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# Analysis of the Impact of Clean Energy and Non-Clean Energy on Economic Growth in Nigeria Using Linear Approach

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## Abstract

*Nigeria is currently experiencing a persistent energy crisis due to its heavy reliance on crude oil, which exposes its economy to the risks associated with global oil price volatility. This interdependence has led to economic volatility, characterized by elevated inflation rates and substantial unemployment. This study conducted an empirical analysis to examine the influence of clean and non-clean energy on economic growth in Nigeria. The analysis employed a linear approach and covered the period from 1990 to 2022, which was determined based on data availability. The paper utilized the Autoregressive Distributed Lag (ARDL) model because of its ability to analyze the influence of previous behaviors of the target variable and other independent variables on the current value of the dependent variable. Evidence has shown that the adverse effects of petroleum on GDP, both in the short and long term, indicate that depending on petroleum could have both positive and negative consequences, potentially impeding overall economic stability or expansion. The findings on hydropower are notably fascinating, indicating a favorable effect in the immediate term but an unfavorable one in the long term. This may demonstrate the initial advantages of hydropower in its contribution to the energy supply, but it could also suggest inefficiencies or sustainability concerns over long periods of time. The lack of considerable influence of the labor force on GDP in both the short and long term is a major worry. This indicates that despite having a large and expanding labor force, Nigeria may not be efficiently utilizing this human resource to improve productivity and stimulate economic growth. Overall, the analysis indicates that in order for Nigeria to attain consistent economic growth, it is imperative to adopt a well-rounded strategy that encompasses energy sector restructuring, economic diversification, and the enhancement of human capital.*

## I. Introduction

The economic structure of Nigeria is significantly shaped by its energy consumption patterns, which are closely connected to the overall dynamics of global energy usage. This is due to the discovery of a substantial correlation between energy (both clean and non-clean) and economic growth in various countries, even under dissimilar circumstances. Recent research has primarily concentrated on the correlation between energy and economic growth, particularly in industrialized and European countries. This research has been conducted by Lin and Moubarak (2014), Shahbaz et al. (2015), InglesiLotz (2016), Rafindadi and Ozturk (2017), Kocak and Sarkgunesi (2017), and Kahia et al. (2017). In the context of developing countries, the available literature is not extensive. It includes the works of Sebri and Ben-Salha (2014), Tawari et al. (2015), Cho et al. (2015), Bhattacharya et al. (2016), as well as Khobai and Le Roux (2018). Over the past 150 years, there has been a twentyfold rise in global energy consumption, and this trend is expected to continue throughout the next century. Throughout history, fossil fuels such as coal, oil, and gas have been the primary sources of commercial energy due to their significant energy content and ease of use. Oil has become the predominant energy source on a global scale. Nevertheless, the environmental consequences of using fossil fuels, including the release of greenhouse gases, have prompted a thorough reassessment of energy alternatives. The global transition is emphasized by international endeavors such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol, which seek to decrease emissions in both rich and developing countries.

The correlation between different energy sources (clean and non-clean) and economic development is of great importance in Nigeria, given its position as the largest economy and most populous country in Africa, with a population of over 200 million and a GDP of $376.3 billion. Despite Nigeria's substantial oil reserves, which account for around 40% of the GDP and 80% of government revenue, the country is currently experiencing a persistent energy crisis. The nation's economy exhibits a significant reliance on oil, rendering it susceptible to variations in global oil prices. The interdependence between these factors has led to a state of economic instability, characterized by elevated levels of inflation and substantial unemployment. Since the late 1960s, following the discovery of oil, the country has faced difficulties in satisfying its own energy needs, resulting in a heavy dependence on oil for both domestic use and export.

Nigeria's economic growth is anticipated to benefit from the transition to clean energy, as it will reduce dependence on foreign fuels, lower greenhouse gas emissions, and enhance the reliability of the energy supply. In addition, investments in clean energy are expected to create new employment prospects, foster technological advancements, and promote sustainable economic growth. Nigeria's objective is to reduce its environmental footprint and establish a more varied and robust economic framework by shifting from non-clean to clean energy sources. Nigeria's transition to utilizing its copious clean energy resources, including solar, wind, and biomass, is of utmost importance in order to fuel its future growth in a sustainable manner.

Therefore, the objective of this study is to examine the impact of clean and non-clean energy on the economic growth of Nigeria using liner approach. Many earlier studies have shown that the relationship between energy and growth has been thoroughly investigated. However, scientists have not reached a unanimous agreement on a definitive hypothesis that accurately describes the relationship between energy and economic growth. Moreover, a significant number of these studies have intrinsic limitations. The Environmental Kuznets Curve (EKC) model, frequently used in these investigations, has various limitations. An inherent limitation of the EKC model is its tendency to neglect significant aspects, such as labor force and capital, that play a vital role in comprehending the relationship between different energy sources (clean and non-clean) and economic growth.

This study seeks to address these gaps by explicitly incorporating these crucial parameters to examine the impact of energy use on economic growth in Nigeria. The ongoing research will also investigate prospective advancements in mitigating the effects of both environmentally friendly and environmentally harmful energy sources on economic development, utilizing a chronological method from 1990 to 2022. This study not only adds to the academic discourse but also offers diverse perspectives that might inform the development of policies and strategic plans in Nigeria's energy and economic sectors.

## II. Literature Review

### Conceptual Review

### Economic Growth

Economic growth is the increase in the amount of goods and services produced by a country over time. Economic growth is important for Nigeria because it can help to reduce poverty and improve the standard of living of the people. Both cross-country research and country case studies provide overwhelming evidence that rapid and sustained growth is critical to making faster progress towards the Sustainable Development Goals – and not just the first goal of halving the global proportion of people living on less than $1 a day.

