Received: 18 August 2025 | Revised: 15 November 2025 | Accepted: 29 November 2025
https://doi.org/10.56946/jeee.v4i2.828
Journal of Environmental and Energy Economics

Research Article

Energy Consumption, Maritime Trade and Economic Growth Nexus: Evidence from Nigeria

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Abstract

Although Nigeria's maritime trade and energy demand is on the rise, the empirical nature of the relationship between energy consumption, maritime trade and economic growth is yet to be determined. Current literature is predominantly based on developed economies or considers these variables separately and ignores the structural and energy peculiarities of Nigeria. This loophole restricts evidence-based policy making to sustainable maritime and economic growth. Hence, an in-depth empirical study is needed to comprehend the dynamics of the effect of energy consumption together with maritime trade on the economic growth in Nigeria. This study therefore explored the nexus between maritime trade, energy consumption and economic growth in Nigeria. Time series data between the year 1990 and 2023 was used in the study. Analysis of the relationships between the variables in the study was done using the Vector Autoregression (VAR) technique. The study findings indicated that the VAR model predicts the most significant determinant of each variable as its one period lag value. The Impact Response Function and forecast error variance decomposition revealed that the energy consumption of fossil source, electricity power consumption, and maritime trade has a positive impact on economic growth in the long run and short run. The study concluded that energy consumption and maritime trade are crucial for economic growth. The study therefore recommended that government should invest more in the energy infrastructure, production of hydro energy especially small and medium hydro power plants, government also needs to enhance the capacity and competitiveness of the maritime trade by modernizing the seaports.

Keywords: Energy Consumption, Economic Growth, Maritime Trade, VAR

1. Introduction

Energy consumption is widely recognized as a fundamental driver of economic growth in emerging economies, including Nigeria Adenigbo et al. [1]. Globally fossil fuels accounts for about 81.7% of total energy consumption Raufi and Maniat, [2]. Also, researchers and policy makers around the globe have been concerned over the long-term implications of high energy consumption and high economic growth [2]. Nigeria, Africa's largest economy remains heavily dependent on non-renewable energy, particularly oil and gas, which currently account for approximately 86 percent of its power generation capacity, with hydro providing most of the remainder Anwar, et al. [3]. Energy remains the main driving factor in the economic and industrial progress of all the nations. It is the interplay of the contemporary economic, environmental and developmental problems of the world Yusuf [4]. The upsurge in demand for energy is occasioned by the massive economic growth Al-mulali, [5]. However, Nigeria continues to struggle with unreliable energy supply, despite this notable significance for economic growth Hundie and Daksa, [6]. Only about 45 percent of the population is connected to the national grid, and supply is often limited to roughly four hours daily [6]. Reliable energy supply is essential for achieving sustainable development goals, including poverty reduction and food security Akinwale, [7].

However, Nigeria faces significant challenges in providing adequate energy access despite abundant natural resources, with energy consumption often skewed towards household use rather than spuring industrial or sector specific growth [7], Olarinde and Adeniran, [8]. Nevertheless, the nature of maritime business is directly related to the patterns of energy consumption since the work of ports, shipping business and logistics systems require substantial amounts of energy, especially petroleum-based fuels and electricity to facilitate their functioning Aruwei and Enaruna, [9], Ateme, [10], Osadume and Uzoma, [11], Salawu and Ghadiri, [12].

Essentially, maritime trade is driven by economic activities within the local and global economy. Maritime trade is crucial in the development of the Nigerian economy and it is the main channel through which the country conducts international trade Adenigbo, [1]. Nigeria is a coastal country which is well positioned in the Gulf of Guinea and this has depended its investment in seaports and maritime transport system thereby promoting importation and exportation of essential commodities, such as crude oil, manufactured goods, agricultural products and industrial raw materials Obasi and Aruwei, [13]. Maritime trade serves as an indispensable medium of economic growth and sustainable development in Nigeria, by facilitating a vast proportion of its international cargo movement [10], Amuka and Ezinna, [14], Peretomode, [15]. However, maritime trade activities are not just efficient and at large scale but also contribute to industrial production, creation of employment and development of infrastructures, as these have a direct effect on the balance of payment of Nigeria UNCTAD [16]. Maritime trade has been a stimulus to development by boosting the level of trade, foreign exchange earnings, and industrialization [9]. However, the efficiency of this vital sector is often hampered by infrastructural deficiencies, poor logistics, and policy shortcomings, which can undermine its potential to contribute to sustainable economic growth [1], Onyemejor, [17], Yekini & Seyed, [18].

