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ECONOMIC INDICES AND ENERGY CONSUMPTION IN NIGERIA

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Abstract

Energy consumption in Nigeria was observed to have been very low in spite of the nation's abundant resource endowments. Successive administrations within the period churned out assorted policy measures aimed at improving energy access. This therefore, prompted an investigation of the impact of selected economic indices on energy consumption in Nigeria from 1990 to 2022. The study is anchored on the energy ladder theory in view of its suitability and central postulation that energy consumption is a function of economic indices. The autoregressive distributed lag (ARDL) method was employed to estimate the parameters of the model and the result revealed that economic growth, trade openness, urbanization and governance had positive impacts on the total energy consumption while energy prices and carbon emissions had negative impacts on the total energy consumption. The Granger causality tests revealed the presence of unidirectional causality running from renewable energy consumption to energy prices and also from trade openness to renewable energy consumption. Hence, the study concludes that Nigeria's energy consumption is largely dominated by non-renewable energy consumption. The study recommends that there should be removal of subsidy on fossil fuels and the proceeds channeled towards renewable energy resources. Also, should be investments on energy infrastructures to enhance accessibility, adoption of improved trade laws and stricter enforcement of the nation's environmental laws.

Keywords: Energy consumption, economic indices, non-renewable energy, renewable energy, Nigeria.

JEL Classification Codes: Q32, Q41

1. Introduction

Energy functions as an important element of the modern global economy, with its accessibility and affordability serving as critical determinants in shaping economic growth and development trends worldwide (Hasson & Masih, 2017). It not only functions as a crucial input in the production, consumption and distribution processes within an economy (Dantama, Abdulahi & Inuwa, 2012); but also represents a fundamental resource essential for both human survival and the advancement of human civilization (Prince, Inim, Callistus & Udo, 2021). When considered in the economic context, energy embodies any resource that enhances the capacity to perform work and its utilization is termed energy consumption (Encarta, 2009). On the other hand, energy consumption refers to the amount of energy consumed or used by individuals, organizations, industries, or nations to meet various needs, including heating, cooling, transportation and industrial processes over a specified period. It is broadly classified into major components of renewable and non-renewable energy consumption based on energy sources. Specifically, renewable energy consumption is referred to as the usage of energy that comes from resources that are continually replenished such as sunlight, winds, rain, tides, waves and geothermal heat whereas non-renewable energy consumption is the utilization of energy that cannot be easily replenished such as petroleum products, hydrocarbon gas liquids, natural gas, coal and nuclear energy (Abalaba & Dada, 2013). Both components of energy consumption are pivotal in an economy as they are utilized to add value to production. According to Dantama et al. (2012), increased agricultural output, increased industrial output, the provision of efficient transportation, adequate shelter, healthcare and other human services holistically require energy consumption.

Theoretical and empirical literature have explicitly linked energy consumption to various economic factors. Among these economic variables, economic growth and trade openness have been recognized as significant drivers of energy consumption (Ogunsola & Tipoy, 2022; Chen et al., 2021). However, little attention has been paid to energy prices as an economic factor affecting energy consumption in Nigeria (Omri & Nguyen, 2014). The interplay of these factors contributes to a comprehensive impact on energy consumption, with economic growth serving as an intermediary in the relationship between energy prices, trade openness and energy consumption (Adewuyi, 2016). Nasreen, and Anwar (2014) emphasized the crucial link between economic growth and energy consumption, stating that a significant relationship makes it challenging to modify energy and environmental policies, whereas a less significant relationship allows for the adoption of energy conservation policies without adverse effects on the economy.

In light of the above discussions, a profound comprehension of the economic factors influencing energy consumption in Nigeria holds great importance, at least for the following reasons. Foremost, the energy consumption mix in Nigeria exacerbates the global challenges of climate change and environmental degradation even in its immediate environment, thus prompting the necessity to discern the drivers that can facilitate a transition from fossil fuel-based energy consumption to renewable alternatives within Nigeria (Olanrewaju et al., 2019). Additionally, understanding the determinants of both non-renewable and renewable energy consumption can offer valuable insights into strategies aimed at bridging the energy deficit, fortifying energy security and addressing energy price shock in Nigeria (World Bank, 2015; Renewables Global Status Report, 2015). Lastly, the energy consumption-mix statistics in Nigeria underscore the underutilization of renewable energy sources in Nigeria, with fossil fuels dominating the electricity sector, while alternative energy sources such as hydropower and solar energy remain untapped.