Economic growth is defined as the increase in the value of goods and services produced by a country over a period of time. It is often measured as the annual percentage change in GDP. According to Amadeo (2021), Economic growth increases the production of goods and services over a specific period. More accurately, the measurement must remove the effects of inflation. Economic growth creates more profit for businesses. As a result, stock prices rise. That gives the company's capital to invest and hire more employees. As more jobs are created, incomes rise. Consumers have more money to buy additional products and services. Purchases drive higher economic growth. For this reason, all countries want positive economic growth. This makes economic growth the most-watched.

**Clean Energy**

Clean energy refers to energy generated from renewable sources, including sun, wind, water, and biomass. Clean energy is widely seen as a more sustainable alternative to non-clean energy, which is derived from fossil fuels including coal, oil, and natural gas. Clean energy refers to energy sources that can be regenerated within an acceptable timeframe, typically within years or a human lifespan, after they have been utilized. Clean energy is derived from natural sources such as the sun, wind, rain, tides, and vegetation. It may be continuously generated as needed. It is typically regenerated by natural processes. For instance, trees are considered a renewable resource due to their ability to be replaced by young trees after being removed and utilized. The various forms of clean energy sources include Solar Energy, Hydroelectric Energy, Geothermal Energy, Wind Energy, and Biomass Energy.

**Non-Clean Energy**

Non-clean energy sources, such as fossil fuels formed from the conversion of plant matter into coal, have specific conditions for their formation and can take several generations to replenish. Occasionally, the circumstances are unlikely to repeat, resulting in a restricted quantity that cannot be replenished quickly once exhauste. As an illustration, fossil fuels have been seeping through the Earth's layers for hundreds of millions of years, and if they are depleted, it will take millions of additional years for them to be replenished (Kandpal & Broman, 2014). Non-clean energy sources include coal, oil, natural gas, and nuclear energy.

**Theoretical Review**

**The Environmental Kuznets Curve Theory (EKC)**

The hypothesis of the Environmental Kuznets Curve (EKC) was formulated throughout the 1950s and 1960s. The idea is named after Simon Kuznets not because he directly contributed to it, but because his 1955 research on the correlation between income inequality and economic growth produced a similar inverted U-shaped curve as the findings of the Environmental Kuznets Curve hypothesis. The Environment Kuznets curve (EKC) hypothesis examines the relationship between emissions and economic activities. The notion of the Environmental Kuznets Curve arises from concerns regarding the depletion of natural resources, its environmental consequences, and the long-term viability of economic expansion. The Club of Rome's report on "The Limits to Growth" highlights the detrimental impact of economic growth on the environment. It concludes that the world will face collapse in the future when the global economy reaches its physical limits in terms of non-clean energy resource extraction, environmental pollution, and agricultural production. This report has sparked a series of research on the Environmental Kuznets Curve (EKC) theory.
This theory is applicable to the study because it elucidates the interconnectedness and cause-and-effect link between per capita income, depletion of natural resources, and environmental pollution in different stages of societal development.

This theory is pertinent to the goals of this study as it examines and elucidates the correlation between economic growth and energy, namely the energy consumed in the exploitation of natural resources. This idea is applicable to Nigeria, where the pursuit of expansion and development leads to an emphasis on exploiting crude oil while neglecting other sustainable sources of money. The ongoing extraction of crude oil results in escalating environmental degradation and pollution caused by oil spillage and the release of greenhouse gases. These consequences are detrimental to the ecosystem. According to this theory, diversification will lead to an increase in the demand for clean energy and a decrease in carbon emissions in the ozone layer. This will also involve utilizing other sectors, such as services, that are currently not fully utilized. The country will continue to experience steady and desirable economic growth.

**Emperical Review**

Increasing data indicates that the utilization of clean energy has the potential to positively impact the economic development of Nigeria. Research conducted by the International Renewable Energy Agency (IRENA) revealed that clean energy has the potential to account for as much as 30% of Nigeria's electricity generation by the year 2030. Implementing this initiative would result in the creation of employment opportunities, stimulate economic expansion, and mitigate the release of greenhouse gases. Nevertheless, there is compelling data indicating that the utilization of non-clean energy sources can play a role in fostering Nigeria's economic expansion. As an illustration, research conducted by the World Bank revealed that the contribution of oil and gas production to Nigeria's Gross Domestic Product (GDP) in 2019 amounted to 10%. This implies that utilizing non-clean energy sources can generate significant income for the nation. With the increasing popularity of green energy as a substitute for traditional, polluting energy sources, it is crucial to establish an energy policy. This is because energy is intrinsically linked to GDP, which serves as a measure of an economy's strength and vitality. Sugiawan and Managi (2016) stated that the environmental Kuznets curve is useful for examining the relationship between economic expansion and energy pollution.

Shafiei and Salim (2014) found that the use of clean energy decreases CO2 emissions, whereas the use of non-clean energy leads to a significant increase in CO2 emissions. According to Seck et al. (2015), a non-energy demanding industry will experience a significant decrease in energy consumption and a substantial impact on the overall energy intensity as a result of a structural adjustment. Therefore, numerous organizations, policymakers, and government agencies have undertaken empirical and theoretical study to explore the importance and correlation between clean energy and economic growth. The majority of these studies investigated the relationship between CO2 emissions and GDP per capita, using a quadratic model.