Although, Nigeria's maritime trade and energy demand is on the rise, the empirical nature of the relationship between energy consumption, maritime trade and economic growth is yet to be determined. Current literature is predominantly based on developed economies or considers these variables separately and ignores the structural and energy peculiarities of Nigeria. This gap restricts evidence-based policy-making to sustainable maritime and economic growth. Hence, an in-depth empirical study is needed to comprehend the dynamics of the effect of energy consumption together with maritime trade on the economic growth in Nigeria. While several past studies have explored the impact of energy consumption in economic growth among nations Rahman and Vu [19]. No prior research, though, to our knowledge, has examined the aspect of whether maritime trade has an effect or not. Greater maritime trade implies more human activities and greater demand of industrial production, transport, and energy consumption, leading to economic growth [9].

In this regard, the correlation of energy use, maritime trade, and economic growth in Nigeria provides the necessary information regarding the importance of energy consumption and maritime trade as the means of enhancing the economic growth of the country in the long term. The second section is devoted to the methodology, theoretical framework, the construction of empirical models, and estimation methodologies. The fourth section, is the results and discussion section, which gives a detailed analysis of the model findings and the last section is the conclusion and recommendations.

2. Literature Review

Balarabe et al [20] have explored this very serious problem in Nigeria with the aim of determining the relationship of economic growth, energy consumption and trade openness on carbon emission. Based on strong econometric method using time-series data, the study uses the superior modelling methods to include the short-run and the long-run relations, in addition to the structural complexities and possible feedback mechanisms. Their results found that economic growth is still largely connected to higher rates of emission and use of energy proves to be a major contributor of advancing environmental degradation. In opposition to some of the hypotheses, trade openness seems to provide a way of reducing the emissions. Raufi et al. [2] investigated the 193 countries data on the trend of energy consumption, economic development and CO_2 emissions during 1965-2023. As the analysis shows, GDP per capita and energy consumption (CO_2 emissions, which demonstrates that the growth of the economy is closely related to the growth of the energy consumption and emissions. The average consumption of energy globally has been 7.6 exajoules per year which is 2% per year. VAR tests and Granger tests indicate that past values have an impact on both variables but short-term correlations are feeble. Ahmad [21] examined the CO_2 emission determinants in South Asia in the period 2000-2021 with the help of the Environmental Kuznets Curve (EKC) modelling, multiple linear regression and panel data analysis. Results also show that one of the main sources of emissions is GDP per capita, and renewable energy will reduce carbon emissions. Yusuf [4] examined the hypothesis of the Environmental Kuznets Curve and the long and short-term dynamic effect of socioeconomic variables on ecological sustainability of Nigeria using data between 1980 and 2020. He employed Autoregressive Distributed Lag (ARDL) method. The empirical results prove the hypothesis of existence of environmental Kuznets curve on long and short term of Nigeria. The energy consumption and total import worsen environmental condition in the long and short run, whereas total export enhances the environmental conditions in the long and short run.

Bunnag [22] examined the cause-and-effect relationship between CO_2 emission, energy consumption, GDP, square of GDP, and foreign direct investment of the Environmental Kuznets Curve of Thailand between the years 1971 and 2014 which was estimated using autoregressive distributed lag (ARDL) model and the vector error correction (VECM). He discovered that GDP and energy consumption are in a two-way relationship. Rahman and Vu [19] explored the energy consumption, population density, exporting and environmental destruction in China. The data was used based on the annual values between 1971 and 2018 and analysed through the Autoregressive Distributed Lag (ARDL) bounds tests and the Vector Error Correction Model (VECM). Results indicated that the variables under the selected variables are cointegrated and that energy consumption and economic growth are indicated as the key factors behind CO_2 emissions in short and long-runs. Exports, on the contrary, lower the CO_2 emissions in the long-run. The economic growth to energy consumption has a short-run causality in either direction, which is unidirectional. Mivumbi and Yuan [23] examined the relationship between the economic growth of environmental pollution and energy consumption between 1990 and 2018 based on the VAR approach. The finding validates a long run co-integrating equilibrium among air pollution, energy consumption and economic growth which was very significant. In the study by Orach et al. [24], time-series analysis was used to determine the long-run and short-run association between environmental degradation (proxied by CO_2 emission), gross domestic product, energy consumption and exports in China between the years 1971 and 2014. The Autoregressive Distributed Lag Model (ARDL) approach to estimation was utilised in the study. Their findings indicated that there is an inverse relationship between energy consumption and economic growth; economic growth and energy consumption respectively and export has a significant negative effect. Moreover, granger causality test indicates that there is a bi-direction causality between exports and economic growth. The cause and effect are running in a unidirectional way with energy consumption causing economic growth.

