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Impact of Non-Renewable Energy Consumption and Economic Growth on Carbon Emission in Nigeria

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Abstract

The study examines the impact of non-renewable energy consumption and economic growth on carbon emission using an annual data spanning from 1980 to 2022. The Autoregressive Distributed Lag Model was employed. From the analysis, the co-integration results reveal that there is a long-run relationship between the variables under study. Furthermore, both the long-run and short-run Autoregressive Distributed Lag (ARDL) estimates unequivocally demonstrate that both economic growth and the non-renewable energy consumption exert statistically significant, and positive impacts on CO_2 emissions. In essence, they jointly contribute to the observed increase in CO_2 emissions over the study period. Based on the findings, it is recommended that adequate regulations, restrictions and innovative ways in fostering economic growth through energy consumption from non-renewable energy sources are implemented alongside policies from energy regulatory Commission and environmental protection agencies, to explore avenues to invest in, and promote, carbon-reducing technology in production processes to mitigate against the effects and degradation of the environment.

Keywords: Non-Renewable Energy, Economic Growth, Carbon Emission, ARDL, Nigeria.

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1. Introduction

Climate change and global warming have been ongoing problems facing governments and policymakers in the 21st Century (VO & VO, 2022). Environmental contamination presents a plethora of challenges, including energy dependence, deforestation, freshwater scarcity, air pollution and climate change are seen as a threat to both the environment and human being. As a result, the connection between the factors that are directly related to climate change must be re-examined since they can cause global devastation, endanger human existence and the ecosystem (Fan et al., 2020). In this regard, CO_2 emission is regarded as the most significant source of Green House Gas with CO_2 accounting for 75% of GHGs emission. Due to the significant expansion of the industrial sector in developed nations, it is reasonable to assume that ecological deterioration significantly impacts their economies (Shahzad et al. 2021).

The utilization of energy resources in the production and consumption of goods and services has been attributed to cause the rising amount of world-wide carbon dioxide (CO_2) in their final form and used in the various sectors (manufacturing industries, residential, transportation sector and agriculture) (Wang et al., 2021). Carbon dioxide (CO_2) emissions resulting from consumptions of non-renewable energy resources such as natural gas, coal and oil are considered to be the main culprits of environmental pollution and global warming (Usman et al., 2022). Economic growth which is the goal of every nation relies heavily on energy use especially in the era of globalization and economic expansion, especially in emerging economies (Zhao, 2021). There are six main GHG contaminants which have significant impact on the atmosphere namely; CO_2, CH4 (Methane), N_2O (Nitrous Oxide), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF_6 (sulfur hexafluoride). Thus, CO_2 is considered to be the main contributor to global warming (Zhang & Da, 2015).

Increased worldwide awareness of ecological problems as a result of increase in economic activities that lead to carbon emission has aided the coordination of international initiatives such as the Kyoto protocol in 1997 and the Paris agreement in 2015. The goal of this initiatives remained to reduce global emissions and provide countries with a sustainable economic prosperity and environmental stability (Adebayo & Rjoub, 2021). Theoretically, the link between pollution and per capita growth is the main hypothesis of the Environmental Kuznet Curve (EKC). This implies, environmental pollution rises with the expansion of economic growth until it exceeds the peak level. The pollution level increases rapidly as the country develops but after reaching its peak, the pollution begins to decline (Wawrzyniak & Doryn, 2020).

Empirically, global energy consumption is anticipated to rise by 80%, whilst greenhouse gas emanations are also projected to increase by 50% over the same period. The projections are in tandem with that of Kahouli (2018), Nkengfack and Kaffo (2019) and Erdogan et al. (2020), who postulated that countries that experience more economic development consume a lot of energy, and therefore causes more environmental degradation. Energy from fossils consumed in-discriminately especially with low carbon technological equipment have a devastating effect on the environment and causing severe respiratory diseases globally (Danish & Wang, 2019). In addition, studies on the relationship between CO_2 emissions, energy consumption, and real GDP differ from country to country. Studies such as Mardani et al. (2018) investigated the relationship between CO_2 emissions, energy consumption and economic growth in G20 using an adaptive neuro-fuzzy inference system (ANFIS) model and discovered that energy consumption and economic growth significantly predicted the emanation of CO_2 in the nations and Arouri et al. (2012) found that CO_2 emissions can influence the GDP and/or energy consumption.

Without any doubt, energy consumption enhances both domestic /residential needs and this positively correlates with economic factors like, reduced poverty, enhanced overall standard of living, and increased exportation and immense contribution to socio-economic growth. However, in the face of economic progress and technological development among countries of the world, the high energy consumption in the production of goods, technology and innovation, possess long run effect on the environment as a result of carbon emission which affects Nigeria adversely.

There have been several research carried out on the nexus between energy consumption, economic growth and Carbon dioxide emission, in an attempt to understand and proffer solution to the problem of greenhouse emission, however with conflicting results. For instance, studies such as that of Alshehry and Belloumi (2015); and Jiang and Li, (2017), on the energy consumption-growth nexus, found a casual feedback nexus. While recent work of Bekun. Emir and Sarkodie (2019) conformed with growth hypothesis. In Nigeria, studies such as that of Youssef, (2017) and Paraclete (2018) also has conflicting results. In addition, Waheed et al. (2019) surveyed both single country and multi-country studies that investigated the association between economic growth, energy consumption and carbon emissions. The results reveal that carbon emission was not linked with economic growth in developed countries. However, Mahmood et al. (2020) investigated the environmental effects of economic growth and energy consumption and discovered that, economic growth and energy consumption contributed to high CO_2 emissions in both the long run and the short-run. These conflicting results has necessitated further research in these areas most especially as it pertains to Nigeria where environmental degradation is quite apparent in the far northern states where there is an increase in the frequency of the drought experienced, activities of gas flaring from the activities in the southern part of Kaduna. In the south especially where oil exploration takes place, their environment is heavily polluted. In states such as Lagos, which is seen as an industrial state also witnesses heavy pollution. This pollution no doubt is the result of the combustion and consumption of non-renewable energy in the quest for economic growth.

The motivation for the study is based on the premise that despite the increased awareness for solutions towards environmental friendliness, and strategy issues such as the decarbonization policies form the Kyoto Protocol and other international policies of the International Energy Agency for countries to diversify the supply mix of energy resources among nations, Nigeria has not been able to key into this policies to mitigate the associated air pollution and greenhouse gas emissions from fossil fuel consumption. This study therefore examines the impact of non-renewable energy consumption and economic growth on carbon emission using an annual data spanning from 1980 to 2022.

2.1 Literature Review

2.2.1 Concept of Energy consumption

Several scholarly works have explained the concept of energy consumption with relation to economic growth. As such, energy consumption is seen as the use of energy resources by manufacturing and processing industries, construction, non-fuel mining, households for either domestic or industrial purposes in the production of goods and services.

