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Energy Consumption and Quality of Life in Nigeria

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Abstract

This study investigates the impacts of energy consumption and quality of life in Nigeria, measured by indicator such as the Human Development Index (HDI). Data used for the study was gotten from the central bank of Nigeria statistical bulletin (2023) and the estimation was conducted with autoregressive distributed lagged (ARDL) approach. Findings reveal that kerosene consumption significantly enhances quality of life, with a 0.034146 and 0.008923 increase in the long and short run, respectively, for every percentage rise in usage. Conversely, premium motor spirit (PMS) consumption has detrimental effects, reducing quality of life by -0.061891 in the long run and -0.025059 in the short run due to associated environmental and health challenges. Income inequality, represented by the Gini coefficient, surprisingly shows a positive correlation with quality of life, highlighting structural inefficiencies and the need for policy reforms. Electric power consumption and its lagged values exhibit an insignificant impact on life quality, reflecting systemic inefficiencies that necessitate substantial reforms to ensure reliable electricity as a driver of socio-economic development. Diesel consumption demonstrates instability, with lagged values positively influencing life quality while current values remain insignificant. The study emphasizes the critical role of energy consumption patterns in shaping quality of life in Nigeria. Targeted energy policies promoting cleaner alternatives, equitable resource distribution, and investments in public health and infrastructure are essential for sustainable improvements in living standards and life expectancy. Recommendations include prioritizing renewable energy, enhancing kerosene distribution as a transitional energy source, addressing income inequality, and strengthening governance frameworks to implement and monitor energy and environmental policies effectively. These findings provide actionable insights for policymakers to address environmental, health, and socio-economic challenges, fostering sustainable development and improved quality of life in Nigeria.

1. Introduction

Energy is essential to sustain and increase quality of life. The significant socioeconomic changes and high pace of population expansion since the industrial revolution have necessitated vast amounts of energy delivered mostly by coal and petroleum. Energy is the vital force driving all economic operations (Alam, 2006). The functions of energy in enabling job development, economic growth, agriculture, transport, and trade which are crucial components for alleviating poverty cannot be over stressed; it is often characterised as ability to conduct work. Energy comes in numerous forms: Heat (thermal), Light (radiant), Motion (kinetic), Electrical, Chemical, Nuclear energy and Gravitational. In the near future, additional population growth and improvements in quality of life will raise the demand for non-renewable fossil fuels and worsen the accompanying environmental concerns (Pasten and Santamarina, 2012). Researchers have recognised major categories of Energy namely: Stored (potential) energy and Working (kinetic) energy. Energy sources are split into two groups: Renewable (an energy source that can be easily replaced) and Nonrenewable (an energy source that cannot be quickly replenished). Renewable and nonrenewable energy sources can be used as primary energy sources to provide usable energy such as heat or used to produce secondary energy sources such as electricity. There are five main renewable energy sources: Solar energy (from the sun), Geothermal energy (from heat inside the ground), Wind energy, Biomass (from plants), Hydropower (from flowing water) (Umeh, Ochuba and Ugwo, 2019).

However, majority of the energy consumed in the Nigeria is from nonrenewable energy sources: Petroleum products, Hydrocarbon gas liquids, Natural gas, Coal, Nuclear energy. Crude oil, and coal are called fossil fuels because they were created over millions of years by the impact of heat from the earth's core and pressure from rock and soil on the remains (or fossils) of deceased plants and organisms such as minuscule diatoms. Nuclear energy is produced from uranium, a nonrenewable energy source whose atoms are split (through a process called nuclear fission) to create heat and, eventually, electricity (Umeh et-al, 2019).

In developing nations, especially in rural areas, 2.5 billion people rely on biomass, such as fuel wood, charcoal, agricultural waste and animal dung to meet their energy requirements for cooking (IEA, 2006). Household use of biomass in developing nations alone accounts for about 7% of world primary energy consumption (IEA, 2006). An estimated 72% of Nigerians depend only on wood as a source of fuel for cooking (NBS-CNB-NCC, 2011). However, the notable aspect that divides the developed from the developing countries (mainly Africa) is their level of quality of life accessible with greater access to energy resources. For instance, Nigeria the behemoth of Africa presently generates roughly 40 Kilowatts of power per one thousand population compared to 120 Kilowatts by Indonesia, 145 Kilowatts by India, 530 Kilowatts by Brazil, and 190 Kilowatts by Morocco. These numbers indicate the inadequacy of power available in the country that limit the earning ability of individuals and deteriorating welfare due to declining disposable income. The country intends to remedy this position through quick investment in the power sector and by modernising the sector through deregulation and privatization. This resulted into energy sector reform and handing over of the successor firms of the defunct Power Holding Company of Nigeria (PHCN) to private investors (Sani,Mukhtar and Gani (2017). These dilemma may not be unconnected with the discrepancy of salaries among the population of Africa. The gap economic disparity in Nigeria may have been accountable for the perceived instability in energy consumptions occasioning low quality of living. Despite being endowed with natural energy resources and/or fossil fuel resources in African countries especially for those in the Sub-Saharan Africa, these countries experience the lowest per capita energy consumption levels in the world (United Nations Economic Commission of Africa, 2004; as cited in Bildirici, 2013). The rate of energy consumption grows with economic growth and the consumption of energy sources improve quality of life, a better degree of socio-economic development is related with a highly developed energy sources (Bildirici, 2013). Energy consumption has a very significant influence in economic development of countries and has become a primary focus of many scholars active in the energy economics literature. The report claims that substantial discrepancies in energy availability across the ruralurban divide can impair Africa's environmental sustainability agenda. It also brings to the fore the importance for assessing the underlying socioeconomic challenges limiting equal energy access. This is where income disparity, which Chancel et al. (2023) estimate to be terrible in Africa, demands attention. On the one hand, high-income inequality often deprives many people of basic needs and resources, causing them to resort to using unclean energy (e.g., kerosene, fossil fuels, and biomass, and primitive cooking equipment/techniques (e.g., smoke-curing, ash-cooking and cooking pots), which have been shown to degrade the environment and intensify exposure to environmental health problems (Sarkodie & Adams, 2020a; Baloch et al., 2020; Galvin, 2020;) However, in societies with equitable economic growth and distribution, there is ubiquitous access to clean cooking fuels and technologies. This can expedite the use of electric cookers, energy-efficient stoves, and green technology for both home and commercial applications, contributing to forest conservation and air pollution and greenhouse gas emission mitigation (World Health Organization (WHO), 2018.

Empirical studies addressing the relationship between energy use and quality of life are widespread (e.g., Leung and Meisen, 2005; Bahadur, 2014). While some study reveals a favourable association between energy usage and quality of life (e.g., Martinez and Ebenhack, 2008; Pourali, 2014), other data suggest a neutral relationship between these variables (e.g., Muhammad and Sabo, 2021; Scheidel and Sorman, 2012). This study attempts to contribute to this increasing body of work and solve existing gaps by investigating the influence of energy consumption and income disparity on quality of life in Nigeria over the period 1981 to 2023. Specifically, it tries to answer crucial concerns, such as: Do energy consumption and wealth inequality significantly influence quality of life in Nigeria and the broader African context?

Previous studies have examined income inequality's effects on renewable electricity access, energy consumption, and clean cooking technologies in Africa, but its direct impact on environmental quality and the relationship between energy consumption income inequality and quality of life remain underexplored. Limited research exists on how energy consumption and income disparity affect quality of life, particularly in developing nations like Nigeria, where energy poverty contributes to environmental degradation. Few comprehensive environmental quality indices integrate income inequality, energy use, and sustainability. Gaps also persist in understanding socioeconomic drivers of clean energy transitions in low-income regions, with many studies relying on outdated data.

This study addresses these gaps by integrating energy consumption, income inequality, and quality of life and in Nigeria. The paper is organized into five sections: introduction, literature review, methodology, results and discussion, and conclusions and recommendations.

2. Literature Review

Conceptual Clarification:

Energy Consumption

Energy consumption refers to the entire amount of energy used by an individual, organization, or system over a certain period. It encompasses numerous forms of energy, such as electricity, fossil fuels, and renewable sources, and is vital for powering industries, residences, and transportation networks. The concept is strongly related to economic prosperity, technical progress, and environmental sustainability. Energy consumption is a fundamental part of modern life, connected with economic prosperity and environmental health. Transitioning to sustainable energy practices is vital to combating climate change and maintaining future energy security. . Energy consumption does not come from one source. There are three main forms of energy production that feed energy consumption: fossil fuels, alternative energy, and renewable energy. Renewable energy is sometimes, but not always, listed under "alternative. Alternative energy generically refers to any energy that is not obtained from a fossil fuel, but does not have to be derived completely from renewable sources.For example, nuclear power generation most typically employs uranium, an abundant but not strictly renewable fuel. Wind power can be directly described as energy created from the wind. It is made when wind turns a turbine, or a windmill, which can be positioned on land or in deep water (offshore). Solar power utilises the sun's energy in two ways: by turning the sun's light directly into electricity when the sun is out (solar panels), or by using the sun's heat to make electricity, a method that works even when the sun is down. Hydropower is formed when quickly flowing water rotates turbines inside a dam, generating electricity. Nuclear energy is created in power plants by the process of nuclear fission. The energy released during nuclear reactions is utilised to produce power. Biofuels, commonly referred to as "biomass," are produced utilising organic resources (wood, agricultural products and trash, food waste, and animal manure) that contain stored energy from the sun. Humans have used biomass since they discovered how to burn wood to generate fire. Liquid biofuels, such as ethanol, also release chemical energy in the form of heat. Renewable and alternative energy sources are sometimes classed as "clean energy" since they produce much less carbon emissions compared to fossil fuels. But they are not without an environmental footprint.

