



## DOES EDUCATION EXPENDITURE STIMULATE ENERGY CONSUMPTION IN NIGERIA?

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### **Abstract**

*Expenditure on education significantly impacts energy consumption by enhancing economic growth and fostering energy management within the populace. Augmented investment in education fosters the advancement of energy consumption, which is vital for promoting sustained economic growth. Based on this, this study examines the effects of education expenditure on energy consumption in Nigeria. The data for the study were obtained from World Development Indicator (WDI, 2022) which covered from 1990-2022. The ARDL methods were employed to analyze the data. The findings show the continuity of energy consumption across time, with the second lag of energy consumption exhibiting a positive and statistically significant coefficient. This signifies that historical energy consumption positively influences present consumption, demonstrating a momentum effect. Conversely,  $(EC(-1))$  ignites curiosity and encourages more investigation. The affirmative connection indicates that investments in higher education may result in elevated energy consumption, driven by economic activities and augmented energy demand from a more educated urban population. The study recommends that authorities should adopt a long-term perspective, prioritizing educational efforts that foster technical innovation and energy efficiency. Future enquiries should examine the impact of education on energy consumption, encompassing curriculum development and public awareness campaigns, to promote the transition to a sustainable energy future in Nigeria.*

**Keywords:** Education expenditure, Energy consumption, ARDL, Nigeria

### **INTRODUCTION**

The necessity to mitigate adverse environmental changes has compelled numerous economies to reevaluate their energy strategies, specifically in terms of their environmental impact, to decrease worldwide energy consumption and emission levels. Many determinants and policies can be employed to attain this worldwide objective; however, education is arguably one of the most crucial and well-suited instruments accessible. Energy consumption is a crucial factor in the economic development and sustainability of nations, especially for countries like Saudi Arabia, which have traditionally relied heavily on fossil fuel resources and energy-intensive industries. Nigeria's energy consumption patterns, as a leading global oil producer, significantly impact its economic resilience and environmental sustainability.

Education expenditure is pivotal in achieving these objectives, as it serves as an essential element for developing human capital, fostering innovative concepts, and promoting ecologically sustainable practices. Enhanced educational funding can improve energy literacy, leading to increased awareness and the adoption of energy-efficient technology and practices (Amirat et al., 2020; Abid et al., 2022; Benlaria et al., 2024). Conversely, increased educational attainment may stimulate enhanced economic activities and industrialisation, resulting in heightened energy consumption levels (Alkhateeb et al., 2020; Akinwale, 2018). Thus, understanding the complex

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relationship between educational expenditure and energy consumption is crucial for policymakers aiming to align economic growth with environmental sustainability.

A multitude of academic studies have examined various aspects of energy use in Nigeria, Sub-Saharan Africa. Akadiri et al. (2024) evaluated energy consumption trends in residential buildings in Nigeria, clarifying the impact of swift urbanisation and defence growth on energy demand. Chen et al. (2023) examined the economic implications of renewable energy projects on sustainable development in Saudi Arabia, highlighting the capacity of renewable energy investments to foster economic growth while alleviating environmental impacts. Owolabi et al. (2024) examined the influence of education and training on the attainment of sustainable development goals and the promotion of economic growth in Nigeria.

The body of literature concerning the effects of education on energy use is limited. Researchers have either demonstrated indirect effects of education on energy consumption or have analysed human capital by incorporating education measured in years of schooling and returns on education. Despite the growing body of academic research, a significant gap remains about the direct relationship between educational expenditure and energy use in Nigeria. While previous research has acknowledged the crucial importance of education in promoting sustainability, few studies have empirically examined the precise effects of educational expenditure on energy consumption trends over time. Moreover, the potential delayed effects of educational investment on energy use remain inadequately investigated.

This study aims to address this knowledge gap by investigating the impact of educational expenditures on energy consumption in Nigeria. It utilises an ARDL methodology to identify both short-term and long-term effects. The study seeks to elucidate the intricate relationship between educational expenditure and energy consumption patterns across time, including potential temporal lags. This study utilises an ARDL test to offer empirical insights into the dynamic relationship between educational expenditure and energy consumption. It fills a crucial void in current research and provides essential insights for policymakers and stakeholders committed to environmentally friendly growth.