To buttress this, Ayres and Wars (2020) describe energy consumption as a flow of energy that drives the machines and heat or cooling the factories of office buildings. In addition, energy usage to transform economic goods into finished products can also be seen as the utilization of energy resources form fossil fuels as input in the production of goods and services involving both domestic and industrial applications. Ahmad and Du (2020) considered energy consumption as a vital factor of production that plays important role for the development of the business as an input during productive activities

The usage of energy resources in this aspect especially for the manufacturing industries leads to carbon emissions that leads to environmental degradation overtime. Energy consumption in varied forms in the productivity is important as it affects the economy in terms of an increase in the GDP, which in turn affects the lives of the people in terms of their income, happiness and health (IEA, 2019). The consumption of energy, whether oil, gas, electricity or coal can also be linked to urbanization in that, an increase in urbanization, normally brings about changes in land use, increases industrial activities, infrastructure and increased use of domestic appliances (IEA, 2019).

The total consumption of energy can be divided into several categories, such as driving (transportation), lighting, heating and communication. However, the industrial sector accounts for the majority of direct use of energy resources, most especially fossil fuels (US Energy Information Administration, 2020). The Residential Energy Consumption Statistics (RECS) world data for 2021 indicate that heating was the largest use of energy usage in homes. The industrial sector consumption of energy is evident in the operation of heavy machines for production of goods, lights, equipment for facility heating, cooling, and ventilation. This is quite evident in some key industries, such as aluminum and steel manufacturing, where the usage of electricity for the processing and production of semi-finished and finished goods alongside other industries (i.e., as food processing industries that use electricity for cooling, freezing, and refrigerating food). In the long run leads to emitting of greenhouse gas or carbon dioxide.

2.2.2 Concept of Carbon Emissions

The result of energy consumption especially from fossil fuels have yes contributed to economic growth in terms of gross domestic product, but as a consequence, have impacted negatively on the environment from carbon emission. CO_2 basically is the primary greenhouse gas emitted through human activities. CO_2 emissions stem mainly from burning oil, coal, and gas. Secondarily, these emissions can also be generated through the demands for energy use, in industries (manufacturing), commercial services and residential usage

Elayouty and Ali, (2021) in their study described carbon emission as a greenhouse consequence that warm the earth's climate, through creating a condition known as 'greenhouse effect'. These gases, including CO_2, nitrous oxide, methane and others are essential in sustaining a suitable temperature for the planet earth. Nevertheless, since the advent of the Industrial Revolution, these gas emissions have speedily amplified concurrently with energy-production and consumption, thus leading to climate change (Elayouty &Ali, 2021).

In another study, Menyah and Wolde-Rufael (2019) posit that CO_2 emissions are burning fossil fuels like fuel, coal oil natural gas, electricity production and consumption, released into the atmosphere as a result of industrial and commercial activities. According to World Health Organization, a carbon footprint is a measure of the impact an activity has on the amount of carbon dioxide produced through the burning of fossil fuels and is expressed as a weight of CO_2 emission produced in tonnes. In summary, carbon emission is the effect of the combustion activities, resulting from the use of fossil fuels during the production or transformation of economic of goods and the provision of essential services.

Regrettably, the unstable electricity supply in Nigeria for the past two decades has necessitated an increase in private and public sector producers of fossil fuel energy resources to generate electricity for industrial, residential and commercial usage, which pollute the environment with CO_2 emissions and other greenhouse gases. The quest for the use of energy (consumption) in varied forms has created environmental and health implications. This can be seen evidently in the Southern region such as Port Harcourt, the West like Lagos state and in the North West like Kaduna state. Nigeria also was rated as the world's 17^{th} emitter of greenhouse gas in 2020.

2.2.3 Concept of Economic growth

The goal of every nation in the world is to ensure that its economic and productive activities contribute to the growth of their economy. This is achieved through the transformation for raw materials from their natural state to semi-finished or finished product. Amadeo (2021) described economic growth as an increase in the production of goods and services over a specific period of time. More accurately, the measurement must remove the effects of inflation. In addition, he further explained that economic growth is an increase of the national income per capita and it comprises the examination, in quantitative terms, the functional relations between the endogenous variables and the increase of the GDP, Gross National Product and National Income.

Haller (2012) opined that economic growth also expresses the national wealth of a country to include the production capacity, expressed in both absolute and relative size, per capita, encompassing also the structural modifications of economy. Economic growth can safely be seen as the process of increasing the sizes of national economies, the macro-economic indications, especially the GDP per capita, rising upwards but not necessarily linear direction having positive effects on the economic-social sector, while development shows how growth impacts on the society by increasing the standard of life economic growth can either be positive, zero, negative.

George (2012) sees economic growth as a complex, long-run phenomenon, subjected to constraints like, excessive rise of population, limited resources, insufficient skilled labour, inadequate infrastructure, inefficient utilization of resources, excessive governmental intervention, institutional and cultural models that make GDP growth difficult. The growth of any economy is subject to the efficient use of the available resources and by increasing the capacity of production of a country.

The relationship between the economy, energy consumption and the environment has become a very important aspect between the energy economist and policy makers. Evidently, meeting the energy needs of a country in a sustainable manner, requires a balanced energy portfolio adapted to different economic and social conditions (Alvarez and Montanes 2023). Theoretically, Economic Growth has been closely linked to increased carbon dioxide emission and energy consumption leading to the opinion of a more prosperous world. There have been many theories which have tried to explain this connection of which some of these have been reviewed in this work.

2.3 Theoretical Review

The theoretical framework of this study is a buildup on Solow's (1956) economic growth model by adding the assumptions that production generates pollution but that allocating some final production to pollution abatement can reduce pollution. The resulting model implies that countries' level of emissions will converge over time. Furthermore, it is in line with the model based on the following framework as adapted from the works of Awodumi and Adewuyi (2020) which takes its root in the Environmental Kuznets Curve from Panayotou (1993).

2.3.1 The Neoclassical Growth theory

The neoclassical theory of growth was developed by Robert Solow (1956). This theory has been developed over the last years with important contributions to questions related to energy, the environment and economic growth (Cass, 1965; Koopmans, 1967), natural resources extraction and growth (Dasgupta and Heal, 1974; Stiglitz, 1974, Chakravorty et al., 1997, Martinet & Rotillon, 2007), environmental quality and income levels (Lopez, 1994; Brock and Taylor, 2004, 2005). This theory is centered on the construct that the economy is built on these factors of production namely capital, labour and technology. At the same time, the basic neoclassical growth theory abstracts from a potentially important aspect of the growth process in the sense that it makes little sense to acquire a piece of machinery, at a particular time and place, unless the machine can be supplied with energy and put to use. That is, it is of first order importance that an economy is able to distribute energy across the economy.

