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Fossil Fuel Consumption, Economic Growth, and Environmental Degradation: Is the 'Energy Consumption-Growth' Nexus Sustainable in Nigeria?

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Abstract
The role of energy consumption in the growth and development of developed and developing economies has been considered a key developmental issue by scholars. Sustainable growth will require a lot of energy-intensive growth that isn't bad for the environment or doesn't do a lot of damage. The question asked by development economists is, therefore, "How Sustainable is the Energy-Induced Growth among Developing Countries?" This study therefore investigated the sustainability of the "energy consumption-growth" nexus with a focus on the consumption of non-renewable (fossil fuel) energy in Nigeria during the period 1980–2019. Data for the study was sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin and the World Development Indicator (WDI) published by the World Bank. Pre-estimation diagnostics (descriptive statistics, correlation, unit root test, and cointegration), model estimation, and post-estimation diagnostics analysis were conducted on the time series data. Based on the unit root test result and cointegration tests, the Autoregressive Distributive Lag (ARDL) short and long run forms were estimated for both the economic growth and environmental degradation models. It was found that fossil fuel consumption exerted mixed (positive and negative) effect on economic growth in the short run but negative effect in the long run. Moreover, economic growth and fossil fuel consumption were found to impact positively on environmental degradation in the short run. Amongst others, the study concludes that the "Energy Consumption-Growth" nexus in Nigeria is not sustainable. An efficient energy consumption in Nigeria was recommended. It was also recommended that the government should encourage and also fund responsible consumption of fossil fuel by manufacturing firms, government parastatals, and households.

Keywords: *Fossil Fuel, CO2 Emission, Sustainability, Environmental Degradation*

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I. Introduction

At some point during economic growth, a remarkable success emerges with the ultimate prize for environmental preservation. Environmental degradation and climate change due to CO2 emissions, ocean acidification, deforestation, and increased levels of water and air pollution have resulted in an increase in human economic activity (Graff-Zivin, 2018). Environmental issues such as biodiversity loss and climate change have also been linked to pollution (Uchudi, 2001). Following WWII's end, a significant amount of hazardous industrial gas emissions such as chlorofluorocarbons, carbon monoxide, sulphur oxide, and carbon dioxide were released into the atmosphere (Ghadar, 2006).The need to successfully integrate economic growth with environmental quality has long been debated (Adedoyin, Alola, & Bekun, 2020; Chem & Taylor, 2019). In this regard, economic growth and energy consumption positively interact, so that as energy consumption rises, output rises as well (Adedoyin, Gumede, Bekun, Etokakpan, & Balsalobre-lorente, 2019; Udi, Bekun, & Adedoyin, 2020; Khan, Teng, Khan, & Khan, 2019; Saidi & Hammani, 2015). As a result, poor environmental quality is unavoidable, which is detrimental to both the environment and the health of humans. A rise in greenhouse gas emissions (GHGs) is also a result of industrialization-driven high economic growth (Pata, 2018; Alola & Yildirim, 2019). GHG emissions from traditional non-renewable energy use are causing a growing problem for the atmosphere, and this issue should be given more attention. Some energy sources release carbon dioxide into the atmosphere when they are burned, which contributes to the greenhouse effect. Industrial society began using fossil fuels to make steam engines in 1763 and to make iron in smelters in the 1800s. This was the beginning of the shift away from renewable energy sources. Co2 and fossil fuel emissions have risen sharply since World War II as a result of an increase in wood and coal use and a rapid increase in oil and natural gas production (Hinrichs, 1996). Every year, more than 50 million tons of fuelwood are consumed in Nigerian communities because more than 70% of the population relies on it for energy (Oyedepo, 2012).Since the dawn of the industrial age, the world's increased reliance on fossil fuels has led to an increase in atmospheric carbon dioxide concentration, which in turn has raised the Earth's temperature and contributed to climate change. Low-energy production and use must undergo a major shift if we are to maintain a sustainable economy that can provide essential goods and services to citizens of both developed and developing countries and maintain a supportive global system (Nfah, Ngundam, & Tchinda, 2007; Kankam & Boon, 2009). Development economies are in charge of global environmental problems caused by climate change and keep them to a minimum, while developing countries face more serious, complex, and rapidly expanding environmental problems due to foreign corporations, businesses, and individuals disregarding environmental protection laws (Robinson, Shaheen, & Shaheen, 2007). Energy-efficient technologies and alternative fuels must be developed in developing countries, but the desire for economic growth and population growth will thwart this effort. Even though energy is essential for economic growth and social progress, sustainable development's long-term climate change mitigation depends on the use of renewable energy sources (Wang, Yu, & Liu, 2019). There is a need to find alternative energy sources because of this. Nations, regions, communities, and institutions are ready to do so (Ozturk & Bilgili, 2015; Akadiri, Alola, Akadiri, & Alola, 2019). For the Millennium Development Goals (MDGs), renewable energy sources are especially important because they can help alleviate poverty while also providing a foundation for long-term human development (Wang & Dong, 2019). According to Shahbaz, Zeshan, and Afza (2012), using both renewable and non-renewable sources of energy boost the economy. It is, however, preferable for an economy to increase the use of renewable energy over non-renewable energy, as the former helps to reduce CO2 emissions.

Fossil fuels are the primary source of energy in most developed and developing countries (Sugiawan & Managi, 2019; Caetano, Mata, Martins, & Felgueiras, 2017). These systems, despite their many advantages, such as the ability to provide thermal power plants with more precise operational control and monitoring (Savvidis, Siala, Weissbart, Schmidt, Borggrefe, Kumar, Pittel, Madlener & Hufendiek, 2019, for example), are plagued by a variety of issues that have been extensively researched and examined (Pillot, Muselli, Poggi, & Dias, 2019). Fossil fuels are at the heart of the transition to low-carbon economies because of their environmental impacts, scarcity, supply risk, and instability of prices and markets. Nigeria, a developing country, is no exception to the trend of environmental challenges becoming more serious, complex, and fast-growing (Robinson et al., 2007). There was a population boom and economic growth as a result of these challenges, which were brought on by urbanization. As a result of their dependence on wood and traditional biomass for their energy needs, rural residents contribute greatly to the destruction of the environment and the emission of greenhouse gases (GHG), which in turn contributes to global warming and environmental degradation (Okafor & Joe-Uzoegbu, 2010). Because of their efforts to supply energy to cities and other industrialized areas, these individuals have contributed to an energy imbalance across the country's socioeconomic and political landscape (Ajayi & Ajanaku, 2007). The major source of greenhouse gases released into the atmosphere has been the practice of gas flaring by oil companies operating in Nigeria. CO2 emissions are among the highest in the world in this region (Martinot & McDom, 2002). According to Acheampong, Adams, and Boateng (2019), it is imperative for economies to drastically reduce their dependence on fossil fuels and invest significantly in renewable energy in order to achieve economic growth. They also stated that the only way to slow down or stop global warming and environmental degradation is to stop using non-renewable energy sources. According to Hanif, Aziz, and Chaudhry (2019), a trade-off between fossil fuels and renewable energy sources is unavoidable for economies hoping to promote environmentally friendly economic growth. Similar criticisms of nuclear energy consumption have been made by Jin and Kim (2018). Because of global warming's rapid pace, it is imperative that renewable energy be developed and expanded. With regard to renewable, clean, or less risky energy, Atems and Hotaling (2018) stress the need for a rapid transition. Transitioning from non-renewable energy sources to renewable energy sources, however, cannot be done in isolation; it requires heavy investment in R & D and labor, conscious and deliberate government policies, and increased access to foreign capital. R & D expenditure is the most heavily emphasized (Shahbaz et al., 2015). Investments in R&D are critical to economic growth because they aid in the discovery of alternative energy sources that reduce the non-renewable energy composition in the energy mix, according to Zafar et al. (2019). (Zafar et al., 2019). However, in developing countries like Nigeria, R & D investment is often a problem. Scientific communities around the world are concerned about the lack of funding for research and innovation. In contrast to public and private sector decision-makers, this mindset emphasizes the question of how much research and innovation contribute to the growth and development of businesses, sectors, and the economy as a whole Kutlača, Šestić, Jelić, & Pantić, 2020). This is the opposite of the current scientific and innovation management mindset. As a result, this research examines the "Energy-Growth Nexus" in Nigeria in relation to non-renewable energy consumption.

