to $\propto_2 < 0$, indicates an existence of the function's maximum or turning point which indicates EKC. If $\propto_1 > 0$, $\propto_2 < 0$ and $\propto_3 > 0$, then the relationship between the variables are cubic or N – shaped which theoretically invalidates the existence of EKC

3.5 Causality Models

The Granger test involves estimating the regression equation 5.4 above. Since this study also focusses on examination of one-to-one causal nexus between carbon dioxide emissions and the macroeconomic determinants of emissions, this study employed a bivariate granger causality technique. The appropriate specification of the model (that is, whether in ARDL, VAR or VECM) depends on the status of the unit roots of the variables and also on the existence of co-integration between the variables. If the variables are not co-integrated, then a VAR model specified in equation is utilized.

$$Y_t = \sum_{t-1}^{n} \alpha_i Y_{t-i} + \sum_{t-1}^{n} \beta j X_{t-j} + U_{1t} \quad \text{.......} 5.6$$

$$X_t = \sum_{t-1}^{n} \lambda_i Y_{t-i} + \sum_{t-1}^{n} \delta j X_{t-j} + U_{2t} \quad \text{.......} 5.7$$

Where:

U_{1t} and U_{2t} are error terms which are assumed to be uncorrelated. $Y_t$refers to carbon dioxide emissions (Co2) and X_t represents the macroeconomic variables that determine emissions. On the other hand, if the variables are co-integrated then, the VAR model must include an error correction term. Engel-Granger (1987) cautioned that the Granger causality test, which is conducted in the first differences of variables through a vector auto-regression (VAR) is misleading in the presence of co-integration. Therefore, an inclusion of an additional variable to the VAR system, such as the Error Correction Term (ECT) would help capture the long run relationship among the variables (Nwosa, 2012). To this end, an augmented form of causality test involving the Error Correction Term is formulated in a bi-variatepth order Vector Error-Correction Model (VECM) as follows (Ferda, 2007)

$$\Delta y_t = \begin{bmatrix} Y_t \\ X_t \end{bmatrix} + \sum_{t-1}^{n} \begin{bmatrix} \alpha_i & Bj \\ \lambda i & \delta j \end{bmatrix} \begin{bmatrix} \Delta Y_{t-i} \\ \Delta X_{t-i} \end{bmatrix} [ECT_{t-i}] + \begin{bmatrix} U_{1t} \\ U_{2t} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.8$$

Therefore, the pairwise granger causality equation between carbon dioxide emissions

(Y_t) and macroeconomic determinants of emissions (Xi_t) is represented thus

$$X_t = \alpha + \alpha_1 X_t + \mu_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5.9$$

The test expectations are:

I. Unidirectional causality from X_t to Y_t If $\sum \alpha i \neq 0$and $\sum \delta j = 0$. In this case, the included macroeconomic variable (determinant of emissions) is statistically significant while carbon dioxide emission is not statistically significant.

ii. Unidirectional causality fromY_t to X_t if $\sum \beta j \neq 0$and $\sum \lambda i = 0$. In this case, carbon dioxide emission is statistically significant while the included macroeconomic variable is not statistically significant.

iii. Feedback or bidirectional causality if $\sum \alpha i \neq 0$and $\sum \delta j \neq 0$. In this case, the two variables Y_t and X_t coefficients are statistically significant in both regressions.

Iv. Independence or no causality if $\sum \alpha i = 0$ and $\delta j = 0$, implies that the coefficients of the two variables are not statistically significant in both regressions.

3.6 Method of Estimation

An econometric methodology of research which includes economic, statistical and econometric tools is used in analysing and presentation of data. Thus an econometric approach of multiple regressions is the instrument for analysing the data. Econometric modelling which this research work makes use of, requires three major steps which includes data collection, construction, estimation and model evaluation (Soludo, 1988). The EKC hypothesis represents a long- run relationship between environmental uality and economic growth. In the last two decades, a number of techniques such as the Engle & Granger (1987) and the full information maximum likelihood method of Johansen (1996) have been employed to test the existence of long run relationship among variables. Recently, a relatively new technique – the autoregressive distributed lag model (ARDL) has become more popular among researchers. The ARDL approach to cointegration, also known as the bounds testing approach, was developed by Pesaran and Shin (1999) and latter extended by Pesaran, *etal.*, (2001). The statistic underlying the procedure is the Wald or *F*-statistic in a generalized Dickey-Fuller type regression, which is used to test the significance of the variables under consideration in a conditional unrestricted equilibrium correction model (UECM). The ARDL approach has several advantages over other traditional techniques such as the ones mentioned above. The first main advantage of this approach is that it is more flexible and can be applied irrespective of whether the underlying regressors are purely *I* (0), *I*(I), or mutually cointegrated. Thus, because the bounds test does not depend on pretesting the order of integration of the variables, it eliminates the uncertainty associated with pretesting the order of

cointegration (Narayan & Narayan, 2004). In essence, the approach does not require all the variables in the system to be of equal order of integration. Also the approach can be applied to studies that employ relatively small sample size. As demonstrated by Pesaran & Shin (1999), the small sample properties of the ARDL approach are far superior to

that of the Johansen and Juselius'(1990) cointegration technique9. Another important advantage of this procedure is that the estimation is possible even when some of the explanatory variables are endogenous. It also allows for the estimation of long-run and short-run parameters of the variables under the same framework. Basically, bounds test approach involves two steps. The first step is to investigate the existence of long-run relationship among the included variables. However, an econometric method of Nonlinear Autoregressive Distributed Lag Model (NARDL) recently developed by

(Hatemi-J, 2012) and (Shin, Yu and Greenwood, 2014) in the version of ARDL will be adopted for the analysis. This J-curve nonlinear autoregressive distributed lag model advanced by Shin, Yu and Greenwood, (2014), models asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. This is an econometric model in which both the short and long run nonlinearities are introduced via positive and negative partial sum decomposition of the explanatory variables. This can be achieved by bound testing (Shin, Yu and Greenwood, (2014). These methods allow for consideration of asymmetry in studying the cointegration and causality between carbon dioxide emissions and Macroeconomic variables. A major challenge in time series econometrics is that of non-stationarity that affects statistical inferences due to the possibility of spurious correlations. A convenient way of overcoming this challenge is differencing the non-stationarity data. However, this creates problems of loss of information of the data generating processes in levels. Therefore, if the variables under consideration are difference and level stationary, there is possibility of dynamic relationship among the variables. Thus, in order to capture the nonlinear and asymmetric cointegration between variables used in the study, a multivariate Nonlinear NARDL bounds testing developed by (Shin et al..2014) is used to account for the non –linear asymmetric nature of the carbon dioxide emissions and macroeconomic variables. Besides, NARDL makes distinction between the short run and long run effects of the independent variables on the dependent variable. However, to be able to account for the dynamic speed at which the short run equilibrium will converge in the long run, Vector Error Correction Mechanism (VECM) framework will be used. In other words, this study will employ NARDL - VECM as modelling framework to investigate the carbon dioxide emissions and its macroeconomic determinants. Furthermore, the direction of causality among the variables will be investigated using pairwise Granger Causality to establish a long run causal relationship between carbon dioxide emissions and its determinants. To determine the direction of causation between the examined variables, the study used asymmetric Granger Causality Test. It establishes the direction of influence if any exists between the variables and also indicates if such a relationship does not exist.

Bounds test approach involves two basic steps. The first step is to investigate the existence of long-run relationship among the included variables. Therefore, the ARDL framework for this study is specified thus:

$\Delta CO2_t = \delta_0 + \alpha_1 CO2_{t-1} + \alpha_2 GDP_{t-1} + \alpha_3 GDP^2{}_{t-1} + \alpha_4 GDP^3{}_{t-1} + \alpha_5 EC_{t-1} + \alpha_6 TO_{t-1} + \alpha_7 POP_{t-1} + \alpha_8 FD_{t-1} + \alpha_9 MAN_{t-1} + \sum_{t=0}^{a} \sigma_i \Delta CO2_{t-1} + \sum_{t=0}^{b} \pi_i \Delta GDP_{t-1} + \sum_{t=0}^{c} \beta_i \Delta GDP^2{}_{t-1} + \sum_{t=0}^{d} \gamma_i \Delta GDP^3{}_{t-1} + \sum_{t=0}^{e} \omega_i \Delta \mathrm{EC}_{t-1} + \sum_{t=0}^{f} \emptyset_i \Delta \mathrm{TO}_{t-1} + \sum_{t=0}^{g} \partial_i \Delta \mathrm{POP}_{t-1} + \sum_{t=0}^{h} \theta_i \Delta \mathrm{FD}_{t-1} + \sum_{t=0}^{i} \forall_i \Delta \mathrm{MAN}_{t-1} + \varepsilon_t$ ……………………………………………………………..........5.10

Where δ_0 is the random walk or drift component and Δ is the first difference operator. Here the α_{i} denote the long-run multipliers while the terms with summation signs ($\sum$) are used to model the short-run dynamic structure. Appropriate lag length is selected based on the Schwarz-Bayesian criteria (SBC). The test procedure follows the F-test or Wald statistics.