In this theory, production in each period begins with a given amount of capital, labour and technology and terminates in the production of goods. Capital has its origin prior periods. It is simply a portion of the economy's output carried forward from previous period. Labour in this case also, is assumed to grow exogenously. Technology in this case is seen as the stock of knowledge available to an economy. Furthermore, the Mainstream economics still base their theories in the neoclassical growth (Solow) model in which labor and capital are the protagonists in economic growth. Thus, the latter are regarded as the primary inputs, while energy is treated as any other input, which will exist perpetually in cheap and large quantities, namely, as an intermediate factor (Stern 2004). However, energy is exhaustible and non-reproducible and for this reason, it receives another theoretical treatment from the environmental perspective

2.3.2 Environment Kuznet Curve.

The Environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita. The EKC has been the main approach among economists to modeling ambient pollution concentrations and aggregate emissions since Grossman and Krueger (1991) introduced it a quarter of a century ago. In the early stages of economic growth, pollution emissions increase and environmental quality declines, but beyond some level of income per capita (which will vary for different indicators) the trend reverses, so that at high income levels economic growth leads to environmental improvement.

According to Panayotou (1993), the environmental impacts or emissions per capita are an inverted U-shaped function of income per capita. If there were no change in the structure or technology of the economy, pure growth in the scale of the economy would result in a proportional growth in pollution and other environmental impacts. This is called the scale effect. The traditional view that economic development and environmental quality are conflicting goals reflects the scale effect alone. Proponents of the EKC hypothesis argue that at higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, result in leveling off and gradual decline of environmental degradation.

Summarily, the EKC can be explained by the following 'proximate factors': an increase in the Scale of production implies expanding production. Different industries have different pollution intensities and typically, over the course of economic development the output mix changes. This is often referred to as the composition effect (Copeland & Taylor, 2004). Changes in input mix involve the substitution of less environmentally damaging inputs to production for more damaging inputs and vice versa. The last two can be seen as technique effect resulting from either environmental restrictions or innovation. In addition, improvements in the state of technology involve changes in both, Production efficiency in terms of using less, ceteris paribus, of the polluting inputs per unit of output. Emissions specific changes in process result in less pollutant being emitted per unit of input.

Some recent studies have indicated that an increase in the gross domestic product and Carbon emission resulting from energy consumption do not lead to environmental degradation especially in some developing or emerging economies. Conversely, some scholars have pointed out that many developed countries reduce their CO_2 emissions through decoupling and decarbonization processes. This debate was explained in the empirical aspect of the research work.

2.4 Empirical literature

Bashir, Susetyo, Suhel, and Azwardi (2021) examined the relationship among urbanization, economic growth, energy consumption, and CO_2 emissions in Indonesia. The study adopted a dataset ranging from 1985-2017 and a vector error correction model and Granger causality test. The empirical results reveal that, in the short run, there is evidence that urbanization and energy consumption can cause CO_2 emissions, and they also prove that urbanization can cause energy consumption. Also, a long-run relationship among the variables and causalities was revealed among the variables. However, unlike the current study which investigates the impact of energy consumption and CO_2 and economic growth in Nigeria, they examined the relationship among Urbanization, economic growth, energy consumption and CO_2 in Indonesia. In terms of timeframe, the study used a data spanning from 1985-2017. In terms of methodology, they employed the VECM and Granger causality test, unlike this study which uses both the Autoregressive distributed Lag in-depth analysis to the about the behavior of the individual variables of study.

Jan, et. al. (2021), examine the effect of economic openness and energy consumption matter for environmental deterioration in Pakistan using an annual dataset ranging from 1971 to 2016. The study employed the Autoregressive Distributed Lag model. The result of the study indicates that energy consumption has both in the long and short term positive and significant impact on CO_2 emission but the long-term impact is greater than the short-term impact. Further, the result show that economic progress acknowledged the environment Kuznets curve hypothesis, hence, the environmental degradation is limited. Finally, the economic progress has an insignificant impact on CO_2 emission. However, though the study is similar to the current study, the economic policies and energy utilization differs from Nigeria on which this work focuses on. Methodologically, the study adopted the linear ARDL,

Gao and Zhang (2021), investigate the relationship among CO_2 emissions, biomass energy consumption, economic growth and urbanization on 13 Asian developing countries. They employed the causality test and FMOLS (Fully Modified Ordinary Least Square) with a data spanning (1990-2015). The findings show that there is long-run relationship among the variables and that biomass energy consumption has no impact on CO_2 emission. The causality test reveal that there is unidirectional causality from GDP to biomass energy consumption in the short-run and from GDP and urbanization to CO_2 emission, respectively. From the long-run causal estimate, there exist a unidirectional relationship from CO_2, biomass energy consumption and urbanization to GDP, respectively. Hence, the study centered on biomass energy consumption while this study will be analyzing energy consumption from fossil fuels. In addition, the study adopted a panel analysis on countries which is not country specific unlike the current study is country specific, Nigeria. The study adopted the causality test method, while this study is going to adopt both the linear ARDL model which is more robust and advance in terms of analysis and the behavioral pattern of the variable under study.

Saidi and Rahman (2021) explored the relationships between environmental quality, economic growth, and energy use in five developing countries which are: Algeria, Nigeria, Indonesia, Saudi Arabia, and Venezuela from 1990 to 2014. They utilized the fully modified ordinary Least square (FMOLS), dynamic ordinary least square (DOLS) methods and panel Granger causality tests methods. The finding proves that in all countries there is bidirectional causality between GDP and energy consumptions, and between GDP and CO_2 except for Algeria. Also, in all countries, there is bidirectional causality between energy consumption and CO_2 except for Venezuela that has a unidirectional causality from CO_2 to energy consumption. Saudi Arabia has the highest impact of GDP on CO_2 followed by Venezuela, Nigeria then Indonesia. While Algeria has the highest impact of energy use on CO_2, then Indonesia and then Nigeria. However, the study focuses more on environmental quality as energy usage. Unlike the current study that focuses on the impact of energy consumption on other variables. Their study employed granger causality methods with a dataset spanning 1990 to 2014 while this study is going to employ the linear ARDL model which is more robust, advanced and consistent in analysis with a dataset spanning 1980 to 2020. Furthermore, this research work is country specific on like this study reviewed is more of a panel analysis. The period of study is from 1980 to 2022.

Ibrahim and Cudjoe (2021), investigate the environmental impact of energy consumption in Nigeria. The study applied Vector Error Correction Model (VECM) with a dataset spanning 1990-2018. The result showed that there is a long run positive impact of GDP on CO_2 emissions in Nigeria and the result refutes the Environmental Kuznet Curve hypothesis that environmental quality improved with an increase in income. Also, the result shows that charcoal consumption has a long run tendency of reducing CO_2 emission while fuel wood consumption has a long run possibility of raising CO_2 emission. Furthermore, the findings reveal that oil has a negative impact on CO_2 emissions while natural gas consumption and fuel oil consumption has a detrimental impact on CO_2 emission. Hydroelectricity consumption on the other hand has a long run negative impact on CO_2 emission. However, the study adopted the VECM technique in its analysis unlike the current study that adopts the ARDL technique of analysis for robustness.