## LITERATURE REVIEW

Expenditure on education significantly impacts energy consumption by enhancing economic growth and fostering energy literacy within the populace. Augmented investment in education fosters the advancement of human capital, which is vital for promoting sustained economic growth (Deming, 2022). Educational activities can equip individuals with the necessary skills to implement energy-efficient behaviours, hence decreasing overall energy consumption (Alvarado et al., 2021). Enhanced educational initiatives can foster the advancement of a knowledge-based economy, crucial for promoting sustainable energy practices (Amirat et al., 2020). With the enhancement of educational quality, individuals get more awareness of energy saving methods and renewable energy technology, motivating them to substantially influence consumption patterns (Abid et al., 2022). The research demonstrates a correlation between education and economic growth, indicating that substantial investment in education is favorably associated with a reduction in CO<sub>2</sub> emissions in Saudi Arabia (Alkhateeb et al., 2020). This tendency aligns with the objectives of Vision 2030, which underscores the minimization of the ecological footprint while fostering economic diversification (Kahouli et al., 2022). Moreover, as individuals enhance their technological intelligence, the incorporation of renewable energy sources is expected to be

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promoted, further advancing sustainable economic development (Yusuf, 2019). By properly directing educational expenditures, Saudi Arabia can attain substantial progress in energy efficiency, thereby advancing the nation's long-term sustainability goals and presenting an optimistic outlook for a more sustainable future (Sarwar, 2022; Akinwale, 2018).

Yeh et al. (2017) examined the conduct of secondary and elementary pupils in Greece. Their research demonstrated the significance of education in fostering environmental consciousness and the adoption of energy-saving and eco-friendly activities. Yao et al. [48] shown that, among OECD countries, education reduces energy consumption and enhances renewable energy utilization from 1965 to 2014. Similarly, the bootstrap ARDL test conducted by Shahbaz et al. (2022) demonstrated that education plays a role in reducing energy usage in the United States. The research conducted by Akintande et al. (2020) demonstrated that education enhances the utilization of renewable energy in the five most populated countries. Fang et al. (2020) proposed that education amplifies the growth-enhancing effect of energy across a panel of 56 countries from 1970 to 2014. Salim et al. (2017) discovered a negative correlation between education and energy usage at the province level in China from 1990 to 2010. Consequently, enhancing education can reduce energy use in China. Alvarado et al. (2021) has demonstrated that enhancements in education can reduce fossil fuel usage in OECD countries. Khan et al. [54] demonstrated that education decreases fossil fuel usage while simultaneously increasing renewable energy consumption in G7 nations.

Almutairi (2024) asserts that investing in human capital via education substantially enhances economic growth in affluent oil-producing countries like Saudi Arabia. Singh et al. (2022) contend that sustainable development objectives pertaining to education and training can improve economic results. In this setting, the contributions of education are essential for attaining sustainable growth, consistent with Sarwar et al. (2021) and underscoring the strategic significance of educational investments emphasized by Mohiuddin et al. (2023). Alam et al. (2023) assert that the strategic reallocation of governmental educational expenditures can produce significant economic advantages, facilitate the achievement of the 2030 goal and foster sustainable growth.

The correlation between educational investment and energy usage in Saudi Arabia is intricate and multifarious. The escalation of spending in education may result in heightened energy consumption attributable to advancements in technology and infrastructure (Almutairi, 2024). Conversely, energy subsidies and governmental policies that advocate renewable energy may alleviate environmental repercussions while fostering economic development (Berradia et al., 2023; Bekun et al., 2023; Adekunle et al., 2022). Research indicates that the consumption of renewable energy positively affects ecological footprints, necessitating balanced strategies (Abid et al., 2022; Adekunle et al., 2023). The examination of income and power usage uncovers significant correlations that warrant additional investigation (Al-Rdaydeh et al., 2021; Alam et al., 2022; Kahouli et al., 2022).

## METHODOLOGY

### Model Specification

$$EC_2 = f(EDS, GDP, FDI, UPO, EXR) \quad 1$$

According to expression (1), energy consumption is explained by a combination of FDI, urbanization, GDP and exchange rate. Considering the possible non-linearities, we convert