Despite Nigeria's status as Africa's leading economy with abundant natural resources in both renewable and non-renewable energy resources, Nigeria exhibits the lowest energy consumption rates among African nations (Oyedepo, 2012). This is reflected in the per capita energy consumption when compared to nations like South Africa and Egypt, highlighting the presence of energy gaps and energy poverty in the country (Ogwumike et al., 2014). A comparative analysis as of 2021 reveals energy consumption per capita at 2548 KWh for Nigeria, 23392 KWh for South Africa, 9639 KWh for Egypt, and 3483 KWh for Ghana, underscoring the limited energy access for a significant portion of the Nigerian population (EIA, 2023). A critical analysis of Nigeria's energy consumption mix reveals a predominance of non-renewable energy sources, highlighting the untapped potential of renewable energy. This situation can be attributed to factors such as inadequate energy infrastructure such as refineries, energy pricing issues and corruption in the Nigerian economy (Ishola, 2006; Diji, 2007). Consequently, a significant portion of households resort to traditional fuels like firewood and charcoal (Ogwumike et al., 2014). The heavy reliance on non-renewable energy sources has led to environmental and health challenges, with Nigeria contributing around 19% of total greenhouse gas emissions in Africa (Ackah et al., 2015). Nigeria's limited share of renewable energy consumption signifies a misalignment with the agenda of United Nation’s Sustainable Development Goals. Recent data from the U.S. Energy Information Administration (EIA) (2023) proves this by underscoring the prevalence of fossil fuels over low carbon sources in Nigeria's electricity consumption.

The Nigerian government has implemented various economic policies and initiatives to address energy consumption challenges (Umar & Zakari, 2021). These include energy sector deregulation to enhance efficiency, the 2005 renewable energy master plan aiming to increase renewable electricity supply, and programs like the Nigeria Energy Support Programme II, co-funded by the EU in 2017, to expand solar access and reduce carbon emissions (Adewuyi, 2016). Though these efforts have increased energy consumption per capita in Nigeria, they have still been proven insufficient to significantly alter the energy consumption mix of the Nigerian economy, as reflected in the 2021 energy consumption breakdown, where oil accounts for 52%, natural gas for 44%, and other renewables for 4% (EIA, 2023). The Energy Information Administration (2023) indicates that about 45% of the population lack access to grid electricity and 85% lack access to clean cooking fuel as of 2021 and also Somoye et al. (2022) stated that even the ones who do have access do not have a steady power supply. This highlights the persistence of the energy gap and energy poverty and, thus, underscores the need to recognize the role played by the economic, socio-political and environmental determinants influencing energy consumption in Nigeria.

2. Literature Review

Basic Theories

The Energy Ladder Theory

The energy ladder theory, also known as the energy ladder hypothesis, is grounded in the economic theory of consumer behaviour (Hosier & Kipondya, 1993). It serves as a conceptual framework for explaining shifts in energy consumption sources during economic development and improved living standards in the economy. According to this theory, as society advances economically, it undergoes a transition in energy sources, moving from less sustainable, lower-quality sources to cleaner, higher-quality options (Guta, 2014). Therefore, household income is seen to significantly influence this transition from solid fuels to more efficient, modern energy sources (Daioglou et al., 2012; Khandker et al., 2012).

The Energy Ladder theory is built on several key assumptions. It assumes a hierarchy of energy sources, with traditional biomass at the bottom, followed by transitional sources, and at the top, modern and cleaner sources like electricity and natural gas. Additionally, it presupposes that economic growth leads to a complete shift away from traditional energy sources toward modern fuels. This shift is influenced by factors such as income, fuel and equipment costs, availability, accessibility, environmental and health impacts, and government policies (Kyeremeh, 2018). The theory also considers cleaner fuels as normal economic goods and traditional fuels as inferior goods (Rajmohan & Weerahewa, 2007; Demurger & Fournier, 2011). One of the notable strengths of the energy ladder theory lies in its ability to highlight the strong connection between income and household energy choices, particularly in urban areas (Kowasari & Zerrifi, 2011).

