IMPACT OF ENERGY CONSUMPTION ON ECONOMIC GROWTH AND ENVIRONMENTAL QUALITY IN NIGERIA

BY

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M.Sc. Soc-Sci/34632/12-13

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DECLARATION

I solemnly declare that this research work titled "Impact of Energy Consumption on Economic Growth and Environmental Quality in Nigeria"is written by me under the supervision of Prof. Mike Duru and Dr.Lawong Damianat the Department of Economics. The work has not been presented anywhere for the award of degree. All sources in the work have been duly acknowledge.

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CERTIFICATION

This thesis titled "Impact of Energy Consumption on Economic Growth and Environmental Quality in Nigeria"written by Ibrahim Kabiru Maji meets the regulations governing the award of the degree of Master of Science in Economics from Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

The study examines the impact of energy consumption on economic growth and environmental quality and also verifies the existence of the Environmental Kuznets Curve(EKC)hypothesis in Nigeria. The traditional production theory and Environmental Kuznets Curve (EKC) theory were used as the theoretical framework of the study and Autoregressive Distributed Lag (ARDL) approach constitute the empirical framework. Data from 1981-2015 wereutilised. The result of the first objective reveals evidence of inverse and significant impact of energy consumption on economic growth.The control variables of capital and trade openness show evidence of positive and significant impact on economic growth but labour reveals a negative and significant impact on economic growth. The study concluded that the negative impact of energy consumption and labour force on economic growth may not be unconnected with the inefficient nature of primary energy utilisation and the large unskilled labour force that dominate the production sector of the economy. The result of the second objective suggests that energy consumption has a negative and significant impact on environmental quality. As such, greater consumption of primary energy such as petroleum and natural gas reduce environmental quality. Moreover, the control variable of trade openness was found to improve environmental quality. Furthermore, the result of the third objectivedid not provide evidence of the existence of EKC hypothesis for Nigeria. Thiscould result from the fact that output level has not been expanded to a certain threshold beyond which additional expansion improves environmental quality.The study recommends apolicy that will enforce the efficient utilisation of primary energy in production and the implementation of environmental tax policy on related primary energy products to create awareness about environmental quality in Nigeria.

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
ADF	Augmented Dickey and Fuller
ARDL	Autoregressive Distributed Lag
CBN	Central Bank of Nigeria
CO2	Carbon Dioxide
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMsq	Cumulative Sum of Squares of Recursive Residuals
DOLS	Dynamic Ordinary Least Squares
ECN	Energy Commission of Nigeria
EIA	Energy Information Administration
EKC	Environmental Kuznets Curves
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Squares
GMM	Generalised Method of Moments
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change

NBS	National Bureau of Statistics
OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
PP	Phillips and Perron
SIC	Schwarz Bayesian Criterion
Tscf	Trillion standard cubic feet
UN	United Nations
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
US	United State
VECM	Vector Error-Correction Model
WDI	World Development Indicator
WMO	World Meteorological Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The nexus between energy consumption and income is widely discussed and debated since the seminal work of Kraft and Kraft (1978). Energy consumption refers to the use of fossil fuel such as petroleum and natural gas as input in the production process. Energy is considered to be the lifeline of an economy, a vital instrument of economic growth and development and recognised as one of the most important strategic commodities. Primary energy is not only essential for the economic progress but its supply is uncertain due to the fact that the deposit of energy sources are definite on the earth surface (Energy Commission of Nigeria, 2013).

In this era of globalisation, the dependency on energy and its increasing demand by countries implies that energy will be one of the challenges in the globe in the next century (Saidi and Hammami, 2015). In order to sustain the ability to increase the real output capacity of a country from one year to another, energy is an important production requirement that has been ignored by the traditional production theory (Ahmed and Azam, 2016).

In order to produce goods and services, the neoclassical traditional production theory emphasisedon labour and capital. However, the use of capital such as machine requires the use of fossil fuel energy. Thus, in contrast to the neoclassical economic theory, the real economic system depends on energy inputs in addition to labour and capital inputs. The real economy is a system where complex process converts raw materials using energy into useful materials and final products. Thus, energy plays an important role in the process of economic growth and development (Kasperowicz, 2016).

Economic growth which is the increase in the real output capacity of a country over time requires energy consumption. However, the consumption of energy such as petroleum, natural gas, and coal as an input in the production process can result in the emissions of carbon dioxide (CO2) that reduces environmental quality. Environmental quality in this context implies ensuring human surrounding is free from toxic substance arising from the use of energy in production. Energy combustion reduces environmental quality by releasing toxic carbon that increasing greenhouse gases (GHG's) (World Development Indicators, 2015). However, the Environmental Kuznets Curve (EKC) hypothesis will be valid when the use of energy in production has reached a turning point and begins to improve environmental quality (Grossman and Krueger, 1995).

The concern about energy consumption and its effect on economic growth and environmental quality had led to the establishment of intergovernmental organization and environmental friendly organizations such as Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environmental Program (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clearer scientific perspective on the current state of information on climate change and its subsequent environmental and socio-economic effects. In the same year, the United Nations General Assembly endorsed the action of WMO and UNEP that jointly establish the IPCC with currently 195 countries as members.

Furthermore, the Kyoto Protocol was adopted on 11 December 1997 in Kyoto, Japan. It is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC), whose objective is to reduce greenhouse effect and global warming. Among the main aim of this protocol is to achieve stabilised greenhouse gas concentrations in the atmosphere. Although, it was founded in1997 the agreement was revalidated with actions in 2005. As at June 2013, there were 192 members who have ratified the protocol, and Nigeria ratifying on December 10, 2004 (Chindo, Abdulrahim, Waziri, Huong and Ahmad,2015).

Subsequently, the Federal Ministry of Environment (FME) was established in Nigeria in 1999 to ensure effective organization of all matters relating to the environment in Nigeria. The creation of this ministry is to ensure that environmental awareness is incorporated in all economic activities. To this effect, a department of climate change was created in FME to specifically handle climate change and environmental related matters (FME, 2014).

Thus, to achieve sustainable economic growth and development, most advanced countries and Nigeria have established alegal framework in line with the objectives of these organisations which are among others;to advance the world's energy supply and demand structure by developing alternative sources of energy in order to mitigate adverse effects of CO2 emissions.

In Nigeria, the dominant source of energy is petroleum, accounting for the bulk of energy consumption. Petroleum account for 42% of total energy, natural gas account for 30%, renewable energy constitutes 18% while other energy sources such as tar sand, coal and the likes constitute 10% (Energy Information Administration, 2016). Out of these fossil fuel energy sources, Nigeria has 37 billion barrels of crude oil reserve with an average production of2.21 million barrels per day in 2014 and 1.92 million barrels per day in 2016 (Central Bank of Nigeria, 2016). The country also possesses 187 Trillion standard cubic feet (Tscf) of natural gas reserve, 2.7 billion tonnes of coal and 31 billion of tar sands reserves.

In Nigeria, the nation's overall economic performance as measured by the real Gross Domestic Product (GDP) has experience growth by about 6.30% annually from 2000 to 2009. Nominal GDP has also increased from ₦54.2 trillion in 2010 to ₦80.2 trillion in 2013 (Energy Commission of Nigeria, 2013). In real terms, total GDP grew by 2.79% between 2014 and 2015 and 5.73% in nominal terms during the same period (National Bureau of Statistics, 2015).

Thus, in addition to labour and capital, energy is also an important production input since it is directly related to the level of output (Omri, Daly, Rault and Chaibi, 2015). However, efficiencyin the use of energy sources for economic activity constitutes a challenge. This may have led to the fall in the contribution of energy to country's GDP from 14.5% in 2013 to 13.50% in 2015 (ECN, 2015). Nevertheless, 83, 93, 97 and 99 million metric tonnes of CO2 were emitted in Nigeria from primary energy in 2011, 2012, 2013 and 2014 respectively (Energy Information Administration of United State, 2015). The consequence of this is the increase in Greenhouse Gas emission from Nigeria (FME, 2015)

As a result, this study incorporates energy consumption and trade openness into the traditional production theory and the Environmental Kuznets Curve (EKC) theory to determine the impact of energy on economic growth and environmental quality in Nigeria. This constitutes part of the contribution of this research work to existing body of knowledge.

1.2 Statement of Research Problem

The consumption of energy from fossil fuel sources as an input to production to achieve economic growth has become a growing concern for most economies. Most advanced countries have committed to reducing their domestic carbon dioxide (CO2) emissions from fossil fuel energy consumption to a certain level (UNFCCC, 2015). This is due to the contribution of fossil fuel energy to CO_2 emissions and environmental degradation (WDI, 2015).Since the industrial revolution, levels of CO_2 emissions from human activities have continued to increase and the burning of fossil fuel and deforestation have been found to be the primary cause of increased CO_2 concentrations in the atmosphere (IPCC, 2007).

Thus, combustion of primary energy such as petroleum, natural gas and coal during production to achieve economic growth and development often translate to CO_2 emissions which contribute to greenhouse gasses, increase global warming and reduces environmental quality. According to World Development Indicators in 2014, fossil fuel energy contributes more than 60% of greenhouse gas and environmental pollution with crude oil and coal identified as the highest emitter.

As such, recent study(Mandelli et al., 2014) have witnessed a new paradigm move by the stakeholders in this area from the use of fossil fuel energy to cleaner sources of energy such as solar energy, wind energy, hydropower energy, and biomass energy among others. Although some advanced countries such Japan and Germany have started replacing the use of fossil fuel energy with cleaner sources of energy for production to save the environment for the future generation, the technologies and initial sunk costs of establishing cleaner energy sources are evidenced to be challenging for a developing country like Nigeria (ECN, 2015;Alam, Murad, Noman and Ozturk, 2016).

Studies have also emphasis on the impact of energy consumption on economic growth and the environment (Shahbaz, Arouri and Teulon, 2014; Mutascu, 2016; Narayan, 2016; Wang, Zhou, Li and Feng (2016). However, investigating energy consumption, economic growth, environmental quality, EKC hypothesis with trade openness in the same framework in Nigeria provides a research gap for this study.

Nigeria possesses about 37 billion barrels of crude oil reserve and about 187 Trillion standard cubic feet (Tscf), with crude oil accounting for 42% of total energy; natural gas accounts for 30% of total energy while coal and other fossil fuel sources such as tar sands account for 10% of total energy (ECN, 2015). As the largest developing country in Africa, Nigeria has continued to make efforts to expand its economic growth since 1990's with an average annual growth rate of 6% for over one decade. This growth rate has, however, been achieved through consumption of energy inputs such as petroleum, natural gas and coal. As such, the studyexamines the impact of energy consumption on economic growth and environmental quality in Nigeria by augmenting energy consumption in the production function.

1.3 Research Questions

This work provides ananswer to the following research questions.

i. What is the impact of energy consumption, labour and capital on economic growth in Nigeria?
ii. What is the impact of energy consumption and trade openness on environmental quality in Nigeria?
iii. Does the Environmental Kuznets Curve (EKC) exist in Nigeria?

1.4 Objectives of the Study

This research work aims at achieving the following objectives:

i. To examine the impact of energy consumption, labour and capital on economic growth in Nigeria

ii. To assess the impact of energy consumption and trade openness on environmental quality in Nigeria?

iii. To test the existence of the Environmental Kuznets Curve (EKC) hypothesis in Nigeria

1.5 Research hypothesis

The null hypothesis includes the followings:

i. H_{01}: Energy consumption, labour and capital does not impact on economic growth in Nigeria.

ii. H_{02}: Energy consumption and trade openness does not affect environmental quality in Nigeria.

iii. H_{03}: The Environmental Kuznets Curve (EKC)hypothesis does not exist in Nigeria

These hypotheses can be rejected when energy consumption and other relevant variables are significant.

1.6 Justification of the Study

First, from the theoretical perspective, this research work contribute significantly by employing an extended or augmented traditional production theory and the Environmental Kuznets Curve (EKC) as the theoretical foundation for the study. The traditional production theory considers labour and capital as the main production input while the augmented production theory includes energy consumption as part of production input. The justification of including energy consumption to augment the theory is that energy is directly related to the level of output. For instance, an increase in output requires not only labour and capital but also energy as aproduction input. Although Shahbaz, Arouri and Teulon (2014) used the extended production theory as their theoretical framework, they only augment for gas consumption. However, gas is only a fraction of fossil energy (petroleum, natural gas, coal and tar-sand) in Nigeria. Other fossil fuel energy sources, particularly petroleum and coal are also used for production purpose in Nigeria. Thus, this study augments for fossil fuel energy in the production theory in order to contributeto scientific knowledge. The study furthercontributed to existing literature by augmenting the production theory and EKC with and anindicator of trade openness to suggest that Nigeria is an open economy.