The Concept of Quality of Life

Quality of life (QoL) refers to the general well-being of individuals and society, comprising a broad variety of characteristics that influence a person's pleasure, happiness, and ability to live a satisfying life. It extends beyond economic richness and encompasses physical, psychological, social, and environmental factors (Diener & Suh, 1997). While the phrase is commonly used in policy-making, healthcare, and sociology, its definition and assessment remain multi-dimensional and context-dependent.

Dimensions of Quality of Life

i. Physical Well-Being: Health is a cornerstone of quality of life. Access to healthcare, nutrition, and physical safety are crucial to achieving excellent health outcomes (World Health Organization [WHO], 2022).
ii. Psychological Well-Being: Mental health, self-esteem, and emotional stability are key factors to quality of life. Psychological well-being enables individuals to cope with stress and participate meaningfully with their surroundings (Ryff & Keyes, 1995).
iii. Social bonds: Interpersonal connections, family bonds, and community engagement play key roles in boosting life satisfaction and establishing a sense of belonging (Putnam, 2000).
iv. Economic and Material Conditions: Employment, income levels, housing quality, and access to resources greatly impact quality of life, as they determine one's ability to meet fundamental requirements and accomplish objectives (Sen, 1999). 5. Environmental Quality: Clean air, safe water, and sustainable living conditions contribute to both physical and emotional well-being, showing the link between environmental and human health (Dasgupta et al., 2021).

Measurement of Quality of Life

Quality of life is quantified using several frameworks and indices, such as: • Human Development Index (HDI): Combines indicators of life expectancy, education, and income to quantify human development (United Nations Development Programme [UNDP], 2023). • World Happiness Report: Measures subjective well-being by surveys assessing happiness and life satisfaction internationally (Helliwell et al., 2022).

• WHOQOL Framework: Developed by the WHO, it examines physical, psychological, social, and environmental health variables (WHO, 2022). Importance of Quality of Life Improving quality of life is a core goal of governments, organizations, and communities. It influences economic productivity, societal cohesiveness, and individual happiness. For example, public initiatives focused at reducing poverty, boosting education, or ensuring universal healthcare directly enhance QoL outcomes (Stiglitz et al., 2009).

Challenges and Future Directions

Despite breakthroughs in QoL assessment and improvement, inequities continue across and within countries. Addressing systemic challenges including financial inequity, healthcare access, and environmental degradation remains crucial to attaining equitable improvements in quality of life (Raworth, 2017). Quality of life is a complex, multi-faceted notion that transcends economic statistics to include health, psychological well-being, social ties, and environmental sustainability. A holistic approach to its evaluation and enhancement is crucial for encouraging well-being at individual and social levels.
Links between Energy Consumption and Quality of Life When Moderated by Income Inequality
Energy consumption and quality of life (QoL) are tightly interconnected, as access to energy resources promotes economic activity, boosts living standards, and facilitates the supply of fundamental services such as healthcare, education, and housing (Smil, 2020). However, this link is greatly influenced by income inequality, which determines how equitably the advantages of energy use are dispersed across a community.

The Relationship between Energy Consumption and Quality of Life
Energy consumption promotes the development of infrastructure, technologies, and services that directly impact QoL dimensions: Access to energy ensures well-equipped healthcare facilities, clean water supply, and proper sanitation systems (World Bank, 2022), Energy powers schools and digital learning tools, improving educational outcomes and drives industrialization, job creation, and entrepreneurship, which are critical for improving living standards (IEA, 2022).

Moderation by Income Inequality

Income inequality impacts the amount to which energy usage transfers into QoL improvements. Wealthier individuals generally consume excessive amounts of energy for luxury reasons, while poorer populations struggle to meet basic energy needs (UNDP, 2023). Investments in energy infrastructure may favor urban or wealthier areas, leaving rural or low-income regions neglected. Inequality exacerbates energy poverty, as households cannot afford sufficient energy for essential necessities, compromising their QoL (Bouzarovski & Simcock, 2017). Conversely, in more equal societies, the benefits of energy use are more widely spread, leading to greater overall increases in QoL.In countries with minimal wealth inequality, rising energy consumption is highly connected with increases in health, education, and economic well-being (Steckel et al., 2013). In highly unequal countries, the positive impact of energy consumption on QoL is lessened due to unequal distribution and inefficient deployment of energy resources (Krausmann et al., 2011). While energy consumption is crucial for boosting quality of life, its impact is tempered by income inequality. Equitable access to energy resources is vital for ensuring that all society groups can experience the advantages of better living standards. Addressing income disparity is thus a vital step in leveraging energy consumption to promote sustainable development and well-being.

Theoretical Literature

Energy-Led Growth Hypothesis (ELGH)

The Energy-Led Growth Hypothesis (ELGH) posits that energy is a fundamental driver of economic growth, emphasizing its role in industrialization, technological advancement, and development. Emerging in the late 20th century, with contributions from Kraft and Kraft (1978), Yu and Hwang (1984), and Stern (1993), it extends traditional growth models like the Solow Growth Model by incorporating energy as a key input alongside labor and capital. This theory is particularly relevant for developing economies with limited energy access and infrastructure. Proponents argue that energy acts as both a direct input and an enabler of the other inputs (labor and capital), enhancing their productivity.

According to Stern (2011), energy is indispensable in modern production processes, powering industrial machinery, transportation systems, and household utilities. Without adequate energy supplies, production efficiency declines, and economic activities slow. Odhiambo (2009) further highlights that energy consumption fosters technological advancements and supports the expansion of economic activities, particularly in developing countries where industrialization is a key goal. Energy is critical for optimizing production processes, which leads to cost reductions and higher output levels. By improving the productivity of capital and labor, energy consumption enhances economic growth potential. This is particularly relevant for energy-intensive industries, where production depends on a stable and affordable energy supply.

The **Energy-Led Growth Hypothesis (ELGH)** has been supported and developed by several economists, researchers, and theorists who highlight the essential role of energy consumption in driving economic growth. These proponents argue that energy is not merely an auxiliary input but a fundamental enabler of industrialization, technological innovation, and sustained economic development. Stern (2011) is one of the most prominent proponents of the ELGH. His work emphasizes the inclusion of energy as a core input in the production function, alongside labor and capital. He argues that energy consumption is directly related to industrial output and economic growth, particularly in energy-intensive economies. Stern also highlights the role of energy in enhancing productivity and technological advancements. Odhiambo (2009) focuses on the relationship between energy consumption and economic development in emerging and developing economies. He emphasizes how energy consumption fosters industrialization, improves labor productivity, and facilitates broader economic activities. His work is particularly relevant to regions like Sub-Saharan Africa, where energy shortages significantly hinder economic growth. Although better known for their general contributions to economics, Samuelson and Nordhaus also explored the role of energy in economic systems in their works on production functions and macroeconomic models. Akinlo (2008) provides empirical support for ELGH in the context of African economies, particularly Nigeria. His studies show that energy consumption positively impacts industrial output, suggesting that energy access is critical for economic development in resource-constrained regions. This group of researchers (2008) explored the causality between energy consumption and economic growth in developed and developing economies. They found stronger evidence of causality in developing countries, aligning with the ELGH framework. Their work underscores the idea that energy is a prerequisite for growth in nations where industrialization and infrastructure are still developing.

Summary, exponents like Stern, Odhiambo, and Akinlo have significantly advanced the understanding and empirical validation of the Energy-Led Growth Hypothesis, especially in developing economies. Their work has provided critical insights for policymakers aiming to prioritize energy infrastructure and access as part of broader economic development strategies. The **Energy-Led Growth Hypothesis (ELGH)** is highly relevant in contemporary economic discussions, particularly for developing regions like Sub-Saharan Africa, where energy infrastructure and access remain significant developmental challenges. The theory highlights the foundational role of energy in driving industrialization, enhancing productivity, and fostering economic growth.

Empirical Literature

Uzoechina et al. (2024) utilised data from the World Bank and the Central Bank of Nigeria Statistical Bulletin to examine the influence of energy consumption and corruption on life expectancy in lower-middle-income West African nations from 1990 to 2021. The findings from the cross-sectional auto-regressive distributed lag method indicated that renewable energy positively and significantly influences life expectancy in lower-middle-income West African nations, both in the short and long term. Nonetheless, non-renewable energy was determined to exert a substantial and adverse effect on life expectancy over the long term, whereas its impact in the short term was unfavourable albeit statistically insignificant. Corruption adversely impacted life expectancy in both the short term and the long term. We advise governments to intentionally promote the shift to renewable energy via public-private partnerships to ensure affordable and clean electricity while addressing corruption.

Abubakar (2024) derives inspiration from the United Nations Sustainable Development Goals and examines the interrelationship between availability to contemporary cooking energy sources, responsible energy consumption, climate change mitigation, and economic progress. The paper analyses the impact of significant socioeconomic and demographic variables on household cooking energy selection in Nigeria, utilising data from the 2018 demographic and health survey. Outcomes The empirical findings indicate that traditional energy sources prevail among Nigerian families at 74.24%, in contrast to contemporary energy sources at 25.76%. In terms of energy demographics, households led by males exhibit a higher utilisation of contemporary energy sources (19.86%) than those led by females (5.90%). Regional research suggests that the northwest area largely employs traditional energy sources (18.60% of the share of total traditional energy sources), while the southwest region displays the biggest usage of modern energy sources (10.52% of the share of total modern energy sources). Binary logistic regression study indicates the positive and statistically significant influence of wealth index, education, and geopolitical region on the chance of employing modern energy sources. Conversely, household size and place of residence imply an adverse link with the chance of adopting modern energy sources. Conclusions These findings have substantial policy implications for energy efficiency, environmental sustainability, and enhancing the quality of life in Nigeria, which is currently plagued by significant energy poverty, especially in rural populations.