EC<sub>2</sub> = Energy consumption  
 EDS = Educational spending  
 GDP = Economic growth  
 FDI = Foreign direct investment  
 UPO = Urban population  
 EXR = Exchange rate  
 Expression (1) as shown above

$$EC_2 = \phi_0 + \phi_1 EDS + \phi_2 GDP + \phi_3 FDI + \phi_4 UPO + \phi_4 EXR_t + \mu \quad 2$$

$$\Delta EC_2 = \phi_0 + \sum_{s=1}^J \cdot \phi_{1s} \Delta EC_{.2t-n} + \sum_{s=1}^J \cdot \phi_{2j} \Delta EDS_{.t-n} + \sum_{s=0}^J \cdot \phi_{3j} \Delta GDP_{.t-n} + \sum_{s=0}^J \cdot \phi_{4j} \Delta FDI_{.t-n}$$

$$+ \sum_{s=0}^J \cdot \phi_{5s} \Delta UPO_{.t-n} + \sum_{s=0}^J \cdot \phi_{6s} \Delta EXR_{.t-n} + \partial_1 EC_{2t-1} + \partial_2 EDS_{t-1} + \partial_3 GDP_{t-1}$$

$$+ \partial_4 FDI_{t-1} + \partial_5 UPO_{t-1} + \partial_6 EXR_{t-1} + \mu \quad 3$$

$$\Delta EC_2 = \phi_0 + \sum_s^J \cdot \phi_{1j} \Delta EC_{.2t-n} + \sum_j^J \cdot \phi_{2j} \Delta EDS_{.t-n} + \sum_j^J \cdot \phi_{3j} \Delta GDP_{.t-n} + \sum_j^J \cdot \phi_{4m} \Delta FDI_{.t-n} +$$

$$\sum_m^J \cdot \phi_{5m} \Delta UPO_{.t-n} + \sum_m^J \cdot \phi_{6m} \Delta EXR_{.t-n} + \partial_1 EC_{2t-1} + \partial_2 EDS_{t-1} + \partial_3 GDP_{t-1} + \partial_4 FDI_{t-1} +$$

$$\partial_5 UPO_{t-1} + \partial_5 EXR_{t-1} + \epsilon ECT_{t-1} + \epsilon_t \quad 4$$

### RESULTS AND DISCUSSIONS

The research provides empirical findings about educational expenditure and energy use in Nigeria. The research utilized autoregressive distributed lag (ARDL) methodologies to analyse both short-term and long-term variable interactions. The stationarity tests indicate that certain variables are stationary at the level, while others attain stationarity following the differencing of the time series data. This combination validates the ARDL methodology, which is applicable to variables integrated at different orders but not two simultaneously. Subsequently, we estimate the ARDL model for both the short and long future.

Table 1: Bound Testing

Test Statistic	Value	k
F-statistic	5.022098	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Source: Author's Compilation, 2025

Table 1 reveals a significant result: the computed F-statistic (5.02) surpasses the upper bound critical value at the 1% significance level (4.68). This results in a strong rejection of the null hypothesis, confirming the existence of a long-term link between the variables. The findings

indicate that education expenditure, energy consumption, and other variables in the study are cointegrated, indicating a shared long-term equilibrium.

The ARDL model, an essential instrument for analyzing the short-term dynamics of educational expenditure and other macroeconomic variables on energy consumption in Nigeria, is scrutinized. Table 2 illustrates the continuity of energy consumption across time, with the second lag of energy consumption (EC(-4)) exhibiting a positive and statistically significant coefficient (1.11, P = 0.04). This signifies that historical energy consumption positively influences present consumption, demonstrating a momentum effect. Conversely, (EC(-1)) ignites curiosity and encourages more investigation. The affirmative correlation indicates that investments in higher education may result in elevated energy consumption, driven by economic activities and augmented energy demand from a more educated labour population.

The Gross Domestic Product (GDP) exhibits a delayed impact, with the present GDP showing a positive and significant value of 16.8 (P = 0.04). This indicates that current economic growth affects energy consumption, mirroring the energy-growth relationship seen in developing economies. The current exchange rate is significantly negative (0.5, P = 0.03), suggesting that an increase in currency rates may promote prudent public expenditure and hence decrease energy use.