Secondly, the Autoregressive Distributed Lag (ARDL) bounds testing approach is employed. In examining energy consumption and economic growth other methods such as bootstrap was used byWesseh and Zoumara (2012); factor analysis was employed by Perobelli and Oliveira (2013) and the Vector Error-Correction Model (VECM) was utilised by Sbia, Shahbaz and Hamdi (2014). However, the VECM and Granger causality approach may only capture the directional relationship among variables without much emphasis on the long-run impacts. Similarly, the factor analysis is more of a deductive method of analysis that may include bias, as such, not sufficient like the ARDL model.The advantages of ARDL model over these methods is that it provides good property and consistent result for small sample size; it gives room for the use of variables that are stationary at thelevel or first difference orboth; long-run and short-run models can be estimated simultaneously without much loss of adegree of freedom.

Furthermore, the increased concern globally to reduce the negative impacts of primary energy on environmental pollution is also another justification for this study. Thus, this study fills a research gap and contribute to theexisting body of knowledge in the field of energy, economic growth and environmental quality nexus. The result will also be of importance to policymakers in Nigeria.

1.7 Scope and Limitation of the Study

The scope of this study covers the period from 1981 to 2015. For the period under study, data on energy consumption, economic growth and environment were collected and the impact of energy consumption on economic growth and environmentalquality in Nigeria was examined and analysed.

The reason for selecting this scope of thestudy is that a large amount of fossil fuel energy in the form of crude oil, natural gas, coal and tar-sand have been utilised for productive purpose over this period (Energy Commission of Nigeria, 2016). Despite the consumption of energy within this period, economic growth has been fluctuating, thus the need to empirically investigate the impact of energy consumption on economic growth during this period.

Carbon dioxide (CO2) emissions have been increasing in Nigeria during this period (Energy Information Administration of United State, 2016). Energy consumption has contributed the largest to CO2 emissions (an indicator of environmental quality) (WDI, 2015).Thus, the need to ascertain the relationship and the impact of energy consumption on economic growth in Nigeria.

Some of thelimitations of the study include not accessing some data from Nigeria's data sources such as National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN), Energy Commission of Nigeria (ECN) and other database organisation of Nigeria. Limited data availability was also experienced since data for some years such as 2016 and 2017 could not access.

1.8 Organisation of the Study

This study isorganised into five chapters as follows: Chapter one presents the introduction, research questions, problem statement, objectives, hypothesis, justification and scope of the study. Chapter two deals with the literature review, comprising the conceptual clarifications, theoretical literature and empirical Literature. Chapter three focused on the methodology of the study. These include; theoretical framework, empirical framework, model specification and sources of data. Chapter four present, analysis and interprets the results and chapter five deals with asummary of findings, conclusion and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This Chapter reviews the conceptual issues, theoretical and empirical literature that address research problem on the effects of energy consumption on economic growth and environmental pollution**.** Most of the literature reviewed has shown a link between energy consumption, economic performance and environmental quality. They emphasised that most economic activities require the use of some form of energy as an intermediate input to facilitate production by household and business which in turn leads to economic growth and environmental problems.

2.2 Conceptual Literature review

As contained in Energy Commission of Nigeria (ECN, 2013) and for the purpose of this study, energy consumption is conceptualised as the use of fossil fuel energy derived from primary sources that can be exhaustible over time. These include; petroleum, natural gas, coal and tar sands use in theproduction process to achieve economic growth. Energy is a basic input used in the production process and it is used along with labour and capital. As shown by Alam et al. (2016) energy consumption is extensive among industries, hence, continuous energy supply is required to sustain the current production level and standard of living of countries, whether theyare developed, emerging ordeveloping.The shortfall in energy supply can affect economic growth because energy consumption is considered as a precondition for sustainable economic development(Streimikiene and Kasperowicz, 2016).Energy supply can be used as aninstrument of foreign policy in the promotion of international cooperation and development (ECN, 2013).

Furthermore, since modern economies rely on energy consumption, then, energy represents a useful production input in the development process of a country that plays a major role in achieving economic growth and technological progress (Perobelli and Oliveira, 2013). As such, the diversification of energy matrix in an economy makes her less vulnerable to crises and better able to meet increasing demand for energy input. The interdependence between energy availability, its supply, demand and utilisationare one of the factors that control national development and rural-urban integration (Hermann, 2001).

Moreover, ensuring sound environmental quality which requires that the surrounding of ahuman being (land, air, water, plant and animals) is free from toxic substance arising from the combustion of energy in the production process is a current issue in theliterature.Combustion of fossil fuels energy such as petroleum, natural gas coal, and from other activities such as cement production, deforestation and logging activities among others lead to CO2 emissions which reduce the quality of theenvironment. Thus, for the purpose of this study, we conceptualised environmental quality as minimizing CO2 emissions from the burning of fossil fuels in production and other economic activities. This includes CO2 produced during consumption of fossil fuel energy-related products like petroleum, gas, diesel, furnace, kerosene etc. (WDI, 2015).

Economic growth, on the other hand, refers to an increase in the capacity of an economy to produce goods and services. These increase in capacity being compared from one period of time to another (National Bureau of Statistic, 2014). Economic growth can also be measured in nominal terms, that include inflation, or in real terms to include anadjustment for inflation. To compare one country's economic growth to another, GDP per capita is often used because it takes into account population differences between countries. The growth process of an economy is thought of not only with regards to increase in productive ability but also as an improvement in the quality of life of the inhabitant of that economy.

Hence inclusive growth implies adirect relationship between the micro and macro determinants of the economy and economic growth. The micro determinant refers to the importance of structural transformation for economic diversification and competitiveness while the macro determinants capture changes in economic aggregates like the gross domestic product, general price level and employment level in the economy. Thus, the causal relationship between energy consumption and economic growth has been debated since the seminal work of Kraft and Kraft (1978). However, empirical evidence hasprovided mixed results owing to differences on country's development path, development stage, the sources of energy used, energy policies, energy demand level, institutional arrangements among others (Alam et al. 2012).

Nigeria has envisioned growing its economy at the rate of 11%-13% so as to be recognised among the 20 largest economies in the world by 2020. Energy demand and supply studies were conducted by the Energy Commission of Nigeria taking into consideration the nation's vision, availability of energy resources and modern development plan and various growth scenarios. Using Model for the Analysis of Energy Demand (MAED), Model for the Energy Supply Strategies Alternatives and their General Environmental Impact (MESSAGE), planning model of International Atomic Energy Agency (IAEA) show that a large amount of fossil energy will be required to meet the above mention growth target come 2020. Some of the growth scenarios considered are as follows:

Reference Growth Scenario

i. Gross Domestic Product (GDP) to grow by an average of 7% per annum

ii. The main driver of growth being the manufacturing sector

iii. The manufacturing sector should account for 15% of GDP by 2020 from 4% in 2011

High Growth Scenario

i. GDP to grow by an average of 10% per annum

ii. Manufacturing sector should contribute an average of 22% to GDP by 2030 from 4% in 2011

iii. Nigeria is to transit from an agrarian economy to industrialised economy

Optimistic Growth Scenario

i. GDP grows by an average of 13% per annum

ii. The manufacturing sector to contribute 22% to GDP by 2030 from it 4% contribution in 2011.

2.3 Theoretical Literature Review

2.3.1 Energy consumption and economic growth

The production theory expressed production as a function of labour and capital. However, production process requires the consumption of energy as additional input. Thus, including energy like petroleum fuel, gas and diesel as a raw material in a production function has become important in the literature (Shahbaz, Arouri and Teulon, 2014).Since the seminal work of Kraft and Kraft (1978), the pioneer study on energy and economic growth nexus, studies have attempted to examine the causal link between energy consumption and economic growth in both developed and developing countries. This interest has not only been fuelled by the increasing economic activities across countries which have triggered a growing demand for energy across the world, but also the notion that energy prices directly affect spending decisions of households, investors, and the overall economy (Narayan and Smyth, 2005).

Research works examining the causal relationship between energy consumption and economic growth should be of interest to both economists and policy makers due to its significant implications for governmental energy policy (Wesseh and Zoumara, 2012). The question is which of the variables causes the other. Is it energy consumption that causes economic growth or is it economic growth that causes energy consumption? Ozturk, (2010) posit that there is no consensus regarding the direction of causality between economic growth and energy consumption, as literature has produced conflicting results.

As such, there are at present four hypothesis (Shahbaz et al., 2013) that can be associated and identified with energy consumption and economic growth nexus. These include; (i) the growth hypothesis; (ii) conservation hypothesis; (iii) bidirectional hypothesis; and (iv) the neutrality hypothesis. The growth hypothesis considers energy consumption as instrumental input for economic growth. The economy is energy dependent, as such, reduction in energy demand lowers economic growth. The conservation hypothesis, on the other hand, assumes that economic growth is the cause of energy consumption. Thus, one-directional causality runs from economic growth to energy demand. So that any policy aimed at reducing energy demand may not have much impact on economic growth.

The bidirectional hypothesis assumes feedback causal relationship between energy consumption and economic growth. Therefore, both variables affect each other. While the neutrality hypothesis posits that lower energy consumption does not affect economic growth, and lower economic growth does not impact energy consumption(Apergis and Payne, 2013).

In the literature, one of the most used methods of establishing acausal link among variables has been the traditional parametric methods such as the Granger and the Toda and Yamamoto methods that focus on asymptotic theory. However, the methods have some drawbacks because parametric tests require assumptions, as such the application of asymptotic theory may lead to spurious results (Hacker and Hatemi, 2003) when some of the assumptions do not hold. The distribution of the statistic may also be significantly different from the asymptotic pattern. This is most especially when it involves small samples size which is typical of most countries. Parametric tests that rely on predicting errors will be sensitive to causality in the mean only, while heteroscedasticity will be ignored. In other not to over-rely on theasymptotic theory that emphasised on large sample size, obtaining robust results of causality with a moderate sample size require the use of a more robust testing technique (Wesseh and Zoumara, 2012).

2.3.2 Environmental Kuznets Curve (EKC) Hypothesis

The Environmental Kuznets Curves (EKC) hypothesishas been used to show the relationship between energy consumption, economic growth and environmental quality. The theory shows how economic growth affects the environment by modelling the environmental impact in terms of negative or a positive externality. The EKC hypothesis of Kuznets (1971) postulated that early process of output growth is expected to invoke environmental degradation while subsequent output growth will enhance environmental quality when acertain threshold of output is achieved. This theory has led some researchers from late 1990s to assume that every economy should concentrate on its growth expansion, and any environmental damages will be eventually corrected after sometimes when a certain limit of output growth is reached (Kaika and Zervas, 2013). Studies have tried to test empirically the EKC hypothesis using different data frequencies of several countries to examine various types of environmental problems, while other studies evaluate the underlying reasons that may drive such relationship (Grossman and Krueger, 1995; Alam et al., 2016).

Grossman and Krueger (1991) were known to haveextended the hypothesis of 1971 Nobel Prize winner, Simon Kuznets from income per capita and income inequality nexus to the income per capita and environmental quality nexus. Thus, last decade has witnessedtransition from studies concerning the degradation of environmental resources to recent studiesrelating to both the sustainability of economic growth and the quality of the environment. The philosophy of the EKC hypothesis is further shown in the work of Beckerman (1992) which reveals that, although economic activities deteriorate environmental quality at anearly stage, at last, the best way to achieve decent and safe environment is to become rich. To become rich economy implies theability to incorporate improved technological changes into theproduction process that enhance thequality of services and information diffusion. The technological improvement may include greener sources of energy that reduce greenhouse gas emission and hence improves the quality of theenvironment.