The remainder of the paper is organized as follows. Section 2 reviews existing literature related to the topic. Section 3 reveals the empirical methodology, data measurement, and model specification for testing the sustainability of the ‘energy-growth’ nexus. Section 4 presents the empirical results and discussions, and section 5 concludes with a summary of our findings and policy implications.

II. Literature Review

2.1 Theoretical Review

- Resource Endowment Theory

At least according to the theory of resource endowment (Liu, Wang, Jing, & Tang, 2020), global economic growth has been accompanied by massive energy consumption since the industrial revolution. The theory of resource endowment posits that countries are endowed with a variety of resources that can influence their path to prosperity (Kassim & Isik, 2020). To put it another way, Afia's (2019) work emphasizes that because energy consumption can satisfy all of our basic needs by improving our living conditions, it can be considered an important source of happiness for humans.

- Growth Theories

When it comes to the production process, factors like energy use and domestic material consumption are just as important as investments because they have an impact on efficiency levels and economic gains (Popescu, Andrei, Nica, Mieilă, & Panait, 2019). According to economic theory, Cobb-Douglass' production function is a useful tool for analyzing the role of various variables in economic growth, as it shows the technological relationship between inputs needed to produce a specific output. However, only labor and capital are considered inputs in this model. Exogenous technology treatment is a limitation of the Solow model, which aims to explain long-term economic growth. In Paul Romer's model, this weakness was further acknowledged. The Romer model treats technology as an exogenous variable in a different way. It becomes crucial to production when infused with energy use (Kassim & Isik, 2020). Aktar, Alam and Al-Amin (2021) point out that technology and energy are intertwined, and that energy, in turn, plays a role in the production process. The dynamic simulation model, which was used in China, is worth mentioning given that numerous studies have shown the importance of energy in strengthening industrial structures. By using information from simulation and prioritizing uncertainties derived from the E&I-SD model, policymakers can plan the coordinated development of energy and industrial structure strategies, according to Han, Lin, Zhang, and Farnoosh (2019), a group of researchers. Bottom-Up An energy market's characteristics, policy effects, and the costs and challenges of technological change are the primary focus of techno-economic models. As opposed to energy-only models, top-down computable general equilibrium models take into account the feedback effects across the entire economy.

- Environmental Kuznets Curve Theory

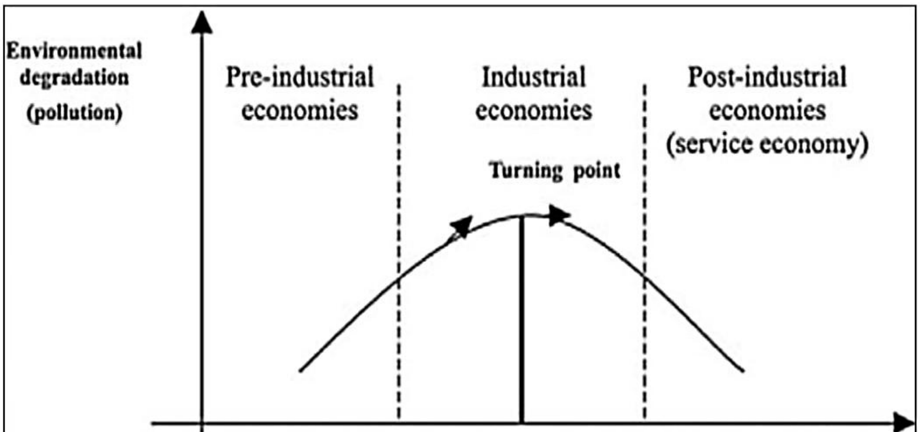


Figure 1: The Environmental Kuznets curve: A development-environment relationship
Source: Adapted from Ong et al (2021)

A non-linear relationship exists between economic growth and environmental quality, according to studies by Shafik and Sushenjit (1992) and Panayotou (1993). People prioritize and demand environmental protection at certain points in the economy. "Environmental Kuznets curve", represented in figure 1 above, is a term coined by economist Simon Kuznets, who defined the same pattern for income inequality (Andrée, Chamorro, Spencer, Koomen, and Dogo, 2019). Economic growth, according to the curve, does not significantly harm the environment, and the amount of biodegradable waste is limited. As agriculture and resource extraction intensify and industrialization takes off, both resource depletion and waste generation increase. There will be a structural shift toward information-based industries and services and more efficient technologies at higher levels of development. Consequently, the demand for environmental quality will rise, which will lead to a steady decline in environmental degradation as a result of this. Kuznets curve theory has important implications for governments around the world. At the pre-industrial and industrial stages, nations need to slow down economic growth in order to protect the environment, while countries at the post-industrial stage can benefit from better environmental performance. Alternatively, Beckerman (1992) and Pettinger (2019) state that the fastest way to improve the environment is along the path of economic growth with higher incomes, which comes from increased demand for goods and services. Because of this, environmental protection measures are not as costly to implement. According to Beckerman (1992), the best way for a country to protect its environment over the long term is to become wealthy. This is according to Beckerman (1992). This study examines the role of domestic fossil fuel consumption in economic growth and the consequences for the environment.