Once cointegration is established, the second stage involve the estimation of the following conditional ARDL (a, b, c, d, e, f, g, h, i) long-run model:

$\Delta CO2_t = \delta_0 + \sum_{t=0}^{a} \sigma_i \Delta CO2_{t-1} + \sum_{t=0}^{b} \pi_i \Delta GDP_{t-1} + \sum_{t=0}^{c} \beta_i \Delta GDP^2{}_{t-1} + \sum_{t=0}^{d} \gamma_i \Delta GDP^3{}_{t-1} + \sum_{t=0}^{e} \omega_i \Delta \mathrm{EC}_{t-1} + \sum_{t=0}^{f} \emptyset_i \Delta \mathrm{TO}_{t-1} + \sum_{t=0}^{g} \partial_i \Delta \mathrm{POP}_{t-1} + \sum_{t=0}^{h} \theta_i \Delta \mathrm{FD}_{t-1} + \sum_{t=0}^{i} \forall_i \Delta \mathrm{MAN}_{t-1} + \varepsilon_t$
…………………………………………………...5.10

Where all variables are as previously defined. Estimation of equations (5.11) involve the selection of the optimal lag orders of the ARDL (a, b, c, d, e, f, g, h, i). Finally, short-run dynamic parameters of the model associated with the long-run estimates can be obtained by estimating the following error correction model (ECT) as specified thus:

$\Delta CO2_t = \delta_0 + \sum_{t=0}^{a} \sigma_i \Delta CO2_{t-1} + \sum_{t=0}^{b} \pi_i \Delta GDP_{t-1} + \sum_{t=0}^{c} \beta_i \Delta GDP^2{}_{t-1} + \sum_{t=0}^{d} \gamma_i \Delta GDP^3{}_{t-1} + \sum_{t=0}^{e} \omega_i \Delta \mathrm{EC}_{t-1} + \sum_{t=0}^{f} \emptyset_i \Delta \mathrm{TO}_{t-1} + \sum_{t=0}^{g} \partial_i \Delta \mathrm{POP}_{t-1} + \sum_{t=0}^{h} \theta_i \Delta \mathrm{FD}_{t-1} + \sum_{t=0}^{i} \forall_i \Delta \mathrm{MAN}_{t-1} + nECT_{t-1} + \varepsilon_t$
…………………………………………………...5.11

Where ECT is the error correction term (representing the residual of the co-integrating equation) and n represents its coefficient. The error correction coefficient shows how quickly the variables converge to equilibrium and should be statistically significant and negative.

3.8 Sources of data

The data gathered for this research are entirely secondary sources materials. This mainly originated from data collection from field work, central Bank of Nigeria statistical bulletin (CBN), Nigeria Bureau of Statistics (NBS) and World Bank Development index.

3.8.1 Key Variables

The variables used in this study are Carbon dioxide emissions (CO2), income per capita, Capita (GDP), Energy consumption (EC), Population density (POP), financial development (FD), Trade Openness (TO) and Manufacturing.

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents the empirical results of the findings from the analyses carried out. It first presents the descriptive statistics of the series used in the model estimation. In order to avoid running spurious regression in the empirical estimations of the specified model, the results of the unit root test are carried out to ascertain the level of stationarity of the data (series) as presented in the second section of this chapter. The third section concerns with the results of the Autoregressive Distributed Lag (ARDL) approach to cointegration. This is followed by the results of Non-linear ARDL (NARDL) in section four, cointegration test results from the NARDL is also presented therein. The results for asymmetric effects of some of the determinants of CO2 emission are also detailed in section five; section six contains the pairwise granger causality test results to determine the direction of causality among the variables, while section seven draws conclusions from the empirical results carried out.

4.2 Descriptive Statistics of the Series

The summary statistics shows the mean, maximum, minimum, skewness and the pattern of the distributions of the variables. Results from Table 1 show, for instance that the squared and the cubic logarithmic values of GDP per capita ($LOGGDP^2$&$LOGGDP^3$), Population (LOGPOP), and Financial development (LOGFD) respectively exhibited higher average values in order of magnitude while the least is carbon emission (LNCO2). Also, from the table the level of asymmetry of the distribution of the series around the mean is measured by the skewness. The skewness of normal distribution is zero (0); hence, values of variables above zero show that such series are positively skewed, or otherwise. Based on this, all the variables are positively skewed except CO2 that is negatively skewed.

Table 4.1: Descriptive Statistics of the Variables

	LOG CO2	LOG GDP	LOG GDP^2	LOG GDP^3	LOG EC	LOG TO	LOG POP	LOG FD	LOG MAN
Mean	0.597683	7.383526	14.76705	22.15074	6.577386	57.27275	4.897151	15.09417	24.30603
Median	0.617537	7.257544	14.51509	21.77393	6.570661	58.41800	4.887862	13.47500	19.47800
Maximum	0.873822	7.848970	15.69794	23.54464	6.682488	110.3050	5.567772	38.39000	54.20700
Minimum	0.307995	7.048496	14.09699	21.14853	6.509513	18.28700	4.443357	8.710000	6.452000
Std. Dev.	0.169908	0.269661	0.539322	0.808755	0.050610	18.31342	0.283085	6.083239	15.39634
Skewness	-0.035450	0.573292	0.573291	0.573328	0.378546	0.115602	0.228152	2.456242	0.694477
Kurtosis	1.818841	1.717051	1.717052	1.716201	1.814860	4.001238	2.250932	9.306858	2.147129
Jarque-Bera	2.100246	4.440915	4.440912	4.444438	2.966618	1.583900	1.153974	95.86344	3.984875
Probability	0.349895	0.108559	0.108560	0.108368	0.226886	0.452961	0.561588	0.000000	0.136363
Sum	21.51660	265.8069	531.6138	797.4265	236.7859	2061.819	176.2974	543.3900	875.0170
Sum Sq. Dev.	1.010408	2.545097	10.18039	22.89297	0.089649	11738.34	2.804789	1295.203	8296.655
Observations	36	36	36	36	36	36	36	36	36

Source: Author's computation from Eviews9 (2018).

Again, from the summary statistics in Table 4.1 above, the values for the kurtosis of the variables measures the Preakness or flatness of the distribution of the series. For kurtosis, the normal distribution is 3. If the values exceed 3, the distribution is assumed to be peaked (leptokurtic) relative to the normal, if it is less than 3, the distribution is flat (platykurtic) relative to the normal. Hence, all the series in the Table are platykurtic relative to the normal because they exhibit values less than 3.

For the normality of the distribution, the Jarque-Bera statistics is used. The underlying null hypothesis is that the series is normally distributed. Thus, if the probability values of Jarque-Bera are significant at either 1% (0.01), 5% (0.05) or 10% (0.10), the null hypothesis is rejected. On this note, the variables in Table 1 above are normally distributed as the null hypothesis stands accepted.

4.3The Unit Root Results

This test statistic help determines whether variables of the models are stationariy or otherwise. This is necessary because the empirical results obtained from the series could be spurious if non-stationary series are regressed on one another. Thus, results in Table 2 show the unit root test using the Augmented Dickey Fuller (ADF) test. The orders at which these variables achieve stationarity are put in the remark section of the table 4.2 below:

Table 4.2: Unit Root Test from Augmented Dickey Fuller (ADF)

Variable	Level		First Difference		Remark
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	
LNCO2	-2.15563	-2.11997	-5.68964	-5.61165	I (1)
	(0.2254)	(0.5173)	(0.0000)*	(0.0003)*	
LNGDP	0.170323	-2.30831	-4.34421	-4.64371	I (1)
	(0.9666)	(0.4187)	(0.0016)*	(0.0038)*	
$LNGDP^2$	0.173949	-2.307533	-4.345886	-4.648091	I (1)
	(0.9666)	(0.4191)	(0.0016)*	(0.0037)*	
$LNGDP^3$	0.173949	-2.307533	-4.345886	-4.648091	I (1)
	(0.9666)	(0.4191)	(0.0016)*	(0.0037)*	
LNEC	-2.30149	-3.45669	-8.24943	-8.07331	I (1)
	(0.1771)	(0.0602)***	(0.0000)*	(0.0000)*	
LNTO	-0.78845	1.484508	-1.63283	-5.63156	I (1)
	-0.78845	1.484508	-1.63283	-5.63156	
LNPOP	0.65327	-6.21045	-4.60971	-4.21489	I(0)
	(0.8991)	(0.2900)	(0.0000)*	(0.0000)*	I(1)
LNFD	-0.0751	-2.11483	-4.25202	-4.18034	I(0)
	(0.9445)	(0.0052)*	(0.0020)*	(0.0119)*	I(1)
LNMAN	-6.159828	-3.042594	-7.079495	-6.514228	I (1)
	(0.0000)*	(0.1357)	(0.0000)*	(0.0000)*	

Source: Author's computation from Eviews9 (2018).

*Note. *, **, and *** indicate the rejection of null hypothesis of non-stationary at 1 percent, 5 percent, and 10 percent level of statistical significance. Figures in parenthesis denote the P-values for each of the tests, and NA represents not available*

From the unit root test results, it can be seen that all the variables, except Financial Development (FD) and Population exhibit both level and first difference stationarity. That is, other variables, CO2, Energy consumption per capita (EC), GDP per capita, Trade openness (TO) and Manufacturing (MAN) are stationary at first difference; hence their order of integration is denoted as I (1). These mixture of levels and first difference stationary variables suggest that autoregressive Distributed lag (ARDL) in the fashion of Peseran, et al., (2001) is followed in the next section.

4.4 ARDL Results

The results of the linear ARDL for the series that appear to cointegrate at different orders as seen in Table 2 is tested with the bound test to determine the possibility of cointegration of the series. Thus, the bound test results in Table 4.3 show that the computed F-statistics with corresponding Likelihood ratios for the variables are higher than the upper critical bound at 5% and 10% critical value.