The study by Benjamin and Olusegun [25] examined how non-renewable energy consumption affects the economic growth and CO_2 emission in the leading oil producing nations in Africa between 1980 and 2015. They used Non-linear Autoregressive Distributed Lag (NARDL) model. The empirical evidence indicates the existence of an asymmetric impact of the non-renewable energy use on the economic growth and CO_2 emission in the sampled African economies other than Algeria. Ekeocha et al. [26] reviewed the energy consumption and economic growth relationship in Nigeria between the year 1999Q1 and 2016Q4 with alternative model specifications. Particularly, the model employed in the study was a nonlinear (or asymmetric) ARDL model and an ARDL-ECM specification which assumes the existence of a linear, but not a nonlinear, relationship. On the whole, they discovered that the contribution of energy consumption to growth has never been significant at any point implying that there is much to be done in ensuring that the projected contribution of energy to the Nigerian economy starts to take shape. The granger causality tests have shown a one-way causality that exists between energy consumption and economic growth meaning that Nigeria will be able to achieve high levels of sustainable growth in case of better and stable supply of energy. The study of Nadeem and Munir [27] attempted to establish the connection between energy consumption and economic growth on a disaggregated level by utilising data on annual data covering 1972-2014. They also conducted the autoregressive distributed lag (ARDL) bound testing method and revealed a long-run connectivity between the economic growth and the disaggregated aspects of energy (aggregate and disaggregate oil, coal, gas and electricity use across various sectors). In a study by Bayar and Ozel [28], Pedroni, Kao and Johansen co-integration and granger causality tests were used to evaluate the association between the economic growth and electricity consumption in the emerging economies over the years, 1970-2011. They stated that consumption of electricity positively affected the economic growth. They also found a bi-directional relationship between growth and consumption of electricity.

Akomolafe and Danladi [29] applied the vector error correction (VEC) model and the granger causality test and only encountered unidirectional causality of electricity consumption on the real GDP. According to the long run estimates, it is established that real GDP is positively associated with electricity consumption in the long run. Okoligwe and Ihugba [30] used the Johansen Cointegration test, the error correction model (ECM) and Granger causality test to determine the relationship between the energy consumption and the economic growth in Nigeria between 1971 and 2012. They discovered unidirectional causality of energy consumption to economic growth. Mahmoudinia et al. [31] investigated the inter-temporal causality between economic growth, energy consumption, electricity consumption and price in the period 1973-2006.They were using the ARDL bounds testing method that showed a long run co-integration of all the variables. The results further indicated a unidirectional causal relationship between energy and electricity consumption and economic growth that has a negative effect on the economic growth in long run. According to Akkemik and Goksal [32], most countries on the nexus of energy consumption panel studies tend to assume that the panel is homogenous yet this is not always the case. Their analysis, thus, presupposed the heterogeneity of panels and took a more developed method of Granger causality tests with fixed coefficients panel. Therefore, when using 79 countries on a panel and 1980-2007 data, they found that the results of 57 countries had a bi-directional causality, 7 countries had unidirectional causality and 15 countries did not have any causality. In the 57 countries with the bi-directional causality, the relationship between the energy consumption and economic growth was clear.

Belke et al. [33] analysed the long-run dependency between energy use and real GDP, with special consideration put on the contribution of energy prices to 25 OECD nations. They based their results on the analysis of annual data on 1981 to 2007 and the cointegration analysis, where they discovered that the common elements in energy consumption, which included economic growth and energy prices, were the only ones that were cointegrated. Their causality tests have shown that there is a two-way relationship between energy consumption and economic growth. Zhang and Cheng [34] examined the nature and the trend of Granger causality between economic growth, energy consumption and carbon emission in China between 1960 and 2007. The outcome proved the existence of a unidirectional Granger causality between GDP and energy consumption, and a unidirectional Granger causality between energy consumption and carbon emissions in the long run. There are indications that both the carbon emissions and consumption of energy do not drive the growth of an economy. Sylvester, et al [35] used the VAR method to investigate the relationship between energy and sustainable economic development. They found that energy consumption had a bidirectional relationship with GDP growth and directly contributed significantly to economic development in Nigeria. Haque and Fausif [36] used the ARDL technique to analyse the relationship between energy consumption and economic growth Saudi Arabia. Their result found no existences of the Energy-Kuznets Curve hypothesis for Saudi Arabia, but an asymmetric effect of economic growth on energy consumption.