2.2 Empirical Review

2.2.1 Energy Consumption and Economic Growth

According to some prior research (both single country and cross-section of countries), the "energy-growth nexus" has been examined in a variety of ways. A recent study on sub-Saharan Africa's energy consumption, political regimes and economic growth from 1971 to 2013 by Adam, Klobodu and Apio (2016) is an example. The variables included energy consumption, energy prices, GDP, and openness. The panel vector autoregressive model is employed (PVAM). A feedback hypothesis was discovered in the study's findings. A study by Karanfil and Li (2015) looked at 160 countries' energy-growth nexus from 1980 to 2010. Electricity consumption and economic performance were the inputs into the model. The panel-specific differences are examined as part of the method. In the study, conservative, feedback, and neutrality hypotheses were found to be true. During the period from 1977 to 2013, Bloch, Rafiq, and Salim (2015) studied the relationship between China's GDP and the country's oil, coal, and renewable-energy resources. Gross domestic product (GDP), oil, natural gas, and electricity were all taken into account in the analysis. ARDL techniques and vector error correction models are used in the methodology. A feedback hypothesis was found by the study. For the Organization of Petroleum Exporting Countries (OPEC) between 1970 and 2014, Medee, Ikue-John, and Amabuike (2018) studied the Toda-Yamamoto Approach to investigate how energy consumption and economic growth are linked. Economic growth and non-renewable energy consumption are the two variables that are used in this study. An augmented granger causality model (AGCM), developed by Toda-Yamamoto, was employed. The authors discovered the most common feedback hypotheses among the world's leading oil exporters. Mesbah (2016) examined Egypt's economic development and energy consumption from 1980 to 2012. Oil, electricity, natural gas, and economic growth are the variables. The Toda Yamamoto causality test is used. The neutrality hypothesis was found to be correct. Using a multivariate panel dataset spanning the years 1990–2012, Aneja, Banday, Hasnat, and Koçoglu (2017) investigated the link between BRICS countries' energy consumption and economic growth during the period 1999–2004. GDP per capita renewable energy consumption, non-renewable energy consumption, and gross fixed capital formation all have a long-term relationship, as shown by the Pedroni panel cointegration test. It also used a panel error correction mechanism, which shows unidirectional causality between economic growth and the consumption of renewable and non-renewable resources. The findings support the hypothesis of conservation. In other words, there's no evidence that energy use correlates with economic growth. According to these findings, the BRICS countries' economic growth is the most important factor in boosting energy consumption. Energy use rises in lockstep with economic expansion. Non-renewable energy's impact on economic growth and carbon emissions in Africa's top oil-producing economies from 1980 to 2015 was examined by Awodumi and Adewuyi (2020). The paper used the non-linear autoregressive distributed lag (NARDL) technique to account for the nonlinearity and structural break in unit root and cointegration analysis. In all countries except Algeria, research shows that per capita consumption of petroleum and natural gas has an asymmetric effect on economic growth and carbon emissions. Positive shifts in Nigeria's non-renewable energy consumption may slow growth, but they reduce emissions at the same time. Increasing the use of these energy products in Gabon promotes growth and improves the environment. Using these energy sources does not have a significant impact on Egypt's environment because it boosts economic growth. Angola's economic growth is aided by a rise in non-renewable energy consumption, but the impact on carbon emissions is mixed. The impact of a decrease in petroleum and natural gas consumption is similar to that of an increase in Egypt and Nigeria, where positive changes were noted. Investing in and promoting carbon-reducing technology in the production processes of oil-producing economies (in Africa) is therefore essential if they are to continue to increase the consumption of their abundant resources, such as oil and natural gas. There is a positive environmental impact of energy consumption when total energy consumption is decomposed into the total renewable and non-renewable energy for the 16-EU countries and Algeria respectively, according to Belaïd and Youssef (2017) and Alola, Bekun, and Sarkodie (2019). Hanif (2018) and Hanif, Aziz, and Chaudhry (2019) looked at East Asia and the Pacific and 25 developing Asian economies using total fossil fuel energy consumption. According to GMM estimates, they found that this type of energy made a significant contribution to CO2 emissions. A study by Hdom (2019), which adopted the ARDL technique, found that the use of fossil fuels to generate electricity in eight South American countries had no impact on carbon emissions. Additionally, research has focused on the role of aggregate non-renewable (and renewable) energy in economic development. The ARDL technique has been used to show that non-renewable energy has significantly contributed to economic growth in Turkey and 28 other countries (Afonso, Marques, & Fuinhas, 2017; Dogan, 2016). Using FMOLS, panel ARDL and causality approaches, Akadiri, Alola, Akadiri, and Alola (2019) found that total renewable energy increased economic growth while increasing carbon emissions in 28 EU countries. There may be a trade-off between economic growth and environmental quality when using renewable energy sources. No one has come to a conclusion about the total amount of non-renewable (and fossil fuel) energy. Fossil fuel consumption in developed economies increased CO2 emissions, but slowed economic growth, as found by Ito (2017) using GMM and pooled mean group estimates. Evidence that total fossil fuel consumption (African countries) and coal consumption (India) contribute positively to growth but raise CO2emissions in ECOWAS member countries was provided by Mensah, Sun, Gao, Omari-Sasu, Zhu, Ampimah, and Quarcoo (2019); as Adewuyi and Awodumi (2017) also showed that results are mixed among ECOWAS member countries.

2.2.2 Economic Growth and Environmental Degradation

It is a common desire and goal of both developed and developing countries to pursue environmentally sustainable growth. Environmental protection and economic growth have been examined by some academics. For instance, Ong, Adedeji, Cheah, Tan, Teh, and Masoud (2021) studied the relationship between economic growth and the Environmental Performance Index. Covering the years 2002 to 2017, the authors examined data from the World Bank and the Yale Environmental Performance Index on economic growth and the Environmental Performance Index in Malaysia. In their study, they found that GDP growth has a big and bad effect on the Environmental Performance Index. Environmental performance was also negatively impacted by population growth. Exports of goods and services and environmental performance are all linked to FDI and their associated added value. Research shows that Malaysia's environmental performance index has declined as the manufacturing sector has grown. According to Tenaw (2021), Ethiopia's emissions of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) were structurally affected by growth between 1975 and 2017. As the ARDL model demonstrates, both the short-run and long-run effects of increased population size on emissions are magnified. A long-run, monotonically increasing relationship exists between CO2 emissions and the composition effect, while the patterns for CH4 and N2O emissions show no increase over time. For both CO2 emissions and CH4 and N2O emission growth, a generally decreasing and an Inverted-U shaped technique effect of growth is achieved. A higher level of income is required for the technique to work in reducing CH4 and N2O emissions, despite the fact that CO2 emissions can be reduced even at a lower level of income. The primary source of pollution in the environment appears to be energy produced from fossil fuels. A Granger causality test by Toda-Yamamoto suggests that the three structural components of growth have a one-way correlation with all emissions. This suggests that a self-correcting mechanism in the growth process may not automatically reduce environmental pollution. To grow economically in a way that is good for the environment, techniques must be strong enough to fight the scale effect. Non-parametric regression analysis was used by Bakehe (2018) in a study of 10 Congo Basin African countries from 1990 to 2010. Scale and composition effects on deforestation are confirmed, but the technique effect is not. Liobikiene and Butkus (2019) looked at the relationship between GHG emissions and economic growth in 147 countries from 1990–2012 and found evidence of a scale and technique effect, but no evidence of a composition effect on growth in their estimation results. Jena (2018) discovered that the negative technique effect dominated the positive scale effect for sulfur dioxide (SO2), whereas the positive scale effect outweighed for nitrogen oxide (NO2) and suspended particulate matter (PM10) in India (SPM). Static and dynamic panel regressions were used to examine the impact of growth on CO2 emissions in 23 SSA countries over the period 1996–2014, and the results showed that scale and composition effects increased emissions while technique effects decreased emissions (Nkengfack, Fotio, and Djoudji, 2019). In other words, the weights of the scales, compositions, and techniques are found to be unevenly distributed across the CO2 emission levels. This is consistent with Shahbaz, Gozgor, Adom, and Hammoudeh (2019) findings that the scale effect of growth increases CO2 emissions in the United States, while the composition and technique effects of growth reduce them. On the other hand, the scale effect, on the other hand, was shown by Ansari and Khan (2021) to increase environmental degradation, while the composition and technique effects have been shown to reduce it in Asian countries from 1991 to 2016. Additionally, this study found that the granger's size and composition had an impact on its ecological footprint.

2.2.3 Energy Consumption on Environmental Pollution

Studies on the environmental impact of energy consumption have been inconclusive. According to a study by Aboje, Abdulfatai, Saka, and Onyeji (2016), the economic and environmental impacts of oil exploration and exploitation in Nigeria were documented. This study examined the amount of gas and oil produced and flared in Nigeria from 1970 to 2010; it also looked at the amount of oil produced during that time period and the average price per barrel during that time period. Between 1970 and 2010, crude oil sales generated \$669 billion, according to data collected and analysed. There was also an estimated \$192 billion in gas produced between 1999 and 2010, which could have been recovered if it had been used properly. However, 587,375,000 m3 of gas was flared, resulting in an additional \$151.3 billion in lost revenue. Thus, not only does the extraction of oil contribute to the country's economy, but it has also greatly contributed to environmental pollution and the need to collect gas for efficient use. An attempt was made to depict the environmental impact of fossil fuel energy, including the effect on global temperature and rising water levels, by Oludaisi, Adama, and Okubanjo (2017). Key to the study's methodology was the assessment of the current mitigation strategy and the recommendation of a long-term approach to efficient energy use, which the study asserted is a direct result of climate change. Mathematical and statistical analysis were used by Martinos, Felgueiras, Smitkova, and Caetano (2019) to show that European countries do not have abundant fossil fuel reserves, but that their findings could change in future years. Analysis of 29 European countries' fossil fuel energy consumption, fossil fuel depletion, and their relationship to other variables, such as energy dependence and renewable energy share in gross final energy consumption, was conducted in the study. Many European countries still rely heavily on fossil fuels, according to the findings of the study. When the Kruskal–Walli's test was used, significant differences were not found in terms of gross inland consumption per capita. By 2050, assuming the Jazz scenario, only 14 percent of oil proven reserves will remain, 72 percent of coal proven reserves will remain, and 18 percent of gas proven reserves will remain. In light of Europe's limited supply of fossil fuels, if they are needed, they will quickly run out. For a period of 38 years (1975–2012), Khan, Zaman, Irfan, Awan, Ali, Kyophilavong, Shahbaz, and Naseem (2016) studied the long-run and causal relationships between selected variables in Pakistan's specific scenario, where all inputs are adjustable. The findings show that both short-run and long-run use of energy and water resources has a significant impact on air pollution. The connection serves as additional evidence that the former's effects on the latter are caused solely by the latter, and not the other way around. Similarly, the results show that energy use and water resources will continue to have an impact on air pollution for the next ten years. The total natural resources rent exhibits the least contributor to affect air pollution in Pakistan. Using panel data regression analysis, Zheng, Yi, and Li (2015) found empirical support for the positive impacts of provincial energy saving regulations and two environmental standards on the improvement of local air quality over the period 2002-2011 in 26 Chinese provinces. Global warming and air pollution, which affect human health and quality of life, can be attributed to the use of fossil fuels such as coal and oil. According to Lott, Pye, and Dodds (2017), the UK could meet its decarbonization targets by 2050 if it made adequate changes to residential heating technology. This would result in a 40% reduction in PM (particulate matter with a diameter of less than 10 m) pollution and a 45% reduction in PM (particulate matter with a diameter of less than 2.5 m) pollution between 2010 and 2050. In contrast, if the established policy strategies were applied in the transportation sector, there would be little change in the pollution profile. Li, Feng, and Li (2017) concluded that Chinese government policy plays a major role in the long-term and more permanent SO2 2.5 emission decline by modifying the industrial structure, switching to cleaner energy sources, limiting population growth, and regulating the number and emissions of vehicles. Government policies are the primary force behind Beijing's efforts to improve air quality, as evidenced by the reforms implemented in the city's economic structure. Analysis of premature deaths attributable to air pollution in three regions of China by Zhang, Qu, Zhao, Zhu, Zhang, Lu, Sabel, and Wang (2018) found that the impact of domestic trade on regional air quality is strong and widespread. Because of this, China's air pollution policy needs to take into account the whole supply chain in order to reduce the negative health effects of air pollution, so this is what they need to do.