Table 4.3: Bound Test Results for Linear Cointegration

ARDL Bounds Test

Date: 08/08/18   Time: 14:10

Sample: 1984 2016

Included observations: 33

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	51.77635	9
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	1.88	2.99
5%	2.14	3.3
2.5%	2.37	3.6
1%	2.65	3.97

Source: Computed by the Author from Eviews9 (2018)

Since the value of F statistics is 51.77635 and is higher than the upper and lower bound critical values, the ARDL co-integration tests affirm that the null hypothesis of no long run relationship among the variables is rejected; hence, there is a long run relationship among the variables.

Table 4.4: ARDL Long Run Coefficients.

Variables (Regressors)	Coefficient	Std. Error	t-Statistic	Prob.*
	Dependent Variable: LNCO2			
GDP(-1)	0.001121	0.000470	2.387400	0.0542**
$LNGDP^2$	-36.699515	17.535068	-2.092921	0.0813***
$LNGDP^3$	23.936051	11.557621	2.071019	0.0838***
LNEC	-1.032059	0.521826	-1.977784	0.0953***
LNTO	0.000579	0.000667	0.868147	0.4187
LNPO	-0.463635	0.216161	-2.144857	0.0756***
LOGFD	0.001666	0.001127	1.478018	0.1899
LNMAN	-1.138536	0.281673	4.042041	0.0012*
C	21.491608	8.176269	2.628535	0.0391**

R-squared = 0.965719

Adjusted R-squared = 0.940532

S.E. of regression = 0.045846

F-statistic = 12.83786

Prob(F-statistic) = 0.000008

Durbin-Watson stat.= 2.766373

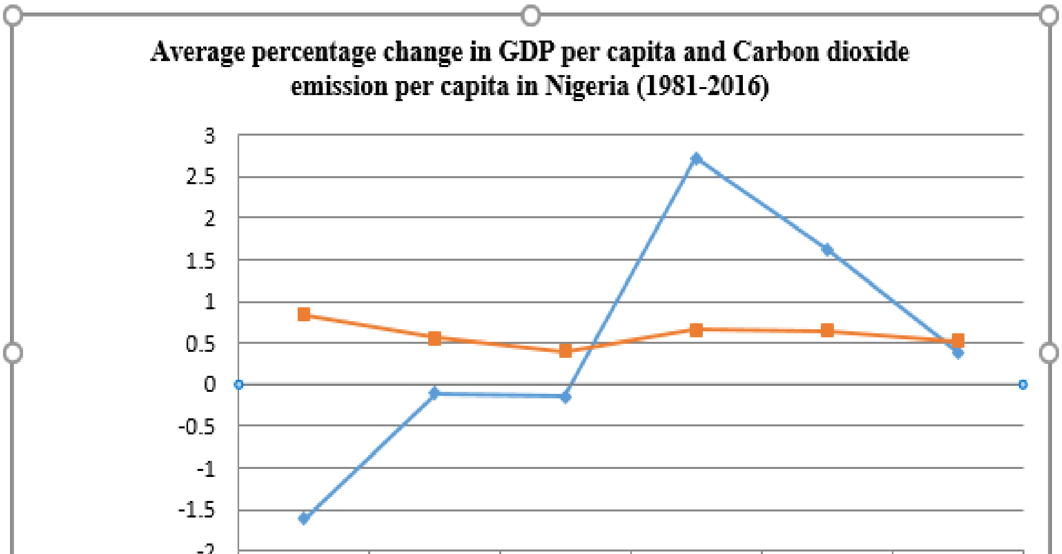
Source: Author's computation from Eviews9 (2018).

Note. *, **, and **indicates the rejection of null hypothesis of non-stationary at 1 percent, 5 percent, and 10 percent level of statistical significance.

Having established that the variables have mixed level or order of cointegration, the results of the linear cointegration of the series in ARDL fashion and the result is divided into short run and long run dynamics of the cointegrations as shown in Table 4 and 5. It can be seen from the results of linear ARDL that, especially from the long run coefficients of the regressors in Table 4 that the selected macroeconomic variables are empirically significant as determinants of long run changes in the level of carbon dioxide emissions except trade openness and financial development in Nigeria. From the table, it could be seen that the long run elasticity of CO2 emission with respect to GDP^2 in Nigeria is negative as theoretically expected. The result implies that holding all other factors constant, a percentage increase in the square of log of GDP per capita ($LOGGDP^2$) decreases CO2 emission by 36.7 %. However, there is a positive relationship between CO2 emission and GDP per capita level as expected. Here, a 1 percent increase in the log of GDP per capita (LNGDP), worsens carbon emission by 0.01%, implying that economic growth weakly determines carbon dioxide emissions in Nigeria. Moreover, a 1 percent increase in the cubic function of GDP, worsens carbon emissions by 23.94% in the long run. This shows that further increase in GDP in the future will worsen environmental pollution. The magnitude of impacts of the quadratic function of GDP shows that as Nigerian economy grows exponentially (which ought to include improvement in clean energy technologies), carbon emission is expected to decrease exponentially. The result for energy consumption also reveals that a 1 percent increase in total energy consumption will lead to a decrease in carbon emission by 0.79 %, implying that the bulk of carbon emission in Nigeria may not be caused directly by household end-users of energies; rather, it may be industrial based and Nigeria is still experiencing low pace of industrialization that could stimulate increase in emissions. This decrease in emissions as energy consumption increases could be attributed to changes in inefficient energy use and gradual adoption of renewable energy among Nigerians. The interesting finding from this analysis is that Nigeria could increase energy consumption for increased economic growth without harming the economy as Nigeria plans for industrial expansion to become one of the world largest economy. From the table above, financial development (measure of the ratio of credit to the private sector) is negatively related to carbon dioxide emission which contradicts the result expected. Though, the impact is not statistically significant. Most studies have viewed financial development as a strong emission induced macroeconomic variable, however Lanoje et al. (1998) noted that efficient financial market provides incentives to its companies or firms to comply with environmental regulations that help to mitigate environmental degradation. Such regulations would have been coming up in Nigeria. The other macroeconomic variables such as Population density is found to negatively impact CO2 emission. This result contradicts the apriori expectation as population is a strong emitter of carbon dioxide emission. This could imply that access to energy is in short supply in Nigeria to serve the increasing demand for it. The result shows that increase in population reduces carbon dioxide emission by 0.46%. The global awareness of climate change might have shaped the behaviour of the growing population towards clean energy access and reduction in inefficient energy use such that increase in population would reduce carbon dioxide emissions in the long run. This is a great discovery seeing the rapid growth of Nigerian population and the fear of continuous increase in carbon dioxide emissions which could worsen climate change threat. Also, trade openness shows a positive function of carbon dioxide emissions but statistically insignificant. This implies that greater openness to trade in Nigeria would cause increase in carbon emissions. Manufacturing which is the share of the value added to GDP is statistically significant but shows negative relationship with carbon dioxide emissions. Specifically, a percentage increase in manufacturing decreases carbon dioxide emissions by 1.14%. This contradicts the expectation seeing that manufacturing contributes much to increase in emission especially emissions from cement industry, petroleum refining, petrochemicals, gas flaring etc. This could mean that most of the industries that heavily emit pollutions have relocated to other countries where they could have reliable access to electricity or have adopted energy efficiency in industry operation and renewable energy for productive uses. Also, few industries such as cement industry, petroleum refining, petrochemicals are in operation in Nigeria and also industrialization is still at a lower level. This finding reveals that Nigeria could make efforts to expand her industrial base in her quest for development since expansion of her industrial base will have negative impact on carbon dioxide emissions in the long run.

The coefficient of the determination of the model, through R-squared and its adjusted value, as well as F-test show that the selected macroeconomic variables are significant predictors of carbon emission in Nigeria for the period of time covered in the study. Specifically, F-statistic equals 12.83786 shows the overall significance of the model while The Adjusted R squared equals 0.940532 implies that 94% variation in carbon dioxide emission is explained by the regression model.

The next objective is to find out if EKC hypothesis holds in Nigeria or not on the bases of the empirical findings from the modified macroeconomic framework from table 4 above. The conditions as theoretically indicated, is that when GDP is positive, GDP^2 is negative and GDP^3 is positive, this indicates an N-shaped relationship between per capita income and the environment, while when GDP is negative, GDP^2 is positive and GDP^3 is negative, the result indicates an inverse of the N-shaped relationship between per capita income and the environment. Also when GDP is positive, GDP^2 is equal to zero and GDP^3 is equal to zero, the model connotes monotonically increasing relationship between income and environment and a U –shaped relationship between income while when GDP is positive, GDP^2 is negative and GDP^3 is equal to zero, it connotes an inverted U-shaped relationship between income and the environment and thus suggesting the validity or existence of EKC. Hence, from the long run ARDL estimate, the results show that GDP per capita is positive, GDP^2 is negative and GDP^3 is positive which validates N-shaped relationship between per capita income and the environment in Nigeria. The finding therefore shows that there is no existence of EKC in Nigeria. This finding complies with the findings of Ozoemena et. al. (2017) and Busayo (2016) and refutes the studies by Oshin and Ogundipe (2015), Aduebe (2013), Nnaji et al... (2013), and Oyedepo (2014) who confirmed the existence of EKC in Nigeria. As already mentioned from the literature, the previous studies on this topic have suffered wrong methodological approach, lack of appropriate diagnostic tests and macroeconomic variable bias. Most of the studies have failed to apply non- linear cubic function which captures the long run and short run behaviour of macroeconomic variables and thereby favouring the EKC which states that environmental degradation is a quadratic function of income. Many researchers such as Martinez-Zarzoso and Bengochea-Morancho (2004) argued that cubic model best represents the relationship between CO2 emissions per capita and GDP per capita. This methodological error could have been the reason the previous studies could not result to convincing empirical findings. As a result of this inconclusive findings over time in this study, the policy recommendations have been inconclusive to be applied across countries.