Halmuratov, et al [37] employed the vector error correction model (VECM) to examine the long-term impact of energy consumption and trade openness on GDP per capita growth for the economy of Uzbekistan with data from 1990 to 2023. The result showed that energy consumption has a positive effect on GDP per capita and trade openness has a negative impact on GDP. By investigating the nexus between marine energy consumption, seaborne trade, and greenhouse gas (GHG) emissions, Guo et al, [38] used data from eight Northern European countries from 2005 to 2017 estimated by the FMOLS and DOLS methods. They found that only in Denmark, Norway and Sweden did the data corroborate an inverted U-shaped relationship (the EKC curve) between maritime GHG emissions and economic development. The increase in energy utilization across all nations directly increased marine GHG emissions; however, the adverse effect of energy consumption on the environment is severe in Denmark, Norway, and Sweden. Container throughput, linear shipping connectivity index, and trade openness exhibit a positive impact on marine GHG emissions. The impact of seaborne proxy variables is severe in Denmark and Sweden.

3. Methodology

3.1. Theoretical Framework

3.1.1. Endogenous Growth Model

This study used the endogenous growth model of Romer [39] developed as a result of the ineffectiveness of Solow growth model. The production function equation under the Solow growth model is that $Y = f(L, K)$ given that the technology is exogenously chosen. The Romer model is dissimilar because technology that is viewed as energy is an endogenous variable. The endogenous growth model of [39] is an explanation of economic growth due to internal factors, especially knowledge accumulation, innovation and development of human capital, and not due to external technological advancements. The model by [39] is justified for this study, considering the issue of energy consumption, maritime trade and economic growth in Nigeria, the model by Romer demonstrates that maritime trade facilitates the movement of technology, skills and knowledge across the borders. In the model by Romer, the spillovers of such knowledge help to promote productivity and innovation, which will result in stable economic growth in the maritime industry and its related industries within Nigeria. In this respect, energy is a factor of production. Industrialization, port operations and transport logistics are backed by efficient energy consumption. The maritime trade promotes investment in port facilities and human resources. Investment in human capital and innovation gives rise to increasing returns as pointed out by Romer strengthening the connection between maritime activity, energy use and long-term economic growth. Additionally, the development of maritime trade and more efficient use of energy is an indicator of further technological development, which is endogenous.

3.2. Model Specification

The model specification used in this research followed the studies of Orach et al, [24] and Benjamin and Olusegun [25] with some modifications.

The functional form of the model is given as;

$$LGDP = f(LECF_t, LEPC_t, LMRT_t) \quad \text{(i)}$$

The research used the Vector Autoregressive (VAR) Model to examine the data of the research. A VAR is a linear model, n- equation, n-variable model, in which one specifies a variable as a factor of the lagged values of the model n- variables. Therefore, the VAR model treats all the variables as endogenous and introduces all the rich dynamics of multiple time series. Assuming there are n-variables of interest, say, $y_1, y_2, \ldots, y_n$; thus the vector of variables in the VAR is $(y_1, y_2, \ldots, y_n)$. This implies that all the variables are endogenous. The VAR model is represented in its compact form as follows:

$$V_t = \alpha + \sum_{i=1}^{p} A_i V_{t-1} + \varepsilon_t \quad \text{(ii)}$$

Where;

V_t is the vector of economic growth (LGDP), energy consumption from fossil source (LECF), electricity power consumption (LEPC) and maritime trade (LMRT). The $\alpha's$ are the intercepts of autonomous variables. A_i is the matrix of coefficients of all the variables in the model. V_{t-1} is the vector of the lagged variables and ε_t is the vector of the stochastic error terms. Data used for the study were sourced from the World Bank's World Development Indicator (WDI), from 1990 to 2023.

4. Results and Discussion

Table 1 contains the result of the descriptive features of the data used in the study. From the result it is observed that economic growth (GDP) has an average growth of 10.6 percent, energy consumption from fossil sources (ECF) is 3.8 percent and electricity power consumption (EPC) was 4.8 percent during the study period. Maritime trade on average stood at 3.3 percent for the study period. All the variables are negatively skewed except electricity power consumption which has a positively skewed. Their kurtosis values showed that GDP and ECF has platykurtic distribution. EPC and MRT are is mesokurtic. The Jarque-Bera probability values showed that all the variables are has normal distributions.