Since the EKC theory postulated an inverted U-shape, its graphical illustration should indicate an initial monotonic increase until a turning point is reached beyond which the curve began to slope downward to implyanimprovement in theenvironmentalqualityas the economy grows further. Thus, the study adopted a graphical illustration of the EKC hypothesis from Alam et al. (2016) as follows:

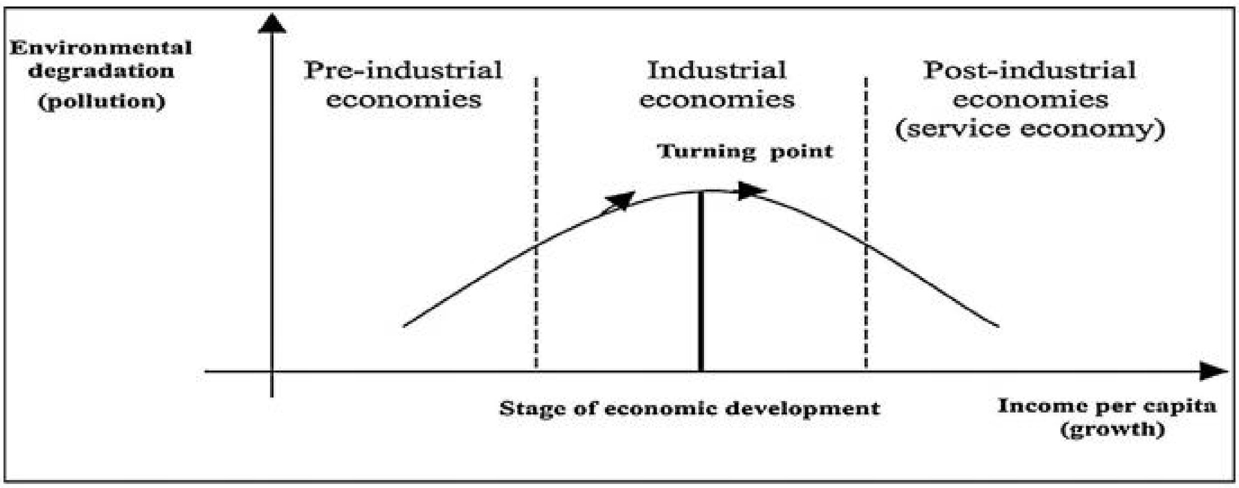


Figure 2.1.EKC hypothesis, adopted from Alam et al. (2016)

In Figure 2.1, the dependent variable on the vertical axis is an indicator of environmental quality. Indicators of environmental quality could be carbon dioxide emissions or other alternative pollutants from agriculture and deforestation among others. Most common forms of pollutants studies of EKC hypothesis are land pollution,air pollution and water pollution. The independent variable on theX-axisof the above Figure is economic growth.

2.4 Empirical Literature Review

2.4.1 Energy consumption and economic growth

The relationship between energy consumption, economic growth and environmental qualityisa current issuein theliteraturedue to the significance of the contribution of energy consumption in the process of achieving economic growth and how it affectsenvironmental quality. Empirical literature in this area seems to be divided into three different categories. One aspect of the literature looked into the link between energy consumption and economic growth, another strand of the literature deals with the impact of energy consumption on environmental quality while another strand of the literature concentrate on the relationship between economic growth and environmental quality referred to as the Environmental Kuznets Curve (EKC) hypothesis.

Despite the fact that current literature emphasis on sustainable utilisation of energy in achieving economic growth with minimal negative externalities to the environment, the empirical results suggest divergence views regarding the outcomes. Some of the literature showsapositive relationship between these variables, some report negative relationship while another reportinsignificant relationship between them. This could be due to the frequency of data used, variable selection and stage of development of the country (s) under consideration. Moreover, most literature doesnot augment for energy consumption and trade openness in a production theory and EKC framework.

Recent literature that examines the impact of energy consumption on economic growth includesthe work of Streimikiene and Kasperowicz (2016), Chiou-Wei, Zhu, Chen and Hsueh (2016), Mutascu (2016), Narayan (2016) andBoutabba (2014). For example, Streimikiene and Kasperowicz (2016) used a panel cointegration to review economic growth and energy consumption for 18 EU countries from 1995-2012. The estimation also utilisedfully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) estimators. Their result shows that economic growth, energy consumption and other determinant are in equilibrium relationship and the panel FMOLS and DOLS suggesta positiveimpact of energy consumption on economic growth and gross fixed capital.

Moreover, Chiou-Wei et al. (2016) investigate the nexus of energy consumption and economic growth using the EGARCH-M model including more variables.The additional variables reveal a negative and significant impact on energy consumption and economic growth.Bi-directionalCausalityexists between economic growth and energy demand for the Philippines, unidirectional runs from economic growth to energy demand for Singapore, and a neutrality hypothesis holds for the rest of the countries. Furthermore, Mutascu (2016) used a bootstrap panel Granger causality technique to assess the relationship between energy consumption and economic growth in G7 countries. The outcome suggests feedback causality between energy consumption and economic growth in Canada, Japan and the United State. Unidirectional causality runs from economic growth to energy consumption in France and Germany and absence of causality exist for the rest of the countries. While Streimikiene and Kasperowicz (2016) andChiou-Wei et al. (2016) used different methods to ascertain the impact of energy consumption on economic growth with additional variables such as capital, Mutascu (2016) concentrate on causality analysis to ascertain growth hypothesis, conservation hypothesis, bidirectional and neutral hypothesis.

Nevertheless, Narayan (2016) evaluate the predictabilitywithin the energy consumption and economic growth bond from income and regional groups by employing a panel data forecasting regression model to examine the existence growth, conservative, feedback, or neutrality hypotheses of 135 countries. The result reveals evidence of neutrality hypothesis. However, apanel of 90 developing countries show evidence of conservative hypothesis but 32 lower-middle-income countries panel reveal that energy use per capita determines economic growth per capita. Thus, despite that the causality of energy consumption and economic growth is as old as the pioneer literature, current literature is still concern about the causality hypothesis. This is necessary in order to proffer the right policy recommendation from empirical findings.

The studies haveconcentratedon testing the hypothesis of energy consumption and economic growth nexus and trying to identify the direction of causality between the variables using long-run methods of estimation. This study focused on impact analysis rather than causality and employed the Autoregressive Distributed Lag (ARDL) method following Pesaran et al. (2001), Shahbaz et al. (2014) and Alam et al. (2016)that can estimate both the long-run and short-run model in the same framework. More, so, our estimation is carried out within a traditional production theory that incorporates energy as an important production input besides labour and capital.

2.4.2 Energy consumption, economic growth and environmental quality

Empirical literature had also investigated the relationship between energy consumption, economic growth and environmental quality.Investigating the link between energy consumption,economic growth and environmental quality in Nigeria is a recent issue. As such, this study will further investigate the relationship between these variables.

Some of the recent studies that examine the link between energy consumption, economic growth and environmental quality include the work of Wang, Zhou, Li and Feng (2016), Zhu, Duan, Guoand Yu (2016), Chen, Chen, Hsu and Chen (2016) and Saidi and Hammami (2015). For instance, Wang et al. (2016) investigated environmental quality, economic growth and energy consumption in China.They used a panel data technique to ascertain the dynamic relationshipamong the variables. Their findingshows evidence of positive bidirectional causality between energy consumption and economic growth, and between energy consumption and indicator of environmental quality which is CO2 emissions. Furthermore, one directional causality runs from economic growth to environmental quality. Thus, China has atendency to continue to reduce environmental quality as it largely depends on primary energy consumption for economic growth.

Additionally, Zhu et al. (2016) ascertain the impact of foreign direct investment(FDI), energy consumption, economic growth and on environmental quality in ASEAN-5 countries that include Indonesia, Malaysia, Philippines, Singapore and Thailand. The findings show anegative impact of FDI on environmental quality for all the quantile except the fifth one quantile.Energy consumption also invokesenvironmental degradation, with the largest impact taking place at higher quantile. However, higher population size tends to improveenvironmental quality in the high-emittingcountries. Their resultalso supports the validity of the halo effect hypothesis in higher CO2 emitting countries. Thus, the contribution of this study lies in quantile analysis that also incorporated the impact of FDI on energy consumption, economic growthand environmental qualityNexus.

On the other hand, Chen et al. (2016) model the global relationship between energy consumption and environmental quality and economic growth using a panel and vector error-correction technique. The findings suggestthat unidirectional causality running from energy consumption to environmental qualityexists for bothdeveloped and developing countries.Similarly, Saidi and Hammami (2015) used Generalised Method of Moments (GMM) with a dataset from 1990–2012 to ascertain the impact of economic growth and environmental quality on energy consumption in

58 countries. Their result attests evidence of the positive and significant effect of carbon emissions on energy consumption for four global panels. However, economic growth is positively related to energy consumption with statistical power for the four panel only.This empirical literatures mostly used panel data analysis and causality test rather than impact analysis.

Since this study used the EKC as one of its theoretical frameworks and also investigate its existence, the next section reviews theempirical literature relating to the Environmental Kuznets Curve (EKC) hypothesis.

2.4.3 Economic growth and environmental quality- The EKC hypothesis

This section reviewed empirical literature that tests the existence of the Environmental Kuznets Curve hypothesis (EKC) hypothesis to verify whether productive activities for economic growth has any positive impact in improving environmental quality. Despite that this kind of study is not common in developing countries, investigating this relation for the case of Nigeria is a useful contribution to thescientific body of knowledge.

After thework of Kuznets (1955) which emphasises the link between per capita income and income inequality; inference has been drawn from his work and apply to several related areas of studies. Among these include the relationship between economic growth and environmental quality. The work of Kuznets showsthat income per capita is negatively related to income inequality at the early stage of economic growth up to a certain stage after which additional increase in income per capita reduces income inequality. As a result, the relationship between per capita income and income inequality was found to be inverted U-shape and named after Kuznets.

Later on, thework of Grossman and Krueger (1995) draws aninference from the Work of Kuznets (1955) to investigate the link between economic growth andenvironmental quality.The findings show that the relationship between economic growth and environmental quality is an inverted U-shape, implying that the early stage of economic growth can lead to environmental degradationuntil a turning point is reached after which additional expansion of output,improves environmental quality. Since then several studies have investigated the EKC hypothesis for different countries.However, recent studies in this respect relate to the work of Ozturk Ahmad (2016), Alam et al. (2016),Pablo-Romero and Jesús (2016), Acaravci (2013) andBello and Abimbola (2010).

The work ofAlam et al. (2016) explore thelinkbetween environmental quality, economic growth, energy consumption and population growth in order to verify the existence of EKC in Brazil, China, India and Indonesia. The study employed the Pesaran et al. (2001) Autoregressive Distributed Lag (ARDL) approach as the empirical model and consider both the linear and nonlinearapproaches. The results show that increase in income and energy consumption significantly invoke environmental qualityin all the four countries. But the link between environmental quality and population growth reveals statistical significance in both short-run and long-runfor India and Brazil. With regards to the EKChypothesis, the result suggests thathigher income in the future will mitigate CO_2 emissions and improves environmental quality in Brazil, China and Indonesia.

In addition, Ahmad (2016) also use the ARDLand vector error-correction model techniques to examine the aggregate and disaggregate CO_2 emissions, energy consumption and economic growth forIndian. The findings reveal that cointegration exists between the dependent variable and its determinants. Energy consumption was found to have a negative effect onenvironmental quality and a bidirectional relationship exists between economic growth and environmental quality. The environmental Kuznets curve was alsovalidated at the aggregated and disaggregated levels.

Moreover, Pablo-Romero and Jesús (2016) utilised panel model for twenty-twoLatin American and Caribbean countries between 1990–2011 toinvestigate the Energy-Environmental Kuznets Curve (EKC) hypothesis for Latin America and the Caribbean. The energy-environmental Kuznets curve is another area of the EKC which assumes an inverted-U shape relationship between energy consumptionand economic growth. The result shows that the energy-environmental EKC does not exist for the region but an exponential growth was found as gross value added increases.Similarly, the early study of Ozturk and Acaravci (2013) investigate the relationship between financial development, economic growth and environmental quality and found the insignificant impact of financial development and economic growth on environmental quality.

Although some of this literatureuses the ARDL approach as their empirical model, most of therecent works in this area have focused on the advanced countries with less attention on the developing countries. Despite that Bello and Abimbola (2010) has investigated for the case ofNigeria; this research work contributes to scientific knowledge by using additional data sets beyond 2010 for Nigeria. Thus testing the EKC for a developing country Nigeria also constitutes another literature gap.

2.4.4 Empirical studies and institutional issues in Nigeria

Literaturehas alsoexplored the link between energy consumption, economic growth and the environmental quality in Nigeria, using different dataset, different control variables, different measurement and obtained different results. This is not counterintuitive as some of the studies are conceptually oriented, others theoretically oriented while some are empirically and policy-oriented.

As such, recent studies on the relationship between energy consumption, economic growth and their effect onenvironmental quality in Nigeria have been reviewed(see for instance, Rafindadi, 2016;Babatunde and Babatunde, 2016;Edomah, 2016;Olatomiwa, Mekhilef, Huda and Ohunakin, 2015;Abam et al., 2014; Amoo and Fagbenle, 2013;Ajoku, 2012; Bello and Abimbola, 2010).