III. Research Method

Ex-post facto design research was chosen for this study because of its unique nature. For the purposes of estimating the long-run effects of the underlying explanatory variables on each of the response variables, this is considered appropriate. During the course of this research, two different methodological frameworks were used. In the first place, the Solow growth model emphasized the importance of physical labor and capital accumulation in the production of national output, with no special consideration given to technological progress and natural resources. Natural resources (e.g., energy) have become increasingly important in the modern economy, which relies heavily on equipment and machinery that have been developed as a result of improved technology to run. Global economic growth has been steadily rising over the past few decades, particularly in newly industrialized countries. In this study, new growth theory is adopted, in which technology is integrated into production functions. Second, the EKC hypothesis sums up the effect of economic growth on carbon emissions (the rising level of economic activity). At lower income levels, the hypothesis suggests that CO2 emission rises, but declines at higher income levels. Trade openness is also a factor in determining the level of greenhouse gas emissions, as is the degree of urbanization (Menyah & Wolde-Rufeal, 2010), which directly impacts carbon emissions. A positive shift in non-renewable energy consumption may have different effects on economic growth than a negative one, and this could have an impact on the environment as well. The data used in the study is drawn from the International Energy Agency, World Development indicators and Central Bank of

Nigeria (CBN) statistical Bulletin. While data for fossil fuel consumption was sourced from the International Energy Agency (IEA) Database (https://www.iea.org), data for CO2 emission, foreign direct investment, rainfall, industrial development, external trade, and temperature were sourced from the World Bank's World Development Indicators Database (https://databank.worldbank.org). Lastly, data on real GDP and government expenditure were sourced from drawn from the electronic Statistical Bulletin of the Central Bank of Nigeria (CBN) (https://www.cbn.gov.ng/documents/statbulletin.asp). Data sourced for this study were analysed under three procedures namely pre-estimation, model estimation, and post-estimation diagnostic. Firstly, results of descriptive statistic (mean, maximum, minimum, and standard deviation), correlation matrix, unit root test, and co-integration test will be presented and discussed in the pre-estimation sub-section. Secondly, short run, long run and error correction models will be presented and discussed in the model estimation sub-section. Lastly, results of both residual (normality, serial autocorrelation, and heteroscedasticity) and stability (mis-specification and Cummulative sum) tests will be provided and discussed for each of the estimated models.

A data set's characteristics are summarized or described using descriptive statistics. Measures of central tendency and measures of variability are the foundations of descriptive statistics (or spread). In this study, the mean and standard deviation is used as a measure of central tendency and variability respectively. A correlation matrix is nothing more than a table that contains the correlation coefficients for various variables. Correlations between all possible pairings of values in a table are represented by a matrix. It is a very useful tool for summarizing massive datasets and identifying and visualizing patterns within the data. Correlation matrices are made up of rows and columns containing the variables. Correlation coefficients are stored in each cell of a table. A unit root test is used in statistics to determine whether a time series variable is non-stationary and has a unit root. The null hypothesis is generally defined as the presence of a unit root and the alternative hypothesis is either stationarity, trend stationarity or explosive root depending on the test used. There are different types of unit root tests but this study adopted only the augmented Dickey-Fuller (ADF) and Phillip-Perron tests. A cointegration test is used to determine whether there is a long-term correlation between numerous time series. The notion was first established by Nobel laureates Robert Engle and Clive Granger in 1987, following the publication of a spurious regression concept by British economist Paul Newbold and Granger. Cointegration tests discover circumstances in which two or more non-stationary time series are integrated in such a way that they cannot stray from long-term equilibrium. The tests are used to determine the degree to which two variables are sensitive to the same average values over a defined time period. The Autoregressive Distributive Lag (ARDL) bounds test was chosen for this paper as the cointegration test. The ARDL limits test is performed under the assumption that the variables are either I(0) or I(1). Thus, prior to performing this test, we use unit root tests to identify the order of integration of all variables. The goal is to avoid producing erroneous findings by ensuring that the variables are not I(2). We cannot comprehend the results of F-statistics supplied by Pesaran, Shin, and Smith (2001) in the presence of order two variables integrated. Pesaran and Shin (1999) and Pesaran et al. (2001) created the ARDL cointegration technique. When compared to prior and traditional cointegration approaches, it has three advantages. The first is that the ARDL does not require that all variables under study be integrated in the same order; it can be used with variables integrated in order one, zero, or fractionally integrated. The second advantage is that the ARDL test is substantially more efficient when sample sizes are small or finite. Finally, and perhaps most significantly, by utilizing the ARDL technique, we may obtain unbiased estimates of the long-run model (Harris & Sollis, 2003). The following are the ARDL models utilized in this study:

$$\alpha\left(L,p\right)y_t = \alpha_0 + \sum_{i=1}^{k}\beta_i\left(L,q_i\right)x_{i,t} + \varepsilon_t \qquad 1$$

Where α_0 is a constant, y_t denote the dependent variable, *L* is a lag operator, $x_{i,t}$ is the vector of regressors (where i = 1, 2, …, k) and ε_t is the disturbance term. In the long-run, we have $y_t = y_{t-1} = \ldots = y_{t-q}$ and $x_{it} = x_{i,t-1} = \ldots = x_{i,t-q}$. Here, $x_{i,t-q}$ denotes q^{th} lag of the i^{th} variable. The long run equation can be written as follows:

$$y_t = \alpha + \sum_{i=1}^{k}\beta_i x_i + \varepsilon_t \qquad 2$$

The error correction (EC) representation of the ARDL model can be written as follows:

$$\Delta y_t = \Delta\alpha_0 - \sum_{j=1}^{p}\alpha_j\Delta y_{t-j} + \sum_{i=1}^{k}\beta_{i0}\Delta x_{it} - \sum_{i=1}^{k}\sum_{j=1}^{q}\beta_{it-j}\Delta x_{i,t-j} - \alpha\left(1,p\right)ECM_{t-1} + \varepsilon_t \qquad 3$$

$$ECM_t = y_t - \alpha - \sum_{i=1}^{k}\beta_i x_{it} \qquad 4$$

Where Δ is the first difference operator, $\alpha_{j,t-1}$ and $\beta_{i,t-1}$ are the coefficients estimated from equation (3), and $\alpha\,(1,\,p)$ measures the speed of adjustment.