Table 1. Descriptive Statistics

Statistic	GDP	ECF	EPC	MRT
Mean	10.62052	3.829404	4.863456	3.290522
Maximum	11.26364	3.977719	5.390142	3.759594
Minimum	9.984155	3.625449	4.559662	2.166674
Std. Dev.	0.486244	0.097024	0.190832	0.408987
Skewness	-0.089328	-0.411482	0.869157	-1.008078
Kurtosis	1.355949	2.227545	3.782681	3.220443
Jarque-Bera	3.874329	1.804771	5.148633	5.827432
Probability	0.144112	0.405601	0.076206	0.054274
Observations	34	34	34	34

Note: GDP-Gross Domestic Product; ECF-Energy Consumption from Fossil Source; EPC-Electricity Power Consumption; MRT-Maritime Trade. **Source.** Author's computation (2025).

Table 2. Unit Root Test Results.

Variable	ADF Test Statistic (Level)	Critical Value @ 5% (Level)	ADF Test Statistic (First Diff.)	Critical Value @ 5% (First Diff.)	Order of Integration	p-Value
GDP	-0.641545	-2.95711	-2.991091	-2.95711	I(1)	0.0465
ECF	-1.336082	-2.954021	-4.432765	-2.95711	I(1)	0.0014
EPC	-1.952167	-2.954021	-6.48355	-2.95711	I(1)	0
MRT	-2.541192	-2.954021	-5.663476	-2.95711	I(1)	0

Source. Author's computation (2025).

The unit root test for the data used in the study is presented in Table 2, from the result all the variable are integrated at order one I(1). Therefore, we proceed to conduct the Johansen cointegration test to check for the existence of a long run relationship among the variables.

Based on the multivariate cointegration test findings in Table 3, the Johansen cointegration test showed that both the trace statistic and maximum Eigen value statistic does not show the existence of cointegrating equations among the variables. The long run relationship between the two variables could not be found to be cointegrated, and therefore, it could be only validated by Vector Autoregressive (VAR) model. The VAR model is therefore appropriate for the study. The VAR lag order selection criteria indicated one lag across all the lag length selection criterion. The result is in the supplementary material.

Table 4 shows Vector Autoregression (VAR) Estimates. The estimates of all the coefficients are elasticities. A keen examination of the findings reveals that the one period lagged value of any variable is the most significant determinant of that variable. The elasticity of GDP to its lagged value is 1.02; the elasticity of fossil source energy consumption to its lagged value is 0.90, the elasticity of hydro source energy consumption to its lagged value is 0.529105 and the elasticity of maritime trade to its lagged value is 0.635866. These findings go hand in hand with the findings of Impulse Response Function and Variance Decomposition analyses. The explanatory value of the variables of the model is also high as illustrated by the R-squared value of 0.995365 that indicates 99 percent explanatory value.

The diagnostic test for the model errors is presented in table 5. We observe that the errors are free from serial correlation based on the VAR Residual Serial Correlation LM Tests result and the VAR Residual Heteroskedasticity tests also indicate that the errors are homoskedastic based on the result.

Table 3. Test for Cointegration.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.484363	34.63030	47.85613	0.4677
At most 1	0.255850	13.43503	29.79707	0.8707
At most 2	0.116622	3.978635	15.49471	0.9053
At most 3	0.000330	0.010559	3.841465	0.9179
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.484363	21.19527	27.58434	0.2646
At most 1	0.255850	9.456395	21.13162	0.7940
At most 2	0.116622	3.968076	14.26460	0.8627
At most 3	0.000330	0.010559	3.841465	0.9179

Source. Author’s computation (2025). NOTE: Trace and Max-eigenvalue tests indicates no cointegration at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values

Table 4. Vector Autoregressive (VAR) model Estimates.