Pourali (2014) assessed the association between environmental life quality indices and energy consumption in high energy- consuming countries like America, China, Japan, India, Iran, Russia, etc. using fixed effects model estimate throughout the period 2007 - 2011. The energy consumption was proxied by energy consumption based on oil consumption; the environmental life quality indices were under-5 children mortality, agricultural subsidies, access to drinking water, access to sanitation and CO2 per capita. The results revealed that there is a considerable positive correlation between environmental life quality measures and energy use.

Muhammad and Sabo (2017) assessed the impact of energy and electricity use on quality of life in Africa using fixed effects and random effects model for the period of 2008 - 2014. they picked twenty three nations from Africa on the basis of availability of data. The Hausman specification test of 1978 was applied to find the proper and superior model for the estimate where fixed effects estimation was chosen above random effects estimation. The findings indicated that energy consumption had positive and statistically significant impact on quality of life whereas electricity consumption had negative and statistically significant impact on quality of life. Hence, the study recommended that African countries should devise means of achieving energy efficiency and ensuring sustainability of energy usage in the region through establishing energy research centers that will help in developing new sources of energy as well as retaining the existing energy with a view to improve quality of life.

Bahadur (2014) investigated the consequences of access to infrastructure on the human development (HDI) utilising dynamic panel estimate using General Methods of Moments across the period 1995 - 2010 covering 91 developing nations. The human development (dependent variable) was proxied by human development index of UNDP; the explanatory variables were access to electricity, access to clean drinking water sources, and access to road proxied by the percentage of the population with access to electricity, proportion of the population using improved drinking water sources, and road density in terms of kilometers of road network per 100 sq. km of land area, respectively. Also four criteria were employed as control variables: the consumer price index (CPI), population growth, Konjunktur (KOF) index of globalization, and democracy index. More so, the paper went further to employ each component of HDI as dependent variable. The results indicated that all three infrastructure variables had significant good impact on HDI. The results with reference to component of HDI (as dependent variable) access to power and availability to clean drinking water sources had major beneficial influence solely on education and health indexes; while road density had considerable positive impact on the income index. Scheidel and Sorman (2012) studied long run link between human growth and quality of life in Greece. The study indicated that there were continuities and discontinuities between ancient, medieval and modern periods of Greek history which have impact on human growth, quality of life and gross national happiness. The study also discovered that challenges encountered in determining quality of life are inherent irrespective of time domain. The study, thus, indicated that institutional arrangement in political and military mobilization, and enslavement, had repercussion that might be simultaneously advantageous and destructive to the quality of life. Qiaosheng, Maslyuk and Clulow (2012) analysed the relationship between energy consumption disparity and human development of one hundred and twenty nine (129) nations spanning the period of 1998 - 2007 employing Lorenz curve and Gini coefficient. The variables of choice were energy consumption and human development proxied by energy consumption per capita (in tones of oil equivalent) and human development index (HDI). The analysis found that the link between the HDI and energy usage per capita was not linear. This shows that at low human development levels, rise in energy consumption will lead to substantial rises in a country's HDI whereas countries with high or medium human development levels, growth in energy consumption is not enough to sustain its human development progress. Hence, it was proposed that countries classed with high or medium human development index should combine more efficient energy usage, development of energy-saving technology, constructing adequate social welfare systems, etc. Pasten and Santamarina (2012) analysed worldwide energy consumption status in relation to quality of life. The variables of choice were energy consumption rate per capita, government's energy for life efficiency, and quality of life, etc. The results highlighted the energy cost of boosting quality of life in the developing world, energy savings that can be realized by reducing overconsumption without compromising quality of life, and the influence of governments on increasing energy for-life efficiency and lowering social disparity Mart and Ebenhack (2008) assessed the influence of energy usage on human development using correlation analysis for one hundred and twenty nations (120). The variables were human development index and energy consumption per capita as proxy for human development and energy consumption. The analysis found that there was strong relationship between human advancement and energy usage per capita. Hence, it was suggested that large advances in human development are attainable for the poor countries with low additional access to energy.

Seng and Meisen, (2005) investigated the effect of electricity consumption on social and economic development in comparison with low, medium and high human development countries based on UNDP classification spanning forty (40) countries using regression analysis. Human development index and GDP per capita were proxies for social and economic development; whereas energy consumption per capita was assessed in Kilowatt-hours. The results revealed that electricity consumption per capita has large beneficial effect on social development and economic performance with respect to medium and low human development countries. It was also discovered that the threshold for shifting from a low to medium human development economy was when a country obtained 500kwh per capita.

Pasternak (2000) investigated the link between human well-being and consumption of energy and electricity in sixty (60) populous countries containing 90% of the world's population over the period1997 – 2020 using correlation analysis. The results showed that there was strong positive connection between power use and Human Development Index. It also discovered that HDI attains a maximum value when energy usage annually was about 4,000 kWh per capita, which was lesser as well as more than consumption levels of most developed and developing countries, respectively.

3. Methodology

Model Specification:

The study adopted the modified version of Muhammad and Sabo (2017) estimation of the impact of energy and electricity consumption on quality of life in Africa using fixed effects and random effects model for the period of 2008 – 2014. The empirical study was modelled as:

$$HDIXit = \beta 0 + \beta 1ENCOit + \beta 2ELCOit + Uit \quad (3.1)$$

Where:

HDIX = Quality of Life

ENCO = Energy Consumption Per Capita

ELCO = Electricity Consumption Per Capita

□ 0 – □ 2 = Coefficients of the independent variables

i = The Cross Section Unit

ut = Stochastic Disturbance Term

t = Time of Observation

3.3 Technique of Data Analysis:

This study employs time series studies to analyze the determinants of quality of life in Nigeria.the estimation methoed used for the study was determine after the stationarity test conducted with augmented dickey fuller unit root testing procedure. The eprical study used aggregate data of human development index s the dependent variable while electricity consumption, kerosene consumption (KPS), Premium Motor Spirit consumption (PMS), diesel consumption (AGO), Coal consumption (COL) and income inequality (GINI) as explanatory variables while inflation rate served as the control variable.

The functional for of the linear equation is expressed as:

HDI= f(EPC, KPC,PMS, AGO, GINI, INFL)

The econometrics form of the equation is expressed as thus:

$$HDIt= \alpha 0+\alpha_1EPCt +\alpha_2KPCt +\alpha_3PMSt+\alpha_4AGO +\alpha_5GINI+\alpha_6INFLt+\mu t$$

Where:

HDI= Human Development Index

EPC: Electric Power Consumption

HHK: Kerosene Consumption

AGO: Diesel Consumption

GINI: Income Inequality

INFL: Inflation Rate

Appriori Expectations: α1- α4>0 while α5 – α6<0

Description of Variables

Human Development Index: he Human Development Index (HDI) is a statistical tool that measures a country's social and economic well-being. It's calculated by the United Nations Development Programme and is based on three key dimensions of human development:

Electric Power Consumption: Electric power consumption is the amount of electrical energy used over a specific period of time. It's a type of energy consumption and is usually measured in watts (W) or kilowatts (kW)

Kerosene Consumption: Kerosene is a clear, strong-smelling liquid which is used as a fuel, for example in heaters and lamps.

Diesel Consumption: Diesel consumption refers to the amount of diesel fuel a vehicle uses to travel a specific distance. It is usually expressed in liters per 100 kilometers.

Income Inequality: Income inequality is the difference in how income is distributed among a population. It can be described as the gap between the rich and poor, or the wealth gap. The size of the gap between the richest and poorest members of society indicates the level of income inequality, with a wider gap representing greater inequality

Inflation Rate: Inflation is typically a broad measure, such as the overall increase in prices or the increase in the cost of living in a country.

Sources of Data

In estimating the relationship between energy consumption and quality of life in Nigeria, the secondary data was used spanning the period of 1981 to 2023. The data was obtained from World Bank's World Development Indicators and United Nations Development Programme (UNDP). This study employed human development index as proxy for quality of life which is consistent with the work of Morote (2010) while income inequality as measured by the gini coefficient index served as a moderating variable in the work. Energy consumption is measured by the fossil fuel energy consumption, kerosene consumption (PKO) and diesel consumption (AGO) while exchange rate entered the model as a control variable.