	1981-1986	1987-1992	1993-1998	1999-2004	2005-2010	2011-2016
% DLOGGDP	-1.61	-0.11	-0.14	2.71	1.62	0.39
Co2	0.84	0.56	0.4	0.65	0.64	0.52

Fig. 4.1: Empirical Relationship between Per Capita income and CO2 Emissions

Source: Computed by the author using underlying data from WDI, 2017.

From the trend estimate of the relationship between carbon dioxide emission and the GDP per capita for the period covered in this study, the trend has exhibited N-Shaped relationship. For example, between 1981 and 1986, emission increased with increase in per capita income and reaches a point after which it falls further between 1992 and 1998. From the figure also, it could be seen that emission rose between 1999 and 2004 during the period of growth in GDP per capita and became flat between 2004 and 2010 and then gradually falls after 2010 along with fall in the GDP per capita. However, the shape of this trend shows that Nigeria has not attained the turning point at which emissions has started falling continuously which violates the EKC hypothesis. This implies that per capita income level of Nigeria has not reached the threshold level at which emissions will continue to fall and as a result of that, the total shift to renewable energy and clean energy technologies among Nigerian people will still be limited with low level of income in the long run. Therefore, it becomes important for government to stimulate economic growth through industrialization with increase in clean energy supply since increase in energy supply is found to negatively related to emissions. This means that Nigeria will not harm the economy as it expands its industrial base and put in all the necessary policies that will favour financial development since this variable negatively relate to carbon dioxide emissions. The policies to moderate the behaviour of the share of private sector to GDP would have been organized such that its impact reduces carbon dioxide emission. As a matter of fact, Nigeria is presently committed to reducing greenhouse gas emissions unconditionally by 20% and conditionally by 45%, which is in line with Nigeria's Nationally Determined Contributions (NDCs). In partnership with the Ministry of Finance, the Ministry of Environment was finalising preparations for a green bond issuance during the first half of the year 2016. The green bond issuance is aimed at attracting investments for low carbon infrastructure development relevant to the targets set in the NDCs in priority projects in renewable energy, transport and afforestation. From the trend figure above, emission fell from 0.64 metric tons between 2005 and 2010 to 0.52 metric tons between 2011 to 2016. This shows that the Ministry of Finance and Federal Ministry is making some significant policy efforts to fulfil the intended Nationally Determined Contributions under Paris Agreement ratified in the UN, (2016). The empirical finding from this study shows that the issuance of green bond to polluters and incentives to private sector in renewable energy investments is making a significant impact on emissions reduction in Nigeria. The evidence could be seen from the negative relationship among energy consumptions, financial development and carbon dioxide emissions which means that increase in these variables will significantly reduce emissions in the long run. Hence, the empirical analysis goes beyond long run to look at the short run dynamics and diagnosis by applying Error Correction Term (ECT) to investigate the period at which the long run disequilibrium is adjusted to long run equilibrium in the following year. This is a measure of the speed at which carbon dioxide emissions will return to long run equilibrium after changes in the short run macroeconomic determinants as shown in the table 4.5 below:

Table 4.5: Short run Dynamics and Diagnosis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNCO2				
DLOG(CO2)	0.539573	0.059032	9.140318	0.0001**
D(GDP(-1))	0.001904	0.000702	2.711636	0.0350**
D(GDP(-2))	0.000120	0.000084	1.424657	0.2041
DLOG(GDP2)	-4.892550	8.571752	-0.570776	0.5889
DLOG(GDP2(-1))	13.129809	9.190004	1.428706	0.2030
DLOG(GDP3)	3.302775	5.732188	0.576181	0.5854
DLOG(GDP3(-1))	-9.035261	6.120848	-1.476145	0.1904
DLOG(EC)	0.674895	0.451323	1.495371	0.1854
DLOG(EC(-1))	0.940296	0.370956	2.534794	0.0444**
D(TO)	0.000066	0.000590	0.111216	0.9151
D(TO(-1))	-0.000705	0.000841	-0.838161	0.4341
DLOG(POP)	0.238577	0.168360	1.417068	0.2062
DLOG(POP(-1))	-113.577660	32.683150	-3.475114	0.0132**
D(FD)	0.002927	0.001430	2.047194	0.0866**
D(LNMAN)	1.138536	0.281673	4.042041	0.0012**
D(LNMAN(-1))	-0.303720	0.191666	-2.584634	0.1354
CointEq(-1)	-1.244889	0.083806	-14.854355	0.0000
Diagnosis				
Tests	F-statistic	P-value		
Breusch-Godfrey Serial Correlation LM Test:	17.47333	0.0105**		
Heteroskedasticity	0.788339	0.6946		
RAMSEY Test	3.357298	0.1264		

Source: Author's computation from Eviews9 (2018).

Note. *, **, and **indicate that the variables are significant at 1 percent, 5 percent, and 10 percent level of statistical significance.

Table 4.5 above reports the result of short run dynamics of the selected macroeconomic variables and CO_2 emission in Nigeria. The negative statistically significant estimate of the Error Correction Term (CointEq(-1) indicates the dynamic nature of the relationships of the variables. Again, since its coefficient is significant and negative, it reveals the speed of dynamic adjustment of the short run to the long run equilibrium of these variables in relation to the dependent variable. Since its coefficient is -1.234869, it means that about 12.3 percent of the deviations from long run equilibrium are corrected for in the succeeding fiscal year. In all, in the short run however, changes in trade openness did not statistically cause increase in carbon emission, while other variables significantly cause positive and negative changes as shown in the table above.

The short-run model also passes through a series of standard diagnostic tests such as functional form specification test (Ramsey test), correlation test, normality and heteroscedasticity.

With respect to diagnostic test, the result for serial autocorrelation test with the null hypothesis that there is no serial autocorrelation in the series is violated because the F-statics value for it and its corresponding probability show rejection of the null hypothesis. Hence, some of the series, especially GDP and its quadratic and cubic values may be serially correlated with each other. On the part of Heteroscedasticity test, the null hypothesis is that the variances for the errors are equal is accepted because the p-value shows insignificant value for its F-statistics. Lastly, the null hypothesis of Ramsay reset test states that the functional form of the estimated model is correctly specified. Based on the values of its f-Statistics and its corresponding P-values that is insignificant, the null hypothesis is accepted, and so the model is correctly specified to produce valid empirical findings.

4.5 Non Linear Autoregressive Distributed (NARDL) Results

The levels of dynamic relationship of many macroeconomic indicators or variables as determinants of CO_2 emission have severally proved to be non-linear. It is possible that positive and negative changes in energy consumption, GDP per capita, and Manufacturing can have differential impacts on CO_2 emission. That is, there is possibility of seeing various macroeconomic variables that determine CO_2 emission to have asymmetric effects on carbon dioxide emissions. Thus, to test for this, the variables were bifurcated or decomposed into positive and negative changes to be able to account for their asymmetric effects. Thus, evidence from NARD results is presented in Table 6 below:

Table 4.6: NARDL Long Run Coefficients AND THE Short Run Dynamics

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Coefficients				
C	-0.449743	0.155715	-2.888245	0.0107**
LNCO2_N(-1)	-0.761584	0.110551	-6.888994	0.0000*
LNEC_N(-1)	-0.350453	0.364110	-0.962490	0.3501
LNEC_P(-1)	0.961467	0.244543	3.931689	0.0012*
LNGDP_N(-1)	-0.269685	0.574829	-0.469156	0.6453
LNGDP_P(-1)	0.123217	0.110101	1.119132	0.2796
LNMAN_P(-1)	0.303890	0.147908	2.054580	0.0566**
LNMAN_N(-1)	-0.432080	0.107667	-4.013106	0.0010*
R-squared	0.889307	Adjusted R-squared		0.792451
F-statistic	9.181749	S.E. of regression		0.040822
Prob(F-statistic)	0.000036	Durbin-Watson stat		2.813274
Short Run Coefficients				
D(LNEC_N(-2))	-5.841917	0.822428	-7.103259	0.0000*
D(LNEC_P(-3))	0.974465	0.237459	4.103715	0.0008*
D(LNGDP_P(-3))	2.029798	0.540748	3.753689	0.0017*
D(LMAN_N(-3))	-0.769984	0.238702	-3.225705	0.0053*
D(LNMAN_N(-2))	-0.386689	0.164537	-2.350174	0.0319**
D(LNGDP_P(-2))	0.905602	0.487748	1.856700	0.0819***
D(LNEC_P(-2))	0.387869	0.252476	1.536258	0.1440

Source: Author's computation from Eviews9 (2018).

Note. *, **, and **indicate that the variables are significant at 1 percent, 5 percent, and 10 percent level of statistical significance. P and N denote positive and negative changes in a given variable as regard to asymmetric nature of the variables.