Before using the estimated results for policy recommendations, post estimation diagnostic tests are conducted to check the efficiency and consistency of the models. While the Jarque-bera test of normality, Breusch–Godfrey test of serial correlation, and Breusch-Pagan-Godfrey heteroscedasticity test were all conducted on the estimated models under the residual post estimation diagnostic; the Ramsey Reset test of mis-specification and CUSUM test of stability of coefficients were conducted on each of the model under the stability post-estimation diagnostics.

IV. Results

4.1 Pre-estimation

Table 1: Descriptive Statistics Result for Time Series Variables

Variables	**Maximum**	**Minimum**	**Mean**	**Standard Deviations**
Key Variables				
Real GDP	72094.09	16211.49	35985.44	19317.89
Real GDP Growth Rate	15.32916	-13.12788	3.176302	5.399415
CO2 Emission Growth Rate	59.87000	-40.01000	2.264250	14.78221
Fossil Fuel Consumption	8.420000	1.730000	4.355000	1.841028
Control Variables				
Rainfall	111.7800	72.97000	93.88100	8.477803
Temperature	27.83000	26.46000	27.18050	0.334173
Total Government Expenditure	9714.600	9.600000	1997.139	2531.364
External Trade	22824.41	8.784517	5602.181	7127.141

Source: Authors' Computation

Table 1 above shows the maximum, minimum, mean and standard deviation statistics of the variables in this study. The real GDP was as high as ₦ 72,094 billion in a fiscal year during the period and was as low as ₦ 16, 211 billion too. Moreso, the difference between the mean and standard deviation shows that the country did not experience significant growth in real GDP during some periods; and this is further confirmed from the real GDP growth rate maximum value of 15.33% with the worst recession of -13.13% in a particular year. The high standard deviation of the real GDP growth rate, when compared with the mean, shows our highly inconsistent the growth rate has been in the country during the period 1980-2019. Emission growth rate of CO2 was as high as 59.87% in a particular year and proved to vary significantly over the period consider in this study as the standard deviation was as higher than the mean. The rate of fossil fuel consumption remained relatively constant as the standard deviation was lower than the mean of fossil fuel consumption. Besides government spending and external trade that proved to vary significantly among the control variables; both rainfall and temperature, which were selected to measure climate change as a consequence of environmental pollution resulting from consumption of fossil fuel, proved not to vary. This implies that much progress has not been made by the country as it concerned a key climate performance indicator.

Table 2 shows the correlation matrix of the variables selected in this study. The two models estimated in this paper have different dependent and independent variables. The correlation coefficients between the variables in the growth model are all less than 0.50; implying that none of the correlational coefficients shows perfect correlation between the variables in the economic growth model. Moreso, none of the correlation coefficients between the independent variables in the environmental degradation implies perfect correlation. This is so because none of correlation coefficient is 1 and also statistically significant.

Table 2: Correlation Matrix Results

Correlation Probability	gdpgr	rgdp	co2egr	fossilfuel_consp	rainfall	temperature	tgexp	ext_trade
gdpgr	1.00							
	----							
rgdp	0.40	1.00						
	0.02	---						
co2egr	0.31	0.03	1.00					
	0.07	0.87	---					
fossilfuel_consp	0.45	0.95	0.02	1.00				
	0.01	0.00	0.92	---				
rainfall	0.24	-0.12	0.00	-0.07	1.00			
	0.16	0.48	0.99	0.68	---			
temperature	0.45	0.60	0.14	0.59	-0.07	1.00		
	0.01	0.00	0.42	0.00	0.67	---		
tgexp	0.37	0.99	0.03	0.95	-0.16	0.61	1.00	

	0.03	0.00	0.86	0.00	0.35	0.00	---	
ext_trade	0.33	0.92	0.06	0.88	-0.12	0.54	0.94	1.00
	0.05	0.00	0.72	0.00	0.49	0.00	0.00	---

Source: Authors' Computation

Table 3 below shows stationarity test results for the variables in the two models estimated for this study. Firstly, based on the ADF and PP tests, three of the time series variables are stationary at level while the other time series variables became stationary after first difference. Secondly, two three time series variables are stationary at level in the growth model. Lastly, one time series was stationary at levels in the environmental degradation model. ARDL Bound cointegration test was as such conducted on both models.

Table 3: Unit Root Test Results

Time Series	Panel A: Levels				
	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Decision
	Test Statistic	5% Critical Value	Test Statistic	5% Critical Value	
gdpgr	-2.76	-2.94	-3.60*	-2.94	Not Stationary
*ln*rgdp	-0.69	-2.94	0.65	-2.94	Not Stationary
co2egr	-9.38*	-2.94	-11.56*	-2.94	Stationary
*ln*fossilfuel_consp	-0.99	-2.95	-1.01	-2.95	Not Stationary
*ln*rainfall	-5.34*	-2.94	-5.43*	-2.94	Stationary
*ln*temperature	-3.87*	-2.94	-3.93*	-2.94	Stationary
*ln*tgexp	-0.62	-3.53	-1.63	-3.53	Not Stationary
*ln*ext_trade	-0.95	-2.94	-0.96	-2.94	Not Stationary
Time Series	Panel B: First Difference				
	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)		Decision
	Test Statistic	5% Critical Value	Test Statistic	5% Critical Value	
gdpgr	-11.63*	-2.94	-12.52*	-2.94	Stationary
*ln*rgdp	-4.24*	-2.94	-4.29*	-2.94	Stationary
*ln*fossilfuel_consp	-4.66*	-2.95	-4.58*	-2.95	Stationary
*ln*tgexp	-7.55*	-3.53	-7.40*	-3.53	Stationary
*ln*ext_trade	-7.23*	-2.94	-7.23*	-2.94	Stationary

Source: Authors' Computation; * implies that the test statistic is greater than the 5% critical value.

Table 4: Bounds Cointegration Tests Result

Panel A: Economic Growth Model				
Test Statistics	**Value**	**Signif.**	**Lower Bound [I(0)]**	**Upper Bound [I(0)]**
F-statistic	30.05412	10%	2.08	3.00
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15
Panel B: Environmental Degradation Model				
Test Statistics	**Value**	**Signif.**	**Lower Bound [I(0)]**	**Upper Bound [I(0)]**
F-statistic	17.50286	10%	2.37	3.20
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Source: Authors' Computation

Table 4 above shows that the bound test statistic (i.e., F-statistic) for both models are greater than the 1%, 2.5%, 5%, and 10% lower bound and most importantly the upper bounds critical values. The F-statistics of 30.05 was greater than the 1%, 2.5%, 5%, and 10% upper bound critical values of 4.15, 3.73, 3.38, and 3.00 respectively in Bound ARDL cointegration result for the economic growth model presented in panel A. Moreover, the F-statistics of 17.50 was greater than the 1%, 2.5%, 5%, and 10% upper bound critical values of 4.66, 4.08, 3.67, and 3.20 respectively in Bound ARDL cointegration result for the environmental degradation model presented in panel B. The foregoing implies that a long run relationship has been established between the variables in the economic growth and environmental degradation models. The following section presents and discusses the results of the estimated economic growth and environmental degradation model.

4.2 Model Estimation

4.2.1 Economic Growth

Figure 2 shows the result of the Schwarz Information Criteria (SIC) test conducted to arrive at the best autoregressive distributive lag (ARDL) model to be estimated. The best model is represented by the model with least height of criteria. In this case, it is 'Model126' with the model lags 4, 4, 3, 4, 4, 4, 4. Hence, the growth model estimated is based on the result of SIC lag selection criteria result. Panel A of table 5 presents the short run form result of the estimated economic growth model. Firstly, the significant coefficients of level and one lag of fossil fuel consumption appeared with positive and negative signs respectively. Secondly, significant coefficients of some of the control variables (namely CO2 emission growth rate and temperature) shows that environmental degradation and climate change resulting from fossil fuel consumption impacted negatively on economic growth. Moreover, rainfall and government spending at level and lags impacted negatively on economic growth. From the foregoing, we can state that fossil fuel consumption had mixed effect on economic growth. While it impacts positively at current year, it impacted negatively after a year of fossil fuel consumption.