Ezenwa, Nwatu and Gershon (2021), examine the nexus among economic growth, renewable energy consumption and CO_2 pollution in Nigeria. The study employed the vector error correction model (VECM) on the annual data for the period 1990-2015. The finding reveals that there is evidence of bi-directional causality between renewable energy consumption (REC) and economic growth (GDP). REC positively granger causes GDP in both short-run and long-run, while GDP has an adverse effect on REC in the short run. Historical decomposition of shocks reveals the relative implications of renewable energy shocks on GDP to be mostly negative between period 1990 and 2007. Additionally, there is persistent and positive influence of REC on economic growth in the period between 2009 and 2015. However, the study is based on the connection among growth, non-renewable energy consumption and economic growth on carbon emission in Nigeria, while this is looking at the impact of energy consumption from non-renewables on growth and carbon emission in Nigeria and adopting the linear ARDL model as inclusive model

Awodumi and Adewuyi (2020) investigates the role of non-renewable energy in economic growth and carbon emissions among the top oil producing economies in Africa during 1980–2015. The study adopted the non-linear autoregressive distributed lag (NARDL) technique. The result reveals evidence of asymmetric effect of per capita consumption of both petroleum and natural gas consumption on economic growth and carbon emission per capita in all the selected countries except Algeria. In Nigeria, although positive change in the non-renewable energy consumption retards growth, it reduces emission. In the case of Gabon, increase in the consumption of these energy products promotes growth and enhances environmental quality. Consumption of these energy types has negligible impact on environmental pollution in Egypt as it enhances economic growth. While positive change in the non-renewable energy consumption contributes to economic growth in Angola, the effect on carbon emission is mixed across time and energy type. In addition, the influence of negative change in petroleum and natural gas consumption is similar to those observed for positive change in Egypt and Nigeria

Yusuf, Abubakar and Mamman (2020), investigate the relationship between greenhouse gas emissions, energy consumption, and output growth among African

OPEC countries (Libya, Nigeria, Angola, Algeria, Equatorial Guinea, and Gabon). The study utilized panel autoregressive distributed lag model (PARDL) estimated by means of mean group (MG) and pooled mean group (PMG) for the period of 1970 to 2016. The empirical result shows that there is a positive and significant impact of economic growth on both CO_2 and methane emissions in the long run, but the impact on nitrous oxide emissions although positive was found to be statistically insignificant. Energy consumption was also found to produce an insignificant positive impact on CO_2, methane, and nitrous oxide emissions in the long run. In the short run, economic growth exerts a significant positive effect on methane emissions; however, its effect on CO_2 and nitrous oxide emissions although positive was found to be statistically insignificant. Energy consumption produces an insignificant impact on all components of greenhouse gasses in the short run.

Alege, Adediran, and Ogundipe (2016), investigate the direction of causal relationships among emissions, energy consumption and economic growth in Nigeria. The study employed The Johansen maximum likelihood cointegration tests with a dataset spanning 1970 to 2013. The result shows that fossil fuel enhances carbon emissions whereas, clean energy source (electricity) mitigate the atmospheric concentration of carbon dioxide (CO_2) emissions. Further, result indicates an existence of unidirectional causation running from fossil fuel to CO_2 emissions and gross domestic product (GDP) per capita. Alternatively, non-fossil energy (electric power) causes more proportionate change in GDP per capita but result could not establish any causal link between electric power and carbon emissions. However, the study adopted the VAR model while this study uses the linear and nonlinear ARDL model which is more robust and more advance with an extended time frame of the study from 1980-2020. This study contributes to the existing literature by considering the triple relationship between energy, the economy and the environment.

Unlike most studies which focus on the bivariate relationships. In addition, it is possible that energy types contribute differently to carbon emission which makes it imperative to isolate their individual effect for policy purposes. This study adopted that neoclassical growth theory which factors in energy into production process. This component helps in facilitating production and economic growth required in the deployment of inputs of capital, labour and energy. In addition, as the level of economic activities rises, the demand for energy tends to increase especially in countries with abundant energy resources. This in turn, facilitates the usage of both capital and labour. Nevertheless, the increase in the carbon emission is harmful to the environment as summarized in the EKC hypothesis.

3.0 Methodology

This study examined the impact of non-renewable energy consumption, economic growth on carbon emission in Nigeria using a dataset from 1980-2022. However, the model is based on the following framework as adapted from the works of Awodumi and Adewuyi (2020).

$$CO_2 = f\,(GDP, E) \qquad (1)$$

Where: CO_2 = Carbon emission, *GDP* is a proxy for economic growth, and *E* = energy consumption. Further included were controlled variables such as crude oil prices and trade openness to capture the non-renewable energy which has the highest carbon emission among the energy sources and the size of international trade integration. Furthermore, obtaining the value of the sum of imports and exports (trade openness) was deflated by GDP and to obtain a simple analysis, though there are other measures of trade integration. Therefore, equation (1) can be re-specified as:

$$CO_2 = f(GDP\ EC, OP, TOP) \qquad (2)$$

Now, the econometric model is introduced to capture all the study variables which are in natural log form (*ln*) and is re-specified in equation (3) as:

$$ln\ CO_{2t} = \delta_0 + \delta_1 lnGDP + \delta_2 lnEC + \delta_3 lnOP + \delta_4 lnTOP + \pi_t \qquad (3)$$

Where: δ_0 is the coefficient of the intercept, while $\delta_1, \delta_2, \delta_3, \delta_4$ are the slope coefficient of GDP, Carbon emission,, Trade openness, Crude Oil price, Energy consumption and π_t is the error term. The ARDL model was employed to examine the impact of non-renewable energy consumption and economic growth on carbon emission in Nigeria due to its advantageous features of it accommodating data irrespective of its order of integration which is either I(0), I(1), or a combination of both. Therefore, the specification is as follows:

$$\begin{aligned}\Delta lnC02t = \alpha + \beta 1 lnC02t-1 + \beta 2 lnGDPt-1 + \beta 3 lnCPt-1 + \beta 4 lnTOPt-1 \\ + \sum_{i=0}^{p-1} \partial 1 \Delta lnC02\, t-1 + \sum_{i=0}^{q-1} \partial 2 \Delta lnGDP\ t-1 + \sum_{i=0}^{q-1} \partial 3 \Delta lnCP\, t-1 \\ + \sum_{i=0}^{q-1} \partial 4 \Delta lnEC\, t-1 + \sum_{i=0}^{q-1} \partial 5 \Delta lnTOP\, t-1 + \mu it \qquad (4)\end{aligned}$$

Where: α is the intercept, $\beta1$- $\beta5$ are the long-run slope coefficients, $\partial1$- $\partial5$ is the short-run coefficients, p is the lag operator of the dependent variable, q is the lag operator of independent variables, t is the period, ln is natural log, Δ first difference operator, $\sum$ is summation, while i is the number of observations and μ is the error term. However, the cointegration relationship is conducted using the f-statistics in which the null hypothesis (H_0) of no-cointegration ($\delta_1 = \delta_2 = \delta_3 = 0$) is rejected against the alternative hypothesis (H_1) of cointegration ($\delta_1 \neq \delta_2 \neq \delta_3 \neq 0$).