From the results of NARDL output shows that -0.350453 and 0.961467 are the coefficients for positive and negative changes in energy consumption per capita respectively. However, since the model is NARDL, the values are not the long run coefficients. Their long run coefficients are obtained by dividing each of these coefficients by the coefficient of the one period lagged value of the dependent variable (LNCO2) used as a regressor. That is, for LNEC_P, the value should be -0.350453 /-

0.761584= -1.112037, and that of LNEC_N as 0.961467/ -0.761584= -1.262457. Doing that for the remaining long run coefficients of the variables, the long run equation can be fitted as:

$$\Delta LNCO2 = -0.449743 - 1.112037 LNEC\_P - 1.262457 LNEC\_N + 0.354111 LNGDP\_P - 0.161790 LNGDP\_N - 0.399024 LNMAN\_P + 0.567344 LNMAN\_N + \varepsilon$$

Based on this fitted long-run regression equation, and the corresponding P-values of the long run coefficients, it is only negative change in energy consumption that will increase pollution. That is, in the long run, a 1 percent increase in negative changes in energy consumption will increase carbon emission by 1.26 percent. Thus, improvement in energy use and shift to renewable energy is hoped to decrease emission in the long run. For the GDP per capita, the long run coefficient shows insignificant results. Thus, once economy improves, extent of pollution would likely be controlled. Similarly, improvement in manufacturing technology would likely cause low emission in the long run based on this result, while negative changes in the manufacturing process can cause increase in pollution.

From the short run coefficients in the lower part of results in Table 4.6, it can be seen that short-run dynamics of shocks in energy consumption per capita, GDP per capita and the level of Manufacturing will have impact on carbon emission. Precisely, positive changes in these variables would likely lead to immediate shocks and increase pollution instantaneously up to three lag periods.

4. 5.1 Asymmetric Cointegration Test from NARDL Model

Having estimated the NARDL, it is expected to check whether the estimated results from NARDL are spurious or otherwise. On this note, wald test cointegration test is suitable and results are usually checked against the critical values of bound testing in pesran et al (2001). Hence, if the calculated F statistics is found to be the greater than the upper critical value, there is evidence of co-integration. If otherwise, there is no couintegration.

Table 4.7: Wald Test:

Equation: Untitled

Test Statistic	Value	Df	Probability
F-statistic	13.64290	(6, 16)	0.0000
Chi-square	81.85738	6	0.0000

Null Hypothesis: C(2)=C(3)=C(4)=C(5)=C(6)=C(7)=C(8)

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2) - C(8)	-0.329504	0.083349
C(3) - C(8)	0.081627	0.376933
C(4) - C(8)	1.393546	0.351757
C(5) - C(8)	0.162395	0.585734
C(6) - C(8)	0.555297	0.089683
C(7) - C(8)	0.735969	0.202508

Restrictions are linear in coefficients.

Source: Author's computation from Eviews9 (2018).

The null hypothesis for the Wald test is that there is no cointegration of the variables. Here, the calculated result for F-statistics is 13.64290, and in comparison with the critical values of pesaran et al (2001), this value falls under I (1). The null hypothesis of no cointegration is rejected.

4. 5. 2 Wald Test for the Presence of Asymmetry

It has been examined from the NARDL results that positive and negative changes in the series (determinants) of CO2 emission. However, are these effects really different from each other statistically? The Wald test helps to verify this. The criterion for decision making is that if the effects are equal, thus, no asymmetric effects, and if otherwise, assumption of asymmetries holds for the model.

Table 4.8: Wald Test: for the presence of Asymmetry

Equation: Untitled

Test Statistic	Value	Df	Probability
F-statistic	20.50997	(5, 16)	0.0000
Chi-square	102.5499	5	0.0000

Null Hypothesis: -C(3)/C(2)=-C(4)/C(2)=-C(5)/C(2)=-C(6)/C(2)=-C(7)/C(2)=-C(8)/C(2)

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-C(3)/C(2) + C(8)/C(2)	0.107181	0.490586
-C(4)/C(2) + C(8)/C(2)	1.829801	0.335456
-C(5)/C(2) + C(8)/C(2)	0.213233	0.771398
-C(6)/C(2) + C(8)/C(2)	0.729134	0.114149
-C(7)/C(2) + C(8)/C(2)	0.966367	0.200976

Delta method computed using analytic derivatives.

Source: Author's computation from Eviews9 (2018).

Decision: Based on the results, the null hypothesis of equality of slope coefficients of the long run equilibrium is rejected at 0.01 level of statistical significance. Hence, there is asymmetry in the *long run impact* of energy consumption, GDP per capita and manufacturing on carbon dioxide emissions in Nigeria.

4.5.3 Granger Causality Test

In view of the dynamic relationship among the variables in this study, especially as evidenced from the NARDL results, there is possibility of these macroeconomic variables to granger cause each other. To be able to examine the direction of causality among them, the pairwise causality results are presented hereunder. From the granger causality test we found that most variables exhibit unidirectional causality. It is only GDP per capita and energy consumption that showed bi-directional causality running from GDP per capita to energy consumption and from energy consumption to GDP per capita. By implication, this shows that when economic output increases, there is likelihood that more energy sources will be utilized. The reverse is also the case when energy consumption increases, per capita income will grow in tandem with such trend. From the table, it could be seen from the table that a unidirectional causality running from carbon emissions to population was observed. This means that when emission increases, there is likelihood that it could be caused by more carbon dioxide emissions released from increase in population in Nigeria. Also, a unidirectional causality runs from manufacturing to GDP per capita is observed and shows that increase in manufacturing output, determines increase in per capita income. more energy will be used, hence, causality that ran from oil price to energy consumption. Also, financial development will unilaterally lead to increase in GDP and not in vice versa account. Although, increase in aggregate output should lead to further financial development, yet it is not so in our results as shown in table 7. Below

Table 4.9: **Granger Causality Test Results**

Date: 08/01/18 Time: 04:35

Sample: 1981 2016

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.	Remark
LNPO does not Granger Cause LNCO2	34	0.25957	0.7732	
LNCO2 does not Granger Cause LNPO		6.20809	0.0057*	LNCO2→LNPOP
LNGDP does not Granger Cause LNEC	34	4.10470	0.0269**	LNGDP↔LNEC
LNEC does not Granger Cause LNGDP		3.78870	0.0345**	
LNMAN does not Granger Cause LNEC	34	6.17072	0.0059*	LNMAN→LNEC
LNEC does not Granger Cause LNMAN		1.08855	0.3501	
LNPOP does not Granger Cause LNEC	34	5.61429	0.0087*	LNPOP→LNEC
LNEC does not Granger Cause LNPO		0.36690	0.6960	
LNGDP does not Granger Cause LNFD	34	0.25111	0.7796	LNFD→LNGDP
LNFD does not Granger Cause LNGDP		4.19998	0.0250**	
LNPOP does not Granger Cause LNFD	34	4.05534	0.0280**	LNPOP→LNFD
LNFD does not Granger Cause LNPO		0.23115	0.7951	
LNMAN does not Granger Cause LNGDP	34	5.11937	0.0125*	LNMAN→LNGDP
LNGDP does not Granger Cause LNMAN		1.95558	0.1597	
LNPOP does not Granger Cause LNGDP	34	5.36734	0.0104*	LNPOP→LNGDP
LNGDP does not Granger Cause LNPO		0.06733	0.9350	

LNTO does not Granger Cause LNGDP	34	4.38014	0.0218**	LNTO→LNGDP
LNGDP does not Granger Cause LNTO		2.93509	0.0691***	
LNPO does not Granger Cause LNMAN	34	5.19053	0.0118*	LNPO→LNMAN
LNMAN does not Granger Cause LNPO		1.26994	0.2960	

Source: Author's computation from Eviews9 (2018).

Note. *, **, and **indicatethe rejection of null hypothesis of no granger cause relation between variables at 1 percent, 5 percent, and 10 percent level of statistical significance. Only variables pairs that at least one argument is significant are included in the table.

CHAPTER FIVE

DISCUSION OF RESULTS, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Discussion of the findings

Increasingly, the level of economic growth and development in virtually all developing countries comes with its attendant effects of environmental pollution. In fact, as economies transit, increased energy consumption is apparently reckoned, and so pollutants are emitted ceaselessly. Thus, the level of carbon dioxide emission challenges sustainable development agenda as climate change endangers the ecosystem. It is against this background that this study aimed at econometric analysis of the determinants of Carbon dioxide emission in Nigeria spanning the period of 1981 to 2016. The study applied both linear and non-linear Autoregressive Distributed Lag cointegration approach to examine the dynamic relationship of the determinants of carbon emission in Nigeria.

The main variables of interest examined as potential predictor of carbon dioxide emission include: energy consumption (EC), financial development (FD), gross domestic product (GDP), population (POP), trade openness (TO) and manufacturing (MAN) among others. The results from the summary statistics of the variables revealed that all the variables were normally distributed based on Jarque-Bera statistics used. Natural logarithmic values of the variables were used in testing for the level of stationarity of the series using an Augmented Dickey Fuller (ADF) unit root test and the results showed that all the variables were first differenced stationary except Financial Development (FD) and Population (POP) that were both stationary at level, I (0), and first difference, I (1). With these mixtures of I (0) and I (1) variables, a linear ARDL cointegration approach was estimated. It was found from the bound test that the null hypothesis of no cointegration was rejected and so, both long run and short run coefficients of cointegrations were estimated.