Sample (adjusted): 1991 2023
Included observations: 33 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LGDP	LECF	LEPC	LMRT
LGDP(-1)	1.022764	-0.006161	0.108642	0.185736
	(0.01958)	(0.03155)	(0.06588)	(0.19066)
	[52.2329]	[-0.19525]	[1.64907]	[0.97420]
LECF(-1)	-0.033305	0.904036	-0.302862	-0.207752
	(0.06813)	(0.10979)	(0.22923)	(0.66338)
	[-0.48885]	[8.23453]	[-1.32122]	[-0.31317]
LEPC(-1)	-0.092150	0.044181	0.529105	-0.618124
	(0.04807)	(0.07746)	(0.16173)	(0.46805)
	[-1.91702]	[0.57038]	[3.27147]	[-1.32065]
LMRT(-1)	0.033516	-0.007664	0.051179	0.635866
	(0.01424)	(0.02295)	(0.04792)	(0.13869)
	[2.35310]	[-0.33391]	[1.06794]	[4.58492]
C	0.262719	0.244570	2.134161	3.022357
	(0.36526)	(0.58858)	(1.22894)	(3.55646)
	[0.71927]	[0.41553]	[1.73659]	[0.84982]
R-squared	0.995944	0.746769	0.711946	0.477876
Adj. R-squared	0.995365	0.710593	0.670795	0.403286
F-statistic	1718.971	20.64276	17.30098	6.406765
Akaike AIC	-3.863778	-2.909565	-1.437180	0.688054
Schwarz SC	-3.637034	-2.682821	-1.210436	0.914798

Source. Author's computation (2025). NOTE: Note: LGDP- Log of Gross Domestic Product; LECF- Log of Energy Consumption from Fossil Source; LEPC- Log of Electricity Power Consumption; LMRT- Log of Maritime Trade.

Table 5. VAR Residual Serial Correlation LM Tests and Heteroskedasticity Tests.

Test	F-Statistic	p-Value
Serial Correlation LM Test (n at lag h)	21.55165	0.1583
Serial Correlation LM Test (n at lag 1 to h)	1.417821	0.1617
Heteroskedasticity (Levels and Squares)	161.8844	0.4435

Source. Author's computation (2025). NOTE: *Edgeworth expansion corrected likelihood ratio statistic.