Pao and Li (2014) examined the relationship between economic growth and the use of both clean and non-clean energy in the economies of Mexico, Indonesia, South Korea, and Turkey, collectively known as MIST. The chosen approach was panel cointegration. The findings indicate that there is a long-term causal relationship between the usage of clean energy and economic growth. Additionally, there is evidence of positive feedback causality in the short term. Clean energy sourcescan lead to a reduction in the usage of fossil fuels over time. However, in the near term, there may be a negative feedback effect. In 2014, Zhang et al. conducted a study on the potential for collaboration in clean energy between the United States of America and China. Their discovery indicates that this collaboration can stimulate economic progress, reduce carbon emissions, enhance environmental conditions, promote sustainable growth, and generate reciprocal advantages for both nations. Sbia et al. (2014) established a link between economic growth and many factors such as foreign direct investment, trade openness, carbon emissions, and clean energy in the UAE. The employed technique was the autoregressive distributed lag approach to cointegration. Their research indicates that trade openness, carbon emissions, and foreign direct investment lead to a decrease in energy consumption, whereas clean energy and economic growth have a favorable impact on energy consumption.

In addition, Awodumi and Adewuyi (2020) examine the influence of non-clean energy usage on both economic growth and CO2 emissions in the top five oil-producing countries in Africa during the period of 1980-2015. They categorized non-clean energy as either petroleum or natural gas. After confirming the presence of nonlinearity and structural break in the data, it employed the Non-linear Autoregressive Distributed Lag (NARDL) approach for analysis.The findings indicated that the per capita consumption of both energy sources had a disparate effect on both economic growth and carbon emission per capita in all nations except Algeria. For example, in the case of Nigeria, the rise in non-clean energy sources resulted in a decline in economic growth but led to an enhancement in environmental quality. In Angola, the utilization of non-clean energy sources contributes to economic growth.

However, the impact on environmental quality is diverse, fluctuating in accordance with energy use. The expansion of these energy sources had a little impact on environmental pollution, as it concurrently contributed to economic prosperity. Kahia and Aissa (2014) conducted a study to examine the influence of clean and non-clean energy consumption on economic growth in 13 net-oil exporting nations in the Middle East and North African (MENA) region from 1980 to 2012. Nevertheless, the fragmented energy sources had a favorable and substantial effect. Unlike the findings of Azam et al. (2021), it was shown that clean energy (electricity) had a greater influence on economic growth compared to non-clean energy (petroleum). In separate research conducted on West Africa from 1995 to 2014, Maji et al. (2019) employed the DOLS, FMOLS, and OLS methods to demonstrate that the utilization of renewable energy and biomass hinders economic progress. According to Twerefou et al. (2018), the outcome was ascribed to the origin and characteristics of the renewable energy utilized in West Africa, primarily derived from wood biomass. Furthermore, they lamented the insufficient utilization of cleaner energy sources such as wind, solar, and hydropower in the area.

Furthermore, Ranjan et al. (2017) analyze the link between energy consumption and economic growth in the BRICS countries (Brazil, Russia, India, China, and South Africa) from 1990 to 2012 using a multivariate panel framework. The findings indicate a sustained connection between GDP per capita, clean energy consumption, non-clean energy consumption, and gross fixed capital formation. Additionally, there is a one-way causality from economic growth to both clean and non-clean energy consumption, hence validating the conservation hypothesis. The findings suggest that economic expansion plays a crucial role in driving energy consumption in the BRICS countries. Consequently, an increase in economic growth will lead to a corresponding increase in energy consumption, and conversely. Bölük and Mert (2014) discovered a correlation indicating that the adoption of renewable energy in 16 EU nations is an effective approach for promoting both environmental and economic progress.

The aforementioned studies demonstrate that the connection between energy and growth has been extensively studied. However, there is still a lack of agreement among scholars on a valid hypothesis that accurately describes the relationship between the energy-growth nexus. Additionally, the majority of the research have certain limitations. The bulk of research have utilized the Environmental Kuznets Curve (EKC) model, which has several inherent shortcomings. One such weakness is that the model fails to consider crucial aspects like labor force and capital, which are vital for comprehending the relationship between energy (clean and non-clean) and economic growth. The inclusion of these elements in the study was deliberate in order to examine the linear relationship. This article explores prospective advancements that examine the relationship and effects of clean energy and non-clean energy on economic growth in Nigeria. The study uses a linear approach spanning from 1990 to 2022.

## III. Methodology

This study adapts the model of Pao, Li & Fu (2014), while retaining the labour and capital stock as the control variables for our model, Liquefied Natural Gas (LNG) as well as Petroleum and other Liquid (POL) are used to proxy non-clean energy consumption and Hydropower (HP) is used to proxy clean energy consumption. Only hydropower is chosen as a proxy for clean energy because data of others such as Solar and Wind are not available for a reasonable number of years in Nigeria. Consequently, the econometric model for clean energy and economic growth and non-clean energy and economic growth are presented is presented as in equation (1);

$$\boldsymbol{gdp_t} = \boldsymbol{f}(\boldsymbol{pol_t}, \boldsymbol{lng_t}, \boldsymbol{hp_t}, \boldsymbol{lf_t}, \boldsymbol{gcf_t}) \quad (1)$$

*gdp* refers to the real gross domestic product, *pol* stands for petroleum and other liquid, *lng* represents liquefied natural gas, *hp* denotes hydroelectric power, *lf* refers to the labor force, and *gcf* stands for gross capital formation. It is anticipated that the three energy variables will enhance domestic income or output (real GDP) in both the short and long term. Moreover, the anticipated expansion of the active labor force is projected to bolster economic growth and facilitate capital accumulation. Data availability is a major concern in developing countries, including Nigeria, when it comes to historical data on variables. Hence, the study's historical data spans a duration of 32 years (1990 - 2022), and the sources of this data are meticulously outlined in Table 3.1.