However, some critics argue that the energy ladder theory oversimplifies the transition by implying a complete switch from traditional to cleaner fuels as income rises (Mensah & Adu, 2015). Empirical studies challenge this notion, showing that households in developing countries often use a mix of traditional and modern fuels as their socioeconomic status improves (Akpalu et al., 2011; Van der Kroon et al., 2014). Despite these criticisms, the energy ladder theory remains relevant, suggesting a positive link between household socioeconomic status and energy consumption while also explaining the varying use of energy based on economic status.

In the context of this study, the energy ladder theory elucidates the economic factors affecting energy consumption as it underscores the significance of income, infrastructure, environmental and health considerations, and government policies in shaping energy consumption choices. As incomes rise and infrastructure improves, households tend to transition from traditional, less efficient energy sources to cleaner, more efficient alternatives. Government policies and awareness campaigns further promote these transitions, especially in developing countries striving for sustainable and clean energy practices.

Environment Kuznets Curve Theory

The environmental Kuznets Curve (EKC) theory is an economic hypothesis on income inequality by Simon Kuznets (1955). This theory delves into the connection between a society's income levels and environmental degradation and is also referred to as the inverted U-shaped relationship. It posits that an increase in gross domestic product (GDP) per capita initially results in heightened environmental pollution during the early stages of an economy's development. However, as the nation's economy advances further, pollution subsequently diminishes (Ergun et al., 2019). The EKC theory operates on the assumption that economic growth and development exert a substantial influence on environmental degradation, and it similarly presumes that technological progress and innovation substantially contribute to the reduction of environmental harm. Applying the EKC theory to understand the economic factors affecting energy consumption, one can observe that in the initial stages of economic development, as countries undergo industrialization and urbanization, energy consumption experiences a rapid surge due to increased demand for energy-intensive activities, such as manufacturing and transportation. However, as these nations attain higher levels of affluence, they may allocate resources to adopt more energy-efficient technologies and practices. Consequently, they shift toward cleaner energy sources and implement energy conservation measures, leading to a reduction in energy consumption relative to their economic output. According to Copeland and Taylor (2004), the impact of aggregate income on energy consumption and pollution can be dissected into three components: the scale effect, which pertains to the growing energy requirements of an expanding economy; the technique effect, connected to advancements in production technologies resulting in reduced energy intensity; and the composition effect, reflecting changes in the proportion of the energy-intensive production sector in GDP. The overall influence of economic growth on energy consumption hinges on which of these effects is the most dominant.

Empirical Literature Review

This section discusses the empirical literature thematically in line with the objectives of the study

Economic Growth and Energy Consumption

Okafor (2012) investigated the causal relationship between economic growth and total energy consumption disaggregated into coal, hydro and oil in Nigeria and in South Africa. The data were analyzed using autoregressive distributed lag technique and Granger causality method and the results revealed that economic growth causes total energy consumption in South Africa. Also, energy consumption causes economic growth in Nigeria. While the study was a comparative analysis involving two countries, and limited to economic growth and total energy consumption nexus in these countries. Abalaba and Dada (2013) studied how energy consumption influences economic growth in Nigeria from 1971 to 2010 using ordinary least squares and Granger causality tests technique. The variables used include real GDP, aggregated energy consumption, consumer prices, monetary policy rate and financial development. The study provides weak evidence in support of the long-run relationship between energy consumption and economic growth. The study further revealed that energy consumption positively and significantly influenced output growth in the short-run. Using the first three lags, they found no causal relationship between energy consumption and economic growth. The study concludes that energy consumption has a short-run positive impact on the economy but, do not enhance long-run economic growth in Nigeria during the period. This current study deviates from previous studies by investigating the inverse relationship, that is, how economic indices influence energy consumption. Moreso, the present study fills a methodological gap by utilizing the autoregressive distributed lag technique which investigates short and long run relationships, in addition to the Granger causality test.