Table 2: Long run Estimation

Variable	Coefficien			
	t	Std. Error	t-Statistic	Prob.*
ENCO(-1)	-1.322048	0.507593	-2.604544	0.0598
ENCO(-2)	0.372437	0.285933	1.302534	0.2627
ENCO(-3)	0.116841	0.267338	0.437055	0.6846
ENCO(-4)	1.106394	0.373829	2.959627	0.0416
EDS	-5.685061	1.883266	-3.018725	0.0392
EDS(-1)	1.013492	0.958218	1.057684	0.3498
EDS(-2)	2.384632	1.048303	2.274754	0.0153
EDS(-3)	1.652008	1.072167	1.540812	0.1982
FDI	1.45E-09	5.29E-09	0.273759	0.7978
FDI(-1)	-1.52E-08	3.82E-09	-3.984178	0.0163
FDI(-2)	-5.78E-09	5.45E-09	-1.060332	0.3488
FDI(-3)	2.26E-08	5.73E-09	3.938733	0.0170
EXR	-0.502895	0.217896	-2.307963	0.0822
EXR(-1)	0.028874	0.158938	0.181667	0.8647
EXR(-2)	0.140752	0.354705	0.396813	0.7118
EXR(-3)	0.805780	0.526876	1.529354	0.2009
UPO	-268.7886	338.0303	-0.795161	0.4710
UPO(-1)	491.4391	641.3622	0.766243	0.4863
UPO(-2)	131.1726	338.2277	0.387823	0.7179
UPO(-3)	-317.9667	112.5669	-2.824691	0.0476
GDP	16.82233	5.706822	2.947758	0.0421
GDP(-1)	-6.518581	6.236182	-1.045284	0.3549
GDP(-2)	6.011723	2.044491	2.940450	0.0424
C	212.8110	126.8769	1.677303	0.1688

R-squared	0.972007	Mean dependent var	134.5146
Adjusted R-squared	0.811044	S.D. dependent var	29.38517
S.E. of regression	12.77345	Akaike info criterion	7.700990
Sum squared resid	652.6437	Schwarz criterion	8.842879
		Hannan-Quinn criter.	8.050077
Log likelihood	-83.81385	Durbin-Watson stat	2.177809
F-statistic	6.038726		
Prob(F-statistic)	0.046321		

Source: Author's Compilation, 2025

Table 3: Short run Estimation

Cointegrating Form				
Variable	Coefficien			
	t	Std. Error	t-Statistic	Prob.
D(ENCO(-1))	0.617115	0.403105	1.530905	0.2005
D(ENCO(-2))	0.989553	0.290957	3.401033	0.0273
D(ENCO(-3))	1.106394	0.373829	2.959627	0.0416
D(EDS)	-5.685061	1.883266	-3.018725	0.0392
D(EDS(-1))	-2.384632	1.048303	-2.274754	0.0853
D(EDS(-2))	-1.652008	1.072167	-1.540812	0.1982
D(FDI)	0.000000	0.000000	0.273759	0.7978
D(FDI(-1))	0.000000	0.000000	1.060332	0.3488
D(FDI(-2))	-0.000000	0.000000	-3.938733	0.0170
D(EXR)	-0.502895	0.217896	-2.307963	0.0822
D(EXR(-1))	-0.140752	0.354705	-0.396813	0.7118
D(EXR(-2))	-0.805780	0.526876	-1.529354	0.2009
	-			
D(UPO)	268.788617338	0.030289	-0.795161	0.4710
	-			
D(UPO(-1))	131.172605338	227715	-0.387823	0.7179
D(UPO(-2))	317.966694112	566906	2.824691	0.0476
D(GDP)	-16.822327	5.706822	-2.947758	0.0421
D(GDP(-1))	-6.011723	2.044491	-2.940450	0.0424
CointEq(-1)	-2.939163	0.732190	-4.014209	0.0159

Source: Author's Compilation, 2025

The coefficient for education spending, (EDS(-2)), is positive (2.3) and statistically significant (P = 0.01). The positive correlation indicates that elevated expenditure on education may lead to augmented energy usage over time. Consequently, this model provides no definitive evidence of a direct correlation between educational expenditure and long-term energy usage. Population growth, denoted as (UPO(-3)), exhibits a positive coefficient of 3.17 and is statistically significant (P = 0.04), suggesting that urban population expansion leads to increased energy consumption in the long term. With population growth, there is an escalating demand for energy to sustain residential, commercial, and industrial operations. Foreign Direct Investment (FDI) exhibits a

positive coefficient of 2.2 and is statistically significant ( $P = 0.01$ ). This implies that foreign direct investment may lead to heightened energy usage. Consequently, whereas foreign direct investment is typically anticipated to stimulate energy consumption through the advancement of production infrastructure and services, its long-term effects on energy consumption remain inconclusive in this analysis. The diagnostic assessments presented in Table 2 confirm the strength and reliability of the estimated Autoregressive Distributed Lag (ARDL) model. The error correction model (ECM) is employed to examine the short-term effects of explanatory factors on energy consumption. The ECT coefficient is negative and statistically significant, indicating convergence instead of divergence. The model rectifies roughly 293% of short-term discrepancies in energy consumption annually.