**Table 3.1: Data sources**

| Variable | Source |
|---|---|
| GDP | World Banks Development index, |
| Petroleum and other liquid | World Banks Development index, |
| Liquefied natural gas | World Banks Development index, |
| Hydropower | World Banks Development index, |
| Labour force | World Banks Development index, |
| Gross capital formation | World Banks Development index, |

Source: Author's Computation

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The data is initially analyzed using descriptive analysis to explore the important statistical characteristics of the data, such as maximum, minimum, mean, standard deviation, skewness, and kurtosis. In order to assess the normality of the data sets, the Jarque-Bera statistics of the variables, together with their corresponding p-values, are also analyzed. The econometrics study commences by assessing the time-series features of the variables, specifically focusing on the presence of a unit root and the order of integration. This is done using the Augmented Dickey-Fuller (ADF) test. The study utilizes the symmetric ARDL model to examine the immediate and long-term effects of clean and non-clean energy on economic growth in Nigeria. Prior to estimating the model, the ARDL-bound test approach is applied to test for the long-term link between the variables at their original levels. Dynamic models often exhibit sensitivity to lag structure. Therefore, the most suitable lag length for the ARDL models is determined by employing the SIC information criterion.Based on the above discussion, the ARDL framework for equation (3.1) above is given as

$$\Delta\log(gdp_t) = \phi_0 + \sum_{i=1}^{q}\phi_{1i}\,\Delta\log(gdp_{t-1}) + \sum_{i=0}^{q}\phi_{2i}\,\Delta\log(pol_{t-i}) + \sum_{i=0}^{q}\phi_{3i}\,\Delta\log(lng_{t-i}) + \sum_{i=0}^{q}\phi_{4i}\,\Delta\log(hp_{t-i}) + \sum_{i=0}^{q}\phi_{5i}\,\Delta\log(lf_{t-i}) + \sum_{i=0}^{q}\phi_{6i}\,\Delta\log(gcf_{t-i}) + \eta_1\log(pol_{t-1}) + \eta_2\log(lng_{t-1}) + \eta_3\log(hp_{t-1}) + \eta_4\log(lf_{t-1}) + \eta_5\log(gcf_{t-1}) + v_t 2$$

The terms denoted by the summation signs describe the short-term dynamics of the error correction model (ECM) along with their corresponding short-term coefficients (ϕ1- ϕ6). The coefficients η1 – η5 represent the long-term multiplier associated with the long-term connection. The symbol ϕ0 represents the intercept, vt is the white noise error, Δ is the operator for calculating the initial difference, and p and q represent the lag length for the conditional ARDL model. In order to examine the presence of a long-term link in the aforementioned model, the thesis employs an F-test to assess the combined significance of the lagged levels coefficient by ordinary least squares (OLS) estimation. Conduct an F-test to examine the null hypothesis that there is no cointegration, namely that η1 = η2 = η3 = η4 = η5 = 0. The alternative hypothesis is that there is cointegration, meaning that η1 ≠ η2 ≠ η3 ≠ η4 ≠ η5 ≠ 0.

## IV. Data Analysis

**Table 4.1: Descriptive statistics of variables**

| | Mean | Std. Dev. | C.V. | Max | Min | J-B | Obs |
|---|---|---|---|---|---|---|---|
| gdp | 2.36E+11 | 1.80E+11 | 0.763 | 5.47E+11 | 2.78E+10 | 3.607 | 32 |
| pol | 0.638348 | 0.162045 | 0.254 | 0.94934 | 0.43155 | 4.846* | 32 |
| lng | 99774.5 | 59286.51 | 0.594 | 175819 | 30326 | 4.120 | 32 |
| hp | 6221.375 | 991.9376 | 0.159 | 8234 | 4387 | 1.840 | 32 |
| lf | 47412448 | 9709509 | 0.205 | 64479317 | 31787602 | 1.855 | 32 |
| gcf | 5.01E+10 | 3.26E+10 | 0.651 | 1.46E+11 | 1.23E+10 | 6.818** | 32 |

Source: Author's computation

Table 4.1 shows the descriptive statistics for the gross domestic product (gdp), petroleum and other liquid (pol), liquefied natural gas (lng), hydropower (hp), the labour force (lf), and gross capital formation (gcf) in Nigeria respectively, from 1990 to 2022. It can be observed that the empirical mean for all the variables is positive. Specifically, the analysis of empirical mean values for various economic and energy variables in Nigeria from 1990 to 2022 indicates positive mean values across all measured categories. The gross domestic product (GDP) has a mean value of approximately 2.36E+11, reflecting significant economic activity and output. Petroleum and other liquids (POL) show a mean value of 0.638348, indicating consistent production and exportation. Liquefied natural gas (LNG) has a mean value of 99774.5, demonstrating substantial production levels. Hydropower (HP) holds a mean value of 6221.375, highlighting ongoing utilization and development of this renewable resource. The labour force (LF) shows a mean value of 47,412,448, representing a large and active workforce. Lastly, gross capital formation (GCF) has a mean value of approximately 5.01E+10, signifying considerable investments in physical assets. These positive mean values suggest robust economic activity and growth across different sectors of the Nigerian economy during the analyzed period. The coefficient of variation (C.V.) is used to measure the relative dispersion of the variables and is calculated as the standard deviation divided by the mean. A more significant coefficient of variation shows that the variables have a more considerable variation than the other. It can be deduced from the table that, among the energy variables, hydropower has the lowest degree of variation with the value of 0.159, and liquefied natural gas (lng) has a higher variation than petroleum and other liquid (pol) with 0.594 and 0.254 values, respectively. The high degree of variation in the gross domestic product (0.763) reflects the frequent degree of the business cycle in the Nigerian economy. The lower degree of variation in the labour force (0.205) tells a story; it implies that the labour force of Nigeria has not been faring well over the decades, despite the high rate of capital accumulation in the economy. The probability value of the Jarque-Bera (J-B) normality test is statistically significant for petroleum and other liquid (pol) and gross capital formation (gcf) at 4.846 and 6.818 values, respectively. This implies that they are not normally distributed. However, since we are using a fairly large sample size, the issue of normality in data will not pose a problem due to the law of large sample size; the parameter estimates based on the data will converge to their true value asymptotically.