3. Data Analysis

Descriptive Statistics

	HDI	HHK	EPC	AGO	PMS	GINI	INF

Mean	50.56073	17391.31	27503.26	1.877604	22751.67	69.04615	22.135
Median	51.12100	15628.76	12529.21	1.654476	16368.00	70.39500	17.84
Maximum	53.95000	32702.31	95177.74	5.790847	97200.00	75.23000	72.8
Minimum	45.99400	7484.347	494.6437	0.548616	137.6000	60.48000	6.9
Std. Dev.	2.905430	7882.681	30658.22	1.202051	23890.51	4.474103	14.93247
Skewness	-0.31442	0.571727	0.987641	1.846414	1.206159	-0.3213	2.002155
Kurtosis	1.564117	2.046080	2.611177	6.481131	4.479142	1.794505	6.318656
Jarque-Bera	2.661961	2.402240	4.390663	27.90152	8.674397	2.021664	38.31798
Probability	0.264218	0.300857	0.111322	0.000001	0.013073	0.363916	0
Sum	1314.579	452174.1	715084.6	48.81769	591543.3	1795.200	752.59
Sum Sq. Dev.	211.0381	1.55E+09	2.35E+10	36.12317	1.43E+10	500.4400	7358.296
Observations	26	26	26	26	26	26	34

Table 1 presents the descriptive statistics for the study examining the effects of energy consumption on quality of life in Nigeria from 1990 to 2023. The test statistics reveal that the dependent variable, human development index (HDI) has a mean value of 50.56073 and a median value of 51.12100. The skewness value of -0.314417 indicates a negative skewness, and the kurtosis value suggests a plytokurtic distribution. The Jarque-Bera statistic of 2.661961 (p-value 0.264218) confirms the presence of a normal distribution. The coefficient for kerosene consumption HHK, shows a mean value of 17,391.31 and a median of 15,628.76. The skewness value of 0.571727 indicates a long right tail, while the kurtosis value of 2.046080 suggests a mesokurtic (normal) distribution. The mean values for EPC, AGO, PMS and GINI are 27,503.26, 1.877604, 22,751.67, and 69.04615, respectively, while their median values are 12,529.21, 1.654476, 16,368.00, and 75.23000. EPC, AGO, and PMS exhibit positive skewness with values of 0.987641, 1.846414, and 1.206159, respectively, indicating long right tails. Conversely, GINI has a skewness value of -0.321299, indicating a long left tail. The kurtosis value of 2.611177 for INF suggests a mesokurtic distribution. AGO, and EPC are leptokurtic, indicating a sharper peak compared to a normal distribution, while OPH is plytokurtic. The significant Jarque-Bera statistic for these variables indicates the absence of a normal distribution.

Stationarity Test:

Unit Root Test

VARIABLES	LEVEL		1st Diff		ORDER
	T.STAT	CRT.VALUE	T.STAT	CRT.VALUE	
HDI	-0.061361	-2.986225	-4.727854	-2.998064	I(1)
HHK	-3.112342	-2.986225	-	-	I(0)
EPC	-1.653920	-2.986225	-5.688960	-2.991878	I(1)
INF	-3.347854	-2.998065	-	-	
AGO	-4.022337	-3.020686	-	-	I(0)
PMS	6.262093	-2.986225	-5.043797	-2.998064	I(1)
GINI	-2.986225	-6.170727	-6.170727	-2.991878	I(1)

Table 2 presents the results of the stationarity test conducted as part of the study examining the relationship between energy consumption and quality of life in Nigeria. The stationarity test results reveal that kerosene consumption (HHK), inflation (INF) and diesel consumption (AGO) and are mean-reverting, indicating they are stationary at their levels. Meanwhile, the other variables included in the study became stationary only after undergoing differencing, suggesting they contain unit roots at their levels. This indicates a mixed order of integration, with some variables being integrated of order I(1) and others of order I(0). The unit root test was conducted using the Augmented Dickey-Fuller (ADF) method, which confirmed this mixed integration order. Consequently, the autoregressive distributed lag (ARDL) modeling approach, as proposed by Pesaran, Shin, and Smith (2001), was adopted for the analysis.

The ARDL estimation procedure is particularly suitable in cases of mixed integration orders, as it allows for robust modeling of short-run dynamics and long-run relationships between variables. The procedure incorporates the lagged values of the dependent variable as regressors in the short-run estimation, making it a dynamic modeling approach. Before proceeding with the ARDL estimation, the bounds cointegration test was employed to assess whether a long-run equilibrium relationship exists among the series under investigation. The ARDL method can only produce valid long-run estimates if the bounds test confirms the presence of cointegration. This step is critical, as it establishes the feasibility of modeling both short-term adjustments and long-term convergence within the framework of the study.

Bounds Test for Cointegration

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k

F-statistic	7.180887	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Table 3. Depicts the bounds of cointegration test for the presence or absence of a cointegrating relationship among the variables. The test statistics show the presence of a long-run cointegrating relationship among the series since the F-statistic value of 7.180887 is greater than the upper bound critical value of at 5%. The evidence of long-run cointegrating relations implies that the null hypothesis, which states that there are no level relationships, has been rejected while the alternative hypothesis is accepted. Hence, there will be convergence in the long run, and that justified the estimation of both error correction and the long-run output of the aforesaid relationship.

Error Corrections Regression

Short run Result

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	0.832875	0.172139	4.838381	0.0002
DLOG(EPC)	0.096766	0.083820	1.154452	0.2653
DLOG(EPC(-1))	0.102756	0.069148	1.486027	0.1567
DLOG(HHK)	0.008923	0.002554	3.493792	0.0030
DLOG(PMS)	-0.025059	0.006117	-4.096579	0.0008
DLOG(AGO)	-0.000351	0.002244	-0.156342	0.8777
DLOG(AGO(-1))	0.008587	0.002438	3.522498	0.0028
D(GINI)	-0.000031	0.000044	-0.707956	0.4892
D(GINI(-1))	-0.000049	0.000024	-2.051508	0.0570
D(INF)	0.000043	0.000067	0.651591	0.5239
CointEq(-1)	-0.404884	0.092083	-4.396945	0.0005

R-squared	0.825977	Mean dependent var	0.460969
Adjusted R-squared	0.782205	S.D. dependent var	0.041952
S.E. of regression	0.003704	Akaike info criterion	-8.052044
Sum squared resid	0.000219	Schwarz criterion	-7.319176
Log likelihood	144.8327	Hannan-Quinn criter.	-7.809119
F-statistic	264.0657	Durbin-Watson stat	2.285401
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

In the short run, the statistical analysis reveals an **R-squared value of 0.825977** and an **adjusted R-squared value of 0.782205**, indicating that approximately 83% of the variations in health outcomes, measured by life expectancy, are explained by the included variables. This highlights the robustness of the model in capturing the relationship between the independent variables and life expectancy. Among these variables, the increase in taxation in Nigeria plays a significant role.

The **Durbin-Watson statistic of 2.285401** confirms the absence of first-order autocorrelation, ensuring that the regression estimates are reliable and not influenced by autocorrelated errors. Furthermore, the **F-statistic value of 264.0657** and its highly significant probability (0.000000) underscore the model's overall goodness of fit, demonstrating that the independent variables collectively explain variations in life expectancy effectively.

The **error correction term (ECT)** is statistically significant at the 5% level, with a coefficient of **-0.404884**. This negative sign indicates that deviations from the long-run equilibrium are corrected at a speed of **41% per quarter**, suggesting a gradual adjustment process back to equilibrium following any short-run disequilibria. The past value of HDI has a positive and significant effect on itself, with a coefficient of **0.832875**. This implies a strong feedback loop where a unit increase in the quality of life leads to an 83% improvement in future quality of life, all other factors being constant. Both the contemporaneous and lagged values of electric power consumption (EPC) are statistically insignificant, indicating that they do not have a substantial impact on quality of life in the short run. This suggests that electricity usage may not yet be a transformative factor in improving life expectancy or living conditions in Nigeria.

The coefficient of kerosene consumption is positive and statistically significant at the 5% level, with a value of **0.008923**. This suggests that a percentage increase in kerosene usage results in a small but meaningful improvement in quality of life. The findings align with economic theory, underscoring the importance of kerosene as a critical energy source for households in Nigeria.

The coefficient for PMS usage is negative and significant at the 5% level, with a value of **-0.025059**. This indicates that a percentage increase in PMS usage reduces the quality of life, potentially due to environmental degradation and air pollution associated with rising PMS consumption. These adverse health effects could outweigh any benefits from its use.

The contemporaneous value of diesel consumption is statistically insignificant, suggesting it has little direct impact on quality of life. However, its one-year lagged value is positive and significant, indicating that diesel consumption may have a delayed beneficial effect on quality of life. This pattern points to an unstable and inconsistent short-run influence of diesel usage.

Income inequality, proxied by the Gini coefficient, has a negative effect on quality of life in the short run, although its first-year lagged values are statistically insignificant. This suggests that while income inequality does exert some immediate adverse effects, its influence diminishes over time. Inflation appears to have an insignificant effect on life expectancy in Nigeria in the short run. This suggests that other factors, such as access to healthcare or education, may play more critical roles in shaping life expectancy compared to price fluctuations.

Long Run Regression Test

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EPC)	0.039627	0.228951	0.173079	0.8648
LOG(HHK)	0.034146	0.006827	5.001708	0.0001
LOG(PMS)	-0.061891	0.022807	-2.713646	0.0153
LOG(AGO)	-0.028348	0.009847	-2.878769	0.0109
GINI	0.000655	0.000112	5.840240	0.0000
INF	0.000107	0.000168	0.636893	0.5332
C	0.694023	1.147566	0.604778	0.5538

In the long run, the regression analysis reveals intriguing dynamics regarding the impact of various factors on the quality of life in Nigeria, measured by life expectancy or human development indices. The coefficient of electric power supply is statistically insignificant, indicating that in the long run, electricity supply does not have a measurable impact on the quality of life. This result might reflect systemic inefficiencies, such as unreliable power delivery, infrastructural deficits, or the inability to harness electricity's potential to significantly enhance living standards in Nigeria.

Kerosene consumption exhibits a **positive and significant effect** on the quality of life, with a coefficient of **0.034146**. This means that a 1% increase in kerosene consumption leads to a **0.034% improvement in the quality of life**, all else being equal. This outcome underscores the importance of kerosene as an energy source, especially for households in rural or low-income areas, where it is likely used for cooking, lighting, and heating, enhancing daily living conditions.