Evidence from ARDL estimations revealed that in the long run, a 1 percentage increase in EC, GDP^2, PO and MAN would likely cause a reduction in carbon emissions by 1.03, 36.7, 0.46 and 1.13 percentages respectively while a 1 percentage increase in GDP, $GDP^{3,}$ FD and TO, would potentially cause 0.001, 23.94, 0.002 and 0.001 percentages increase in total carbon emission in metric tons in Nigeria. In the short run however, the first lagged values of change in Co2, EC, GDP, and GDP^2 would instantaneously cause about 0.53, -0.94, 0.002, and 13.12 percentage changes in carbon dioxide emissions. From these magnitudes of impacts, GDP is indicative of the fact that it is a strong predictor of carbon emission both in the short and long run in Nigeria. Also, change in TO, OP and FD imperatively and significantly determine the level of carbon emission in Nigeria in the short run as well. It was intriguingly found as well that the speed of convergent of the short run shocks (changes) in these determinants to their long run equilibrium as indicated by the dynamic error correction in Table 4 was significant at 1 per cent with a coefficient of -0.86 per cent.

With the understanding that GDP, EC, and MAN are likely going to exhibit asymmetric relationship with carbon emission, a NARDL modelling approach to cointegration was also carried out as seen in Table 5. One of the specific results of interest from the NARDL analysis is that in the long run, a negative change in one period lag of EC by 1 per cent would likely warrants increase in carbon emission by 0.96 per cent. On the part of EC, a 1 per cent increase in its positive/negative series would likely cause 1.11/1.26 decrease in CO2 and 0.35/0.16, 0.57/0.40 per cent increase/decrease in carbon dioxide emissions. Overall, evidence from the NARDL results and Wald test indicate asymmetric nature of cointegration of carbon emission and its determinants in Nigeria since there is no equality of slope for the period covered. Therefore, positive and negative changes are observed among CO2 emissions and its determinants such that emission increases and falls and thereby creating N-Shaped asymmetric relationship among the selected macroeconomic determinants. Again, only GDP and EC that showed bidirectional causality between each other. However, a unidirectional causality running from CO2 emissions to population density was observed which implies that increase in carbon dioxide emission is determined by increase in the emissions released from increase in population density. A unidirectional causality was also found running from energy consumption to GDP per capita. This implies that increase in energy consumption will increase per capita income in Nigeria. This finding stresses the importance of increase in energy consumption in stimulating economic growth in Nigeria. The great challenge facing Nigeria is energy supply which is short of excess demand for it. This has dealt with the Nigerian economy such that the quest for industrialization so that Nigeria will become one of the largest economy in the vision 2020 has been a mere dream. For Nigeria to expand her industrial base without harming the economy, the place of efficient use of energy and promotion of renewable energy technologies through efficient policies cannot be ignored. Therefore, the findings from this paper will play a significant role in providing efficient adaptation and mitigation policies that will be geared towards ensuring a sustainable economy.

5.2 Conclusion

There are various strands of empirical evidences attesting that carbon emission likely increase in the wake of high output and decrease with low output. In line with such views, this study carried out econometric analysis of carbon emission determinants in Nigeria. In this study, increasing trend of GDP per capita was symmetrically and asymmetrically found to have caused rise in carbon emission. Changes in energy consumption, GDP per capita and manufacturing, all showed to be linearly and non-linearly related to carbon dioxide emission. The interesting finding is the negative relationship found between carbon emissions and energy consumption which shows a significant impact of green bond that has been recently introduced in Nigeria in a bid to fulfil the Independent Nationally Determined Contributions (INDCs). This shows that Nigeria could expand energy consumption without harming the environment. An N-shaped relationship between income and carbon dioxide emissions in Nigeria shows that Nigeria has not reached the threshold level income as suggested by EKC. Therefore, coordinating the macroeconomic determinants of CO2 emissions in the country's energy policy circle and creating a responsible climate policy institution will help a great deal in attaining high growth in income per capita and yet maintaining environmental quality in Nigereia.

5.3 Policy Recommendations

With the knowledge that increases in greenhouse gases poses a threat to an economy, it is necessary for the government of Nigeria to work out formidable energy and environmental policies that will help in addressing the challenge of greenhouse gas emission. As part of the policy fallouts from the empirical findings of this study, Nigeria should be tenacious in meeting the requirement in the signed pacts of the Paris Agreement on greenhouse gas emission and her Nationally Determined Contributions (NDCs) to reduce GHG emission conditionally by 20% and conditionally by 45%. Therefore, to ensure increase in economic growth while maintaining environmental quality, government and the concerned agencies should consider the following policy recommendations:

1. In partnership with the Ministry of Finance, and the Ministry of Environment, the government of Nigeria should maintain expenditure on infrastructures that are

environmentally friendly and encourage renewable energy investors through subsidies and incentives so that as the economy grows, the threat of climate change can be adapted and mitigated through reduction in emissions.

2. It was found that energy consumption and financial development negatively responded to carbon dioxide emissions in the long run, therefore, the Ministry of finance in partnership with the ministry of environment should strengthen efforts already signed in the first half of the year 2016 towards issuance of green bond. The policy tool of environmental tax should also be utilized immensely. In this case, taxing polluters for externality will in a way help to succour adverse effects of pollution (emission) from industrialists.

3. A unidirectional causality was found between energy use and per capita GDP. Therefore, government should increase energy supply to meet excess demand for it since increase in energy use per capita is the bedrock to stimulating increased per capita GDP which is currently low in Nigeria. And from the economic –environment relationship, the N-shaped case of Nigeria, shows that Nigeria is still far from the threshold income level needed to stabilize fall in carbon dioxide emissions. Therefore, boosting the supply of energy through different clean technologies will undoubtedly stimulate economic activities and increase per capita income level in Nigeria.

4.From the long run asymmetric impact of macroeconomic variables, a negative change in energy use worsens emissions. Thus government should set up energy efficient measures that will improve energy use such as burning of fossil fuel generator for power supply and promote access to renewable energy which is hoped to decrease emissions in the long run.

5. African led research is essential and currently insufficient to build climate resilient economy, therefore efforts should be geared by the Nigerian government to expand investment on Research and Development (R&D) to be able to discover alternative energy sources that will lead to capacity production while maintaining low level of carbon dioxide emissions.

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APPENDICES

Table 1: Data

Year	GDP	GDP^2	GDP^3	Co2	pop	TO	FD	EC	MAN
1981	1654.633	2737812	4.53E+09	0.873822	85.06	63.399	15.63	676.387	51.972
1982	1595.146	2544489	4.059E+09	0.846782	87.25	54.956	17.92	691.781	54.207
1983	1476.665	2180541	3.22E+09	0.754192	89.48	63.78	17.00	693.556	53.698
1984	1410.679	1990015	2.807E+09	0.854322	91.81	74.454	16.16	677.765	42.167
1985	1489.424	2218384	3.304E+09	0.835908	94.23	74.202	15.43	682.819	50.5
1986	1324.115	1753281	2.322E+09	0.856517	96.73	44.345	20.04	671.499	51.597
1987	1151.126	1325090	1.525E+09	0.673575	99.31	46.806	14.44	676.856	38.616
1988	1205.805	1453965	1.753E+09	0.782169	101.94	49.811	12.94	678.856	42.935
1989	1250.683	1564207	1.956E+09	0.457129	104.6	58.54	9.24	684.448	31.909
1990	1374.437	1889076	2.596E+09	0.400572	107.3	62.499	8.71	697.192	29.931
1991	1331.612	1773191	2.361E+09	0.409453	110.04	77.575	9.40	712.248	33.61
1992	1304.09	1700651	2.218E+09	0.641477	112.83	68.807	13.43	721.97	27.63
1993	1298.441	1685949	2.189E+09	0.567027	115.68	110.305	12.32	715.438	30.931
1994	1277.993	1633266	2.087E+09	0.42585	118.59	88.619	15.04	680.71	37.508
1995	1242.738	1544398	1.919E+09	0.307995	121.58	72.036	10.05	682.27	20.618
1996	1272.729	1619840	2.062E+09	0.351623	124.64	64.568	9.01	693.778	17.075
1997	1276.241	1628791	2.079E+09	0.3539	127.79	68.974	10.69	699.651	18.809
1998	1278.651	1634949	2.091E+09	0.345099	131.02	59.573	13.00	687.118	22.021
1999	1253.048	1570129	1.967E+09	0.375221	134.34	62.569	13.52	694.171	21.551
2000	1287.059	1656522	2.132E+09	0.647072	137.76	64.019	12.35	703.245	17.51
2001	1310.506	1717426	2.251E+09	0.664257	141.27	67.133	16.57	720.04	20.147
2002	1326.243	1758920	2.333E+09	0.762546	144.9	56.713	13.04	724.611	15.814
2003	1426.903	2036053	2.905E+09	0.705683	148.66	53.185	13.82	746.61	14.916
2004	1860.062	3459832	6.436E+09	0.716724	152.55	54.14	13.14	748.341	12.987
2005	1875.03	3515736	6.592E+09	0.753488	156.59	58.296	13.24	757.959	12.071
2006	1976.708	3907376	7.724E+09	0.693421	160.76	56.257	13.18	744.545	11.13
2007	2056.839	4230585	8.702E+09	0.649214	165.08	58.001	25.25	750.783	11.467
2008	2128.667	4531222	9.645E+09	0.639511	169.53	65.472	33.75	752.86	11.196