The exceptional R-squared value of 0.97 and the corrected R-squared of 0.81 indicate that the model effectively accounts for a significant variation in energy consumption, suggesting a strong overall model fit. The Durbin-Watson statistic, measured at 2.1778, approaches the optimal value of 2, indicating little autocorrelation among the residuals. This assertion is additionally corroborated by the Breusch-Godfrey Serial Correlation LM test ( $P = 0.2710$ ) and the ARCH test ( $P = 0.029$ ), wherein the null hypothesis, positing the absence of serial correlation, is upheld at the 5% significant level. These results highlight the efficacy of the ARDL model, affirming its reliability in the analysis of energy use.

Table 4; Breusch-Godfrey Serial Correlation LM Test

F-statistic	2.689832	Prob. F(2,2)	0.2710
Obs*R-squared	20.41158	Prob. Chi-Square(2)	0.0000

Source: Author’s Compilation, 2025

Table 5: Heteroskedasticity Test: ARCH

F-statistic	5.330716	Prob. F(1,25)	0.0295
Obs*R-squared	4.745333	Prob. Chi-Square(1)	0.0294

Source: Author’s Compilation, 2025

Figure 1: CUSUM

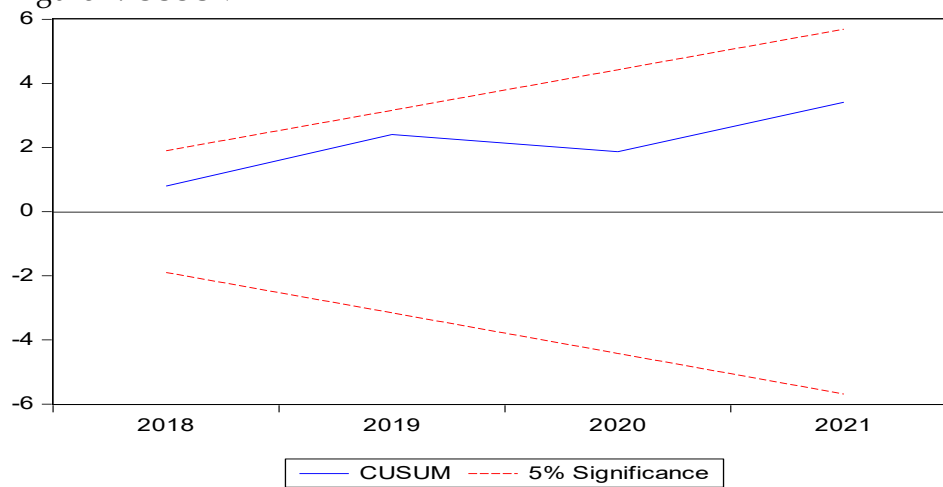
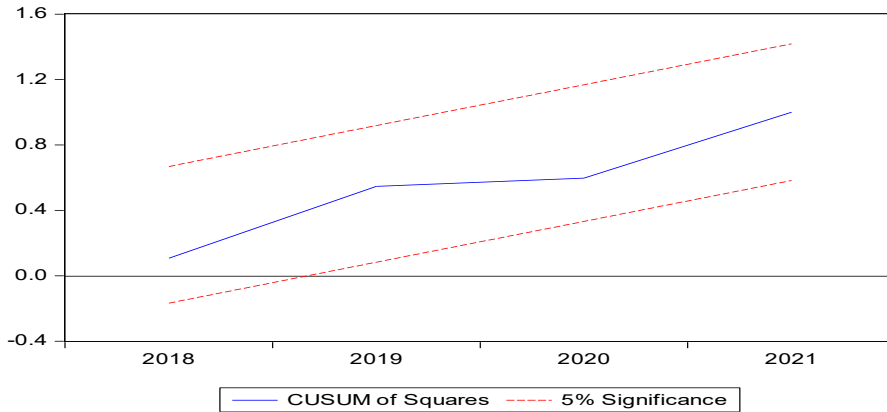


Figure 2: CUSUM of Squares



The CUSUM test graph (Figure 1) and the CUSUM of Squares test graph (Figure 2) offer substantial evidence on the stability of the estimated model. In Figure 1, the CUSUM line consistently resides inside the 5% significance limits throughout the sample duration, signifying the stability of the model's coefficients over time without any structural fractures. Likewise, in Figure 2, the CUSUM of Squares test indicates that the plot remains within the critical limits, despite a little rising trend around the 16th period. This indicates that although slight variations may arise, the general model stays consistent. These tests affirm the model's reliability and the lack of major structural instability during the observed period, instilling confidence in the model's stability.