Contrarily, the consumption of premium motor spirit (PMS) has a **negative and significant impact** on the quality of life, with a coefficient of **-0.061891**. This means that a 1% increase in PMS usage results in a **0.062% decrease in the quality of life**. This decline could be attributed to the environmental and health consequences of increased PMS consumption, such as air pollution from vehicle emissions, which exacerbate respiratory and cardiovascular health issues, ultimately reducing life expectancy.

Interestingly, income inequality, proxied by the Gini coefficient, has a **positive and significant impact** on the quality of life, with a coefficient of **0.000655**. This implies that as the gap between the rich and poor widens, there is a slight improvement in the quality of life. While counterintuitive, this result could reflect the disproportionate benefits of economic growth in favor of the wealthy, who may drive improvements in infrastructure, healthcare, and services that indirectly benefit the broader population. Alternatively, it might indicate that economic metrics other than equality (such as absolute income levels or overall wealth) are more critical in driving quality-of-life improvements in Nigeria.

Discussion of Findings

The statistical analysis highlights several noteworthy short- and long-run dynamics affecting the quality of life in Nigeria, as measured by life expectancy and related indicators.

Short-Run Analysis

The model demonstrates robust explanatory power, with an R-squared value of 0.825977 and an adjusted R-squared of 0.782205, indicating that approximately 83% of the variations in life expectancy are attributable to the included variables. The absence of autocorrelation, confirmed by the Durbin-Watson statistic of 2.285401, and the highly significant F-statistic reinforce the reliability of the regression estimates.

The error correction term (ECT), significant at the 5% level, reveals a 41% quarterly adjustment speed toward equilibrium, suggesting that deviations from long-run relationships are gradually corrected over time. A positive and significant coefficient for the lagged Human Development Index (HDI) highlights a strong feedback loop, where improvements in quality of life persist and amplify over time.

Energy variables reveal mixed short-term effects. While kerosene consumption has a positive and significant impact, improving quality of life by 0.0089% for every 1% increase, electricity consumption is insignificant. This finding suggests that kerosene remains a critical energy source for Nigerian households, particularly in rural areas. In contrast, the lack of short-run influence of electricity consumption might point to systemic inefficiencies in electricity supply or usage.

The negative and significant impact of premium motor spirit (PMS) consumption (-0.025%) underscores its detrimental health and environmental consequences. PMS usage, often linked to vehicle emissions, contributes to air pollution, reducing life expectancy despite its role in mobility and economic activities. Diesel consumption shows no immediate impact, though its lagged effect is positive and significant, reflecting potential delayed benefits on quality of life.

Income inequality, represented by the Gini coefficient, exerts an immediate negative effect on quality of life, consistent with the understanding that disparities in wealth distribution limit access to essential resources and opportunities for vulnerable populations. However, its lagged values are insignificant, suggesting that the immediate impacts of inequality do not persist over time. Inflation also appears insignificant in the short run, emphasizing the importance of other structural factors, such as healthcare and education, in shaping life expectancy.

Long-Run Analysis

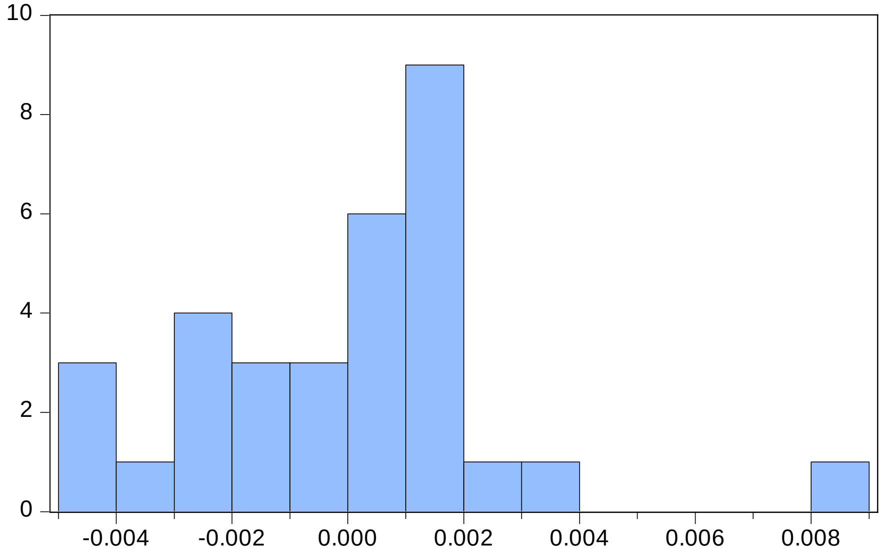
In the long term, the dynamics evolve, offering additional insights into Nigeria's socioeconomic structure. Electricity supply remains statistically insignificant, potentially reflecting infrastructural and systemic challenges that limit its transformative potential. This underscores the need for reforms to enhance the reliability and accessibility of electricity to drive improvements in quality of life.

Kerosene consumption continues to have a positive and significant impact, with a 1% increase in consumption leading to a 0.034% improvement in quality of life. This emphasizes kerosene's role in meeting the basic energy needs of households, particularly in underprivileged areas.

Conversely, PMS consumption has a more pronounced negative effect in the long run, with a 1% increase leading to a 0.062% decline in quality of life. The long-term environmental and health costs associated with PMS consumption likely outweigh its immediate utility, reflecting broader issues of pollution and reliance on fossil fuels.

A surprising finding is the positive and significant relationship between income inequality and quality of life in the long run. This counterintuitive result could reflect the role of wealthy populations in driving localized improvements in infrastructure and services. Alternatively, it may suggest that absolute income levels or total economic growth exert a more substantial influence on quality of life than income distribution itself. This finding highlights the complexity of inequality's effects and warrants further investigation into the mechanisms at play.

Post Estimation Test



Series: Residuals	
Sample 1992 2023	
Observations 32	
Mean	-9.71e-17
Median	0.000543
Maximum	0.008393
Minimum	-0.004871
Std. Dev.	0.002661
Skewness	0.462381
Kurtosis	4.606659
Jarque-Bera	4.582051
Probability	0.101163

The normality test conducted as part of the statistical analysis confirms the presence of a normal distribution in the dataset. This conclusion is drawn based on the results of the Jarque-Bera test, which yielded a Jarque-Bera statistic value of 4.582051 and an associated probability (p-value) of 0.101163. The Jarque-Bera test is a commonly used method for assessing whether a dataset conforms to the characteristics of a normal distribution, focusing specifically on skewness and kurtosis. A normal distribution typically has skewness and kurtosis values close to zero and three, respectively. The Jarque-Bera statistic combines these two measures to determine whether deviations from these expected values are significant.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.673093	Prob. F(2,14)	0.2231
Obs*R-squared	6.172998	Prob. Chi-Square(2)	0.0457

The Breusch-Godfrey Serial Correlation LM Test was utilized in this study to assess the serial independence of the error term. The results indicate an F-statistic value of 1.673093 and an observed R-squared value of 6.172998, both of which are statistically insignificant, with probability values of 0.2231 and 0.0457, respectively. These findings suggest that there is no evidence of serial correlation in the residuals of the model.

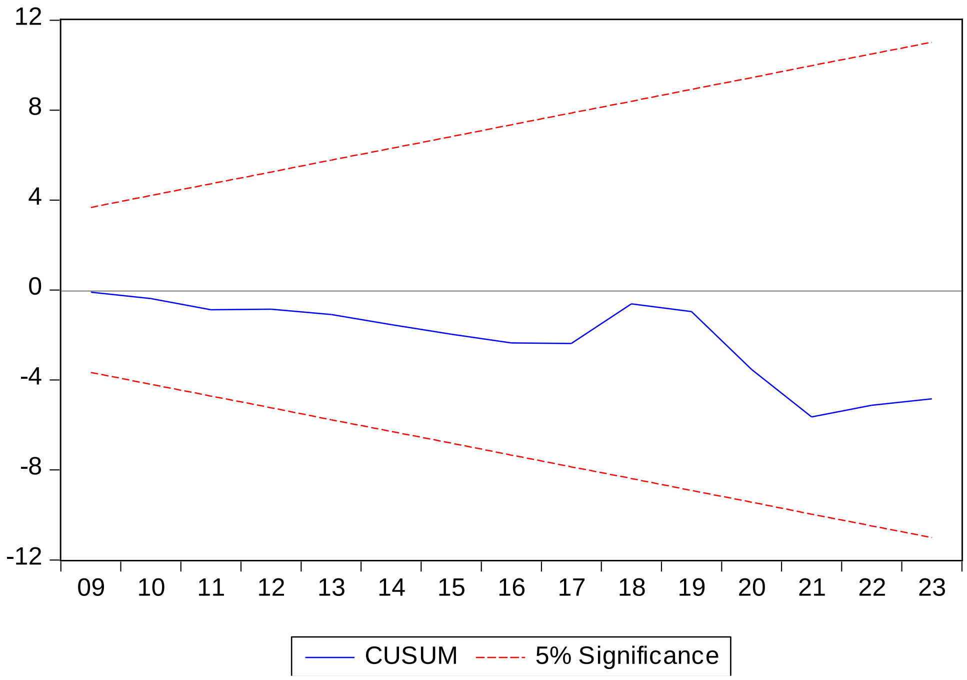
In essence, the absence of significant evidence for serial correlation implies that the model's residuals are likely independent. This is a desirable outcome, as it affirms that the model does not encounter issues of autocorrelation, which could undermine the reliability of the coefficient estimates. Ensuring that residuals are independent enhances the validity of the regression results and supports the overall robustness of the model.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.996768	Prob. F(15,16)	0.0182
Obs*R-squared	23.59988	Prob. Chi-Square(15)	0.0722
Scaled explained SS	10.63959	Prob. Chi-Square(15)	0.7777

The equality of the variance of the residuals was evaluated using the Breusch-Pagan-Godfrey heteroskedasticity test, which assesses whether there is evidence of unequal variance of the residuals across different levels of the independent variables in regression analysis. The results indicate an F-statistic value of 2.996768 an Obs*R-squared value of 23.59988, and a scaled explained SS value of 10.63959, with probability values of 0.0182, 0.0722, and 0.7777 respectively.