2009	2216.499	4912870	1.089E+10	0.496985	174.11	53.486	38.39	721.453	12.565
2010	2327.321	5416421	1.261E+10	0.580256	178.83	34.746	15.42	755.989	6.452
2011	2376.639	5648412	1.342E+10	0.589977	183.69	41.774	12.48	778.499	7.106
2012	2412.861	5821897	1.405E+10	0.595563	188.66	35.947	11.80	798.303	7.698
2013	2475.948	6130319	1.518E+10	0.556657	193.75	30.759	12.59	779.852	8.929
2014	2563.092	6569441	1.684E+10	0.451265	198.93	27.124	14.51	763.391	9.636
2015	2562.522	6566520	1.683E+10	0.453457	204.21	20.662	14.21	771.621	9.428
2016	2455.919	6031536	1.481E+10	0.447891	261.85	18.287	15.68	767.506	8.68

Table 2: ARDL BOUND TEST

ARDL Bounds Test

Date: 08/08/18 Time: 14:10

Sample: 1984 2016

Included observations: 33

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	51.77635	9

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	1.88	2.99
5%	2.14	3.3
2.5%	2.37	3.6
1%	2.65	3.97

Test Equation:

Dependent Variable: D(CO2,2)

Method: Least Squares

Date: 08/08/18 Time: 14:10

Sample: 1984 2016

Included observations: 33

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(CO2)	0.493902	0.063352	7.796145	0.0001
DLOG(EC)	0.672721	0.529788	1.269794	0.2447
DLOG(EC(-1))	0.557653	0.366436	1.521829	0.1719
D(FD)	0.001349	0.001369	0.985120	0.3574
D(GDP(-1))	0.001070	0.000645	1.658065	0.1413
D(GDP(-2))	1.86E-05	7.66E-05	0.242593	0.8153

DLOG(GDP2)	9.492386	4.799160	1.977926	0.0885
DLOG(GDP2(-1))	-2.845263	4.462753	-0.637558	0.5440
DLOG(GDP3)	-6.315808	3.210538	-1.967212	0.0899
DLOG(GDP3(-1))	1.646473	2.915120	0.564805	0.5898
D(MAN)	-0.001131	0.001671	-0.676969	0.5202
D(MAN(-1))	0.003842	0.001996	1.924530	0.0957
DLOG(POP)	0.028863	0.149782	0.192701	0.8527
DLOG(POP(-1))	-68.29366	26.39733	-2.587143	0.0361
D(TO)	-0.000149	0.000680	-0.219204	0.8327
D(TO(-1))	0.000136	0.000841	0.161878	0.8760
C	10.54299	8.826457	1.194476	0.2712
LOG(CO2(-1))	0.097885	0.065236	1.500467	0.1772
LOG(EC(-1))	-0.295363	0.547281	-0.539692	0.6061
FD(-1)	0.001178	0.001581	0.745127	0.4805
GDP(-2)	0.000609	0.000576	1.055848	0.3261
LOG(GDP2(-1))	-0.418037	0.459605	-0.909558	0.3933
MAN(-1)	-0.004337	0.004299	-1.008776	0.3467
LOG(POP(-1))	-0.319135	0.296643	-1.075822	0.3177
TO(-1)	0.000237	0.000956	0.247848	0.8114
D(CO2(-1))	-1.141219	0.074939	-15.22874	0.0000

R-squared	0.956788	Mean dependent var	0.002637
Adjusted R-squared	0.935314	S.D. dependent var	0.166168
S.E. of regression	0.020137	Akaike info criterion	-4.947366
Sum squared resid	0.002838	Schwarz criterion	-3.768300
Log likelihood	107.6315	Hannan-Quinn criter.	-4.550646
F-statistic	86.88005	Durbin-Watson stat	3.076660
Prob(F-statistic)	0.000001		

Table 3: ARDL REGRESSION OUTPUT

Dependent Variable: D(CO2)

Method: ARDL

Date: 08/08/18 Time: 14:07

Sample (adjusted): 1984 2016

Included observations: 33 after adjustments

Maximum dependent lags: 2 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (2 lags, automatic): LOG(CO2) LOG(EC) FD GDP(-1)
LOG(GDP2) LOG(GDP3) MAN LOG(POP) TO

Fixed regressors: C

Number of models evalulated: 39366

Selected Model: ARDL(1, 1, 2, 1, 2, 2, 2, 2, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(CO2(-1))	-0.244889	0.083806	-2.922080	0.0266

LOG(CO2)	0.539573	0.059032	9.140318	0.0001
LOG(CO2(-1))	-0.309796	0.063458	-4.881887	0.0028
LOG(EC)	0.674895	0.451323	1.495371	0.1854
LOG(EC(-1))	-1.019397	0.500724	-2.035847	0.0879
LOG(EC(-2))	-0.940296	0.370956	-2.534794	0.0444
FD	0.002927	0.001430	2.047194	0.0866
FD(-1)	-0.000853	0.001081	-0.788861	0.4602
GDP(-1)	0.001904	0.000702	2.711636	0.0350
GDP(-2)	-0.000389	0.000485	-0.801306	0.4535
GDP(-3)	-0.000120	8.40E-05	-1.424657	0.2041
LOG(GDP2)	-4.892550	8.571752	-0.570776	0.5889
LOG(GDP2(-1))	-27.66445	9.300289	-2.974580	0.0248
LOG(GDP2(-2))	-13.12981	9.190004	-1.428706	0.2030
LOG(GDP3)	3.302775	5.732188	0.576181	0.5854
LOG(GDP3(-1))	17.45968	5.988862	2.915359	0.0268
LOG(GDP3(-2))	9.035261	6.120848	1.476145	0.1904
MAN	-0.000955	0.001426	-0.669869	0.5279
MAN(-1)	-0.001522	0.002118	-0.718659	0.4994
MAN(-2)	-0.006826	0.002310	-2.955371	0.0254
LOG(POP)	0.238577	0.168360	1.417068	0.2062
LOG(POP(-1))	-114.3934	32.90767	-3.476193	0.0132
LOG(POP(-2))	113.5777	32.68315	3.475114	0.0132
TO	6.57E-05	0.000590	0.111216	0.9151
TO(-1)	-4.95E-05	0.000649	-0.076361	0.9416
TO(-2)	0.000705	0.000841	0.838161	0.4341
C	26.75466	11.34150	2.359006	0.0564

R-squared	0.965719	Mean dependent var	-0.009282
Adjusted R-squared	0.940575	S.D. dependent var	0.110748
S.E. of regression	0.017154	Akaike info criterion	-5.361505
Sum squared resid	0.001766	Schwarz criterion	-4.137090
Log likelihood	115.4648	Hannan-Quinn criter.	-4.949526
F-statistic	51.06625	Durbin-Watson stat	3.079880
Prob(F-statistic)	0.000040		

*Note: p-values and any subsequent tests do not account for model selection.

Table 4: ARDL LONG AND SHORT RUN REGRESSION OUTPUT

ARDL Cointegrating And Long Run Form

Dependent Variable: D(CO2)

Selected Model: ARDL(1, 1, 2, 1, 2, 2, 2, 2, 2, 2)

Date: 08/08/18 Time: 14:13

Sample: 1981 2016

Included observations: 33

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(CO2)	0.539573	0.059032	9.140318	0.0001
DLOG(EC)	0.674895	0.451323	1.495371	0.1854
DLOG(EC(-1))	0.940296	0.370956	2.534794	0.0444
D(FD)	0.002927	0.001430	2.047194	0.0866
D(GDP(-1))	0.001904	0.000702	2.711636	0.0350
D(GDP(-2))	0.000120	0.000084	1.424657	0.2041
DLOG(GDP2)	-4.892550	8.571752	-0.570776	0.5889
DLOG(GDP2(-1))	13.129809	9.190004	1.428706	0.2030
DLOG(GDP3)	3.302775	5.732188	0.576181	0.5854
DLOG(GDP3(-1))	-9.035261	6.120848	-1.476145	0.1904
D(MAN)	-0.000955	0.001426	-0.669869	0.5279
D(MAN(-1))	0.006826	0.002310	2.955371	0.0254
DLOG(POP)	0.238577	0.168360	1.417068	0.2062
DLOG(POP(-1))	-113.577660	32.683150	-3.475114	0.0132
D(TO)	0.000066	0.000590	0.111216	0.9151
D(TO(-1))	-0.000705	0.000841	-0.838161	0.4341
CointEq(-1)	-1.244889	0.083806	-14.854355	0.0000

Cointeq = D(CO2) - (0.1846*LOG(CO2) -1.0321*LOG(EC) + 0.0017*FD + 0.0011*GDP(-1) -36.6995*LOG(GDP2) + 23.9361*LOG(GDP3) -0.0075 *MAN -0.4636*LOG(POP) + 0.0006*TO + 21.4916)

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CO2)	0.184576	0.061678	2.992556	0.0242
LOG(EC)	-1.032059	0.521826	-1.977784	0.0953
FD	0.001666	0.001127	1.478018	0.1899
GDP(-1)	0.001121	0.000470	2.387400	0.0542
LOG(GDP2)	-36.699515	17.535068	-2.092921	0.0813
LOG(GDP3)	23.936051	11.557621	2.071019	0.0838
MAN	-0.007473	0.003309	-2.258602	0.0647
LOG(POP)	-0.463635	0.216161	-2.144857	0.0756
TO	0.000579	0.000667	0.868147	0.4187
C	21.491608	8.176269	2.628535	0.0391