Panel B of table 5 presents the long run form result of the estimated economic growth model. Firstly, the coefficient (i.e., -48.32824) appeared with a negative sign and also statistically significant since p-value of 0.0250 is less than 0.05. This implies that fossil fuel consumption is expected to impact negatively on economic growth in Nigeria. Moreover, the selected control variables are also expected to have significant impact on economic growth in the long run.

Lastly, panel C presents the error correction representation for the selected ARDL growth model. The coefficient (i.e., -0.720431) of the ECM [i.e., CointEq(-1)] has the hypothesized negative sign and it is statistically significant (p-value of 0.00<0.05). This implies that deviations from the short-term in economic growth adjust quickly to long run equilibrium. That is, the long run equilibrium in economic growth model can almost immediately be restored should there be short run distortion in economic growth.

The last panel of the table 5 present some model statistic namely R^2 and p-value of F-statistic. The R^2 value of 0.9936 shows that the model is a good fit. Thus, about 99.36 per cent variation in growth rate in GDP is explained by the systematic changes in the independent variables. Moreover, the probability of F-statistics (i.e., 0.02) shows that the entire model is statistically significant at 1% level. To further check that the model is adequate for adoption and policy formulation, both residual and stability post-estimation tests were conducted on the economic growth model in the following section.

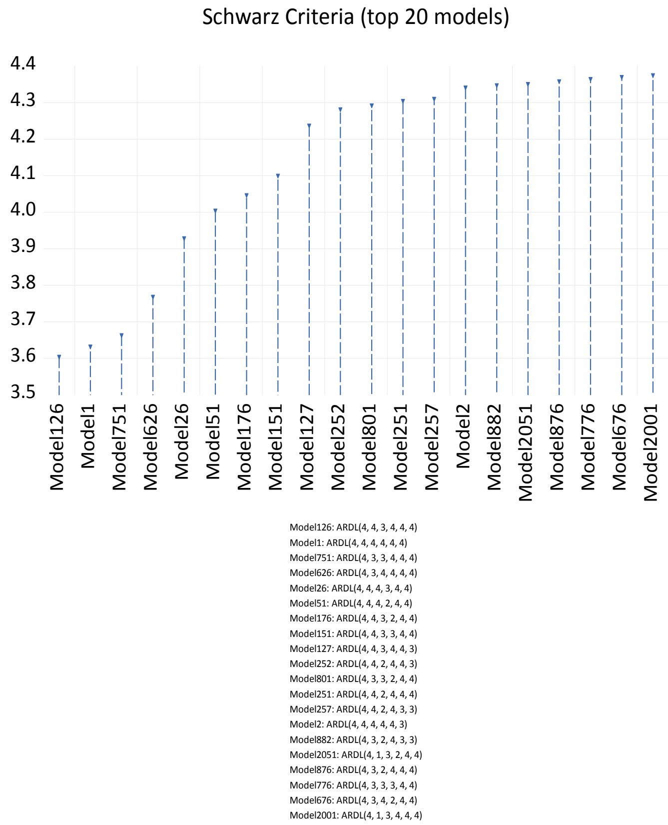


Figure 2: Graph showing most suitable ARDL model for the estimated Economic Growth Model using the Schwarz Information Criteria (SIC)

Table 5: Economic Growth Models

Panel A: Short-Run Form		
Variables	**Coeff.**	**p-value**
gdpgr_1	0.509570*	0.0139

gdpgr_2	1.151164**	0.0101
gdpgr_3	1.052317*	0.0172
gdpgr_4	-0.992619**	0.0067
*ln*fossilfuel_consp	62.53031*	0.0130
*ln*fossilfuel_consp_1	-25.31932*	0.0390
*ln*fossilfuel_consp_2	-12.00205	0.1660
*ln*fossilfuel_consp_3	13.95530	0.1103
*ln*fossilfuel_consp_4	-4.347071	0.5132
co2egr	-0.108115	0.1020
co2egr_1	-0.359506*	0.0070
co2egr_2	-0.183341*	0.0235
co2egr_3	-0.082881	0.1487
*ln*temperature	-596.4906*	0.0113
*ln*temperature_1	-259.0581**	0.0089
*ln*temperature_2	-334.2058	0.0550
*ln*temperature_3	-11.45735	0.7294
*ln*temperature_4	71.62108	0.2127
*ln*rainfall	0.979851	0.8961
*ln*rainfall_1	29.50089*	0.0248
*ln*rainfall_2	63.93257*	0.0149
*ln*rainfall_3	47.72482*	0.0123
*ln*rainfall_4	22.76165	0.1054
*ln*tgexp	-30.03136**	0.0083
*ln*tgexp_1	-12.19753*	0.0234
*ln*tgexp_2	2.906772	0.3054
*ln*tgexp_3	26.48718**	0.0025
*ln*tgexp_4	5.733665	0.1671
C	2991.592*	0.0327
Panel B: Long-run Form		
*ln*fossilfuel_consp	-48.32824*	0.0250
co2egr	1.018615*	0.0283
*ln*temperature	1567.937*	0.0197
*ln*rainfall	-228.8904*	0.0458
*ln*tgexp	9.856978*	0.0347
C	-4152.501*	0.0188
Panel C: Error Correction Term		
CointEq(-1)*	-0.720431**	0.0001
R-squared = 0.9936 | p-value (F-statistic) = 0.02		

Source: Authors' Computation

NB: * and ** signifies significance at 5% and 1% significant level respectively.

4.2.2 Environmental Degradation

Figure 3 shows the result of the Akaike's Information Criteria (AIC) test conducted to arrive at the best autoregressive distributive lag (ARDL) environmental degradation model to be estimated. The best model is represented by the model with least height of criteria. In this case, it is 'Model455' with the model lags 1, 1, 4, 0. Hence, the environmental degradation model estimated is based on the result of AIC lag selection criteria result. Panel A of table 6 presents the short run form result of the estimated environmental degradation model. Firstly, the significant coefficients of level real GDP appeared with positive sign. This shows that economic growth impacted positively on environmental degradation proxied by CO2 emission growth rate. Secondly, significant coefficient of lag 4 of fossil fuel consumption appeared with a positive sign showing fossil fuel consumption will still impact positively on environmental degradation even after four years. Moreover, the significant coefficient (i.e., -7.432409) of level international trade appeared with a negative sign. From the foregoing, we can state that economic growth and fossil fuel consumption impacted positively on environmental degradation proxied by CO2 emission growth rate.

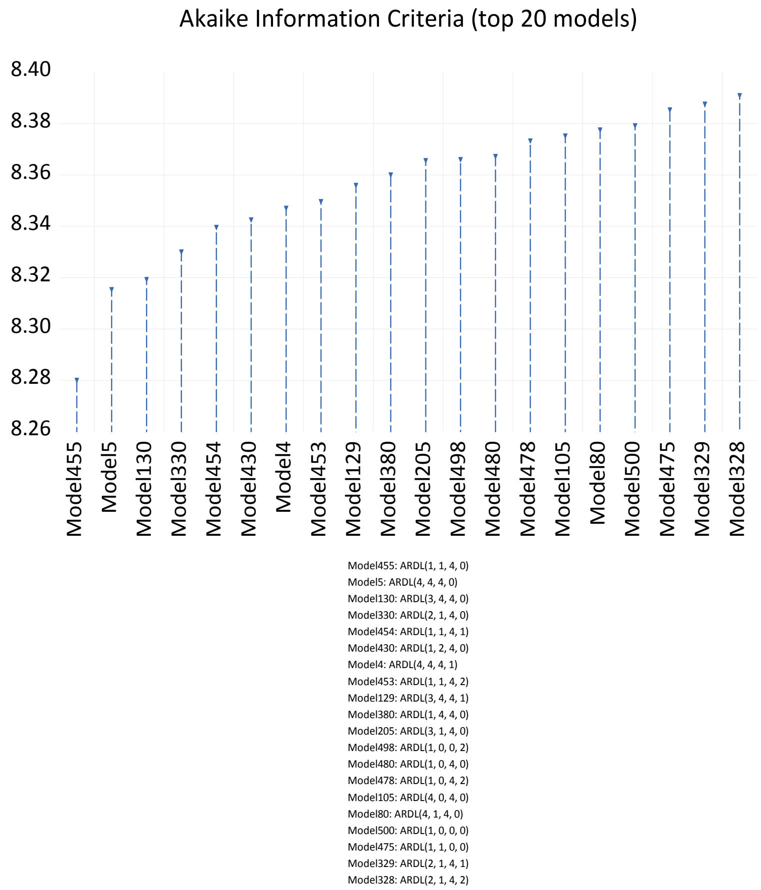


Figure 3: Graph showing most suitable ARDL model for the estimated Environment Degradation Model Using Akaike's Information Criteria (AIC)