Energy Prices and Energy Consumption

Mukhtarov, Mikayilov, Maharramov, Aliyev and Suleymanov (2022) examined the impact of high oil prices on renewable energy consumption in Iran from 1980 to 2019 using general to specific modelling approach. The estimation results indicated that oil price and carbon dioxide emissions both have statistically significant and negative impact on renewable energy consumption. The negative influence of higher oil prices on renewable energy consumption may be interpreted as a sign of satisfaction coming from higher oil prices, which postpones the transition from traditional energy sources to renewable for Iran. Furthermore, the study found that income does not have a statistically significant influence on renewable energy use. The present study focused in Nigeria and employed the autoregressive distributed lag technique making it different from previous study that focused in Iran. The present study further disaggregated energy consumption into total energy consumption, renewable and non-renewable energy consumption.

Ayodele and Alege (2021) studied the impact of oil price volatility on renewable energy consumption in Nigeria from 1986 to 2017. The method of analysis used was the Vector Error Correction Model (VECM) alongside the impulse response and variance decomposition test. The variables of interest were renewable energy consumption as the dependent variable while oil price, real economic growth and carbon emission were the independent variables. The impulse response result revealed in the long run that shocks to oil price volatility produces a positive impact on renewable energy consumption in Nigeria; renewable energy consumption responds negatively to shocks in real GDP and renewable energy responds negatively to shocks in carbon emission. The variance decomposition shows that real GDP and oil price volatility causes the most variation to renewable energy consumption. This current study used a different methodology of autoregressive distributed lag technique and studied not just renewable energy consumption but also non-renewable energy and total energy consumption, in relation to how changes in energy prices affect them.

Trade Openness and Energy Consumption

Ogunsola and Tipoy (2022) investigated the determinants of energy consumption in African oil-exporting countries from 1980 to 2018. The variables of interest were energy consumption, trade openness, economic structure and per capita income. Employing the cross-sectional autoregressive distributed lag (CS-ARDL) and cross-sectional distributed lag (CS-DL) modelling approaches, the study revealed that per capita income had no significantly impact on energy consumption while trade openness had a significant positive effect. The study also revealed that economic structure had a significant negative effect on energy consumption within the period. This study differs from present study because it is a panel study on Africa oil countries while this current study is based in Nigeria.

Somoye, Ozdeser and Seraj (2022) examined the determinants of renewable energy consumption in Nigeria from 1960 to 2019, using autoregressive distributed lagged model and the Toda-Yamamoto approach. The variables used were gross domestic product, financial development, fossil fuel energy and trade openness. The result indicates that gross domestic product and financial development promote renewable energy consumption. Also, fossil fuel consumption harms renewable energy consumption in the long run. In the short-run, trade openness had a negative impact on renewable energy consumption. The variables of interest in the present study are economic growth, energy prices and trade openness while the dependent variable is disaggregated into total, renewable and non-renewable energy consumption. This study adopted autoregressive distributed lag technique making it different from previous studies.

The review of empirical literature was done chronologically, following from the study's objectives. The multiple empirical works of literature were written by different scholars in Nigeria and across Nigeria using various methods of analysis such as the OLS, VAR, VECM and ARDL to understand the impacts of the selected economic indices on energy consumption in Nigeria. This has resulted in different findings which make it apparent that the impact of economic growth, energy prices and trade openness on total energy consumption, renewable and non-renewable energy consumption needs further investigation.

3. Methodology

Theoretical Framework

The framework for this study is based on the energy ladder theory which is grounded in the economic theory of consumer behaviour (Hosier & Kipondya, 1993). The theory considers economic factors (income) as well as other social and environmental factors as factors affecting energy consumption. Kyeremeh (2018) stated that the energy ladder theory demonstrates a positive linear relationship between a household's socio-economic status and the use of energy sources. The theoretical energy consumption function for a micro (household) energy consumption analysis is thus stated as:

$$EC = f(X) \tag{3.1}$$

Where; EC = Energy consumption, X = Vector of household factors affecting energy consumption.