This study offers valuable insights into the correlation between educational expenditure and energy consumption in Nigeria, enhancing the current literature on the impact of educational investments on energy consumption trends. The results indicate that educational expenditure positively influences energy usage, implying a complex and incremental link that develops over time. Drawing on the academic work of Amirat et al. (2020) and Abid et al. (2022), our study confirms that educational programs foster a knowledge-based economy, enhance energy literacy, and promote sustainable energy practices. As individuals seek greater educational degrees, their comprehension of energy saving techniques and renewable energy inventions is substantially enhanced, hence positively impacting their energy consumption behaviours. This aligns with the objectives stated in Africa's Vision 2030, emphasising the imperative for sustainability and the reduction of dependence on fossil fuel sources. Singh et al. (2022) provide a pivotal study that emphasises the essential role of education and training in achieving sustainable development goals and enhancing the economy in Nigeria. Their empirical findings demonstrate that expenditures in education improve economic performance and promote the adoption of sustainable practices, hence strengthening the lasting benefits outlined in our research. A significant discovery is the lagged impact of educational expenditure on energy usage. The current and immediate past values of education spending were not statistically significant; however, the second lag exhibited a positive and significant coefficient. This indicates that the advantages of educational spending on energy usage materialize gradually. The findings correspond with the research of Benlaria et al. (2022), which examined the economic impacts of renewable energy on sustainable development in Saudi Arabia. Investments in renewable energy, supported by educational programs, can promote sustained economic growth. Education is crucial for equipping citizens with the skills necessary to develop and deploy renewable energy technologies, hence influencing energy consumption patterns towards more sustainable sources. In contrast to the immediate effects suggested by Edsand et al. (2020), our research reveals that the relationship between education expenditure and energy use is more intricate and progressive.

Concerning demographic considerations, population expansion exerts a positive and marginally significant influence on energy consumption, consistent with the results of Wang et al. (2020) and Almutairi (2024). As the population grows, the demand for energy to support residential, commercial, and industrial activities simultaneously increases. Felimban et al. (2019) do an extensive assessment of energy consumption in residential buildings, emphasizing how population growth and urban expansion increase the need for residential energy. Their research emphasizes the necessity for energy-efficient building practices and regulations to mitigate the effects of increasing energy demand due to demographic changes.

The impact of urbanization was positive, indicating that although urbanization may lead to heightened energy consumption from infrastructure and service growth, this effect may be mitigated by efficiencies achieved through urban planning and technological adoption. This data aligns with Li et al. (2023), who contend that urbanization may result in both heightened and diminished energy consumption, contingent upon the phase of urban growth and policy measures implemented. The utilization of the Autoregressive Distributed Lag (ARDL) model and bounds testing methodology has successfully delineated both the long-term and short-term interactions between educational expenditure and energy usage. The significant F-statistic obtained from the limits test confirms the existence of a long-term association among the examined variables. Nonetheless, the absence of a notable short-term effect from educational spending underscores the need for patience and continuous investment in educational initiatives to achieve long-term sustainability goals. This statement corresponds with the views of Alvarado et al. (2021) and Liao et al. (2019), who clarify the lasting benefits of educational efforts in promoting sustainable energy habits. The evidence indicates that while educational expenditure does not have immediate effects on energy use, it is crucial in shaping future energy usage trajectories. Investments in education that improve energy literacy, foster technological innovation, and encourage sustainable practices will be essential for achieving long-term energy efficiency and environmental goals. Future investigations should examine the precise mechanisms through which educational expenditure influences energy consumption, potentially by analysing the roles of curriculum development, vocational training, and public awareness initiatives in promoting energy-efficient technologies and the adoption of renewable energy sources.

## CONCLUSION

This study examined the relationship between educational expenditure and energy demand in Nigeria, utilizing the Autoregressive Distributed Lag (ARDL) methodology. The findings indicate that educational expenditure has a delayed but positive impact on energy consumption, highlighting the need for long-term investments in education for fostering sustainable energy consumption practices. The interaction between economic development and oil price fluctuations significantly affects energy consumption patterns, highlighting the energy-intensive nature of the Nigerian economy and its reliance on oil-generated revenues. The delayed effect of educational spending suggests that initiatives aimed at improving energy literacy and promoting sustainable behaviours may require a prolonged period to provide measurable results. Therefore, authorities must to adopt a long-term perspective, prioritizing educational efforts that foster technical innovation and energy efficiency. Future enquiries should examine the impact of education on energy consumption, encompassing curriculum development and public awareness campaigns, to promote the transition to a sustainable energy future in Nigeria.

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