**Table 4.2: Pair-wise correlation matrix**

| | gdp | pol | Lng | Hp | lf | gcf |
|---|---|---|---|---|---|---|
| gdp | 1 | | | | | |
| pol | 0.713*** | 1 | | | | |
| lng | 0.826*** | 0.704*** | 1 | | | |
| hp | 0.106 | 0.308* | 0.425** | 1 | | |
| lf | 0.912*** | 0.725*** | 0.851*** | 0.353** | 1 | |
| gcf | 0.861*** | 0.731*** | 0.764*** | 0.153 | 0.896*** | 1 |

Source: Authors' computation.

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 4.2 depicts the pairwise correlation between the variables: gross domestic product (gdp), petroleum and other liquids (pol), liquefied natural gas (lng), hydropower (hp), the labour force (lf), and gross capital formation (gcf). It can be generally observed from the table that all the variables are positively correlated with each other. Specifically, the correlation between GDP and other variables shows that all, except for hydropower (0.106), significantly correlate with GDP, indicating strong associations. The highest correlation with GDP is observed with the labour force (0.912) and gross capital formation (0.861). Among the energy variables, liquefied natural gas (0.826) shows the highest correlation with GDP. The correlations among energy variables reveal that petroleum and liquefied natural gas (0.704) have a stronger association compared to petroleum and hydropower (0.308). Additionally, the correlation between hydropower and liquefied natural gas is weak but significant (0.425). These correlations suggest strong interdependencies among most variables, except for hydropower, which generally shows weaker associations.

**Table 4.3: ADF unit root test result**

| Variable | Level | | first difference | | Remark |
|---|---|---|---|---|---|
| | c | c & t | C | c & t | |
| log(gdp) | -0.544 | -1.681 | -4.278 | -4.172 | *I*(1) |
| log(pol) | -1.001 | -2.289 | -6.922 | -7.183 | *I*(1) |
| log(lng) | -1.258 | -2.873 | -6.110 | -6.016 | *I*(1) |
| log(hp) | -3.468 | -3.452 | -6.879 | -6.704 | *I*(0) |
| log(lf) | -1.456 | -1.689 | -3.535 | -3.434 | *I*(1) |
| log(gcf) | 0.233 | -3.079 | -3.952 | -4.103 | *I*(1) |

Source: Authors' computation.
*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

The ADF unit root test findings for several economic variables are presented in Table 4.3. The ADF test was performed under two distinct assumptions: one with simply a constant (c) and the other with both a constant and a trend (c & t). The results are crucial in establishing whether the variables are stationary at their current levels or if they need to be differenced in order to attain stationarity. The ADF test statistic for the logarithm of GDP (log(gdp)) is -0.544 when only a constant is included, and -1.681 when both a constant and a trend are included at the level. These data do not provide enough evidence to reject the null hypothesis of a unit root at standard levels of significance. Nevertheless, upon observing the initial disparity, the ADF values of -4.278 and -4.172 are notably below the crucial values, hence suggesting stationarity. Thus, the logarithm of GDP, log(gdp), is integrated of order one, denoted as I(1). The logarithm of petroleum and other liquids (log(pol)) has Augmented Dickey-Fuller (ADF) values of -1.001 (constant) and -2.289 (constant and trend) at the specified level, which also fail to reject the null hypothesis. Upon seeing the initial disparity, the ADF test statistics are -6.922 and -7.183, signifying that the series achieves stationarity after undergoing one differentiation. Consequently, it can be classified as I(1). The ADF test statistics for the logarithm of liquefied natural gas (log(lng)) are -1.258 (c) and -2.873 (c & t) at the given level. These statistics indicate that the null hypothesis of a unit root cannot be rejected. Upon initial comparison, the test statistics are -6.110 and -6.016, signifying that the logarithm of the natural logarithm (lng) is integrated of order 1 (I(1)). The logarithm of hydropower (log(hp)) has certain distinct characteristics. The ADF test statistics for log(hp) are -3.468 (c) and -3.452 (c & t) at the given level. These statistics are significant at conventional levels, indicating that log(hp) is stationary at the level, or in other words, it has a zero order of integration (I(0)). The ADF test statistics for the log of the labor force (log(lf)) are -1.456 (c) and -1.689 (c & t) at the level. These statistics do not provide enough evidence to reject the null hypothesis. Upon initial comparison, the values are -3.535 and -3.434, suggesting that log(lf) exhibits a first-order difference (I(1)). The logarithm of gross capital formation (log(gcf)) exhibits ADF test statistics of 0.233 (c) and -3.079 (c & t) at the level, suggesting that it is not stationary. Upon initial comparison, the results of -3.952 and -4.103 indicate that log(gcf) falls under the category of I(1). To summarize, the results suggest that all variables, with the exception of hydropower, are integrated of order one (I(1)), which implies that they become stationary after undergoing initial differencing. Hydropower is fixed at a constant level (I(0)). This suggests that the integrated variables have the ability to cointegrate, resulting in stationary residuals when paired with the stationary variables. This feature enables the utilization of the ARDL model, which is capable of accommodating both integrated and stationary regressors. This facilitates a robust analysis to effectively meet the objectives of the study.