From Equation (3.1);

X = f(income, energy prices, social status, family size, energy equipment cost, availability and accessibility to energy, environment) (3.2)

Lawal (2023) presented a macro level specification of Equation (3.1) by representing the elements of the vector X and regrouping them into sub-sectors vectors of socio-political, economic and environmental factors. The study gave a macro energy consumption function as shown in Equation (3.3):

$$EC = f(Y, S, V) \qquad (3.3)$$

Where; EC = Energy consumption in the economy, Y =Vector of economic variables, S = Vector of socio-political variables, V = Vector of environmental factors.

Transforming the above Equation (3.3) into its scalar form gives;

$$EC = f(y_1, y_2, \dots y_n; s_1, s_2, \dots, s_m; v_1, v_2, \dots v_l) \qquad (3.4)$$

Where: EC = Energy consumption (renewable energy consumption and non-renewable energy consumption),

$$Y = f(y_1, y_2 \dots y_n) \qquad (3.5)$$

$$S = f(s_1, s_2 \dots s_m) \qquad (3.6)$$

$$V = f(v_1, v_2 \dots v_l) \qquad (3.7)$$

Assuming a consumption function, Equation 3.3 can be stated as

$$EC = \Omega Y^{ai} S^{bj} V^{yk} \qquad (3.8)$$

From the above, ai, bj, and yk are the elasticity; Ω = Initial energy consumption (it is a measure of the energy consumption that would have been observed in the absence of increase or decrease in energy consumption due to changes in social, economic and environmental factors). In the same way, $(\pi^{ai}\pi^{bj}\,\pi^{yk}-1) \times 100\%$ estimates the percentage change in energy consumption by reason of social, economic and environmental factors.

Model Specification

To investigate the economic factors affecting energy consumption in Nigeria, having adjusted the energy ladder theory which serves as the theoretical framework of this study, this study adapted the Lawal (2023) model which is specified as;

$$TEC = f(RGDP, FDI, TRAD, GS, INF, AGROUT, CO2, EF, GE, URB, LE, EI, CP1) \qquad (3.9)$$

Where, RGDP is Real gross domestic product, FDI is foreign direct investment, TRAD is trade openness, GS is government spending, INF is inflation, AGROUT is agricultural output, CO2 is carbon dioxide emissions, EF is ecological footprint, GE is governance effectiveness, URB is urbanization, LE is life expectancy index, EI is education index and CPI is corruption perception index.

$$TEC = f(GDP, EP, TO, URB, CO2, GOV) \qquad (3.10)$$

Total energy consumption is disaggregated into renewable and non-renewable energy consumption and stated in Equations 3.11 and 3.12.

$$REC = GDP + EP + TO + + URB + CO2 + GOV \qquad (3.11)$$

Investigating the economic factors affecting non-renewable energy consumption, the following model is specified as:

$$NREC = GDP + EP + TO + + URB + CO2 + GOV \quad (3.12)$$

Rewriting Equations 3.10, 3.11 and 3.12 above in an econometric form, we have the following:

$$TEC_t = \beta_0 + \beta_1 GDP_t + \beta_2 EP_t + \beta_3 TO_t + \beta_4 URB_t + \beta_5 CO2_t + \beta_6 GOV_t + \varepsilon_t \quad (3.13)$$

$$REC_t = \beta_0 + \beta_1 GDP_t + \beta_2 EP_t + \beta_3 TO_t + \beta_4 URB_t + \beta_5 CO2_t + \beta_6 GOV_t + \varepsilon_t \quad (3.14)$$

$$NREC_t = \beta_0 + \beta_1 GDP_t + \beta_2 EP_t + \beta_3 TO_t + \beta_4 URB_t + \beta_5 CO2_t + \beta_6 GOV_t + \mu_t \quad (3.15)$$

Where, TEC is the total energy consumption, REC and NREC are both renewable and non-renewable energy consumption. GDP is GDP growth rate, a proxy for economic growth, EP represents energy prices and TO stands for trade openness. GDP, TO and EP represent economic factors. Urbanization (URB) proxied by urban population (% of total population) and governance (GOV) proxied by government effectiveness index, represent socio-political factors. Carbon emission (CO2) proxied by emissions from gaseous fuel consumption (% of total), is the environmental factor. β_0 is the intercept, while $\beta_1 - \beta_6$ are the coefficients. ε and u are stochastic error terms and the t denotes time measured in years.