Since these probability values are greater than the 0.05 threshold, there is evidence of homoskedasticity in the residuals. This result suggests that the model specification is appropriate, indicating that the variance of the residuals remains consistent across different levels of the explanatory variables. Homoskedasticity is a desirable property for linear regression models, as it implies that the coefficient estimates are reliable and that the model's predictions are stable across the range of the independent variables.



The cusum test was employed to test the stability of the regression. A critical assessment of the cusum line above shows that the line is within the accepted margin. This implies that the estimate lies within the 95 percent confidence interval.

Summary

i. Kerosene consumption positively and significantly impacts quality of life, with a 0.034146 increase for every percentage rise in usage.
ii. Premium motor spirit (PMS) consumption negatively affects quality of life, with a percentage increase causing a -0.061891 decline.
iii. These findings highlight the need for cleaner, sustainable energy policies to mitigate the adverse health impacts of fuel usage.
iv. The positive correlation between income inequality (Gini coefficient) and quality of life, though counterintuitive, may indicate structural inefficiencies or areas needing policy reforms to promote equitable growth.
v. Electricity has an insignificant impact on quality of life, indicating systemic inefficiencies and the need for reforms to make it a reliable driver of socio-economic improvements.
vi. Kerosene consumption positively influences the Human Development Index (HDI), with a percentage increase resulting in a 0.008923 improvement.
vii. PMS consumption has a negative and significant impact, reducing quality of life by -0.025059 per percentage increase due to environmental and health challenges linked to pollution.

viii. Diesel consumption exhibits instability; lagged values positively influence quality of life, while current values are insignificant.
ix. Electric power consumption and its lagged values have an insignificant effect on life quality in the short run.
x. Income inequality (Gini coefficient) and general price level changes also show no significant impact on life expectancy.

Conclusion

The analysis underscores a nuanced picture of the determinants of quality of life in Nigeria. While kerosene consumption emerges as a positive driver, other energy sources like diesel and PMS have mixed or negative effects, reflecting the environmental and health challenges associated with energy use. Income inequality and inflation, though intuitively impactful, show limited statistical significance, emphasizing the need for broader structural reforms to improve living conditions in Nigeria. The gradual adjustment towards equilibrium, as evidenced by the ECT, highlights the importance of long-term strategies in addressing these issues.

Both short- and long-run dynamics emphasize the critical role of energy consumption patterns in shaping quality of life in Nigeria. Targeted energy policies, equitable resource distribution, and investments in infrastructure and public health are necessary to achieve sustainable development and improve life expectancy

Recommendations

Based on the findings from the analysis, the following recommendations are proposed to address the identified challenges and promote sustainable improvements in quality of life in Nigeria:

i. Develop policies to encourage the adoption of cleaner and more sustainable energy alternatives to reduce the negative impacts of premium motor spirit (PMS) consumption.
ii. Enhance the distribution and affordability of kerosene as a transitional energy source while working towards cleaner, long-term solutions.
iii. Invest in upgrading the electric power supply infrastructure to make it more reliable and impactful on socio-economic development.
iv. Prioritize renewable energy projects to reduce dependency on fossil fuels and combat climate-related health issues.
v. Implement policies to reduce income inequality by improving access to education, healthcare, and economic opportunities for disadvantaged groups.
vi. Introduce stringent environmental regulations to limit pollution from fuel consumption, particularly PMS and diesel.
vii. Provide financial and technical support to farmers and small businesses to adopt energy-efficient practices.

viii. Develop data-driven policies by integrating findings from national and international research to address Nigeria's unique challenges effectively.
ix. Strengthen governance and institutional frameworks to ensure efficient implementation and monitoring of energy and environmental policies.
x. Foster partnerships between government, private sector, and international organizations to mobilize resources and expertise for sustainable development initiatives.

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Appendix One

Dependent Variable: HDI
Method: ARDL
Date: 12/09/24 Time: 12:39
Sample (adjusted): 1992 2023
Included observations: 32 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LOG(EPC) LOG(HHK) LOG(PMS)
LOG(AGO) GINI INF
Fixed regressors: C
Number of models evaluated: 1458
Selected Model: ARDL(2, 2, 1, 0, 2, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
HDI(-1)	1.427991	0.181145	7.883129	0.0000
HDI(-2)	-0.832875	0.172139	-4.838381	0.0002
LOG(EPC)	0.096766	0.083820	1.154452	0.2653
LOG(EPC(-1))	0.022034	0.075903	0.290292	0.7753
LOG(EPC(-2))	-0.102756	0.069148	-1.486027	0.1567
LOG(HHK)	0.008923	0.002554	3.493792	0.0030
LOG(HHK(-1))	0.004902	0.003013	1.627037	0.1233
LOG(PMS)	-0.025059	0.006117	-4.096579	0.0008
LOG(AGO)	-0.000351	0.002244	-0.156342	0.8777
LOG(AGO(-1))	-0.002540	0.002140	-1.186594	0.2527
LOG(AGO(-2))	-0.008587	0.002438	-3.522498	0.0028
GINI	-3.13E-05	4.42E-05	-0.707956	0.4892
GINI(-1)	0.000247	4.71E-05	5.247373	0.0001
GINI(-2)	4.95E-05	2.41E-05	2.051508	0.0570
INF	4.34E-05	6.66E-05	0.651591	0.5239
C	0.280999	0.424139	0.662516	0.5171

R-squared	0.995977	Mean dependent var	0.460969
Adjusted R-squared	0.992205	S.D. dependent var	0.041952
S.E. of regression	0.003704	Akaike info criterion	-8.052044
Sum squared resid	0.000219	Schwarz criterion	-7.319176
Log likelihood	144.8327	Hannan-Quinn criter.	-7.809119
F-statistic	264.0657	Durbin-Watson stat	2.285401
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

ARDL Cointegrating And Long Run Form
Dependent Variable: HDI
Selected Model: ARDL(2, 2, 1, 0, 2, 2, 0)
Date: 12/09/24 Time: 12:39
Sample: 1990 2023
Included observations: 32

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	0.832875	0.172139	4.838381	0.0002
DLOG(EPC)	0.096766	0.083820	1.154452	0.2653
DLOG(EPC(-1))	0.102756	0.069148	1.486027	0.1567
DLOG(HHK)	0.008923	0.002554	3.493792	0.0030
DLOG(PMS)	-0.025059	0.006117	-4.096579	0.0008
DLOG(AGO)	-0.000351	0.002244	-0.156342	0.8777
DLOG(AGO(-1))	0.008587	0.002438	3.522498	0.0028
D(GINI)	-0.000031	0.000044	-0.707956	0.4892
D(GINI(-1))	-0.000049	0.000024	-2.051508	0.0570
D(INF)	0.000043	0.000067	0.651591	0.5239
CointEq(-1)	-0.404884	0.092083	-4.396945	0.0005

Cointeq = HDI - (0.0396*LOG(EPC) + 0.0341*LOG(HHK) - 0.0619 *LOG(PMS) -0.0283*LOG(AGO) + 0.0007*GINI + 0.0001*INF + 0.6940)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EPC)	0.039627	0.228951	0.173079	0.8648
LOG(HHK)	0.034146	0.006827	5.001708	0.0001
LOG(PMS)	-0.061891	0.022807	-2.713646	0.0153
LOG(AGO)	-0.028348	0.009847	-2.878769	0.0109
GINI	0.000655	0.000112	5.840240	0.0000
INF	0.000107	0.000168	0.636893	0.5332
C	0.694023	1.147566	0.604778	0.5538

ARDL Bounds Test
Date: 12/09/24 Time: 12:39
Sample: 1992 2023
Included observations: 32
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	7.180887	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Test Equation:
Dependent Variable: D(HDI)
Method: Least Squares
Date: 12/09/24 Time: 12:39
Sample: 1992 2023
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	0.495329	0.226414	2.187713	0.0439
DLOG(EPC)	0.064681	0.111488	0.580167	0.5699
DLOG(EPC(-1))	0.078719	0.093771	0.839482	0.4136
DLOG(HHK)	0.007933	0.003630	2.185571	0.0441
DLOG(AGO)	-0.003688	0.002768	-1.332388	0.2014
DLOG(AGO(-1))	0.008437	0.003252	2.594348	0.0196
D(GINI)	-6.91E-05	6.26E-05	-1.103436	0.2862
D(GINI(-1))	-5.41E-05	3.25E-05	-1.666771	0.1150
C	0.103232	0.565995	0.182391	0.8576
LOG(EPC(-1))	0.039191	0.127018	0.308545	0.7616
LOG(HHK(-1))	0.012841	0.002970	4.323367	0.0005