Rafindadi (2016) tried to explore the effect of economic growth on energy consumption and environmental quality in Nigeria using the ARDL bounds test. The result shows that economic growth is inversely related to energy consumption and environmental quality. On the contrary, financial development increases energy consumption and improves environmental quality. However, trade openness also increases energy consumption and improves environmental quality. Moreover, Babatunde and Oluseyi et al. (2016) evaluate energy consumption and carbon footprint from the hotel sector in Lagos, Nigeria. Linear regression approach was utilised to characterise energy consumption index with a correlation analysis used to ascertain interdependence of CO2 footprint and energy consumption. The finding reveals a significant correlation between energy consumption per unit guest room and the CO2 emissions (an indicator of environmental quality).

Similarly, Edomah (2016) emphasizes the importance of sustainable energy development in Nigeria. He identified the constraints to sustainable energy development in Nigeria to include among others, legal and regulatory constraint, market performance, and cost and pricing constraint. The findings suggest the need for both policymakers and stakeholders to work together so as to achieve sustainable energy development.While Olatomiwa et al. (2015) used a hybrid optimisation method to investigate the economic evaluation of hybrid energy systems for the rural energy consumption of the geopolitical zones in Nigeria. They found that a hybrid energy will improve performance in fuel consumption and improves environmental quality.

Abam et al. (2014) on the other hand used a statistical approach to examine energy resource structure and ongoing sustainable development policy in Nigeria. Their conclusion suggests that energy development strategy must adhere to sustainable practice to balance economic growth, social expansion and environmental quality.

Furthermore, Ajoku (2012) assess the modern use of solid biomass energy for sustainable economic growth and development in Nigeria using survey approach. He found that it possesses high potentials for bio-energy development in Nigeria, but however, required more awareness in order to increase the potentials. Nevertheless,Bello and Abimbola(2010) used a time series analysis to investigate the impact of economic growth on environmental quality and also test the existence of EKC for Nigeria. The result suggests thateconomic growth is not the cause of environmental degradation but rather, it is caused by financial development and thus, did not find evidence of EKC in Nigeria.

However, most of this literatureistowardthe policy aspect and none of them used an extended production theory and the Environmental Kuznets Curve (EKC) hypothesis in the same framework to investigate the impact of energy consumption on economic growth and environmental quality in Nigeria. This research employs the ARDL approach to bounds test to contribute to theexisting body of knowledge in this area. More, so, investigating the existence of

EKC for Nigeria is not common in literature. The next chapter deals with the methodological aspect of the study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Methodology, in this case, refers to the combination of methods employed to achieve the objectives of a research work. These methods include among others, the theoretical framework, empirical framework, descriptive statistics, correlations, estimation techniques, data sources and variable measurements and, the stationarity property of the data.

3.2 Theoretical Framework

The first theoretical framework of the studyis the traditional production theory. Production refers to the transformation of inputs into theoutput, while inputs refer to the resources that a firm uses in its production process for the purpose of creating a good or service. A production function indicates the highest output level that a firm can produce for every specified combination of inputs while holding technology constant at some predetermined state. It is often assumed that firms produce output with two inputs, labour and capital (Velasco, 2011). However, productionincludes the use of other input such as energy as an additional input in the process of creating good and services (Shahbaz, Arouri and Teulon, 2014).

As such, the justification for using this theoretical framework is that it allows the incorporation of energy consumption as a complementary production input along with labour and capital in theproduction process that aims to achieve greater economic growth and development. Studies like Paoand Li (2014), Shahbaz et al (2014) and Sbia et al. (2014) have employed the traditional production theory as their theoretical framework. However,with regards to Nigeria, the study has extended the production theory by including energy consumption as a production input besides labour and capital following Shahbaz et al. (2014). This study is further contributed to literature by including trade openness beside energy consumption to signify that Nigeria is not a closed economy and to also enhance the functional specification of the model. Thus, the traditional production theory is given by:

$$Y = f(L, K, \ldots) \qquad (3.1)$$

where$Y$ represent the level of output, L and K represent labour and capital respectively. The empirical framework model energy consumption as a complementary production input along with labour and capital.

In addition, the second theoretical framework ofthe study is the Environmental Kuznets Curve (EKC) theory. The theory as postulatedby Grossman and Krueger (1991) shows that the relationship between economic growth and environmental quality is an inverted U-shape. According to the theory, the early stage of economic growth will be associated with higher environmental pollution up to a maximum point beyond which further expansion on economic growth will improve environmental quality. The justification of employing the EKC hypothesis for the energy-environmental quality nexus is that energy consumption is directly related to economic growth and environmental quality (Shahbaz et al. 2014). Moreover, the EKC hypothesis investigated the relationship between economic growth and environmental quality including energy consumption as a control variable. The EKC hypothesis will be suitable as the theoretical framework of these two objectives. As such, the empirical framework that tests the EKC hypothesis use the following general reduced form model:

$$Y_t = \alpha_0 + \beta_1 X_{t1} + \beta_2 X_{t2}^2 + \beta_3 X_{t3}^3 + \beta_4 Z_{t4} + \mu_t \quad (3.2)$$

where Y_t is the dependent variable measured by an indicator of environmental quality, X_t represent income which is the independent variable and Z_t denotes other variables such as energy consumption and trade openness that can influence Y_t. The symbol α_0 is the intercept, β_i refer to the estimated coefficient of the explanatory variables while μ_t is the stochastic error term. From equation (3.2) we developed a more specific model to include the variable of interest.

3.3 Empirical model and estimation technique

The empirical model for the impact of energy consumption on economic growth and environmental quality is Autoregressive Distributed Lag (ARDL) bounds testing approach of (Pesaran et al., 2001). The justification of using this model is owing to the advantages of the model that includes; providing good property and consistent result for small sample size; use of variable stationarity at level and first difference or combination of both, thus purely I(0), Purely I(1) or their mixture can be considered in ARDL model; simultaneous estimation of long and short-run model. Since I(2) cannot be used in ARDL model, a unit root test was conducted and none of the variable's stationarity exceeds I(1).

Although, the first theoretical framework is the traditional production theory, to be more precise this work uses the extended or augmented version of the production theory that includes energy consumption as additional production input besides labour and capital. Trade openness was also included to signify that Nigeria is an open economy.It was justified early that apart from labour and capital energy consumption is also required as aproduction input, thus, energy is directly related to the level of output (Shahbaz et al., 2013; Omri et al., 2015). Therefore, the production theory was augmented following Shahbaz et al. (2014) to include energy consumption as production input and trade openness as additional control variable as follows:

$$Y = f(L, K, E, T) \tag{3.3}$$

Where E denotes energy consumption in the production function while L,$K$and T are labour, capital and trade openness.

In order to normalise the variables in the estimation, equation (3.3) can be converted to a logarithm form. Then, an intercept with an error term can be included to form the econometric model as follows:

$$lnY_t = \alpha_0 + \alpha_1 lnL_t + \alpha_2 lnK_t + \alpha_3 lnE_t + \alpha_4 lnT_t + \varepsilon_t \tag{3.4}$$

Where $lnY_t, lnL_t, lnK_t,\ lnE_t$and lnT_t represent economic growth, labour, capital stock, energy consumption and trade openness in their log form respectively. The α_0 is the intercept,$\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are the slopes of the respective variables and ε_t is the error term. It is expected that $\alpha_1, \alpha_2, \alpha_3, \alpha_4 > 0$, however, inefficient utilization of labour, capital, energyconsumption and incompetent trade relations can hinder economic growth, in that case, we may expect $\alpha_1, \alpha_2, \alpha_3, \alpha_4 < 0$. From equation (3.4) we can then develop the ARDL dynamics model as:

$$\Delta lnY_t = \varphi_0 + \sum_{i=1}^{n} \varphi_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \varphi_{2i} \Delta lnL_{t-i} + \sum_{i=0}^{n} \varphi_{3i} \Delta lnK_{t-i} + \sum_{i=0}^{n} \varphi_{4i} \Delta lnE_{t-i}$$

$$+ \sum_{i=0}^{n} \varphi_{5i} \Delta lnT_{t-i} + \pi_1 lnY_{t-1} + \pi_2 lnL_{t-1} + \pi_3 lnK_{t-1} + \pi_3 lnE_{t-1} + \pi_4 lnT_{t-1} + \mu_t \qquad (3.5)$$

The error-correction for the long-run model (3.5) is given as:

$$\Delta lnY_t = \varphi_0 + \sum_{i=1}^{n} \varphi_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \varphi_{2i} \Delta lnL_{t-i} + \sum_{i=0}^{n} \varphi_{3i} \Delta lnK_{t-i} + \sum_{i=0}^{n} \varphi_{4i} \Delta lnE_{t-i}$$

$$+ \sum_{i=0}^{n} \varphi_{5i} \Delta lnT_{t-i} + \eta ect_{t-1} + \mu_t \qquad (3.6)$$

Furthermore, the empirical specification for objective two and three can be developed from equation (3.2) as follow:

$$lnCO_{2t} = \rho_0 + \rho_1 lnY_t + \rho_2 lnY_t^2 + \rho_3 lnE_t + \rho_4 lnT_t + \vartheta_t \qquad (3.7)$$

where$lnCO_{2t}$ is the indicator of environmental quality,$lnY_t^2$is the square of economic growth that will be used to answer the third objective,lnT_timplies trade openness and other variables are as defined earlier. Including trade openness suggest that Nigeria is an open economy. The symbol ρ_0 is the intercept and ϑ_t is error term. It is expected thatρ_1, ρ_3 and$\rho_4 > 0$ while $\rho_2 < 0$ for EKC hypothesis to exist in Nigeria.

Moreover, the dynamic ARDL model for equation (3.7) is modelled as follows:

$$\Delta lnCO_{2t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta lnY_{t-i}^2 + \sum_{i=0}^{n} \beta_{3i} \Delta lnE_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta lnT_{t-i}$$

$$+\theta_1 lnCO_{2t-1} + \theta_2 lnY_{t-1} + \theta_3 lnY_{t-1}^2 + \theta_4 lnE_{t-1} + \theta_5 lnT_{t-1} + \vartheta_t \qquad (3.8)$$

Similarly, the error-correction specification for themodel (3.8) is as follows:

$$\Delta lnCO_{2t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta lnY_{t-i}^{2} + \sum_{i=0}^{n} \beta_{3i} \Delta lnE_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta lnT_{t-i}$$

$$+\zeta ect_{t-1} + \vartheta_t \tag{3.9}$$

Where η and ζ are the coefficients of the error-correction terms. Thus, model (3.5) provide answer to objective one while model (3.8) provide answer to objective two and three. The next section describes the variables, measurement and sources of data.

3.4 Variables, measurements and data sources

For the purpose of this research study, six variables were collected with different measurement from World Bank's World Development Indicators (WDI) and other database sources from 1981 to 2015.The justification of starting the data collection from 1981 is due to theconstraint of data availability for much earlier periods. Among the constraint and limitation of the study include not having access to some data from sources such as Central Bank of Nigeria (CBN), Energy Commission of Nigeria (ECN), National Bureau of Statistics (NBS), World Bank's World Development Indicators (WDI) and other database organisation. The constraint in data availability was experiencedas instances of incomplete datasetwas witness in some database sources.Thevariables, their measurement and data sources werepresented in Table 3.1.

Table 3.1. Variables, measurements and data sources

S/N	Variables	Measurements	Sources	Description of the variable
1	Energy consumption	Energy use (kg of oil equivalent per capita)	WDI, ECN	Energy consumption is the use of primary energy before transformation to other end-use fuels
2	Gross Domestic Product (GDP)	GDP per capita (constant 2005 US$)	WDI	GDP is the sum of gross value added by all domestic producers in the economy.
3	CO2 emissions	CO2 emissions (metric tons per capita)	WDI, EIA	CO2 emissionis carbon dioxide produced during consumption fuels (solid, liquid, and gas).
4	Labour	Labour force participation rate, total (% of total	WDI	Labour is a person whosupplieshis

		population ages 15+) (national estimate)		skill for the production of goods and services during a given period of time.
5	Capital	Gross fixed capital formation (% of GDP)	WDI	Capitals are to the machine, equipment and infrastructure used in production during a specific period of time.
6	Trade openness	Trade % of GDP	WDI	Trade is the sum of exports and imports of goods and services measured as a share of GDP.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the results of the research work are discussed and analysed. Thisincludes the unit root tests, trends and scattered diagrams of the relationship between the variables, descriptive statistics, correlation matrix, cointegration tests, long-run results, short-run results, diagnostics and stability tests.