The estimation technique and procedure used for this study is the autoregressive distributed lag (ARDL) framework provided by Pesaran and Shin (2001). This procedure is adopted because it has better small sample properties than alternative methods like Engel-Granger (1987), Johansen and Julius (1990) and Philip and Hansen (1990). This method avoids the classification of variables as I(1) and I(0) by developing bands of critical values which identifies the variables as being stationary or non-stationary processes. The ARDL method can distinguish between dependent and explanatory variables. In using the ARDL technique, we first test to determine whether the modeled variables are co-integrated, that is, whether a long run relationship exists between the dependent and independent variables. Once the long run relationship or co-integration has been established, the next stage involves the estimation of the long run and short run coefficients. The short run coefficients are estimated using the error correction modeling which aims at reconciling the long run behaviour of co-integrated variables with their short run responses.

To illustrate the ARDL modelling approach adopted for the study, Equation 3.14 and 3.15 will be restated as follows:

Equation 1

$$\Delta REC_t = \beta_0 + \sum \beta_j \Delta REC_{t-i} + \sum \delta_j \Delta LnGDP_{t-i} + \sum \varphi_k \Delta LnEP_{t-i} + \sum \pi s \Delta TO_{t-l} + \sum \text{ϟ}_P \Delta LnURB_{t-l} + \sum \ddot{\Upsilon}_q \Delta CO2_{t-l} + \sum \alpha_r \Delta GOV_{t-1} + \eta_1 REC_{t-1} + \eta_2 LGDP_{t-1} + \eta_3 LEP_{t-1} + \eta_4 LURB_{t-1} + \eta_5 TO_{t-1} + \eta_6 CO2_{t-1} + \eta_7 GOV_{t-1} + \mu t \quad \textbf{(3.16)}$$

Equation 2

$$\Delta NREC_t = \beta_0 + \sum\beta_j\Delta NREC_{t-j} + \sum\delta_j\Delta LnGDP_{t-j} + \sum\varphi_k\Delta LnEP_{t-l} + \sum\pi s\Delta TO_{t-l} + \sum\varkappa_P\Delta LnURB_{t-l} + \sum\ddot{\Upsilon}_q\Delta CO2_{t-l} + \sum\alpha_r\Delta GOV_{t-1} + \eta_1 NREC_{t-1} + \eta_2 LnGDP_{t-1} + \eta_3 LnEP_{t-1} + \eta_4 TO_{t-1} + \eta_5 LnURB_{t-1} + \eta_6 CO2_{t-1} + \eta_7 GOV_{t-1} + \mu t \quad \textbf{(3.17)}$$

The study's model (Equation 3.13) is therefore stated as

$$\Delta NTEC_t = \beta_0 + \sum\beta_j\Delta NTEC_{t-j} + \sum\delta_j\Delta LnGDP_{t-j} + \sum\varphi_k\Delta LnEP_{t-l} + \sum\pi s\Delta TO_{t-l} + \sum\varkappa_P\Delta LnURB_{t-l} + \sum\ddot{\Upsilon}_q\Delta CO2_{t-l} + \sum\alpha_r\Delta GOV_{t-1} + \eta_1 NTEC_{t-1} + \eta_2 LnGDP_{t-1} + \eta_3 LnEP_{t-1} + \eta_4 TO_{t-1} + \eta_5 LnURB_{t-1} + \eta_6 CO2_{t-1} + \eta_7 GOV_{t-1} + \mu t \quad \textbf{(3.18)}$$

In the ARDL equations and model above, the terms with the summation signs ($\sum$) represent the Error Correction Model (ECM) dynamics. The coefficients η_i are the long run multipliers corresponding to the long run relationship. β_0 and μt represent the constant and the white noise or disturbance term respectively while β_j, δ_j, ϕ_k, πs, $\varkappa_P$, $\ddot{\Upsilon}_q$ and α_r represents the short run effects. Δ is the first difference operator, L stands for logarithm of the data while k is the lag length for the Error Correction Model. The reason for taking variables log is to smooth out the data series and make sure that it is not negatively or positively skewed.