Sources of Data

The data employed for the study was soured from various sources. Thus, crude oil prices (CP), carbon emission (CO_2), Trade Openness (TOP) Energy Consumption (EC) and GDP per capital were gotten from OPEC statistical data bank and World Development Indicator 2022.

4.0 Results and Discussion of Findings

Table 1: *Descriptive Statistics*

Variable	CO_2(kt)	RGDP (in Bn)	CP	TOP	EC
Mean	75337.15	51,700	69.89496	0.442954	715.2886
Median	72126.22	48,800	53.22500	0.464985	708.1564
Maximum	131685.6	86,900	231.6239	0.575306	798.6302
Minimum	19.71794	26,300	12.76000	0.289606	636.3569
Std. Dev.	34761.65	18,700	62.23329	0.106187	41.37789
Skewness	-0.215520	0.344436	1.299668	-0.189225	0.172863
Kurtosis	2.187527	1.848384	3.669612	1.419460	2.012172
Jarque-Bera	1.480339	3.151335	12.60862	4.622331	1.916831
Probability	0.477033	0.206869	0.071828	0.099146	0.383500
Observations	42	42	42	42	42

Source: Authors' Computation using Eviews12

The descriptive statistics of variables containing means, median, minimum, maximum, standard deviation, skewness, kurtosis, etc., are shown in Table 1. Furthermore, it shows the average of value of CO_2, within the period under study is 75337.15kilowatt with a standard deviation of 34761.65. The maximum value is 131685.6 and minimum value 19.71794. The average value of RGDP is 51,700 billion with a standard deviation of 18,700 billion. Its maximum value is 86,900 billion, while minimum value stands at 26,300 billion. Furthermore, crude oil price (CP) has an average value of 69.89496 with a standard deviation of 62.23329. Its maximum value is 231.6239 while minimum value stands at 12.76000. The average value and standard deviation of trade openness (TOP) are 0.442954 and 0.106187 respectively, while its maximum and minimum values within the period are 0.575306 and 0.289606. non-renewable Energy consumption (E) has an average value of 715.2886 with standard deviation of 41.37789. its maximum and minimum values stand at 798.6302 and 636.3569 respectively.

The skewness measures the degree of the asymmetry of the series. Thus, the results of the skewness report that CO_2 emission (CO_2) and trade openness (TOP) is negatively skewed with values of -0.215520 and -0.189225 respectively. This implies that the distribution has a long-left tail with lower value than the sample mean. RGDP and energy consumption (E) have a normal skewness of 0.344436 and 0.172863, meaning that the distribution of the series is symmetry around the mean. crude oil prices (OILP) have a positive skewness of 1.299668, implying that more of the distribution have a higher value than the sample mean. The Kurtosis on the other hand measures the flatness or peakedness of the distribution series. Evidence of the report shows that all the variables except oil price (OILP) are platykurtic (flatted curve) since they are less than 3, thus implies that the distribution has lesser values than the sampled mean. Oil price (OILP) is Mesokurtic (normal distribution) with a kurtosis of 3.669612. The jargue-Bera test statistic measure the difference of the skewness and kurtosis of the series with those from the normal distribution. Thus, given the result of the probability values (at 5% level of significance) of the Jarque Bera statistic, it can be concluded that the series are normally distributed.

Table 2: *ADF Unit Root Test*

Variables	Level		First Difference		
	ADF	**5% Critical value**	**ADF**	**5% Critical value**	**Remark**
CO2	-0.5194	-2.9350	-6.33766	-2.9369	I (1)
RGDP	-0.4849	-2.9350	-6.3770	-2.9369	I (1)
OILP	-2.3333	-2.9369	-4.6989	-2.9389	I (1)
E	-1.9255	-2.9350	-5.3641	-2.9369	I (1)
TOP	-0.9522	-2.9350	-5.3498	-2.9389	I (1)

Source: Authors' Computation using Eviews12

The outcomes of the unit root test unveil that all variables included in the model, comprising CO_2, RGDP, CP, EC, and TOP, exhibit first-order integration, represented as I(1). This signifies that the null hypotheses are rejected after the initial differencing where the absolute value of the ADF statistics is greater than the absolute value of the critical value at 5% level of significance, indicative of the stationary nature of these variables at the first difference level, I(1). Critically, it is observed that none of the data manifests second-order differencing, I(2). This result is significant as it mitigates the risk of spurious regression within the model.

Table 3: *Optimal Lag length*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-68.46532	NA	2.537030	3.767452	3.980729	3.843974
1	-60.23586	13.92676*	5.752944*	3.396711*	3.652644*	3.488537*
2	-60.17394	0.101622	1.842036	3.444817	3.743405	3.551948
3	-59.84985	0.515218	1.910770	3.479479	3.820723	3.601915

* indicates lag order selected by the criterion
Source: Authors' Computation using Eviews12

From Table 3, following the pragmatic approach to lag selection, all the lag selection criteria selected lag1 as the optimal level. Furthermore, the Akaike Information Criterion (AIC) emerges as the preferred choice due to its capacity to deliver a more concise model with the lowest value, specifically, 3.396711. Consequently, this study opts for a lag of 1 in the context of the Autoregressive Distributed Lag (ARDL) regression.

Table 4: *Cointegration test*

F-Bounds Test			**Null Hypothesis: No levels relationship**	
Tests	**Value**	**Signif.**	**I(0)**	I(1)
F-statistic	6.01	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Authors' Computation using Eviews12

The cointegration test, as illustrated in Table 4, revealed that the F-statistic obtained from the F-Bounds test is 6.01. This value is compared against the critical value bounds provided for the test. Specifically, at the 5% significance level, the lower bound critical value (I(0)) is 2.56, and the upper bound critical value (I(1)) is 3.49. Since the F-statistic of 6.01 is greater than the upper bound critical value of 3.49, we reject the null hypothesis that there is no levels relationship among the variables in the model. This result indicates that there is strong evidence to support the presence of a long-term (cointegrating) relationship among the variables being analyzed.