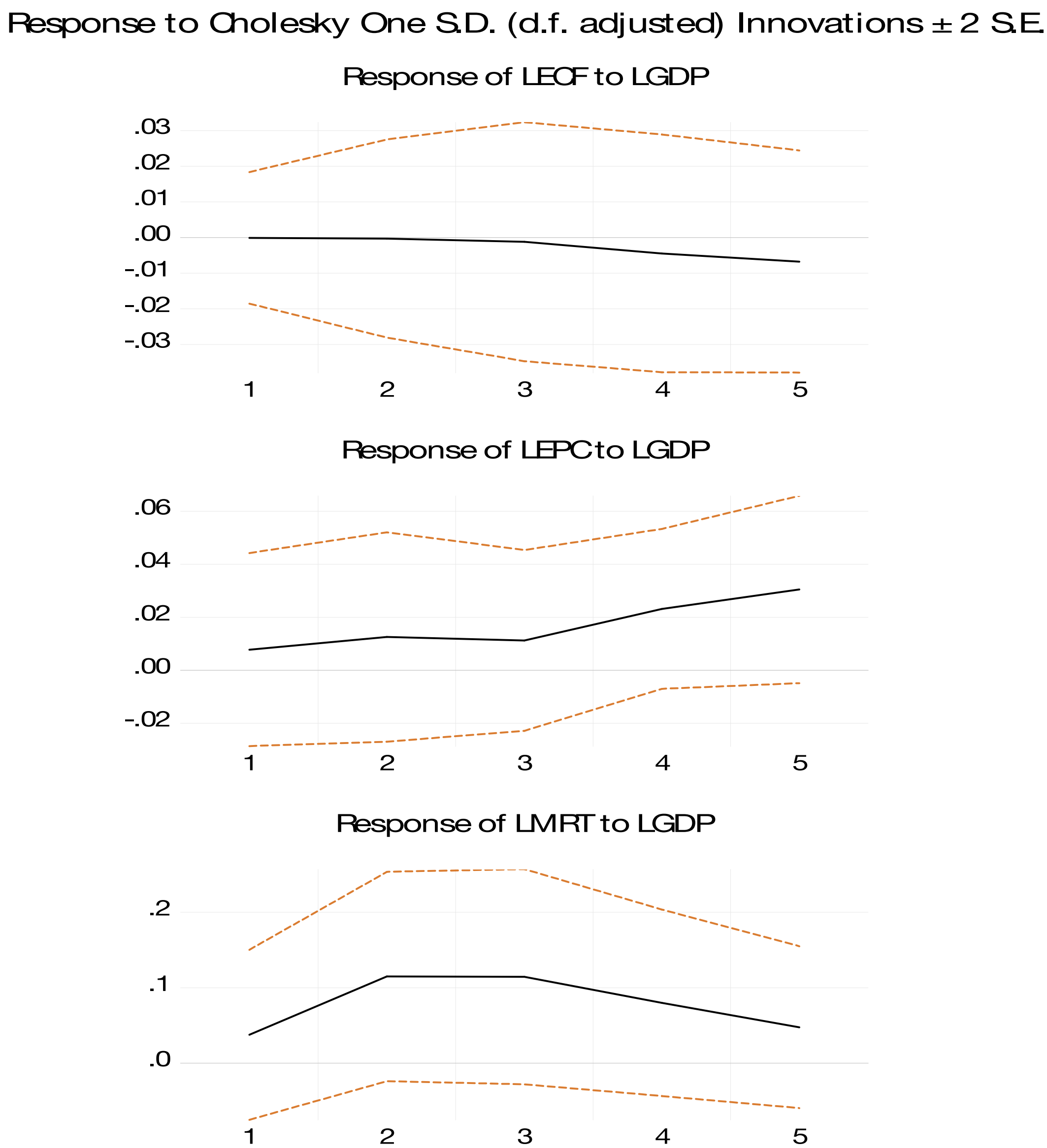

Figure 1. Impulse Response Function (Source: Author's computation, 2025). Note: LGDP- Log of Gross Domestic Product; LECF- Log of Energy Consumption from Fossil Source; LEPC- Log of Electricity Power Consumption; LMRT- Log of Maritime Trade.

Figure 1 presents the impulse response role of the energy consumption of fossil source, the energy consumption of the hydro source and the maritime trade to one standard deviation innovations of economic growth. The end result of the Impulse Response Function indicated that the energy consumption of fossil source to economic growth did not produce an initial response but it declined slowly over the course of the study and produced a positive impact both in the long run and short run. This aligns with the findings of [2], [22], [35] and [37], although this is contrary to that of [24] and [31]. Consumption of energy through hydro source had a positive correlation over the period, and an even higher one following the third period. On the one hand, there is a positive and growing effect of maritime trade in the short run, on the other hand, it reached equilibrium and began to decrease although it was still within the positive horizon. This however did not align with the findings of [37] as they found a negative impact between trade openness and economic growth.

Table 6. Variance Decomposition

(i)Variance Decomposition of LGDP

Period	S.E.	LGDP	LECF	LEPC	LMRT
1	0.032706	100.0000	0.000000	0.000000	0.000000
2	0.049012	89.89369	0.095266	5.843328	4.167718
3	0.064456	78.01347	0.247024	13.72150	8.018005
4	0.079177	68.69799	0.448765	20.53544	10.31781
5	0.092917	62.05032	0.711602	25.73401	11.50406

(ii)Variance Decomposition of LECF

Period	S.E.	LGDP	LECF	LEPC	LMRT
1	0.052703	0.085687	99.91431	0.000000	0.000000
2	0.070698	0.067331	99.28654	0.541398	0.104735
3	0.082314	0.053196	98.41077	1.333806	0.202229
4	0.090435	0.044157	97.59931	2.097849	0.258682
5	0.096263	0.039477	96.95421	2.723972	0.282345

(iii)Variance Decomposition of LEPC

Period	S.E.	LGDP	LECF	LEPC	LMRT
1	0.110042	3.731752	0.185641	96.08261	0.000000
2	0.125628	4.805728	1.409561	92.30559	1.479119
3	0.130982	5.601384	3.432963	87.37051	3.595145
4	0.134463	6.073263	5.668444	82.91015	5.348144
5	0.137616	6.318334	7.620183	79.61970	6.441779

(iv)Variance Decomposition of LMRT

Period	S.E.	LGDP	LECF	LEPC	LMRT
1	0.318455	1.890935	7.032149	3.195169	87.88175
2	0.388024	1.569375	6.122743	9.180588	83.12729
3	0.418078	1.397497	5.734099	13.88025	78.98816
4	0.431545	1.316777	5.637205	16.74079	76.30523
5	0.437426	1.281948	5.696239	18.19547	74.82634

Source: Author's computation, 2025. Note: Cholesky Ordering; LGDP- Log of Gross Domestic Product; LECF- Log of Energy Consumption from Fossil Source; LEPC- Log of Electricity Power Consumption; LMRT- Log of Maritime Trade.