LOG(PMS(-1))	-0.012829	0.008178	-1.568745	0.1363
LOG(AGO(-1))	-0.013506	0.004542	-2.973854	0.0090
GINI(-1)	0.000192	6.95E-05	2.768148	0.0137
INF	-1.88E-05	8.82E-05	-0.212946	0.8341
HDI(-1)	-0.403696	0.131216	-3.076573	0.0072

R-squared	0.851916	Mean dependent var	0.003098
Adjusted R-squared	0.713088	S.D. dependent var	0.009214
S.E. of regression	0.004936	Akaike info criterion	-7.477824
Sum squared resid	0.000390	Schwarz criterion	-6.744956
Log likelihood	135.6452	Hannan-Quinn criter.	-7.234899
F-statistic	6.136469	Durbin-Watson stat	1.953862
Prob(F-statistic)	0.000412		

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.673093	Prob. F(2,14)	0.2231
Obs*R-squared	6.172998	Prob. Chi-Square(2)	0.0457

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 12/09/24 Time: 12:40
Sample: 1992 2023
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
HDI(-1)	0.109594	0.222343	0.492905	0.6297
HDI(-2)	-0.037464	0.208772	-0.179450	0.8602
LOG(EPC)	0.003278	0.082291	0.039839	0.9688
LOG(EPC(-1))	-0.000185	0.074311	-0.002495	0.9980
LOG(EPC(-2))	-0.020846	0.068917	-0.302484	0.7667
LOG(HHK)	-0.001752	0.002633	-0.665189	0.5167
LOG(HHK(-1))	-7.70E-05	0.002913	-0.026422	0.9793
LOG(PMS)	-0.002815	0.006119	-0.460097	0.6525
LOG(AGO)	0.001071	0.002271	0.471587	0.6445
LOG(AGO(-1))	-0.000152	0.002102	-0.072264	0.9434
LOG(AGO(-2))	0.000364	0.002414	0.150688	0.8824
GINI	-1.29E-05	4.58E-05	-0.282294	0.7818
GINI(-1)	6.82E-06	4.91E-05	0.138711	0.8917
GINI(-2)	-1.47E-05	2.46E-05	-0.597077	0.5600
INF	7.54E-06	6.41E-05	0.117641	0.9080
C	0.077664	0.414715	0.187270	0.8541
RESID(-1)	-0.355137	0.322038	-1.102780	0.2887
RESID(-2)	-0.512585	0.313390	-1.635612	0.1242

R-squared	0.192906	Mean dependent var	-9.71E-17
Adjusted R-squared	-0.787136	S.D. dependent var	0.002661
S.E. of regression	0.003557	Akaike info criterion	-8.141360
Sum squared resid	0.000177	Schwarz criterion	-7.316883
Log likelihood	148.2618	Hannan-Quinn criter.	-7.868069
F-statistic	0.196835	Durbin-Watson stat	2.348305
Prob(F-statistic)	0.998938		

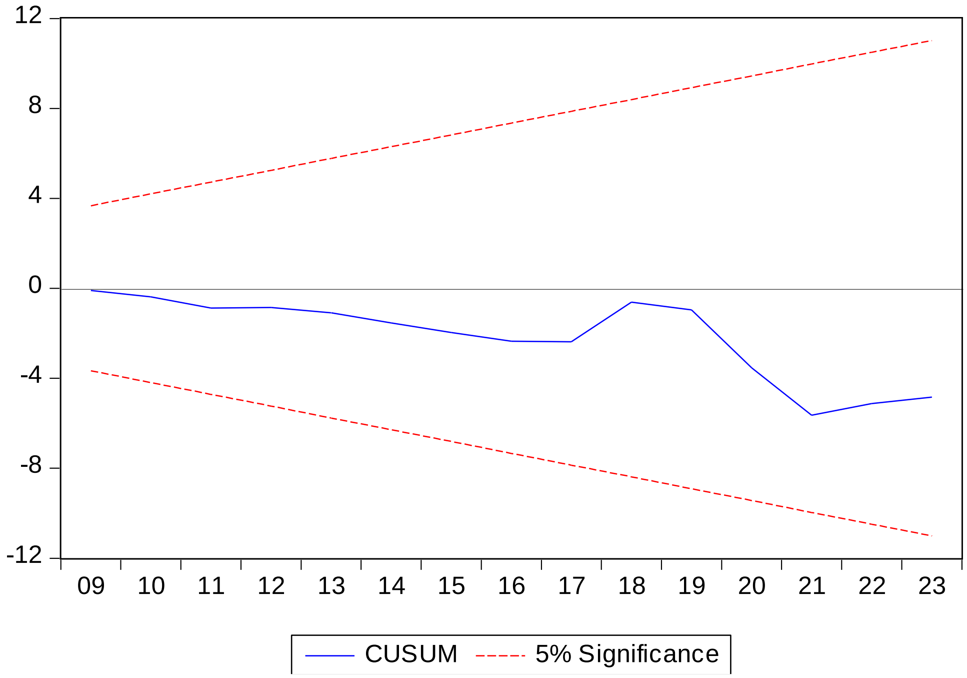
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.996768	Prob. F(15,16)	0.0182
Obs*R-squared	23.59988	Prob. Chi-Square(15)	0.0722
Scaled explained SS	10.63959	Prob. Chi-Square(15)	0.7777

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/09/24 Time: 12:40
Sample: 1992 2023
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001936	0.001081	1.790968	0.0922
HDI(-1)	-0.000490	0.000462	-1.061064	0.3044
HDI(-2)	0.000371	0.000439	0.846275	0.4099
LOG(EPC)	-0.000301	0.000214	-1.408183	0.1782
LOG(EPC(-1))	0.000353	0.000193	1.825150	0.0867
LOG(EPC(-2))	-0.000434	0.000176	-2.462924	0.0255
LOG(HHK)	-2.26E-06	6.51E-06	-0.346922	0.7332
LOG(HHK(-1))	1.00E-05	7.68E-06	1.303555	0.2108
LOG(PMS)	-2.06E-05	1.56E-05	-1.318553	0.2059
LOG(AGO)	9.77E-06	5.72E-06	1.708614	0.1068
LOG(AGO(-1))	1.09E-05	5.45E-06	1.996470	0.0632
LOG(AGO(-2))	-3.01E-05	6.21E-06	-4.840179	0.0002
GINI	6.67E-08	1.13E-07	0.591862	0.5622
GINI(-1)	9.00E-08	1.20E-07	0.749769	0.4643
GINI(-2)	-4.28E-09	6.15E-08	-0.069574	0.9454
INF	7.70E-08	1.70E-07	0.453675	0.6562

R-squared	0.737496	Mean dependent var	6.86E-06
Adjusted R-squared	0.491399	S.D. dependent var	1.32E-05
S.E. of regression	9.44E-06	Akaike info criterion	-19.99667
Sum squared resid	1.43E-09	Schwarz criterion	-19.26381
Log likelihood	335.9468	Hannan-Quinn criter.	-19.75375
F-statistic	2.996768	Durbin-Watson stat	2.953005
Prob(F-statistic)	0.018189		



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Appendix One

Dependent Variable: HDI
Method: ARDL
Date: 12/09/24 Time: 12:39
Sample (adjusted): 1992 2023
Included observations: 32 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LOG(EPC) LOG(HHK) LOG(PMS)
LOG(AGO) GINI INF
Fixed regressors: C
Number of models evalulated: 1458
Selected Model: ARDL(2, 2, 1, 0, 2, 2, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*

HDI(-1)	1.427991	0.181145	7.883129	0.0000
HDI(-2)	-0.832875	0.172139	-4.838381	0.0002
LOG(EPC)	0.096766	0.083820	1.154452	0.2653
LOG(EPC(-1))	0.022034	0.075903	0.290292	0.7753
LOG(EPC(-2))	-0.102756	0.069148	-1.486027	0.1567
LOG(HHK)	0.008923	0.002554	3.493792	0.0030
LOG(HHK(-1))	0.004902	0.003013	1.627037	0.1233
LOG(PMS)	-0.025059	0.006117	-4.096579	0.0008
LOG(AGO)	-0.000351	0.002244	-0.156342	0.8777
LOG(AGO(-1))	-0.002540	0.002140	-1.186594	0.2527
LOG(AGO(-2))	-0.008587	0.002438	-3.522498	0.0028
GINI	-3.13E-05	4.42E-05	-0.707956	0.4892
GINI(-1)	0.000247	4.71E-05	5.247373	0.0001
GINI(-2)	4.95E-05	2.41E-05	2.051508	0.0570
INF	4.34E-05	6.66E-05	0.651591	0.5239
C	0.280999	0.424139	0.662516	0.5171

R-squared	0.995977	Mean dependent var	0.460969
Adjusted R-squared	0.992205	S.D. dependent var	0.041952
S.E. of regression	0.003704	Akaike info criterion	-8.052044
Sum squared resid	0.000219	Schwarz criterion	-7.319176
Log likelihood	144.8327	Hannan-Quinn criter.	-7.809119
F-statistic	264.0657	Durbin-Watson stat	2.285401
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

ARDL Cointegrating And Long Run Form
Dependent Variable: HDI
Selected Model: ARDL(2, 2, 1, 0, 2, 2, 0)
Date: 12/09/24 Time: 12:39
Sample: 1990 2023
Included observations: 32

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	0.832875	0.172139	4.838381	0.0002
DLOG(EPC)	0.096766	0.083820	1.154452	0.2653
DLOG(EPC(-1))	0.102756	0.069148	1.486027	0.1567