**Table 4.4: ARDL bound-test**

| Lag structure | F-stat | C.V. | | |
|---|---|---|---|---|
| ARDL(1,1,1,2,0,1) | 7.867 | Sig. | I(0) | I(1) |
| | | 10% | 2.578 | 3.858 |
| | | 5% | 3.125 | 4.608 |
| | | 1% | 4.537 | 6.370 |

Source: Author's computation.

Table 4.4 displays the outcome of the bound test conducted to examine the cointegration connection among various variables, including real gross domestic product (GDP), petroleum and other liquid (POL), liquefied natural gas (LNG), hydropower (HP), the labor force (LF), and gross capital formation (GCF). The test's null hypothesis, as per tradition, assumes that there is no enduring connection between the variables. The decision rule states that if the F-statistics falls within the range of I(0) and I(1), the test is considered inconclusive. If the value exceeds the upper limit I(1), then the null hypothesis of no long-term association is rejected. However, if the value is lower than the lower bound I(0), it is not possible to reject the null hypothesis that there is no long-term link. The test result indicates that the calculated F-statistic of 7.867 is statistically significant at the 10%, 5%, and 1% levels of significance. Therefore, we can conclude that there is a long-term relationship between real gross domestic product (GDP), petroleum and other liquid (POL), liquefied natural gas (LNG), hydropower (HP), the labor force (LF), and gross capital formation (GCF). The subsequent part presents and examines the outcomes in both the long-term and short-term.

**Table 4.5: ARDL Estimation Results**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| **Long Runs Estimates** | | | | |
| $\log(pol_t)$ | -4.314 | 2.403 | -1.795 | 0.090* |
| $\log(lng_t)$ | 1.671 | 0.604 | 2.766 | 0.013** |
| $\log(hp_t)$ | -3.470 | 1.857 | -1.869 | 0.078* |
| $\log(lf_t)$ | 2.124 | 1.856 | 1.144 | 0.267 |
| $\log(gcf_t)$ | 0.038 | 0.495 | 0.076 | 0.940 |
| **Short Runs Estimates** | | | | |
| $\Delta\log(pol_t)$ | -0.217 | 0.096 | -2.265 | 0.036** |
| $\Delta\log(lng_t)$ | 0.071 | 0.047 | 1.506 | 0.149 |
| $\Delta\log(hp_t)$ | 0.291 | 0.091 | 3.207 | 0.005*** |
| $\Delta\log(hp_{t-1})$ | 0.323 | 0.112 | 2.876 | 0.010** |
| $\Delta\log(lf_t)$ | 0.263 | 0.277 | 0.949 | 0.355 |
| $\Delta\log(gcf_t)$ | 0.862 | 0.070 | 12.324 | 0.000*** |
| $const.$ | -0.400 | 0.056 | -7.116 | 0.000*** |
| $ecm_{t-1}$ | -0.124 | 0.016 | -7.766 | 0.000*** |

Source: Authors' computation.
**** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$*

Table 4.5 displays the calculated long-term and short-term effects of the regressors on the real gross domestic product. It is evident that petroleum and other liquid fuels have a substantial adverse effect on the real gross domestic product (GDP) in both the short and long term. The findings indicate that a one percent increase in petroleum and other liquid fuels leads to a decrease of 0.217% and 4.314% in the GDP in the short and long term, respectively. In the long term, the impact of liquefied gas on real gross domestic product is substantial. The analysis reveals that a one percent increase in liquefied gas leads to a 1.67% increase in real gross domestic product in the long run. Hydropower has been found to have a considerable beneficial influence on the real gross domestic product in the near term, but a negative impact in the long term. Based on the data, it can be inferred that a 1% increase in hydropower results in a 0.291% rise in the gross domestic

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product in the near term, but a 3.47% decline in the gross domestic product in the long term. There is no empirical evidence to support the claim that the labor force has a significant impact on real gross domestic product, whether in the short term or the long term. In the short term, there is a large impact of gross capital formation on real gross domestic product. Specifically, a one percent rise in gross capital formation leads to a 0.862% increase in real gross domestic product. The error correction term indicates that approximately 12.4% of the imbalance in the gross domestic product caused by a sudden shock is rectified within a year, given the independent variables.

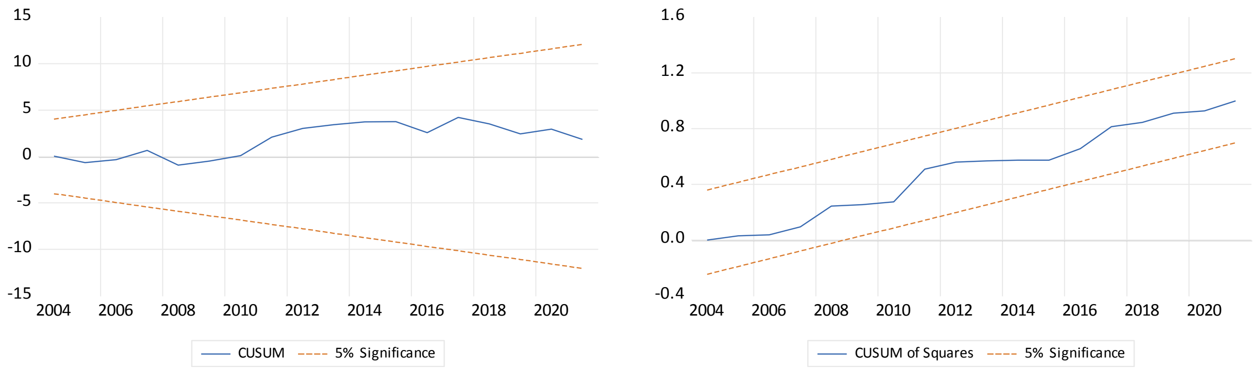


Figure 4.1: ARDL models cusum and cusumsq plots

Figure 4.1 depicts the model's stability tests graphically. The first panel displays the cumulative sum of residuals (cusum) test, whereas the subsequent panel exhibits the cumulative sum of square residuals (cusumsq) test. The test dynamics are represented by the smooth blue line, while the 5% Bartlett standard error bound is indicated by the dotted red lines. The null hypothesis, as tradition dictates, posits that the regression model remains constant across time, while the alternative hypothesis suggests that the model experiences a discontinuity at a specific point. In order for the model to be considered stable, it is necessary for the blue line or test line to remain inside the upper and lower bounds. Otherwise, the model is not considered stable.Fortunately, it can be deduced from the figure that the blue line did not move outside the bound, hence the null hypothesis that the symmetric ARDL regression model is stable over time.