To further investigate the short run dynamic characteristics on energy consumption of fossil source, electricity power consumption, maritime trade and economic growth in Nigeria, the forecast error variance decomposition was used. Table 7 provides the results of the four variables. Based on the analysis of the variance decomposition of economic growth in Table 7(i), it is evident that the largest percentage of changes that economic growth undergoes is as a result of the economic growth shock. Contribution of own shock is 100% in the first period and falls slightly to 89.9% at the end of the 5-period horizon. The remaining 3 variables had a minimal contribution to the same. The largest source of energy used on hydro is the most consumed energy in the fifth period of 25.7 percent. This is similar to the findings of [21], who found a long run relationship between the variables.

Table 7(ii) indicated that energy consumption through the fossil source had a strong endogenous effect on the shocks of the same. The contribution of own shock is 99.9% in the first period, which decreases to 96.95% in the fifth period. The other variables contribute highly with a strong exogenous effect on the energy consumption of fossil. Among them, the energy consumption through hydro is number one with 2.7% implying that the energy consumption through fossil is actually a result of the energy consumption through hydro.

Table 7(iii) showed that the economic growth exogenously affects energy consumption in the short run and long run in the case of hydro. Despite the fact that in the fifth period, the energy consumption of fossil corresponded to the variation in energy consumption of hydro, which is the largest in the long term, on the same parameter as compared to energy consumption of hydro, was only 7.6. Therefore, showing similar results as the impulse response function.

In Table 7(iv) we have seen that both energy consumption of fossil has a strong exogenous effect on maritime trade in the short run as well as the long run. During the fifth period, the hydro energy contributed to 18.2% of change in maritime trade in long term. So, it is similar to the impulse response functionality in terms of the results.

5. Conclusion and Recommendations

This paper has explored the nexus between energy consumption, maritime trade and economic growth in Nigeria based on time series data between 1990 and 2023. The relationships of the variables of the study were analysed using Vector Autoregression technique. The paper found that the one-period lagged value of each variable is the most significant determinant of each variable, highlighting the dependence of energy consumption, trade activity and economic performance in Nigeria The forecast error variance decomposition and Impulse Response Functions revealed that the energy consumption of fossil source, electricity power consumption and maritime trade have a positive impact on the economic growth in the long run and short run. These results emphasize the significance of sound energy provision and efficient maritime sector as the key drivers of the economic development of Nigeria in the long run. Generally, the research confirms the necessity of policies to enhance energy infrastructure, increase maritime trade capacity, and stabilize economic conditions to promote the growth in the long term.

Based on the findings the government needs to increase investment in energy infrastructure by modernizing the current fossil fuel-based power plants to enhance efficiency and minimize downtimes. Increase hydro energy production particularly small and medium scale hydro power plants which are cheaper and less damaging. Enhance energy diversification so that the supply of energy maintains the same momentum with the increasing demand due to the maritime trade and industrialized activities. Government also needs to improve the capacity and competitiveness of the maritime trade by modernizing the seaports which includes investment in cargo handling facilities, dredging of the channels and increasing the terminal.

5.1. Limitations of the Study

The use of Vector Autoregression (VAR) technique aligns with the data preliminary test like the unit root test and the Johansen cointegration test. However, the linear nature of the VAR may not fully capture nonlinear interactions. Other energy source like gas was not explicitly included.

5.2. Future Research Direction and Recommendation

Future research can include data from more energy sources, use a nonlinear model like the NARDL or the Threshold VAR. Institutional variables can also be included. Furthermore, a comparative regional study can also be conducted to assess if similar relationships hold.

Declarations

Ethics approval/declaration: Not applicable.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

Author Contributions: Porwekobowei Aruwei, Christopher Oghenemaro Etugbo and Ikhisemon-Oje Agboniyokpa contributed equally to the conceptualization, data collection and analysis of the study. Specifically, Porwekobowei Aruwei provided support in data analysis, interpretation and contributed to the manuscript's critical revision. All authors reviewed and approved the final manuscript.

Funding: Not Applicable.

Data Availability Statement: Data used in the study will be provided by the corresponding author upon request.

Acknowledgments: The authors acknowledge the support provided by the Department of Maritime Economics and Finance, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria, which contributed to the successful completion of this research.

Conflicts of Interest: The authors declare no conflict of interest.

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