Table 5: Serial Correlation LM Test:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	17.47333	Prob. F(2,4)	0.0105
Obs*R-squared	29.61075	Prob. Chi-Square(2)	0.0000

Test Equation:

Dependent Variable: RESID

Method: ARDL

Date: 08/08/18 Time: 14:19

Sample: 1984 2016

Included observations: 33

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CO2(-1))	-0.028371	0.038466	-0.737563	0.5017
LOG(CO2)	0.052802	0.025311	2.086163	0.1053
LOG(CO2(-1))	0.006632	0.031530	0.210350	0.8437
LOG(EC)	-0.220500	0.182379	-1.209020	0.2932
LOG(EC(-1))	-0.159838	0.227721	-0.701904	0.5214
LOG(EC(-2))	0.163486	0.166348	0.982793	0.3814
FD	6.20E-05	0.000712	0.087126	0.9348
FD(-1)	-0.000581	0.000489	-1.188565	0.3004
GDP(-1)	-0.000268	0.000336	-0.799954	0.4686
GDP(-2)	0.000572	0.000214	2.677367	0.0554
GDP(-3)	9.37E-06	4.00E-05	0.234299	0.8263
LOG(GDP2)	-1.953993	3.574803	-0.546602	0.6137
LOG(GDP2(-1))	-2.283875	4.347282	-0.525357	0.6271
LOG(GDP2(-2))	-3.136056	4.108499	-0.763309	0.4878
LOG(GDP3)	1.290263	2.392177	0.539368	0.6183
LOG(GDP3(-1))	1.668299	2.776999	0.600756	0.5804
LOG(GDP3(-2))	1.800781	2.736354	0.658095	0.5464
MAN	-0.001203	0.000597	-2.016505	0.1140
MAN(-1)	-0.001733	0.000938	-1.847896	0.1383
MAN(-2)	-0.000609	0.001143	-0.532977	0.6223
LOG(POP)	0.007081	0.069478	0.101924	0.9237
LOG(POP(-1))	3.391554	15.78172	0.214904	0.8404
LOG(POP(-2))	-3.574216	15.66434	-0.228175	0.8307
TO	0.000122	0.000241	0.504567	0.6404
TO(-1)	-0.000116	0.000297	-0.391288	0.7155
TO(-2)	0.000436	0.000387	1.126995	0.3228
C	5.244630	5.536416	0.947297	0.3971
RESID(-1)	-1.419274	0.244679	-5.800559	0.0044
RESID(-2)	-1.021465	0.276637	-3.692433	0.0210

R-squared	0.897295	Mean dependent var	-9.67E-14
Adjusted R-squared	0.178363	S.D. dependent var	0.007428

S.E. of regression	0.006733	Akaike info criterion	-7.516191
Sum squared resid	0.000181	Schwarz criterion	-6.201079
Log likelihood	153.0172	Hannan-Quinn criter.	-7.073696
F-statistic	1.248095	Durbin-Watson stat	2.509273
Prob(F-statistic)	0.465305		

Table 6: Heteroskedasticity Test :

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.788339	Prob. F(25,7)	0.6946
Obs*R-squared	24.35106	Prob. Chi-Square(25)	0.4992
Scaled explained SS	0.791515	Prob. Chi-Square(25)	1.0000

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 08/08/18 Time: 14:20

Sample: 1984 2016

Included observations: 33

Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025621	0.041773	0.613330	0.5591
D(CO2(-1))	-0.000265	0.000351	-0.755466	0.4746
LOG(CO2)	4.09E-06	0.000287	0.014257	0.9890
LOG(CO2(-1))	0.000186	0.000144	1.298230	0.2353
LOG(EC)	0.000335	0.002061	0.162683	0.8754
LOG(EC(-1))	-0.001235	0.001923	-0.642004	0.5413
LOG(EC(-2))	-0.002371	0.001428	-1.660728	0.1407
FD	-9.32E-07	5.10E-06	-0.182554	0.8603
FD(-1)	-4.31E-06	5.23E-06	-0.824656	0.4368
GDP(-1)	2.67E-06	2.36E-06	1.132811	0.2946
GDP(-2)	-1.80E-06	2.32E-06	-0.775726	0.4633
GDP(-3)	-6.69E-08	3.19E-07	-0.209625	0.8399
LOG(GDP2)	-0.069855	0.035252	-1.981610	0.0880
LOG(GDP2(-1))	-0.023068	0.028387	-0.812615	0.4432
LOG(GDP2(-2))	-0.023292	0.036027	-0.646521	0.5386
LOG(GDP3)	0.046557	0.023557	1.976377	0.0887
LOG(GDP3(-1))	0.013948	0.018878	0.738825	0.4840
LOG(GDP3(-2))	0.016626	0.023696	0.701649	0.5055
MAN	4.05E-06	6.93E-06	0.583788	0.5777
MAN(-1)	-4.25E-07	9.38E-06	-0.045272	0.9652

MAN(-2)	-5.19E-06	8.22E-06	-0.631536	0.5478
LOG(POP)	0.000315	0.000758	0.414819	0.6907
LOG(POP(-1))	0.000124	0.001604	0.077363	0.9405
TO	2.28E-06	2.84E-06	0.804664	0.4475
TO(-1)	2.50E-06	2.97E-06	0.842777	0.4272
TO(-2)	4.94E-07	3.94E-06	0.125516	0.9036

R-squared	0.737911	Mean dependent var	5.35E-05
Adjusted R-squared	-0.198121	S.D. dependent var	7.62E-05
S.E. of regression	8.34E-05	Akaike info criterion	-15.92067
Sum squared resid	4.87E-08	Schwarz criterion	-14.74160
Log likelihood	288.6910	Hannan-Quinn criter.	-15.52395
F-statistic	0.788339	Durbin-Watson stat	2.843059
Prob(F-statistic)	0.694622		

Table 7: Ramsay Reset Test

Ramsey RESET Test

Equation: UNTITLED

Specification: D(CO2) D(CO2(-1)) LOG(CO2) LOG(CO2(-1)) LOG(EC) LOG(EC(-1)) LOG(EC(-2)) FD FD(-1) GDP(-1) GDP(-2) GDP(-3) LOG(GDP2) LOG(GDP2(-1)) LOG(GDP2(-2)) LOG(GDP3) LOG(GDP3(-1)) LOG(GDP3(-2)) MAN MAN(-1) MAN(-2) LOG(POP) LOG(POP(-1)) LOG(POP(-2)) TO TO(-1) TO(-2) C

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.832293	5	0.1264
F-statistic	3.357298	(1, 5)	0.1264

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.000709	1	0.000709
Restricted SSR	0.001766	6	0.000294
Unrestricted SSR	0.001056	5	0.000211

Unrestricted Test Equation:
Dependent Variable: D(CO2)
Method: ARDL
Date: 08/08/18 Time: 14:22
Sample: 1984 2016
Included observations: 33
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic):
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(CO2(-1))	-0.089441	0.110634	-0.808443	0.4556
LOG(CO2)	0.566842	0.052186	10.86202	0.0001
LOG(CO2(-1))	-0.422946	0.081881	-5.165357	0.0036
LOG(EC)	0.199017	0.462267	0.430523	0.6847
LOG(EC(-1))	-0.645158	0.470872	-1.370134	0.2290
LOG(EC(-2))	-0.516982	0.390087	-1.325298	0.2424
FD	0.001995	0.001314	1.518367	0.1894
FD(-1)	-0.001022	0.000921	-1.109802	0.3176
GDP(-1)	0.001563	0.000623	2.507664	0.0540
GDP(-2)	-0.000341	0.000412	-0.828571	0.4451
GDP(-3)	-6.49E-05	7.72E-05	-0.841204	0.4386
LOG(GDP2)	0.143255	7.765549	0.018448	0.9860
LOG(GDP2(-1))	-19.22660	9.127147	-2.106529	0.0890
LOG(GDP2(-2))	-7.648519	8.341648	-0.916907	0.4013
LOG(GDP3)	-0.050269	5.190251	-0.009685	0.9926
LOG(GDP3(-1))	11.99228	5.886727	2.037172	0.0972
LOG(GDP3(-2))	5.298199	5.572888	0.950710	0.3854
MAN	-0.003782	0.001960	-1.929920	0.1115
MAN(-1)	0.002236	0.002725	0.820484	0.4493
MAN(-2)	-0.005148	0.002161	-2.382506	0.0630
LOG(POP)	0.193201	0.144786	1.334389	0.2396
LOG(POP(-1))	-48.10025	45.67806	-1.053027	0.3405
LOG(POP(-2))	47.50077	45.46852	1.044696	0.3440
TO	0.000322	0.000519	0.619621	0.5626
TO(-1)	0.000865	0.000743	1.165045	0.2966
TO(-2)	-0.000180	0.000861	-0.209424	0.8424
C	20.64556	10.17173	2.029700	0.0981
FITTED^2	-0.692860	0.378138	-1.832294	0.1264

R-squared	0.997309	Mean dependent var	-0.009282
Adjusted R-squared	0.982775	S.D. dependent var	0.110748
S.E. of regression	0.014535	Akaike info criterion	-5.814596
Sum squared resid	0.001056	Schwarz criterion	-4.544832

Log likelihood	123.9408	Hannan-Quinn criter.	-5.387359
F-statistic	68.61924	Durbin-Watson stat	3.163371
Prob(F-statistic)	0.000084		

*Note: p-values and any subsequent tests do not account for model selection.