Panel A: Short-Run Form		
Variables	**Coeff.**	**p-value**
co2egr_1	-0.383533*	0.0267
*ln*rgdp	170.5566*	0.0366
*ln*rgdp_1	-151.4270	0.0727
*ln*fossilfuel_consp	-2.009877	0.9628
*ln*fossilfuel_consp_1	-39.31694	0.4432
*ln*fossilfuel_consp_2	19.95812	0.6958
*ln*fossilfuel_consp_3	-52.55730	0.3062
*ln*fossilfuel_consp_4	89.69468*	0.0156
*ln*ext_trade	-7.432409*	0.0212
C	-162.9567	0.4380
Panel B: Long-run Form		
*ln*rgdp	13.82658	0.4378
*ln*fossilfuel_consp	11.39740	0.6184
*ln*ext_trade	-5.372049*	0.0256
C	-117.7830	0.4365
Panel C: Error Correction Term		
CointEq(-1)*	-1.383533**	0.0000
R-squared = 0.5008 | p-value (F-statistic) = 0.04		

Source: Authors' Computation
NB: * and ** signifies significance at 5% and 1% significant level respectively.

Panel B of table 6 presents the long run form result of the estimated CO2 emission growth rate model. Firstly, the coefficient (i.e., 13.82658) of real GDP appeared with a positive sign but not statistically significant since p-value of 0.4378 is greater than 0.05. This implies that economic growth is expected to have insignificant positive impact on environmental degradation in the long run. Moreover, the coefficient (i.e., 11.39740) of fossil fuel consumption appeared with a positive sign but not statistically significant since p-value of 0.6184 is greater than 0.05. This implies that fossil fuel consumption is expected to have insignificant positive impact on environmental degradation in the long run. Again, significant coefficient of international trade appeared with a negative sign.

Lastly, panel C presents the error correction representation for the selected ARDL environmental degradation model. The coefficient (i.e., -1.383533) of the ECM [i.e., CointEq(-1)] has the hypothesized negative sign and it is statistically significant (p-value of 0.00<0.05). This implies that deviations from the short-term in environmental degradation adjust quickly to long run equilibrium. That is, the long run equilibrium in environmental degradation model can almost immediately be restored should there be short run distortion in environmental degradation.

The last panel of the table 6 present some model statistic namely R^2 and p-value of F-statistic. The R^2 value of 0.5008 shows that the model is a good fit. Thus, about 50.08 per cent variation in CO2 emission growth rate is explained by the systematic changes in the independent variables. Moreover, the probability of F-statistics (i.e., 0.04) shows that the entire model is statistically significant at 1% level. To further check that the model is adequate for adoption and policy formulation, both residual and stability post-estimation tests were conducted on the environmental degradation model in the following section.

4.3 Post-estimation Diagnostics

4.3.1 Residual Diagnostics

Three (3) post-estimation residual diagnostics test were conducted on each of the model estimated in this study. They are the Jarque-Bera normality test, Breusch-Godfrey Serial Correlation test, and the Breusch-Pagan-Godfrey Heteroskedasticity test. Figure 4 and 5 are the results for the Jarque-Bera normality test conducted on both the economic growth and environmental degradation models respectively. From figure 4, we found that the histogram is bell shaped and the p-value (i.e., 0.53) of the Jaque-Bera statistic (1.25) is greater than 0.05. This implies that we fail to reject the null hypothesis of normal distribution of residual of the model. Hence, the residuals in the economic growth model are normally distributed. Moreso, figure 5 also shows that the histogram is bell shaped and the p-value (i.e., 0.09) of the Jaque-Bera statistic (4.71) is greater than 0.05. This implies that we also fail to reject the null hypothesis of normal distribution of residual of the model. Hence, the residuals in the environmental degradation model are normally distributed.

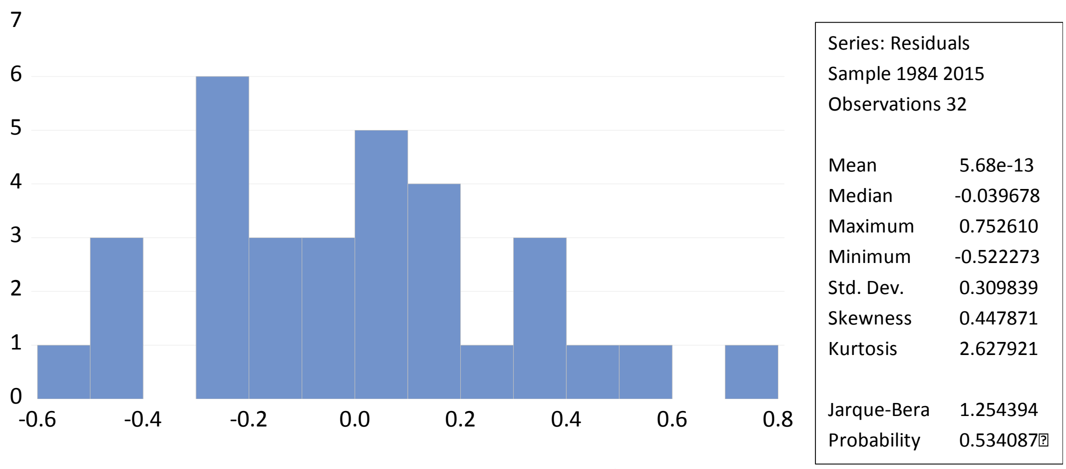
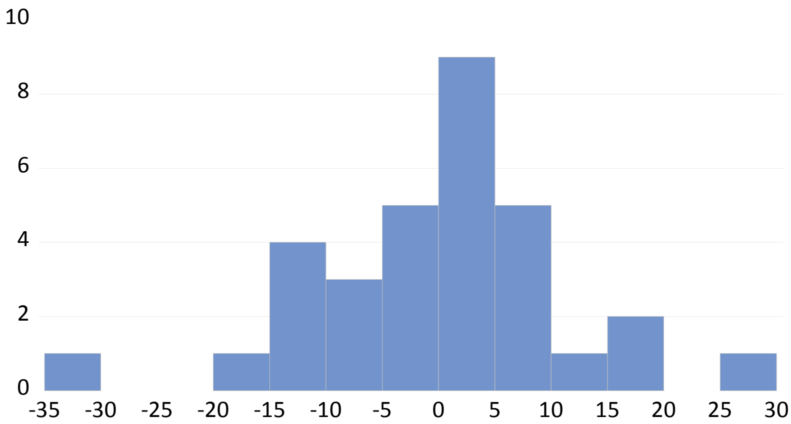


Figure 4: Graph & Statistics showing the result of the normality test conducted on the estimated Economic Growth Model



Series: Residuals	
Sample 1984 2015	
Observations 32	
Mean	-1.72e-13
Median	1.434644
Maximum	26.75943
Minimum	-34.41007
Std. Dev.	11.29679
Skewness	-0.472164
Kurtosis	4.626038
Jarque-Bera	4.714340
Probability	0.094688

Figure 5: Graph & Statistics showing the result of the normality test conducted on the estimated Environmental Degradation Model

Table 6 shows the result of serial correlation and heteroscedasticity test conducted on the estimated models. Firstly, the p-values (i.e., 0.10 and 0.90) of the test statistic of the Breusch-Godfrey Serial Correlation and Breusch-Pagan-Godfrey Heteroskedasticity tests conducted on economic growth model are greater than 0.05. This implies that we fail to reject the null hypothesis of no serial correlation and heteroscedasticity respectively. Moreover, the p-values (i.e., 0.91 and 0.24) of the test statistic of the Breusch-Godfrey Serial Correlation and Breusch-Pagan-Godfrey Heteroskedasticity tests conducted on environmental degradation model are greater than 0.05. This implies that we fail to reject the null hypothesis of no serial correlation and heteroscedasticity respectively. The foregoing implies that both models are free from the problem of serial correlation and heteroscedasticity.