4.2 Stationarity Tests for variables

Stationarity test or unit root test was conducted on the variables using the two most famous unit root test of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP).Despite that they have low power in small sample size, the essence is to ensure that all the variables are stationary and no variable stationarity exceedI(1)since ARDL model does not allow the use of avariable that exceeds first difference. The unit root test carried out on the variables show that the variables do not exceed stationarity at first difference. The use of ADF and PP tests is to ensure that all variables involved are time-invariant (i.e. they all possess zero mean, constant variance and not autocorrelated). Therefore, purely I(0) orpurely I(1) or their combination can be used (Pesaran et al. 2001).Table 4.1 presents the unit root test, suggesting that all variables are stationary at the first differences with a significance power of 1% for themajority of the variables, as a result, wecan proceed with other analysis in the next section.

Table 4.1 Unit root tests for variables

	ADF				PP			
Variables	Level	Z	First difference	Z	Level	Z	First difference	Z
	-2.1809	0	-4.7951***	0	-2.1745	2	-4.7637***	2
$ln\,Y_t$	(0.4845)		(0.0027)		(0.4879)		(0.0029)	
	-2.8899	0	-6.1538***	0	-2.9824	2	-8.1083***	9
$ln\,E_t$	(0.1781)		(0.0001)		(0.1516)		(0.0000)	
	-2.0939	0	-5.9669***	0	-2.1603	3	-6.0114***	6
$ln\,CO_{2t}$	(0.5306)		(0.0001)		(0.4954)		(0.0001)	
	-2.2182	0	-6.1892***	1	-2.2322	1	-5.4244***	4
$ln\,K_t$	(0.4649)		(0.0001)		(0.4576)		(0.0005)	
	-1.6042	1	-2.7586**	0	-1.1782	4	-2.9589**	3
$ln\,L_t$	(0.7696)		(0.0492)		(0.8992)		(0.0122)	

	-0.6755	7	-4.8085***	8	-2.0123	2	-7.9928***	3
$ln\,T_t$	(0.9649)		(0.0038)		(0.5740)		(0.0000)	

Note: values in (.) are probability values, *** and ** imply significance at 1%, and 5% respectively while *Z*is the lag length for the ADF and PP

4.3 Trend of variablesand scattered plots

Figure4.1 shows the trend of the variables from 1981 to 2015. Except for energy consumption, all other variables used in this model moved in the same direction. For example, variables of economic growth, CO2 emissions, capital, labour and trade openness decline between 1981-1987; rise moderately between 1988-2003 and further rises higher from 2004-2015. However, energy consumption has been fairly stable throughout the period.

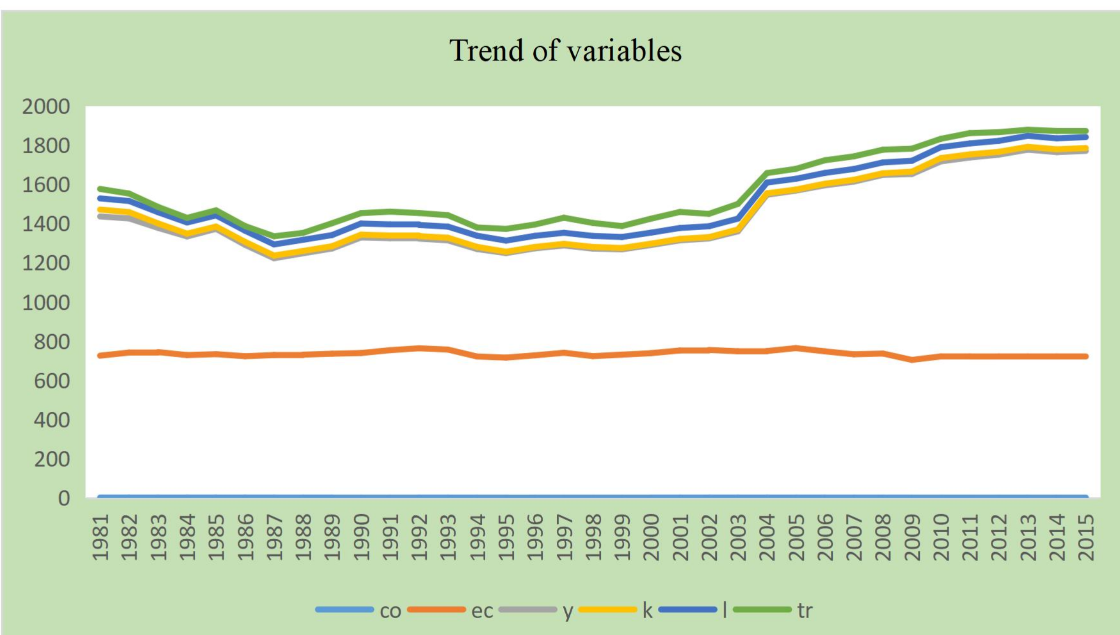


Figure 4.1. Trend of variables 1981-2015

In addition, Figure 4.2-4.4 present scattered plots of the variables. The scattered plots show the relationship between two variables. Based on the objectives of the study, Figure 4.2-4.4 show the relationship between energy consumption and economic growth; energy consumption and CO2 emissions (indicator of environmental quality) and; economic growth and CO2 emissions. For instance, the plot of Figure 4.2reveals an indirect relationship between energy consumption and economic growth. Figure 4.3 shows that the link between the energy consumption and CO2 emissions is positive while the relationship between economic growth and CO2 emissions seems not to be clear in Figure 4.4. The scattered plots give a tentative direction of the expected relationship between variables of interest, however, we cannot draw aconclusion since they are not subjected to diagnostic tests.

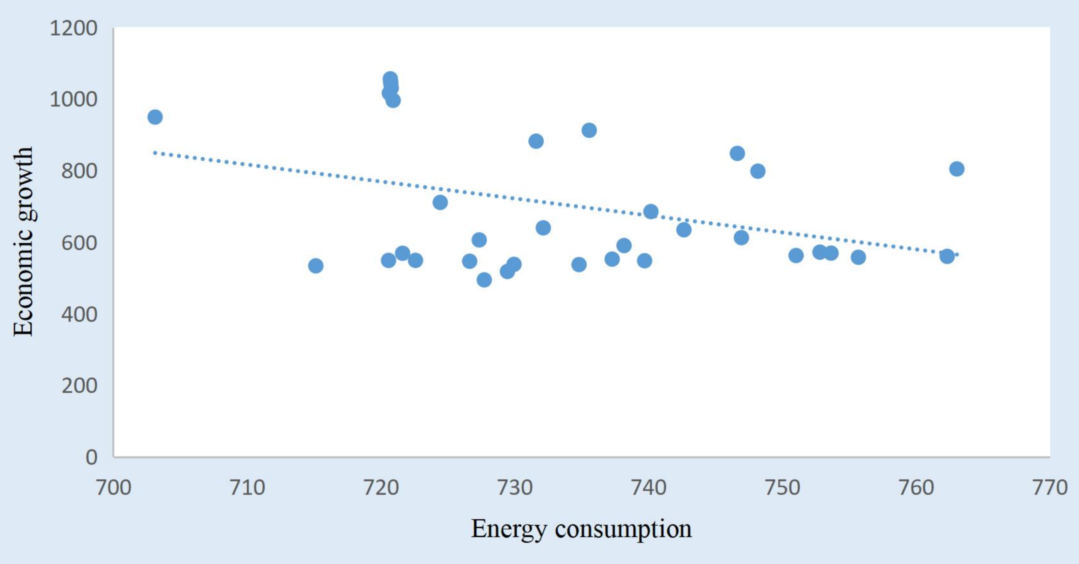


Figure 4.2. Energy consumption and economic growth 1981-2015

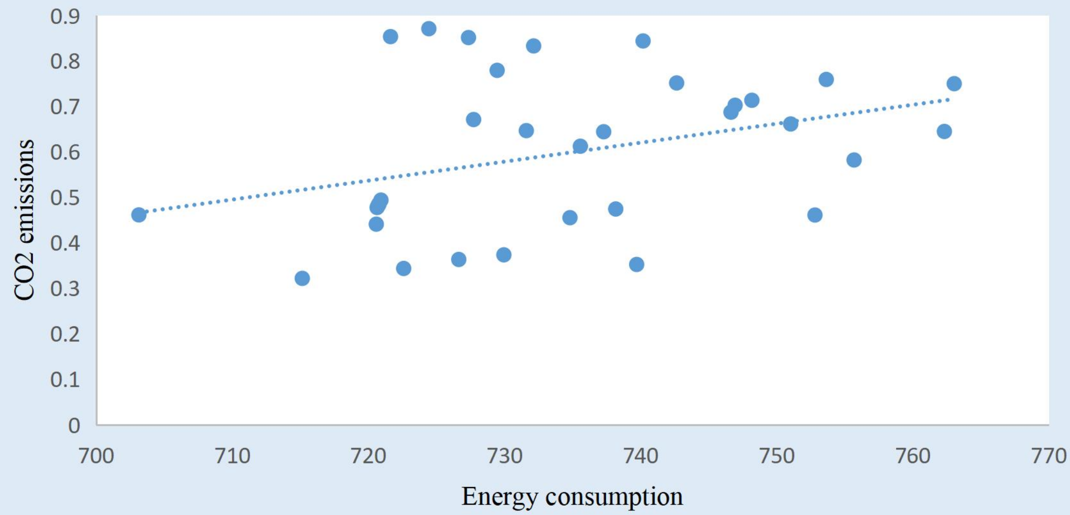


Figure 4.3. Energy consumption and CO2 emissions 1981-2015…

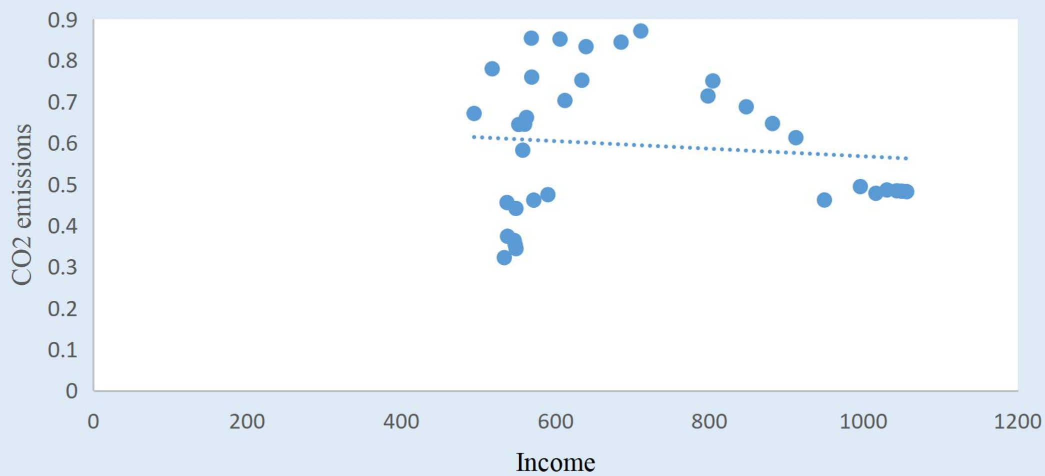


Figure 4.4. Economic growth and CO2 emissions 1981-2015

4.4 Descriptive statistics and correlation matrix

The result of the descriptive statistics and correlation matrix for the model of energy impact on economic growth is presented in Table 4.2 with the mean, median, standard deviation, skewness, kurtosis, Jarque-Bera and probability. The statistic of Jarque-Bera and the probability values showthat the statistic is normally distributed and serially uncorrelated. The correlation matrix, on the other hand, reveals both the size and sign of the relationship between the variables. For instance, inverse correlation run from economic growth to energy consumption, labour and trade openness while positive correlation runs from economic growth to the level of capital.Similarly, negative correlation runs from energy consumption to capital and labour and positive correlation between energy consumption to trade openness. Furthermore, a mixed correlation exists among the control variables

Table 4.2. Descriptive statistics and correlation:Energy consumption-economic growth nexus

Variables	$ln\, Y_t$	$ln\, E_t$	$ln\, K_t$	$ln\, L_t$	$ln\, T_t$
Mean	6.5221	6.5982	2.4497	4.0294	51.6888
Median	6.4065	6.5952	2.4820	4.03069	53.0302
Maximum	6.9621	6.6373	3.5617	4.0431	81.8129
Minimum	6.2030	6.5556	1.6973	4.0037	23.6089
Std. Dev.	0.2572	0.0194	0.4237	0.0129	15.8239
Skewness	0.6119	0.2631	0.6216	-0.4807	-0.1657
Kurtosis	1.7673	2.4369	3.3854	1.8647	2.1177
Jarque-Bera	4.4006	0.8662	2.4704	3.2278	1.2954
Probability	0.1177	0.6485	0.2908	0.1991	0.5232
$ln\, Y_t$	1				
$ln\, E_t$	-0.3199	1			
$ln\, K_t$	0.2132	-0.2570	1		

$ln\, L_t$	-0.5661	-0.14361	0.5091	1	
$ln\, T_t$	-0.2146	0.3595	-0.5494	-0.3965	1

Again, the result of the descriptive statistics and correlation matrix for amodel of the impact of energy consumption and economic growth on environmental quality is presented in Table 4.3. The probability values and the statistics of Jarque-Bera reveal evidence of normal distribution and serially uncorrelated variables. More, so, an inverse correlation runs from the carbon emissions to economic growth and trade openness and positive correlation runs from carbon emissions to energy consumption. Additionally, negative correlation runs from economic growth to carbon emissions, energy and trade openness. Mixed correlation runs from trade openness to other variables. For instance, there is positive causality from trade openness to energy consumption and a negative correlation between energy consumption to trade openness. These descriptive statistics and correlation matrix provide inside on the characteristics of the variables and their relationships.