Table 5: *ARDL Long Run Estimate*

Dependent Variable: (CO2)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RGDP	0.250698	0.08443	2.969360	0.0030
OILP	0.071320	0.03542	2.013435	0.0436
EC	0.062520	0.02496	2.504696	0.0122
TOP	0.032491	0.01568	2.071657	0.0388
C	0.063740	0.02619	2.433918	0.0150

Source: Authors' Computation using Eviews12

The long-run coefficient of ARDL method depicts a positive relationship between economic growth (RGDP) and CO_2 emission. The RGDP coefficient of 0.250698 implies that, holding other independent variables constant, a percentage increase in RGDP will lead to about 0.25 increase in CO_2 emission. Furthermore, the p-value is 0.0030 which is less than 0.05(at 5% significant level). Thus, the null hypothesis that economic growth does not have significant impact of CO_2 emission is rejected. Similarly, oil price (OILP) has a positive coefficient of 0.071320, with a significant p-value of 0.0436, indicating that a percentage increase in OILP will lead to about 0.07% increase in CO_2 emission. In line with a-priori expectation non-renewable energy consumption (EC) has a significant positive impact on CO_2 emission. Given its coefficient of 0.062520 and p-value of 0.0122 implies that a percentage increase in energy consumption will lead to about 0.06% increase in CO_2 emission. trade openness (TOP) has a positive coefficient of 0.032491 with a significant p-value of 0.0388, implying that a percentage increase in trade openness will lead to about 0.03% increase in CO_2 emission.

Table 6: *ARDL Error Correction Regression (Short Run Estimate)*

Dependent Variable: D(CO2). Selected Model: ARDL(1, 1, 1, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP)	0.571055	0.14763	3.868064	0.0005
D(OILP)	0.021814	0.01066	2.046226	0.0408
D(E)	0.232501	0.07894	2.945271	0.0032
D(TOP)	0.150129	0.06842	2.194217	0.0282
CointEq(-1)*	-0.519940	0.09913	-5.244833	0.0001

R-squared	0.784959	Mean dependent var	-0.198780
Adjusted R-squared	0.773288	S.D. dependent var	1.367807
S.E. of regression	0.983217	Akaike info criterion	2.917875
Sum squared resid	34.80175	Schwarz criterion	3.126847
Log likelihood	-54.81644	Hannan-Quinn criter.	2.993971
Durbin-Watson stat	1.678646		

Source: Authors' Computation using Eviews12

The short-run estimate as depicted in the table revealed that RGDP is a coefficient of 0.571055 with a p-value of 0.0005, this implies that economic growth has a positive and significant impact on CO_2 emission. Therefore, a percentage increase in RGDP will lead to about 0.57% increase in CO_2 emission within the period under study. Similarly, the crude oil price (CP) has a coefficient of 0.021814 with a p-value of 0.0234, meaning that, a percentage increase in the crude oil price will also lead to about 0.02% increase in CO_2 emission. Similarly, non-renewable energy consumption (EC) has a significant positive effect on CO_2 emission, this is given by its coefficient of 0.232501 and significant p-value of 0.0318. Thus, a percentage increase in non-renewable energy consumption will lead to about 0.23% increase in CO_2 emission. Trade openness (TOP) has a coefficient of 0.150129 with a significant p-value of 0.0413, implying that a percentage increase in trade openness will lead to about 0.15 increase in CO_2 emission.

The Error Correction Term (ECT (-1)) is negative and statistically significant with a coefficient of -0.519940 and a probability level of 0.0000 at 5 percent level which implies that about 0.51% of the disequilibrium which occurs in the short run is corrected over the long run. In other words, the annual speed of adjustment from the short run shocks or divergence to long run equilibrium is approximately 52%. The R-squared also known as the goodness of fit is 0.784959, meaning that about 78% variation in the dependent variable (CO2 emission) can be explained by the independent variables (RGDP, OILP, E, TOP). The Durbin-Watson value of 1.678646, which is approximately 2, indicates that there is no serial correlation in the model.

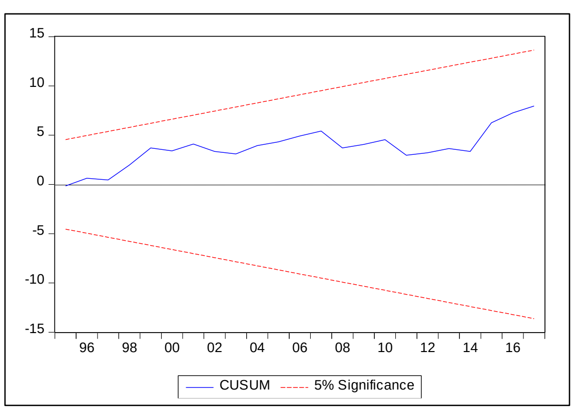
Table 7: *Diagnostic Test Result*

Tests	Type	F-statistic/value	Prob.
Heteroscedasticity	Breusch-Godfrey LM Test:	1.4334	0.2549
Serial correlation	Breusch-Pagan-Godfrey	4.2296	0.5260
Normality	Jarque-Bera	1.2465	0.5665

Source: Authors' Computation using Eviews12

The diagnostics test result presented in Table 7 contain the heteroscedascity, serial correlation and normality test. The result shows that the model is free from heteroscedasticity, serial correlation and the distribution is normal through their probability values. All the p-values are above the 5% critical value. The cumulative sum (CUSUM) plot from the recursive estimation of the model indicates stability of long-run coefficients over the sample period. It could be seen that the CUSUM plot do not crossed either of the five percent (5%) critical lines. Therefore, it could be concluded that the estimated parameters for the study are stable for the period under study and can be used for policy decision.

Figure 1: *Cusum Test*



Discussion of Findings

The study examined the impact of non-renewable energy consumption, economic growth on carbon emission using the Autoregressive distributed lag model. After co-integration was established, the ARDL long run estimate reveals that an increase in the consumption of non-renewable energy in the long run will increase carbon emission. This finding is in line with the works of Jan, et.al. (2021). The result of the study indicates that non-renewable energy consumption has both in the long and short term positive and significant impact on CO_2 emission. Furthermore, the result shows that economic progress acknowledged the environment Kuznets curve hypothesis and improvements in technology will lead to reduction of carbon emission and saving the environment from degradation.

5.0 Conclusion and Recommendations

5.1 Conclusion

The study used an annual data spanning from 1980-2022 to examine the impact of non-renewable energy consumption and economic growth on carbon emission in Nigeria. The result of the ARDL long run analysis revealed that all the variables such as crude oil price and carbon emission have positive and significant effect on *GDP* while only, *LTOP* was negative and insignificant. Furthermore, the short run analysis shows that results the Error Correction Mechanism, was also significant revealing that if there is any shock in the long-run the model is going to correct it through the speed of adjustment by 18.84 per cent. Therefore, the study concludes that consumption of non-renewable energy resources, through trade openness and crude oil consumption to foster economic growth, leads to carbon emission which in turn leads to attendant environmental consequences.

5.2 Recommendations

Based on the findings, it is recommended that the Nigerian government should ensure that adequate regulations, restrictions and innovative ways in fostering economic growth in energy consumption from non-renewable energy resources are implemented. In addition, it is recommended that state of the art equipment should be employed especially in the production of exportable products in addition to employment of carbon emission-reducing techniques to reduce the consequential effects of energy usage from crude oil and trade openness. It is therefore imperative for policymakers, Energy Regulatory Commission and environmental protection agencies to explore avenues to invest in, and promote, carbon-reducing and energy-saving technology in production processes in their quest for economic growth, if they must continue to increase the consumption of their abundant resources in non-renewables.