Table 6: Serial Correlation & Heteroskedasticity Tests Result

Economic Growth Model		**Environmental Degradation Model**	
Tests	**F-statistics [p-value]**	**Tests**	**F-statistics [p-value]**
Breusch-Godfrey Serial Correlation	50.39 [0.10]	Breusch-Godfrey Serial Correlation	0.10 [0.91]
Breusch-Pagan-Godfrey Heteroskedasticity	0.43 [0.90]	Breusch-Pagan-Godfrey Heteroskedasticity	1.43 [0.24]

Source: Authors' Computation

4.3.2 Stability Diagnostics

Two stability post-estimation diagnostic tests were conducted on each of the model. They are the Ramsey RESET test of mis-specification and the cumulative sum test. Firstly, the result of the Ramsey RESET test of mis-specification conducted on estimated models are presented in table 7 below. The p-values (i.e., 0.74 and 0.74) of the test statistics (i.e., t-statistic = 0.38 and F-statistic = 0.15) resulting from the Ramsey RESET test of mis-specification conducted on the economic growth model are all greater than 0.05. This confirms that the economic growth model is was misspecified; suggesting that the variables included in the model are adequate and sufficient. Moreover, the p-values (i.e., 0.07 and 0.07) of the test statistics (i.e., t-statistic = 1.91 and F-statistic = 3.64) resulting from the Ramsey RESET test of mis-specification conducted on the environmental degradation model are all greater than 0.05. The result also confirms that the environmental degradation model was not misspecified; suggesting that the variables included in the model are adequate and sufficient.

Table 7: Ramsey RESET Mis-specification Test Results

Economic Growth Model			**Environmental Degradation**		
Test Statistics	**Values**	**P-value**	**Tests Statistics**	**Values**	**P-value**
t-statistic	0.38	0.74	t-statistic	1.91	0.07
F-statistic	0.15	0.74	F-statistic	3.64	0.07

Source: Authors' Computation

The results of the cumulative sum (CUSUM) test conducted on the estimated growth and environmental degradation models in this study are presented in figures 6 and 7 respectively. The CUSUM test result shown in figure 6 indicate the absence of any instability of the coefficients because the plots of the CUSUM statistics fall inside the critical bands of the 5 per cent confidence intervals of parameter stability. Therefore, there exists stability in the coefficients of the independent variables in economic growth model over the sample period. Moreover, The CUSUM test result shown in figure 7 also indicate the absence of any instability of the coefficients because the plots of the CUSUM statistics fall inside the critical bands of the 5 per cent confidence intervals of parameter stability. Therefore, there exists stability in the coefficients of the independent variables in environmental degradation model over the sample period.

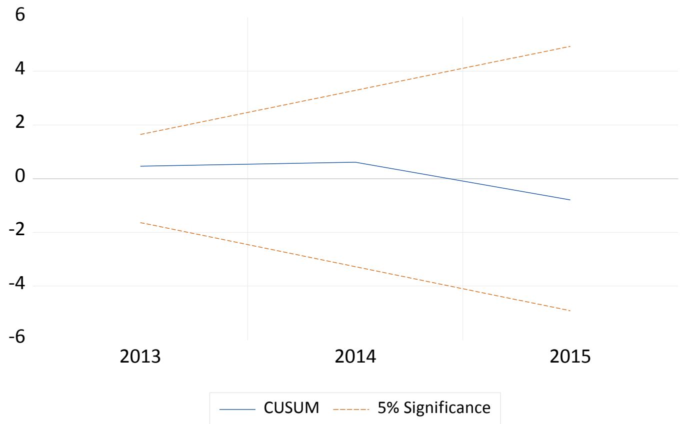


Figure 6: Cummulative Sum Test Result for Economic Growth Model

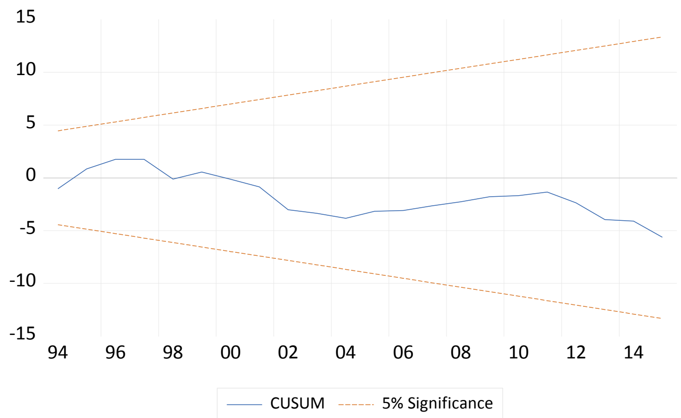


Figure 7: Cummulative Sum Test Result for Environmental Degradation Model

4.4 Discussion of findings

The analysis of the data collected has revealed some notable findings that makes this study a significant contribution to knowledge in the area of sustainable economic growth. Firstly, this study found that, in the short run, fossil fuel consumption had mixed effect on economic growth. While it impacts positively at current year, it impacted negatively after a year of fossil fuel consumption. This is evidence that the “Energy Consumption-Growth” nexus is not sustainable in Nigeria. After a period of time, the positive impact of fossil fuel consumption on growth will change to negative. And this is not unrelated to the consequent environmental pollution/degradation and climate change that will eventually affect important sectors like the agricultural sector after some time. Fossil fuel consumption is expected to impact negatively on economic growth in Nigeria in the long run. While the finding of the positive effect of fossil fuel consumption on growth agrees with the findings of Adam et al (2016), Karanfil and Li (2015), Salim (2015), Medee et al (2018), Mensah et al (2019) and Kang et al (2019); the finding on the negative effect of fossil fuel consumption on growth agree with the findings made by Adewuyi (2020) and Ito (2017). This study, based on the found positive impact of economic growth and fossil fuel consumption on environmental degradation proxied by CO2 emission growth rate, answers the question raised in the topic: “Energy Consumption-Growth” nexus is not sustainable in Nigeria. Though the finding on the impact of non-renewable energy (i.e., fossil fuel) consumption on environmental degradation does not agree with findings of Adewuyi (2020), it agreed with finding of Hanif (2018), Hanif et al (2019), Ito (2017), Mensah et al (2019), Kang et al (2019), Ong et al (2021) and Tenaw (2021).

V. Conclusion and Recommendation

The role played by energy in the process of growth and development has been widely discussed by energy and development economist. But emphasis has also been made on the need to ensure that in the consumption of energy for production, countries but pay serious attention to the environmental externalities resulting from it. This study has made some notable findings. And based on these findings some conclusion has been drawn. Firstly, the abundance and consumption of non-renewable energy in Nigeria has mixed effect on the growth of the economy. Secondly, the consequences of the consumption of fossil fuel like CO2 emission and climate change have also contributed to low growth rate in Nigeria over the years. Thirdly, the level of growth and consumption of fossil fuel evident is Nigeria is accompanied by increase in the CO2 emission growth rate. Finally, the "Energy Consumption-Growth" nexus in Nigeria is not sustainable. From the conclusions drawn, this study therefore recommends efficient energy consumption in Nigeria. The government should encourage and also fund responsible consumption of fossil fuel by manufacturing firms, government parastatals, and households. A well designed and implemented policy on increasing production in renewable energy like hydroelectric should be given priority if the country hopes to come out successful in achieving at least one of the sustainable development goals (SDG) in the year 2030.

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