**Table 4.6: ARDL post-diagnostic tests results**

| Test | Stat. | Prob. |
|---|---|---|
| $\chi^2_{LM}$ | 0.112 | 0.738 |
| $\chi^2_{White}$ | 13.633 | 0.254 |
| $RESET$ | 0.046 | 0.830 |
| $\chi^2_{J-B}$ | 1.410 | 0.494 |

Source: Authors' computation.
**** p < 0.01; ** p < 0.05; * p < 0.1*

The viability of the predicted symmetric model was verified using post-diagnostic tests, as shown in Table 4.6. The χ_LM^2 refers to the Breusch-Pagan LM test, which is employed to detect the existence of autocorrelation in the residuals of the estimated time series model. It is used to test the null hypothesis of no autocorrelation. The χ_White^2 is a statistical test used to assess heteroscedasticity, specifically to test against the null hypothesis of homoscedasticity. The RESET test is conducted to assess the linearity specification of the regression model with respect to higher-order regressors. The χ_(J-B)^2 is a statistical test called the Jarque-Bera test, which is used to assess the normality assumption of statistical models. By analyzing the calculated statistics and their corresponding probability, we may conclude that the null hypothesis of no autocorrelation of errors, homoscedasticity, regression stability, and normality of residuals can be accepted. This is because the probabilities associated with these hypotheses are deemed unimportant.

## V. Discussion, Implication of Findings and Conclusions

The analysis of Nigeria's economic data from 1990 to 2022 reveals significant insights into the relationships between key variables such as GDP, petroleum and other liquids (pol), liquefied natural gas (lng), hydropower (hp), labour force (lf), and gross capital formation (gcf). The results obtained from the ARDL model demonstrate that the energy industry, specifically petroleum and liquefied natural gas, have a significant impact on the country's economic structure.The ARDL model for Petroleum and Other Liquids (POL) shows that there is a substantial and adverse effect of petroleum and other liquids on Nigeria's GDP, both in the short and long run. More precisely, a one percent rise in petroleum and other liquids leads to a 0.217% decline in GDP in the short run and a 4.314% decline in the long run. This suggests that Nigeria's heavy reliance on petroleum may be detrimental to its economic stability, possibly due to the volatility of global oil prices, which can cause significant economic fluctuations for oil-dependent countries like Nigeria. Policymakers should consider diversifying the economy to mitigate the adverse effects of this reliance.

Similarly, the research findings indicate that the use of Liquefied Natural Gas (LNG) has a substantial and favorable effect on the Gross Domestic Product (GDP) over an extended period. Specifically, a one percent rise in LNG usage corresponds to a 1.671% gain in GDP.This indicates that LNG is a more stable and beneficial energy resource for Nigeria's long-term economic growth compared to crude oil. Investing in the LNG sector could enhance energy supply reliability and boost economic stability, making it a crucial component of Nigeria's energy strategy.

Also, the impact of hydropower on GDP is mixed; it has a positive effect on GDP in the short run with a 0.291% increase for every one percent rise in hydropower, but it has a negative long-term impact, reducing GDP by 3.470% for the same increase. This could reflect initial benefits from improved energy supply, countered by long-term sustainability and efficiency challenges. These findings suggest a need for careful planning and investment in the hydropower sector to address potential inefficiencies and ensure long-term sustainability.

The study shows no significant impact of the labour force on GDP in both the short and long term, despite Nigeria having a large and growing labour force. This suggests structural issues within the economy, such as underemployment, lack of industrial diversification, and inadequate investment in human capital, which prevent the effective utilization of this resource. Reforms in education, vocational training, and better industry engagement are essential to harness the potential of the labour force and enhance productivity.

In the short run, there is a strong correlation between gross capital formation (GCF) and GDP. Specifically, a one percent rise in GCF leads to a 0.862% increase in GDP. This suggests that allocating resources towards tangible assets such as infrastructure and machines has a favorable impact on the immediate expansion of the economy. However, in order to achieve consistent and enduring long-term expansion, it is imperative to make ongoing and well-planned investments to establish a strong economic framework.

The error correction term demonstrates that approximately 12.4% of the imbalance in GDP caused by a sudden shock is rectified within a year, showcasing the model's capacity to restore equilibrium following disruptions.The constant term shows a significant negative impact, suggesting other underlying factors negatively influencing GDP that are not captured by the model's variables.

### Implication of Findings

The findings drawn from this study have multiple and substantial consequences for policymakers, stakeholders, and Nigeria's broader economic strategy. The analysis provides valuable insights into the dynamics of important economic indicators, such as GDP, petroleum and other liquids (POL), liquefied natural gas (LNG), hydropower (HP), the labor force (LF), and gross capital formation (GCF).