4. Findings and Discussion

This study examined how economic factors influenced energy consumption in Nigeria between 1990 and 2022. Pre-tests, including descriptive statistics and the Augmented Dickey-Fuller (ADF) root test, were conducted. Cointegration and an error correction model, based on the ARDL specification, were employed as the contemporary econometric techniques for estimation.

The result of the study revealed that gross domestic product (GDP), as an indicator of economic growth, had a statistically significant positive impact on total energy consumption and non-renewable energy consumption but a negative and significant impact on renewable energy consumption. This aligns with the environmental Kuznets hypothesis, suggesting that in early development stages, countries prioritize economic growth, leading to increased energy consumption. However, as economic growth reaches a certain level, there is a shift towards renewable energy consumption for environmental sustainability. In the context of Nigeria, the results validate this theory, indicating increased non-renewable energy consumption due to economic growth arising from dependency on oil, while renewable energy consumption decreases due to cost and accessibility issues for manufacturing firms, industries, and households. This outcome is in line with Chen et al. (2021) findings of a negative association between economic growth and renewable energy consumption in less democratic countries. In contrast, Somoye et al. (2022) and Lawal (2023) reported a positive impact of economic growth on renewable energy consumption in Nigeria and Africa, respectively.

Energy prices proxied by oil prices had a positive effect on renewable energy consumption but a negative impact on both non-renewable energy consumption and total energy consumption in the long run. It was estimated that a 1% increase in oil prices increased renewable energy consumption by 0.62% while reducing non-renewable energy consumption by 33% and reduced the total energy consumption by 61.5% on average. These findings align with theoretical expectations and the theory of normal demand, indicating that increased crude oil prices in Nigeria reduce the demand for energy products especially non-renewable energy products. In response, the country shifts towards an alternative energy source. These findings are consistent with Chen et al. (2021) study, which observed a positive impact of real oil prices on renewable energy consumption in less democratic countries. In accordance with the findings, Omri and Nguyen (2014) found that oil prices had an insignificant positive impact on renewable energy consumption.

Trade openness, another major economic indicator had an insignificant negative effect on renewable energy consumption. It also had a statistically significant positive impact on non-renewable energy consumption and a statistically significant positive impact on total energy consumption. This implies that external factors from trade openness in Nigeria contribute to a reduction in renewable energy consumption but an increase in non-renewable and total energy consumption in Nigeria. The Pollution Haven Hypothesis (PHH) supports this, suggesting that industries relocate to developing nations to avoid environmental regulations and taxes, leading to higher non-renewable energy consumption and lower renewable energy consumption. This outcome highlights the level of poor implementation of environmental policies in Nigeria. This finding aligns with the findings of Ogunsola and Tipoy (2022). Chen et al. (2021) also noted a negative significant impact of trade openness on renewable energy consumption in less democratic countries. Conversely, Omri and Nguyen (2014) found a positive significant impact of trade openness on renewable energy consumption in Nigeria.

The Granger causality test revealed the presence of unidirectional causality running from renewable energy consumption to energy prices and also from trade openness to renewable energy consumption. The post-estimation tests confirm the reliability of the three models in this study for prediction and policy implications, as evidenced by autocorrelation, heteroscedasticity, and Ramsey RESET tests results with probability values exceeding 0.05 for all the models.

5. Conclusion and Recommendations

Over the years, the Nigerian government has adopted several policies and programs to increase the total energy consumption in Nigeria while also considering a swift shift from non-renewable energy consumption to renewable energy consumption. Despite these efforts, this study revealed that non-renewable energy consumption is still on the increase compared to renewable energy consumption in Nigeria which is triggered by key economic factors including economic growth, oil prices and trade openness. To attain the UN Sustainable Development Goals by 2030, implementing the recommendations outlined in this study would help the country make significant strides towards adopting renewable energy as against non-renewable energy. Specifically, policies aimed at encouraging sustainable economic growth, accessibility and affordability of renewable energy resources and strict environmental policies can contribute in boosting renewable energy consumption in Nigeria.

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