Table 4.3. Descriptive statistics and correlation: Energy consumption-CO2 emissions nexus

Variables	$ln\, CO_{2t}$	$ln\, Y_t$	$ln\, E_t$	$ln\, T_t$
Mean	-0.5604	6.5221	6.5982	51.6888
Median	-0.4901	6.4065	6.5952	53.0302
Maximum	-0.1381	6.9621	6.6373	81.8129
Minimum	-1.1338	6.2030	6.5556	23.6089
Std. Dev.	0.2948	0.2572	0.0194	15.8239

Skewness	-0.2656	0.6119	0.2631	-0.1657
Kurtosis	1.9242	1.7673	2.4369	2.1177
Jarque-Bera	2.0993	4.4006	0.8662	1.2954
Probability	0.3501	0.1108	0.6485	0.5232
$ln\, CO_{2t}$	1			
$ln\, Y_t$	-0.0053	1		
$ln\, E_t$	0.3872	-0.3199	1	
$ln\, T_t$	-0.3447	-0.2146	0.3595	1

4.5 Cointegration tests

After the unit root test, thetrend of variables, descriptive statistics and correlation analysis, the next step is to test the joint null hypothesis of the variables in order to establish the existence of long-run equilibrium relationship among them. The null hypothesis for objective one is given by *H0*: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$while the alternative hypothesis is H_a:$\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0$. On the other hand, the null hypothesis for objective two and three is given by*H0*: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$and the alternative hypothesis is specified as H_1: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq 0$. The null hypotheses suggest the absence of cointegration while the alternative hypotheses indicates the existence of cointegration among the variables. In order to establish the existence of cointegration in the two models, the estimated values of F-statistic through the OLS are compared with the critical values of Narayan (2005). Cointegration exists if the values of the F-statistics are greater than the value of the upper bounds of the Narayan critical bounds values. On the other hand, cointegration does not exist if the estimated F-statistics are smaller than the lower bounds values of the Narayan critical values and the outcome is inconclusive if the F-statistics fall between the upper and the lower bounds values.

Table 4.4 Cointegration tests

Bound testing for cointegration		
Models	Lags	F-statistics
$Y_t = f(K_t, L_t, E_t, T_t)$	(1,3,1,1,2)	8.8473[0.004]***
$CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$	(1,0,0,0,0)	4.7789[0.007]***
Critical values		
Significance level	Lower Bounds	Upper Bounds
1% level	4.590	6.368
5% level	3.276	4.630
10% level	2.696	3.898

Note: optimal lag is 6 and number of regressors (*k*) =4. Values in parenthesis [.] are p-values, *** indicates significance at 1%

Table 4.4presents the cointegration results for the two models. The cointegration results for the two models show that a long-run equilibrium relationship exists between the dependent variables economic growth and environmental qualitywith their determinants.In Table 4.5 the F-statistic of the first model that examines the impact of energy consumption on economic growth is 8.8473 which is greater than the upper bound of Narayan (2005) critical values at 1%, 5% and 10%. Furthermore, the F-statistic of the second model which examines the impact of energy consumption on environmental quality is 4.7789. This is also greater than the upper bound of Narayan critical values at conventional 5% and 10% level of significance. Thus, the null hypothesis H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$ and H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ for the two models can be rejected. The next section present the long-run and the short-run results.

4.6 Long-run results, short-run results and diagnostic tests

Table 4.5 contains the long-run and short-run result of the ARDL model. The impact of energy consumption on economic growth was estimated based on Akaike Information Criterion (AIC) while the impact of energy consumption on environmental quality was estimated base on Schwarz Bayesian Criterion (SIC) (see Appendix II). The two selection criteria give us the best results and the rationale for using them are that the AIC selection method does relatively better when the sample size is small compared to a large sample size while SBC improves performance for both small sample size and large sample size (Sbia et al., 2014). The presentation of the results is based on the model for each objective. The column of model $Y_t = f(K_t, L_t, E_t, T_t)$ presents the long-run, short-run and diagnostic results of the first objective while the column of model $CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$presents the long-run, short-run and diagnostic test of the second object. This second model was also used for the third objective which test the existence of EKC hypothesis in Nigeria. The long-run results were presented in Panel A, the short-run results were presented in Panel B while the diagnostic results were presented in Panel C.

With respect to the first objective, the coefficient of energy consumption is negative and significantly related to economic growth in Nigeria. This suggests that an increase in the utilization of energy consumption (fossil fuel energy)can hinder economic growth in Nigeria. Precisely, a 1% increase in energy consumption can reduce economic growth by 4.5%. This finding may not be surprising because a lot of energy is being used in production process without conservation in Nigeria. Moreover, primary energy sourcessuch as petroleum, gasand diesel are often used in production in place of electricity. The Energy Commissions of Nigeria (ECN) is the legal institution for primary energy and other related energy sources, but this institution lack enforcement capability to ensure efficiency in energy utilisation for production purposes to achieve sustainable economic growth and development.For instance, most production sectors that are supposed to use hydropowerenergy for production are still using fossil fuel energyin Nigeria. This result is consistent with the work of Chindo et al. (2014) which found out that energy consumption has a negative impact on economic growth in Nigeria.

Furthermore, the level of capital is positive and significantly related to economic growth in the long-run, implying that efficient use of capital increases economic growth. To be concise an increase in the level of capital by 1% can increase economicgrowth by 1.1%. The capital which includes the use of machines and equipment in the production is an important requirement of economic growth and development. This result seems to support the current situation in Nigeria since the replacement of ancient production tools with modern capital increases productivity. The result supports the findings of Streimikiene and Kasperowicz (2016) which reveals positive impact of capital on economic growth.

In contrast, the coefficient of the long-run impact of labour on economic growth is negative and significant. This implies that ineffective use oflabourforce in production can hinder economic growth in Nigeria. This outcome is in line with a report by NBS (2015) which shows that the labour productivity of Nigeria is low compared to other developing countries. Thus, the need for increased effort in building human capital resources in Nigeria cannot be over emphasis. Additionally, the long-run coefficient of trade openness is positive and significantly related to economic growth. Despite that Nigeria import most of the manufactured good, the result shows that trade relation positively affects economic growth. This could be due to the fact that 70% of government revenue is generated from crude oil export. Thus, including trade in a production theory can explain the fact that Nigeria is not a closed economy. The result is in agreement with the findings of Shahbaz et al. (2013) who found a positive relationship between trade and economic growth.

Moreover, the short-run results in Panel B reveal evidence that energy consumption and labour have an inverse relationship with economic growth but not statistically significant. This suggests that they possess lesser power to impact economic growth in the short-run. Similarly, the level of capital and trade were also positive but not statistically significant, as such, conclusion cannot be drawn from these short-run results.

Table 4.5 Long-run results, short-run results and diagnostic tests

	$Y_t = f(K_t, L_t, E_t, T_t)$		$CO_{2t} = f(Y_t, Y_t^2, E_t, T_t)$	
	Coefficients	t-stat &p-values	Coefficients	t-stat &p-values
Variables	Long-run results (Panel A)			
$ln\,Y_t$	-	-	15.8807	0.6527[0.519]
$ln\,Y_t^2$	-	-	-1.1928	-0.6458[0.524]
$ln\,E_t$	-4.4907	-2.1874**[0.041]	12.3116	2.7230**[0.011]
$ln\,K_t$	1.0794	3.4061***[0.003]	-	-
$ln\,L_t$	-34.7805	-4.4241***[0.000]	-	-
$ln\,T_t$	0.5687	2.0176*[0.058]	-0.5513	-2.9956***[0.006]
Constant	171.4922	4.8448***[0.000]	-132.4426	-1.9384*[0.063]
	Short-run results (Panel B)			
$\Delta ln\,Y_t$	-	-	7.3284	0.6260[0.537]
$\Delta ln\,Y_t^2$	-	-	-0.5505	-0.6197[0.541]
$\Delta ln\,E_t$	-.20313	-0.3155[0.755]	5.6814	3.0944***[0.005]
$\Delta ln\,K_t$	0.0421	0.6812[0.503]	-	-
$\Delta ln\,L_t$	-2.9884	-0.6359[0.531]	-	-
$\Delta ln\,T_t$	0.0657	1.0496[0.305]	-0.25443	-2.7004**[0.012]
Constant	48.8184	3.6813***[0.001]	-61.1176	-1.7468*[0.092]
ect_{t-1}	-0.2847	-2.6144**[0.016]	-0.4615	-4.0154***[0.000]
	Diagnostic tests (Panel C)			
$\chi^2 serial$	0.1081	[0.742]	0.4445	[0.505]
$\chi^2 func$	0.1751	[0.676]	0.8490	[0.357]
$\chi^2 norm$	0.1624	[.922]	8.2861	[0.016]
$\chi^2 hetr$	0.1365	[0.712]	0.5320	[0.466]

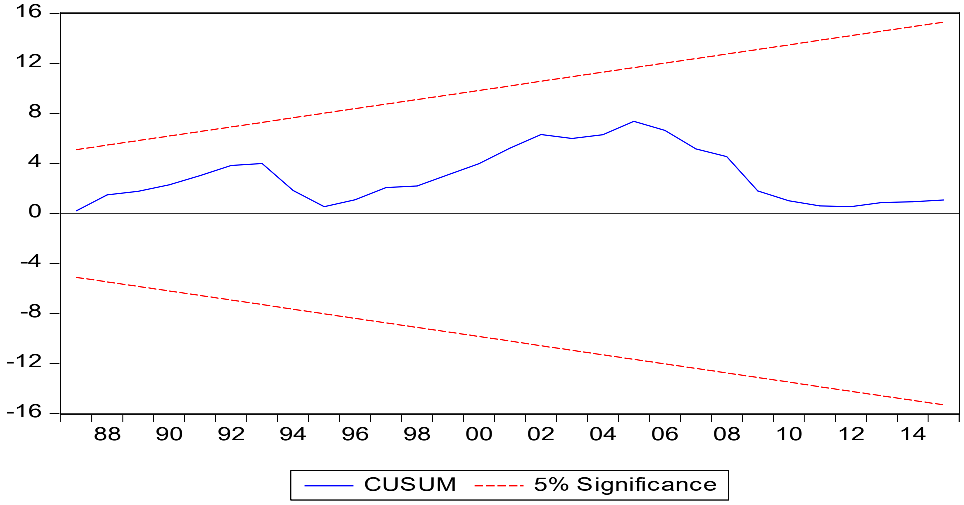
Note: Values in parenthesis [.] are p-values, ***, ** and * suggest significance at 1%, 5% and 10%. $\chi^2 serial$,$\chi^2 func$, $\chi^2 norm$, $\chi^2 hetr$are tested for serial correlation, functional form, normality and heteroscedasticity respectively

Table 4.5 also presents the result of the second objective which is the impact of energy consumption on environmental quality. The long-run result shows that energy consumption has a negative and significant impact on environmental quality in Nigeria. This implies that increase in energy consumption increases the amount of CO2 emissions as such reduces environmental quality. This result is intuitive since combustion of primary energy like petroleum, diesel and gas in the production process leads to carbon emissions. The higher the quantity of energy consumed the greater the expected CO2 emissions. According to a report by World Bank in the year 2014, primary energy consumption contributes about 60% to global CO2 emissions and greenhouse gases. This result is also consistent with the result of Saidi and Hummami (2015) and Chen et al. (2016) which reveal a negative impact of energy consumption on environmental quality.