Firstly, economic diversification is crucial for Nigeria due to the adverse effects of petroleum on GDP in both the immediate and long-term. This indicates an urgent necessity for Nigeria to broaden its economic base. The economy's heavy reliance on petroleum renders it extremely vulnerable to fluctuations in global oil prices, which in turn can result in economic instability. Policymakers ought to prioritize the development of alternative sectors such as agriculture, industry, and services, as these sectors have the potential to generate more consistent and enduring sources of revenue. Implementing diversification strategies can

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effectively reduce the dangers associated with relying solely on a particular commodity and facilitate the promotion of more extensive economic growth.

Secondly, the positive long-term impact of LNG on GDP highlights the potential of natural gas as a more stable and beneficial energy resource compared to crude oil. Investing in the LNG sector can enhance energy security, reduce environmental impact, and provide a steady source of income through exports. This suggests that the government and private sector should prioritize the development of LNG infrastructure and related industries to capitalize on its economic benefits.

Thirdly, the mixed impact of hydropower, with short-term benefits but long-term negative effects, indicates the need for sustainable and efficient energy policies. While hydropower can contribute to energy supply and economic growth initially, inefficiencies and sustainability issues can arise over time. Policymakers should prioritize enhancing the efficacy of hydropower initiatives and investigating alternative renewable energy sources to guarantee enduring sustainability and energy resilience.

Furthermore,non-significant impact of the labour force on GDP points to potential underutilization of human resources. This could be due to underemployment, lack of industrial diversification, and insufficient investment in education and vocational training. To harness the full potential of the labour force, there is a need for comprehensive reforms in the education system, better alignment of vocational training with industry needs, and policies that encourage job creation in diverse sectors. Developing human capital can significantly enhance productivity and drive economic growth.

In the same vein, the significant short-term impact of gross capital formation on GDP underscores the importance of infrastructure investment. Continuous and strategic investment in physical assets like transportation, communication, and industrial infrastructure is essential for supporting economic activities and fostering growth. Policymakers should prioritize infrastructure development to create a conducive environment for business operations and attract further investments.

Finally, regarding policy stability and resilience, the presence of an error correction term indicates that the economy has mechanisms in place to restore equilibrium after disturbances, but the pace of adjustment is comparatively sluggish. This suggests that policies should be formulated with the aim of strengthening economic resilience and minimizing susceptibility to external shocks. Establishing policy consistency and fostering a conducive regulatory framework can contribute to the attainment of enduring economic stability.

## VI. Conclusion and Recommendations

In conclusion, the study's findings highlight the urgent need for economic diversification away from an over-reliance on volatile petroleum to more stable and sustainable sources like natural gas and energy, which show promise in supporting long-term economic stability. The Nigerian government can also promote economic growth while reducing environmental impact by incentivizing businesses to invest in clean energy technologies and making clean energy more affordable for consumers. Furthermore, the underutilization of the labor force points to a pressing need for significant reforms in education and workforce training to harness Nigeria's human capital's potential fully. Implementing these changes will require concerted efforts from policymakers, stakeholders, and the international community to foster an environment that encourages economic resilience, sustainable development, and an improved quality of life for all Nigerians. This strategic shift could redefine Nigeria's economic landscape and set a precedent for other emerging economies facing similar challenges.

## VII. Recommendations

**Petroleum and Other Liquids (pol)**

i. **Diversification Strategy**: Reduce the economy's over-reliance on petroleum by diversifying into other sectors such as agriculture, manufacturing, and services.

ii. **Oil Price Management**: Enact strategies to effectively handle the consequences of unpredictable fluctuations in global oil prices on the economy, potentially by creating stability funds.

iii. **Investment in Technology**: Promote the adoption of cutting-edge technologies in the oil industry to enhance operational efficiency and mitigate environmental consequences.

**Liquefied Natural Gas (lng)**

i. **Investment in LNG Infrastructure**: Prioritize investments in LNG infrastructure to enhance production, storage, and export capabilities.

ii. **Long-term Contracts**: Secure long-term international contracts for LNG exports to ensure a stable revenue stream.

iii. **Domestic Utilization**: Promote the use of natural gas domestically to reduce reliance on more polluting fossil fuels and support industrial growth.

**Hydropower (hp)**

i. **Efficiency Improvements**: Invest in the modernization and maintenance of existing hydropower plants to improve efficiency and output.

ii. **Sustainability Practices**: Develop and implement sustainable practices to address long-term environmental and operational challenges associated with hydropower.

iii. **Diversification of Energy Sources**: Augment hydropower with additional clean energy sources such as solar and wind in order to establish a well-rounded energy portfolio.

**Labour Force (lf)**

i. **Educational Reforms**: Implement comprehensive reforms in the education system to improve the quality of education and align it with market needs.

ii. **Vocational Training**: Enhance vocational training programs to equip the labor force with skills relevant to various industries, thereby reducing underemployment.

iii. **Job Creation Policies**: Develop policies that encourage the creation of jobs in diverse sectors, ensuring better utilization of the available labor force.

**Gross Capital Formation (gcf)**

i. **Infrastructure Development**: Prioritize continuous investment in infrastructure, including transportation, communication, and industrial facilities, to support economic activities.

ii. **Public-Private Partnerships**: Promote the formation of public-private partnerships to utilize private funding for the advancement of infrastructure projects.

iii. **Efficient Allocation**: Ensure efficient allocation of capital towards high-impact projects that can drive economic growth and development.

**General Recommendations**

i. **Clean Energy Incentives**: Incentivize businesses to invest in clean energy technologies to reduce environmental impact and promote sustainable growth.

ii. **Affordability of Clean Energy**:Enact measures to enhance the affordability and availability of clean energy for consumers.

iii. **International Collaboration**: Foster international collaborations to gain technical and financial support for implementing these recommendations and ensuring sustainable development.

Nigeria can attain a more varied, robust, and enduring economy by implementing these suggestions. This will enhance the standard of living for its population and serve as a favorable model for other developing countries.

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