References

Ali, S. S. S., Razman, M R., & Awang, A (2020). The Nexus of population, GDP growth, electricity generation, electricity consumption and carbon emissions output in Malaysia. International Journal of Energy Economics and Policy, 10(3), 84.

Alege, P. O., Adediran, O., & Ogundipe, A. A. (2016). Pollutant emissions, energy consumption and economic growth in Nigeria. International journal of energy economics and policy, 6(2), 202-207.

Acheampong, A. O. (2018). Economic growth, CO2 emissions and energy consumption: what causes what and where? Energy Economics, 74, 677-692.

Abbasi, K. R., Shahbaz, M., Jiao, Z., & Tufail, M (2021). How energy consumption, industrial growth, urbanization, and CO2 emissions affect economic growth in Pakistan? A novel dynamic ARDL simulations Approach. Energy, 221, 119793.

Anjum, Z., Burke, P. J., Gerlagh, R., & Stern, D. I. (2014). Modeling the emissions-income relationship using long-run growth rates. CCEP Working Papers 1403

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is free trade good for the environment? American Economic Review, 91, 877-908.

Akpan, G. E., & Akpan, U. F. (2012). Electricity consumption, carbon emissions and economic growth in Nigeria. International Journal of Energy Economics and Policy 2(4), 292.

Awodumi, O. B., & Adewuyi, A. O. (2020). The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil producing economies in Africa. Energy Strategy Reviews, 27, 100434.

Anderson, D. and W. Cavendish (2001), 'Dynamic Simulation and Environmental Kuznets Curve', Journal of Public Economics 80(2), 269-286.

Adedoyin, F.F., Nwulu, N., & Bekun, F. V. (2021). Environmental degradation, energy consumption and sustainable development: accounting for the role of economic complexities with evidence from World Bank Income Clusters. Business Strategy and the Environment.

Azam, A., Rafiq, M., Shafique, M., Zhang, H., Ateeq, M., & Yuan J. (2021). Analyzing the relationship between economic growth and electricity consumption from renewable and non-renewable sources: Fresh evidence from newly industrialized countries. Sustainalbe Energy Technologies and Assessments, 44, 100991.

Adebayo, T.S., Awosusi, A, A., Odugbesan, J.A., Akinsola, G.D., Wong, W.K., & Rjoub, H. (2021). Sustainability of Energy-induced growth nexus in Brazil: do carbon emissions and urbanization matter?. Sustainability, 13(8), 4371.

Ali, H.S., Nathaniel, S.P., Uzuner, G., Bekun, F.V., & Sarkodie, S.A. (2020). Trivariate modelling of the nexus between electricity consumption, urbanization and economic growth in Nigeria: fresh insights from Maki Cointegration and casuality tests. Heliyon, 6(2), e03400.

Asongu, S.A., Agboola, M.O., Alola, A.A., & Bekun F.V. (2020). The criticality of growth, urbanization, electricity and fossil fuel consumption to environment sustainability in Africa. Science of the Total Environment, 712, 136376.

Adams, S., Adedoyin, F., Olaniran, E., & Bekun, F. V. (2020). Energy consumption, economic policy uncertainty and carbon emissions: causality evidence from resource rich economies. Economic Analysis and Policy, 68, 179-190.

Adedoyin, F. F., & Zakari, A. (2020). Energy consumption, economic expansion, and CO2 emission in the UK: the role of economic policy uncertainty. Science of the total Environment, 738, 140014.

Abdollahi, H. (2020). Investigating energy use, environment pollution, and economic growth in developing countries.

Anser, M. K., Usman M., Godil, D. I., Shabbir, M. S., Sharif, A., Tabash, M. I., & Lopez, L. B. (2021). Does globalization affect the green economy and environment? The relationship between energy consumption, carbon dioxide emissions, and economic growth. Environmental Science and Pollution Research, 1 – 14.

Anser, M. K., Usman M., Godil, D. I., Shabbir, M. S., Sharif, A., Tabash, M. I., & Lopez, L. B. (2021). Does globalization affect the green economy and environment? The relationship between energy consumption, carbon dioxide emissions, and economic growth. Environmental Science and Pollution Research, 1 – 14.

Baz, K., Xu, D., Ali, H., Ali, I., Khan, I., Khan, M. M., & Cheng, J. (2020). Asymmetric impact of energy consumption and economic growth on ecological footprint: using asymmetric and nonlinear approach: Science of the total environment, 718, 137364.

Balcilar, M., Ozdemir, Z. A., Tuncsiper, B., Ozdemir, H., & Shahbaz, M. (2020). On the nexus among carbon dioxide emissions, energy consumption and economic growth in G – 7 Countries: new insights from the historical decomposition approach. Environment, Development and Sustainability, 22(8), 8097 – 8134.

Bashir, A., Susetyo, D., Suhel, S., & Azwardi, A. (2021). Relationships between Urbanization, Economic Growth, Energy Consumption, and CO 2 Emissions: Empirical Evidence from Indonesia. The journal of Asian Finance, Economics and Business, 8(3), 79 – 90.

Balsalobre – Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic Growth, renewable electricity and natural resources contribute to CO2 emissions? Energy Policy, 113 356 – 367 .

Chontanawat, J. (2020). Relationship between energy consumption, CO2 emission and economic growth in ASEAN: Cointegration and causality model. Energy Reports, 6, 660-665.

Cowan, W.N., Chang, T., Inglesi-Lotz, R., & Gupta, R. (2014). The nexus of electricity consumption, economic growth and CO2 emissions in the BRICS countries. Energy Policy, 66, 359-368.

Ezenwa, N., V., & Gershon, O. (2021, March). Renewable Consumption Shocks on CO2 Emissions and Economic Growth of Nigeria. In IOP Conference Series: Earth and Environmental Science (Vol. 665, No. I, p. 012013). IOP Publishing.

Gao, J., & Zhang, L. (2012). Does biomass energy consumption mitigate CO2 emissions? The role of economic growth and urbanization: evidence from developing Asia. Journal of the Asia Pacific Economy, 26(1), 96 – 115.

Jiang, Q., Khattak, S. I., & Rahman, Z. U. (2021). Measuring the simultaneous effects of electricity consumption and production on carbon dioxide emissions (CO2e) in China: New evidence from an EKC – based assessment. Energy, 229 120616.

Joo, Y. J., Kim, C. S., & Yoo, S. H. (2015). Energy consumption, CO2 emission, and economic growth: evidence from Chile. International Journal of Green Energy, 12(5), 543 – 550.

Jan, A., Xin – Gang, Z., Ahmad, M., Irfan, & Ali, S. (2012). Do economic openness and electricity consumption matter for environmental deterioration: silver bullet or a stake?. Environmental Science and Pollution Research, 1 – 16.