Furthermore, the long-run result reveals a positive and significant impact of trade openness on environmental quality in Nigeria. The implication of this is that trade relation between Nigeria and the rest of the world can assist in bringingin new technologies that will help to improve environmental quality in Nigeria. Thus, good trade relations with the rest of the world can contribute to the work of Federal Ministry of Environment toimproving environmental qualityin Nigeria. This result is consistent with theories of international trade which shows that comparative specialisation or absolute specialisation in trade can benefit countries. Similarly, the short-run result of the impact of energy consumption on environmental quality is negative and significant, thus, corroborating the long-run findings. Furthermore, the short-run effect of trade openness on environmental quality is positive and significant, as such consistent with the long-run result.

To achieve the third objective which is to test the existence of the Environmental Kuznets Curve (EKC) hypothesis for Nigeria, we look at the impact of$Y_t$andY_t^2onCO_{2t}. If the coefficient of Y_t is positive and significant and that of Y_t^2 is negative and significant, then EKC exist, otherwise,EKC does not exist. The result shows that the coefficient of economic growth and the coefficient of square of economic growth are positive and negative respectively but fail to be significant. As such, the study conclude that EKC does not exist in Nigeria. The essence of testing the EKC hypothesis is to ascertain whether the economy has reached a turning point of economic growth beyond which further expansion of output can mitigate CO2 emissions and improves environmental quality. The result shows that Nigerian economy has not reach the turning point and the result is consistent with findings of Bello and Abimbola(2010) that reveals non-existence of EKC in Nigeria.

To further strengthen the robustness of the results, adiagnostic test for serial correlation, function form test for model specification, normality test and heteroscedasticity test were conducted and the results were presented in Panel C of Table 4.5. The first model passed all the diagnostic tests.The second model also passed all the diagnostic tests except normality test. In order to strengthen the diagnostic tests, a stability test was further carried out using the Cumulative Sum of Recursive Residuals (CUSUM) and the Cumulative Sum of Squares of Recursive Residuals (CUSUMsq). The results in Figure 4.5 and 4.6 show that the models are within the critical bounds at 5% level of significance. Thus, we conclude that the models are stable.



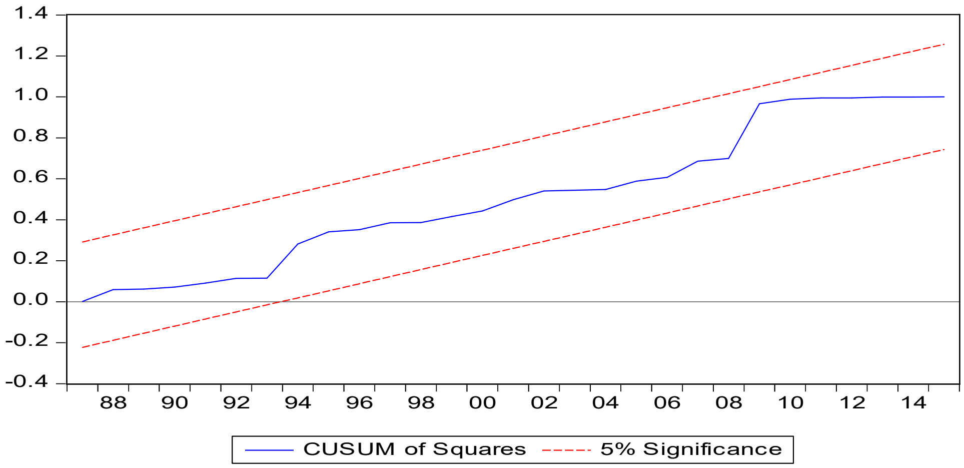
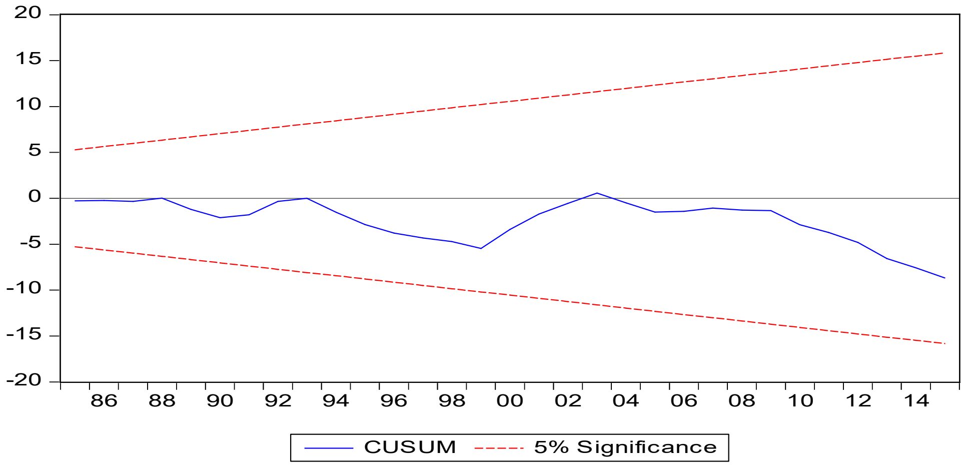


Figure 4.5. Stability test energy consumption and economic growth



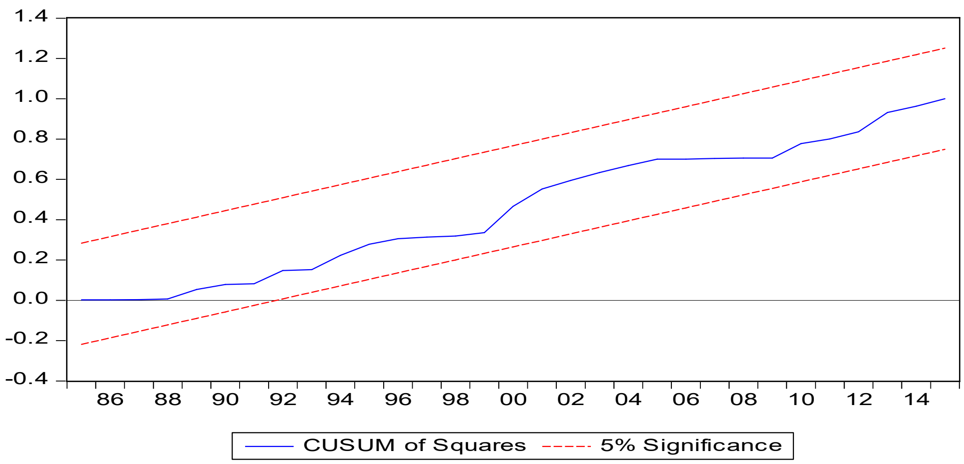


Figure 4.6. Stability test for energy consumption, economic growth and CO2 emissions

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of key findings

The study examines the impact of energy consumption on economic growth and environmental quality and verifies the existence of the EKC hypothesis in Nigeria. The traditional production theory and EKC theory serve as the theoretical framework of the study while the Autoregressive Distributed Lag (ARDL) model constitutes the empirical model. Dataset ranging from 1981-2015 wereutilised. After estimating the model, the results reveal evidence of thenegative and significant impact of energy consumption on economic growth. Other determinants in the model such as capital and trade openness reveal evidence of positive and significant impact on economic growthwhile labour suggests anegative and significant relationship with economic growth. The study concluded that the negative impact of energy consumption and labour force on economic growth may not be counter-intuitivegiven the inefficient nature of primary energy utilisation and low labour productivity in the economy.

The result of the second objective that assesses the impact of energy consumption on environmental quality suggests that the elasticity of energy consumption is negative and significant related to environmental quality. As a result, greater consumption of primary energy such as petroleum, diesel, natural gas among other invoked carbon emissions which subsequently reduce environmental quality. Trade openness was also found to improve environmental quality,meaning that efficient trade relation with the rest of the word can bring in technologies like abatement technologies of carbon capture from United State to Nigeria.

Furthermore, the third objective tries to ascertain the existence of EKC in Nigeria, however, the result did not provide any evidence for the existence of EKC hypothesis for Nigeria. This is not unconnected with the fact that production level has not been expanded to a certain turning point beyond which additional expansions can reduce carbon emissions and subsequently improves environmental quality.Production process is still yet to attain its optimum point in Nigeria.

5.2 Recommendations

The study found that energy consumption and the labour force have anegative impact on economic growth, due largely from theinefficient use of primary energy source in production and the low productivity of labour in Nigeria. The study further found that energy consumptionreduces environmental quality but trade openness improve environmental quality. Based on these, we recommend the following policy measures:

a) First, efficient use of primary energy to achieve economic growth should be strictly enforce by the policymakers. For instance, designinga ratio of primary energy to labour and capitalfor certain level of output can be put in place. This implies coming up the certain percentage of labour, percentage of capital and percentage of energy required to produce a particular product. Achieving this will further require monitoring the production sector of the Nigerian economy.
b) Second, enforcement of environmental tax policy on related primary energy products could be a useful policy measure to increase efficiency in energy utilisation and awareness about environmental quality.For example, a 1% of Environmental Added Tax (EAT) can be included in the selling price of energy-related product like the Value Added Tax (VAT). This will go a long way in creating awareness and reducing environmental degradation.

c) Third, more emphasis on human capital development is required by the government to transform the benefit of the large labour force into comparative production advantage in Nigeria. This will require stringent implementation of the acquisition of basic education, especially, primary and secondary school education in Nigeria in line with other countries like Malaysia. To achieve this, a comprehensive database of all inhabitants of Nigeria need to be in place.

d) Since trade openness has revealed a positive impact on both economic growth and environmental quality, the government should give more attention to good trade relations with comparative and absolute advantages. This will bring in new technologies, increase specialization, economic growth and subsequently improves environmental quality in Nigeria.

e) Finally, the positive relationship between capital and economic growth is a signal to policymakers for a paradigm shift toward further encouraging the use of modern methods of production in Nigeria.

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Appendix I: Primary energy resources

S/N	Resources	Reserves	Production (2010)	Domestic Utilization (2010)
1.	Crude Oil	37 billion barrels	0.896 billion barrels	0.164 billion barrels
2.	Natural Gas	187 Tscf	2.392 Tscf	75.7% - fuel, industries, re-injection and gas lift. 24.3% - gas flare
3.	Coal	2.7 billion tonnes	0	Negligible
4.	Tar Sands	31 billion barrels of oil equivalent	0	0.224 million tonnes
5.	Nuclear	Yet to be quantified	0	30 k W experimental nuclear reactor

Source: NNPC 2013, CBN

Appendix II. Estimation Worksheets

Objective 1

```
                  Autoregressive Distributed Lag Estimates
ARDL(1,3,1,1,2) selected based on Akaike Information Criterion
*******************************************************************************
 Dependent variable is LY
 32 observations used for estimation from 1984 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
LY(-1)                     .71533            .10889              6.5696[.000]
 LK                        .042074           .061766              .68119[.504]
LK(-1)                    .090173           .074303              1.2136[.240]
LK(-2)                    .045810           .068117              .67251[.509]
LK(-3)                     .12923           .064590              2.0007[.060]
 LL                        -2.9884            4.6999             -.63585[.532]
LL(-1)                    -6.9125            5.5436             -1.2469[.228]
 LEC                       -.20313            .64383             -.31551[.756]
LEC(-1)                   -1.0752            .64758             -1.6604[.113]
 LTR                       .065682           .062575              1.0496[.307]
LTR(-1)                    .16452           .050662              3.2475[.004]
LTR(-2)                  -.068308           .047694             -1.4322[.168]
 INPT                      48.8184           13.2610              3.6813[.002]
*******************************************************************************
 R-Squared                       .97908   R-Bar-Squared                  .96586
 S.E. of Regression             .049698   F-stat.    F( 12,  19)  74.0940[.000]
 Mean of Dependent Variable      6.5226   S.D. of Dependent Variable      .26899
 Residual Sum of Squares        .046927   Equation Log-likelihood        58.9922
 Akaike Info. Criterion         45.9922   Schwarz Bayesian Criterion     36.4649
 DW-statistic                    1.9874   Durbin's h-statistic     .045332[.964]
*******************************************************************************
```

```
                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=   .10807[.742]*F(   1,  18)=  .060997[.808]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   .17509[.676]*F(   1,  18)=  .099031[.757]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   .16235[.922]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .13654[.712]*F(   1,  30)=   .12856[.722]*
*******************************************************************************
A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values
```

Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,3,1,1,2) selected based on Akaike Information Criterion