DLOG(HHK)	0.008923	0.002554	3.493792	0.0030
DLOG(PMS)	-0.025059	0.006117	-4.096579	0.0008
DLOG(AGO)	-0.000351	0.002244	-0.156342	0.8777
DLOG(AGO(-1))	0.008587	0.002438	3.522498	0.0028
D(GINI)	-0.000031	0.000044	-0.707956	0.4892
D(GINI(-1))	-0.000049	0.000024	-2.051508	0.0570
D(INF)	0.000043	0.000067	0.651591	0.5239
CointEq(-1)	-0.404884	0.092083	-4.396945	0.0005

Cointeq = HDI - (0.0396*LOG(EPC) + 0.0341*LOG(HHK) - 0.0619 *LOG(PMS) -0.0283*LOG(AGO) + 0.0007*GINI + 0.0001*INF + 0.6940)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EPC)	0.039627	0.228951	0.173079	0.8648
LOG(HHK)	0.034146	0.006827	5.001708	0.0001
LOG(PMS)	-0.061891	0.022807	-2.713646	0.0153
LOG(AGO)	-0.028348	0.009847	-2.878769	0.0109
GINI	0.000655	0.000112	5.840240	0.0000
INF	0.000107	0.000168	0.636893	0.5332
C	0.694023	1.147566	0.604778	0.5538

ARDL Bounds Test
Date: 12/09/24 Time: 12:39
Sample: 1992 2023
Included observations: 32
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	7.180887	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Test Equation:
Dependent Variable: D(HDI)
Method: Least Squares
Date: 12/09/24 Time: 12:39
Sample: 1992 2023
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HDI(-1))	0.495329	0.226414	2.187713	0.0439
DLOG(EPC)	0.064681	0.111488	0.580167	0.5699
DLOG(EPC(-1))	0.078719	0.093771	0.839482	0.4136
DLOG(HHK)	0.007933	0.003630	2.185571	0.0441
DLOG(AGO)	-0.003688	0.002768	-1.332388	0.2014
DLOG(AGO(-1))	0.008437	0.003252	2.594348	0.0196
D(GINI)	-6.91E-05	6.26E-05	-1.103436	0.2862
D(GINI(-1))	-5.41E-05	3.25E-05	-1.666771	0.1150
C	0.103232	0.565995	0.182391	0.8576
LOG(EPC(-1))	0.039191	0.127018	0.308545	0.7616
LOG(HHK(-1))	0.012841	0.002970	4.323367	0.0005
LOG(PMS(-1))	-0.012829	0.008178	-1.568745	0.1363

LOG(AGO(-1))	-0.013506	0.004542	-2.973854	0.0090
GINI(-1)	0.000192	6.95E-05	2.768148	0.0137
INF	-1.88E-05	8.82E-05	-0.212946	0.8341
HDI(-1)	-0.403696	0.131216	-3.076573	0.0072

R-squared	0.851916	Mean dependent var	0.003098
Adjusted R-squared	0.713088	S.D. dependent var	0.009214
S.E. of regression	0.004936	Akaike info criterion	-7.477824
Sum squared resid	0.000390	Schwarz criterion	-6.744956
Log likelihood	135.6452	Hannan-Quinn criter.	-7.234899
F-statistic	6.136469	Durbin-Watson stat	1.953862
Prob(F-statistic)	0.000412		

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.673093	Prob. F(2,14)	0.2231
Obs*R-squared	6.172998	Prob. Chi-Square(2)	0.0457

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 12/09/24 Time: 12:40
Sample: 1992 2023
Included observations: 32
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
HDI(-1)	0.109594	0.222343	0.492905	0.6297
HDI(-2)	-0.037464	0.208772	-0.179450	0.8602
LOG(EPC)	0.003278	0.082291	0.039839	0.9688
LOG(EPC(-1))	-0.000185	0.074311	-0.002495	0.9980
LOG(EPC(-2))	-0.020846	0.068917	-0.302484	0.7667
LOG(HHK)	-0.001752	0.002633	-0.665189	0.5167
LOG(HHK(-1))	-7.70E-05	0.002913	-0.026422	0.9793
LOG(PMS)	-0.002815	0.006119	-0.460097	0.6525
LOG(AGO)	0.001071	0.002271	0.471587	0.6445
LOG(AGO(-1))	-0.000152	0.002102	-0.072264	0.9434
LOG(AGO(-2))	0.000364	0.002414	0.150688	0.8824
GINI	-1.29E-05	4.58E-05	-0.282294	0.7818
GINI(-1)	6.82E-06	4.91E-05	0.138711	0.8917
GINI(-2)	-1.47E-05	2.46E-05	-0.597077	0.5600
INF	7.54E-06	6.41E-05	0.117641	0.9080
C	0.077664	0.414715	0.187270	0.8541
RESID(-1)	-0.355137	0.322038	-1.102780	0.2887
RESID(-2)	-0.512585	0.313390	-1.635612	0.1242

R-squared	0.192906	Mean dependent var	-9.71E-17
Adjusted R-squared	-0.787136	S.D. dependent var	0.002661
S.E. of regression	0.003557	Akaike info criterion	-8.141360
Sum squared resid	0.000177	Schwarz criterion	-7.316883
Log likelihood	148.2618	Hannan-Quinn criter.	-7.868069
F-statistic	0.196835	Durbin-Watson stat	2.348305
Prob(F-statistic)	0.998938		

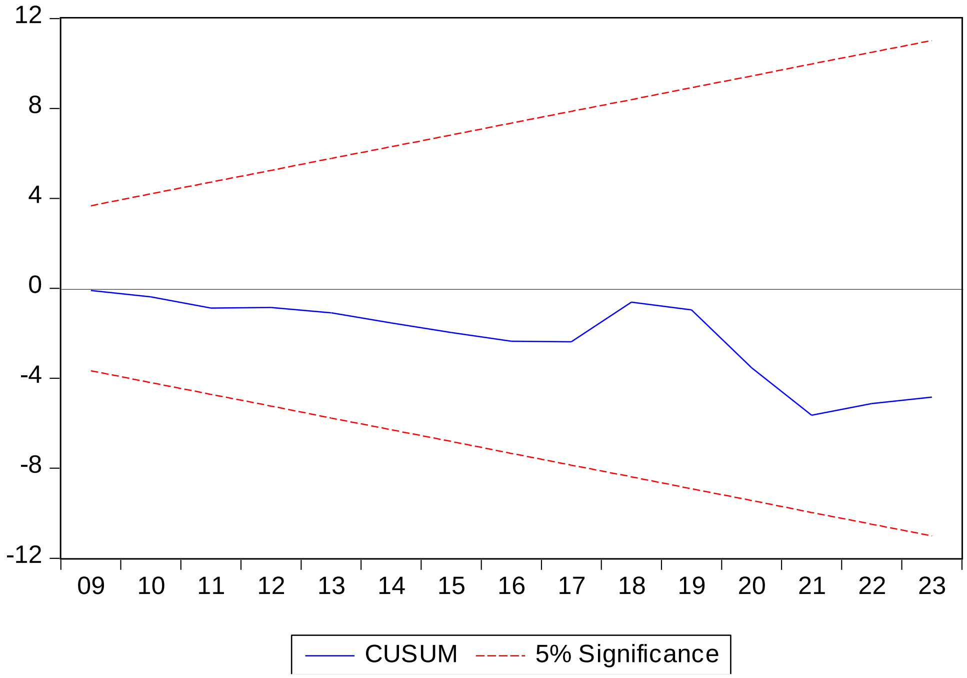
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.996768	Prob. F(15,16)	0.0182
Obs*R-squared	23.59988	Prob. Chi-Square(15)	0.0722
Scaled explained SS	10.63959	Prob. Chi-Square(15)	0.7777

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/09/24 Time: 12:40
Sample: 1992 2023
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001936	0.001081	1.790968	0.0922
HDI(-1)	-0.000490	0.000462	-1.061064	0.3044
HDI(-2)	0.000371	0.000439	0.846275	0.4099
LOG(EPC)	-0.000301	0.000214	-1.408183	0.1782
LOG(EPC(-1))	0.000353	0.000193	1.825150	0.0867
LOG(EPC(-2))	-0.000434	0.000176	-2.462924	0.0255
LOG(HHK)	-2.26E-06	6.51E-06	-0.346922	0.7332
LOG(HHK(-1))	1.00E-05	7.68E-06	1.303555	0.2108
LOG(PMS)	-2.06E-05	1.56E-05	-1.318553	0.2059
LOG(AGO)	9.77E-06	5.72E-06	1.708614	0.1068
LOG(AGO(-1))	1.09E-05	5.45E-06	1.996470	0.0632
LOG(AGO(-2))	-3.01E-05	6.21E-06	-4.840179	0.0002
GINI	6.67E-08	1.13E-07	0.591862	0.5622
GINI(-1)	9.00E-08	1.20E-07	0.749769	0.4643
GINI(-2)	-4.28E-09	6.15E-08	-0.069574	0.9454
INF	7.70E-08	1.70E-07	0.453675	0.6562

R-squared	0.737496	Mean dependent var	6.86E-06
Adjusted R-squared	0.491399	S.D. dependent var	1.32E-05
S.E. of regression	9.44E-06	Akaike info criterion	-19.99667
Sum squared resid	1.43E-09	Schwarz criterion	-19.26381
Log likelihood	335.9468	Hannan-Quinn criter.	-19.75375
F-statistic	2.996768	Durbin-Watson stat	2.953005
Prob(F-statistic)	0.018189		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