Ibrahim, A. S., & Cudjoe, D. (2021). The environmental impact of energy consumption in Nigeria. Evidence from CO2 Emissions.

Khan, M. K., Khan, M. I., & Rehan, M. (2020). The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. Financial innovation, 61), 1 – 13.

Khan, M. B., Saleem, H., Shabbir, M. S., & Huobao, X. (2021). The effects of globalization, energy consumption and economic growth on carbon dioxide emissions in South Asian countries. Energy & Environmental. 0958305X20986896.

Kongkuah, M., Yao, H., Fongjong, B. B., & Agyemang, A. O. (2021). The Role of CO_2 emissions and economic growth in energy consumption: empirical evidence from Belt and Road and OECD countries. Environmental Science and Pollution Research, 28(18), 22488 – 22509.

Lin, B., & Li, Z. (2020). Is more use of electricity leading to less carbon emission growth? An analysis with a panel threshold model. Energy Policy, 137, 111121.

Li, K., Hu, E., Xu, C., Musah, M., Kong, Y., Mensah, I. A., ... & Su, Y. (2021). A heterogeneous analysis of the nexus between energy consumption, economic growth and carbon emissions: Evidence from the group of twenty (G20) countries. Energy Exploration & Exploitation, 39(3), 815 – 837.

Longe, A. E., Adekoya, T. M., Soyemi, C. O., Agbanuji, D. A., & Adekomi, I. J. The Asymmetric Impact of Oil Price and Electricity Consumption on Economic Growth: Evidence from Nigeria.

Magazzino, C., Porrini, D., Fusso, G., & Schneider, N. (2021). Investigating the link among ICT, electricity consumption, air pollution, and economic growth in EU countries, energy sources, part B: Economics, Planning and Policy, 1 – 23.

Nibedita, B., & Irfan, M. (2021). The role of energy efficiency and energy diversity in reducing carbon emissions: empirical evidence on the long-run trade-off or synergy in emerging economies. Environmental Science and Pollution Research, 1 – 17.

Odugbesan, J. A., & Rjoub, H. (2020). Relationship among economic growth, energy consumption, CO2 emission, and urbanization: evidence from MINT countries. Sage open, 10(2), 2158244020914648.

Olarinde, M., Martins, I., Abdulsalam, S. (2014), An empirical analysis of the relationship between CO2 emissions and Economic growth in West Africa. America Journal of Economics, 4(1), 1 – 17.

Polat, B. (2012). The impact of renewable and non-renewable energy consumption on economic growth: a dynamic panel data approach. Asia – pacific Journal of Accounting & Economics, 28(5), 592 – 603.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper, technology and employment programme, international Labour Office, Geneva, WP238.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: turning a black box into a policy tool. Environment and Development Economics, 2, 465 – 484.

Shahbaz, M., Sbia, R., Hamdi, H., & Ozkurk, I. (2014). Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emitrates. Ecological Indicators, 45 622- 631.

Shaari, M. S. (2017). The effects of electricity consumption and economic growth on Carbon Dioxide emission.

Salahuddin, M., Alam. K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. Renewable and Sustainable Energy Reviews, 81, 2002 – 2010.

Salari, M., Javid, R. J., & Noghanibehambari, H. (2012). The nexus between CO2 emissions, Energy consumption, and economic growth in the US. Economic Analysis and Policy, 69, 182 – 194.

Saint Akadiri, S., Alola, A. A., Olasehinde – Williams, G., & Etokakpan, M. U. (2020). The role of electricity consumption, globalization and economic growth in carbon dioxide emissions and its implications for environmental sustainability targets. Science of the Total Environment, 708, 134653.

Saint Akadiri, S., Alola A. A., Bekun, F. V., & Etokakpan, M. U. (2020). Does electricity consumption and globalization increase pollutant emissions? Implications for environmental sustainability target for China. Environmental Science and Pollution Research, 27(20), 25450-25460.

Saidi, K., & Rahman, M. M. (2021). The link between environmental quality, economic growth, and energy use: new evidence from five OPEC countries. Environment systems and decisions, 41(1), 3 – 20.

Schneider, N. (2021). Pollution growth, electricity demand and environmental sustainability in Nigeria: insights from a vector auto – regressive approach. International journal of Environmental Studies, 1 – 28..

Tong, T., Ortiz, J., Xu, C., & Li, F. (2020). Economic growth, energy consumption, and carbon dioxide emissions in the E7 countries: a bootstrap ARDL bound test. Energy, Sustainability and Society, 10(1), 1 – 17.

Rahman, M. M. (2020). Environmental degradation: The role of electricity consumption, economic growth and globalization. Journal of Environmental Management, 253, 109742.

Rahman, H. U., Zaman, U., & Gorecki, J. (2021). The role of Energy Consumption, Economic Growth and Globalization in Environmental Degradation: Empirical Evidence from the BRICS Region. Sustainability, 13(4), 1924.

Wasti, S. K. A., & Zaidi, S. W. (2020). An empirical investigation between CO2 emission, energy consumption, trade liberalization and economic growth: A case of Kuwait. Journal of Building Engineering, 28, 101104.

Usman, O., lortile, I. B., & Ike, G. N. (2020). Enhancing sustainable electricity consumption in a large ecological reserve-based country: the role of democracy, ecological footprint, economic growth, and globalization in Brazil. Environmental Science and Pollution Research, 27(12), 13370-13383.

Ummalla, M., & Goyari, P. (2021). The impact of clean energy consumption on economic growth and CO2 emissions in BRICS countries: Does the environmental Kuznets curve exist?. Journal of Public Affairs, 21(1), e2126.

Waheed, R., Sarwar, S., & Wei, C. (2019). The survey of economic growth, energy consumption and carbon emission. Energy Reports, 5, 1103-1115.

Yusuf, A.M., Abubakar, A. B., & Mamman, S. O. (2020). Relationship between greenhouse gas emission, energy consumption, and economic growth: evidence from some selected oil-producing African countries: Environmental science and pollution research international, 27(13), 15815.

Yao, S., Zhang, S., & Zhang, X. (2019). Renewable energy, carbon emission and economic growth: A revised environmental Kuznets Curve perspective. Journal of cleaner production, 235, 1338-1352.

Zhang, P., Cai, W., Yao, M., Wang, Z., L., & Wei, W. (2020). Urban Carbon emissions associated with electricity consumption in Beijing and the driving factors. Applied Energy, 275, 115425.

Zhang, J., Dai, Y., Su, C. W., Kirikkaleli, D., & Umar, M. (2021). Intertemporal change in the effect of economic growth on carbon emission in China. Energy & Environment, 0958305X211008618.

Zhao, M., Lu, L., Zhang, B., & Luo, H. (2021). Dynamic Relationship Among Energy Consumption, Economic Growth and Carbon Emissions in China. Research of Environmental Sciences, 1509-1522.