Dependent variable is LY
32 observations used for estimation from 1984 to 2015

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LK	1.0794	.31691	3.4061[.003]
LL	-34.7805	7.8616	-4.4241[.000]
LEC	-4.4907	2.0529	-2.1874[.041]
LTR	.56872	.28188	2.0176[.058]
INPT	171.4922	35.3971	4.8448[.000]

Error Correction Representation for the Selected ARDL Model
ARDL(1,3,1,1,2) selected based on Akaike Information Criterion

Dependent variable is dLY
32 observations used for estimation from 1984 to 2015

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLK	.042074	.061766	.68119[.503]
dLK1	-.17503	.066744	-2.6225[.015]
dLK2	-.12923	.064590	-2.0007[.057]
dLL	-2.9884	4.6999	-.63585[.531]
dLEC	-.20313	.64383	-.31551[.755]
dLTR	.065682	.062575	1.0496[.305]
dLTR1	.068308	.047694	1.4322[.166]
dINPT	48.8184	13.2610	3.6813[.001]
ecm(-1)	-.28467	.10889	-2.6144[.016]

List of additional temporary variables created:
dLY = LY-LY(-1)
dLK = LK-LK(-1)
dLK1 = LK(-1)-LK(-2)
dLK2 = LK(-2)-LK(-3)
dLL = LL-LL(-1)
dLEC = LEC-LEC(-1)
dLTR = LTR-LTR(-1)
dLTR1 = LTR(-1)-LTR(-2)
dINPT = INPT-INPT(-1)
ecm = LY -1.0794*LK + 34.7805*LL + 4.4907*LEC -.56872*LTR -171.4922*INPT

R-Squared	.64979	R-Bar-Squared	.42860
S.E. of Regression	.049698	F-stat. F(8, 23)	4.4066[.002]
Mean of Dependent Variable	.015742	S.D. of Dependent Variable	.065746
Residual Sum of Squares	.046927	Equation Log-likelihood	58.9922
Akaike Info. Criterion	45.9922	Schwarz Bayesian Criterion	36.4649
DW-statistic	1.9874		

R-Squared and R-Bar-Squared measures refer to the dependent variable dLY and in cases where the error correction model is highly restricted, these measures could become negative.

Cointegration result for objective 1

Variable Addition Test (OLS case)

Dependent variable is DLY

List of the variables added to the regression:

LY(-1) LEC(-1) LK(-1) LL(-1) LTR(-1)

31 observations used for estimation from 1985 to 2015

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
INPT	51.1401	15.8704	3.2224[.012]
DLY(-1)	-.12006	.18764	-.63984[.540]
DLY(-2)	-.53331	.22417	-2.3790[.045]
DLEC	-.30070	.65883	-.45642[.660]
DLEC(-1)	-.18000	.80049	-.22487[.828]
DLEC(-2)	-.40387	.76775	-.52604[.613]
DLEC(-3)	.88882	.66248	1.3417[.217]
DLK	-.049226	.066926	-.73552[.483]
DLK(-1)	-.23073	.071058	-3.2471[.012]
DLK(-2)	-.32417	.073395	-4.4167[.002]
DLL	3.5550	5.7973	.61321[.557]
DLL(-1)	-2.7948	6.3127	-.44272[.670]
DLL(-2)	-14.3579	10.6712	-1.3455[.215]
DLL(-3)	-3.2816	8.8886	-.36919[.722]
DLTR	.15688	.069455	2.2587[.054]
DLTR(-1)	.12993	.066114	1.9653[.085]
DLTR(-2)	.093880	.068478	1.3710[.208]
DLTR(-3)	.17734	.054063	3.2803[.011]
LY(-1)	-.048260	.18850	-.25602[.804]
LEC(-1)	-1.5963	.95166	-1.6774[.132]
LK(-1)	.41462	.092495	4.4827[.002]
LL(-1)	-10.4899	2.8257	-3.7124[.006]
LTR(-1)	.25229	.066224	3.8097[.005]

Joint test of zero restrictions on the coefficients of additional variables:

Lagrange Multiplier Statistic	CHSQ(5)=	26.2524[.000]
Likelihood Ratio Statistic	CHSQ(5)=	58.1666[.000]
F Statistic	F(5, 8)=	8.8473[.004]

Objective 2 and 3

```
                   Autoregressive Distributed Lag Estimates
ARDL(1,0,0,0,0) selected based on Schwarz Bayesian Criterion
*******************************************************************************
 Dependent variable is LCO
 33 observations used for estimation from 1983 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
LCO(-1)                     .53853            .11492            4.6860[.000]
 LEC                        5.6814            1.8360             3.0944[.005]
 LY                         7.3284           11.7066             .62600[.537]
 LY2                       -.55045            .88829            -.61967[.541]
 LTR                       -.25443           .094217            -2.7004[.012]
 INPT                     -61.1176           34.9884            -1.7468[.092]
*******************************************************************************
 R-Squared                     .75916   R-Bar-Squared                    .71456
 S.E. of Regression            .15239   F-stat.    F(  5,  27)  17.0218[.000]
 Mean of Dependent Variable   -.58502   S.D. of Dependent Variable      .28524
 Residual Sum of Squares       .62702   Equation Log-likelihood        18.5693
 Akaike Info. Criterion       12.5693   Schwarz Bayesian Criterion      8.0797
 DW-statistic                  1.7902   Durbin's h-statistic      .80237[.422]
*******************************************************************************


                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   1)=   .44453[.505]*F(   1,  26)=   .35501[.556]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   .84901[.357]*F(   1,  26)=   .68658[.415]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   8.2861[.016]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .53203[.466]*F(   1,  31)=   .50798[.481]*
*******************************************************************************
A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values


            Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,0,0,0,0) selected based on Schwarz Bayesian Criterion
*******************************************************************************
 Dependent variable is LCO
 33 observations used for estimation from 1983 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 LEC                       12.3116            4.5213             2.7230[.011]
 LY                        15.8807           24.3325             .65265[.519]
 LY2                       -1.1928            1.8471            -.64579[.524]
 LTR                       -.55134            .18405            -2.9956[.006]
 INPT                    -132.4426           68.3270            -1.9384[.063]
*******************************************************************************
```

```
Error Correction Representation for the Selected ARDL Model
ARDL(1,0,0,0,0) selected based on Schwarz Bayesian Criterion
*******************************************************************************
 Dependent variable is dLCO
 33 observations used for estimation from 1983 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
dLEC                      5.6814             1.8360              3.0944[.005]
dLY                       7.3284            11.7066              .62600[.537]
 dLY2                     -.55045             .88829            -.61967[.541]
dLTR                     -.25443            .094217            -2.7004[.012]
dINPT                   -61.1176            34.9884            -1.7468[.092]
ecm(-1)                  -.46147             .11492            -4.0154[.000]
*******************************************************************************
 List of additional temporary variables created:
dLCO = LCO-LCO(-1)
dLEC = LEC-LEC(-1)
dLY = LY-LY(-1)
 dLY2 = LY2-LY2(-1)
dLTR = LTR-LTR(-1)
dINPT = INPT-INPT(-1)
ecm = LCO  -12.3116*LEC  -15.8807*LY +   1.1928*LY2 +   .55134*LTR + 132.4426
*INPT
*******************************************************************************
 R-Squared                    .44976   R-Bar-Squared                    .34786
 S.E. of Regression           .15239   F-stat.    F(  5,  27)    4.4139[.005]
 Mean of Dependent Variable  -.016918  S.D. of Dependent Variable       .18871
 Residual Sum of Squares      .62702   Equation Log-likelihood         18.5693
 Akaike Info. Criterion      12.5693   Schwarz Bayesian Criterion       8.0797
 DW-statistic                 1.7902
*******************************************************************************
 R-Squared and R-Bar-Squared measures refer to the dependent variable
dLCO and in cases where the error correction model is highly
restricted, these measures could become negative.
```

Cointegration test for objective 2 and 3

```
                       Variable Addition Test (OLS case)
*******************************************************************************
 Dependent variable is DLCO
 List of the variables added to the regression:
LCO(-1)         LEC(-1)         LY(-1)          LY2(-1)         LTR(-1)
 32 observations used for estimation from 1984 to 2015
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 INPT                    -178.8726            39.9098            -4.4819[.000]
DLCO(-1)                  .088018             .16376             .53748[.598]
DLCO(-2)                   .38888             .16174             2.4043[.029]
 DLEC                      7.2224             1.6277              4.4372[.000]
DLEC(-1)                   3.9794             1.7920             2.2206[.041]
 DLY                      42.8868            22.3310              1.9205[.073]
DLY(-1)                  -39.8800            17.5827            -2.2681[.038]
 DLY2                     -3.2737             1.7293             -1.8930[.077]
DLY2(-1)                   2.9774             1.3667             2.1785[.045]
 DLTR                     -.19651             .12229             -1.6069[.128]
DLTR(-1)                 -.032122             .12398            -.25908[.799]
LCO(-1)                   -.49178             .15606            -3.1512[.006]
LEC(-1)                    .33265             2.5646             .12971[.898]
LY(-1)                    53.6496            13.7977             3.8883[.001]
LY2(-1)                   -4.0579             1.0443            -3.8856[.001]
LTR(-1)                   -.15643             .13665            -1.1448[.269]
*******************************************************************************
 Joint test of zero restrictions on the coefficients of additional variables:
 Lagrange Multiplier Statistic     CHSQ( 5)=  19.1662[.002]
 Likelihood Ratio Statistic        CHSQ( 5)=  29.2368[.000]
 F Statistic                   F(  5,  16)=   4.7789[.007]
*******************************************************************************
```

Appendix III. Data used for the estimation

year	CO2 emissions	Energy con	Income	Capital	Labour	TradeOp
1981	0.870971874	724.445274	710.6061	35.22126	56.9666	48.29332
1982	0.843982948	740.1818	685.0285	31.95333	56.9668	37.7485
1983	0.751665589	742.648579	634.1195	23.0065	56.96641	27.03717
1984	0.851423347	727.35741	605.7565	14.22397	56.96719	23.60888
1985	0.833035882	732.143731	639.5429	11.96524	56.96563	25.90006
1986	0.853537887	721.630923	568.5368	15.15382	56.96875	23.71676
1987	0.671203496	727.733243	494.239	13.60753	56.9625	41.64666
1988	0.779383188	729.462394	517.6942	11.87108	56.975	35.31198
1989	0.455483659	734.812571	536.9417	11.74232	56.95	60.39176
1990	0.474552558	738.174442	590.0519	14.25014	57	53.03022
1991	0.461303369	752.810024	571.6511	13.73268	56.9	64.8766
1992	0.645018907	762.315597	559.8226	12.74817	56.9	61.03097
1993	0.582305872	755.683607	557.3815	13.55003	56.9	58.10985
1994	0.441207323	720.583605	548.5813	11.16543	56.8	42.30887
1995	0.322040394	715.14821	533.4169	7.065756	56.7	59.76783
1996	0.363611758	726.643537	546.2431	7.289924	56.6	57.69099
1997	0.352610133	739.711791	547.6899	8.356764	56.5	76.85999
1998	0.343834089	722.595865	548.6618	8.60161	56.3	66.17325
1999	0.373763101	729.956829	537.6261	6.994108	56.2	55.84639
2000	0.644398113	737.287753	552.1869	7.017881	56	71.38053
2001	0.661488951	751.025864	562.2306	7.579868	55.7	81.81285
2002	0.759338561	753.639997	568.9709	7.009923	55.5	63.38364
2003	0.702663375	746.942814	612.1304	9.904054	55.1	75.2189
2004	0.713585957	748.174067	797.8757	7.39337	54.8	48.44813
2005	0.750050856	763.038852	804.1524	5.458996	54.9	50.74836
2006	0.687395022	746.640972	847.5391	8.265865	55.1	64.60931
2007	0.64686256	731.60567	881.5914	9.249637	55.2	64.46291
2008	0.612540586	735.575691	911.9575	8.323477	55.4	64.97297
2009	0.461569798	703.143769	949.0064	12.08816	55.5	61.80285
2010	0.494090977	720.927803	995.6802	16.99081	55.6	42.65138
2011	0.477830387	720.643645	1015.815	15.97916	55.8	52.7941
2012	0.485960682	720.785724	1030.168	14.62636	55.9	44.38014
2013	0.481895535	720.714685	1055.837	14.47118	56.1	31.02589
2014	0.483928108	720.750205	1043.002	14.54877	56	37.70301
2015	0.482911821	720.732445	1049.419	14.50997	56.05	34.36445