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Impact of Non-Renewable Energy on Non-Oil Manufacturing Sector Output in Nigeria (1986 – 2024)

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Abstract

Manufacturing sector is a vital engine of economic growth and development it has consistently faced challenges due to unreliable and inadequate energy supply. The country's heavy reliance on fossil fuels has led to frequent power outages, elevated energy costs and substantial carbon footprint. Sustainable socioeconomic development in any nation is fundamentally dependent on a stable and sufficient energy supply. This paper examined the impact of non-renewable energy on non-oil manufacturing sectors output in Nigeria from 1986 to 2024. The paper employed the used of Auto Regressive Distributed lag (ARDL) Model. The ARDL bounds test revealed that there is a long-run equilibrium relationship among the variables. The result revealed that coal energy consumption was found to have a positive influence on non-oil manufacturing sector in the long run. Similarly, petroleum energy consumption revealed to have a positive impact on non-oil manufacturing sector Lastly, liquified natural gas was found to have a positive influence on non-oil manufacturing sector in the long run. The paper recommended that; the Nigerian Coal Corporation (NCC) and the Nigerian Electricity Regulatory Commission (NERC), in collaboration with the National Assembly, should prioritize the development of coal energy in Nigeria by allocating increased funding to the sector. The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) should prioritize enhancing the efficiency of petroleum energy supply in Nigeria. Additionally, increased investment and funding in the sector are essential. Should also improve the efficiency of liquefied natural gas utilization in Nigeria

Keywords: *Non-renewable Energy, Gas Energy, Manufacturing sector, Output, Nigeria*

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Background to the Study

Energy is a vital element for manufacturing sectors being one of the drivers of economic growth and is generally viewed as the stimulus for most economic activities. Nigeria's manufacturing sector has long been plagued by the challenges of unreliable and inadequate energy supply, with non-renewable energy sources such as fossil fuels dominating the country's energy mix. While other countries have limited access to these sources of energy, Nigeria is among nations that are endowed with different forms of non-renewable energy, with many still untapped Ifeanyi (2017). The reliance on non-renewable energy has significant implications for the manufacturing sector, including increased operating costs, reduced competitiveness, and decreased productivity.

The importance of energy lies in other aspect of development increase in foreign earnings when energy products are exported, transfer of technology in the process of exploration, production and marketing; increase in employment in energy industries; improvement of workers welfare through increase in worker's salary and wages, improvement in infrastructure and socioeconomic activities in the process of energy resource exploitation (Awodumi & Adeolu, (2020). Thus, in the quest for optimal development and efficient management of available energy resources, equitably allocation and efficient utilization can put the economy on the part of sustainable growth and development. Arising from this argument, adequate supply of energy thus becomes central to the radical transformation of the nation's economy. However, some energy economists contend that energy consumption cannot stimulate economic growth given that the small fraction of energy usage is used in the production process (Uzokwe & Onyije, 2020).

Non-renewable energy on the sector has received limited attention despite the importance of the manufacturing sector to Nigeria's economic growth and development in the literature. According to Asaleye *et al.* (2018), Nigeria's energy production level is less than the energy production in large African economies, paradoxically; the country's total population, which invariable defines its energy consumption demand, is higher than the population of these countries. This suggests that energy supply despite the pivotal role of non-renewable energy and the increasing demand for manufacturing sector output necessary to meet up with the increase in the country's population, access to reliable and affordable energy, especially electricity appears to be disturbing issue confronting the manufacturing sector in Nigeria. Eniayo (2018) maintained that one of the most challenging factors to development in Nigeria is the poor quality, unreliability, and limited availability of power supply to the manufacturing sector.

The Nigerian manufacturing sector comprises of firms that engage in the transformation of raw materials into semi-finished or finished goods. The components of the manufacturing sector are; consumer goods and capital goods (Kwode, 2020). The consumer goods subsector of the manufacturing sector output encompasses goods produced for primary consumption, while capital goods manufactured goods produced for secondary consumption because these outputs constitute industrial raw materials. The manufacturing sector is considered to among the wealth generating sectors of economy because of its role in the provision of raw materials

needed to industrialization and economic diversification. Asaleye *et al*., (2018) asserted that on the average, the Nigerian manufacturing companies spend about 40 per cent of the production overhead on electricity per annum. This translates to increases in the cost of operation and prices of goods made in Nigeria when compared with prices of similar goods from other countries.

Manufacturing sector contribution to GDP is less in Nigeria compare other countries that were at the same level some few years, back ranges from 28% to 34% (Malaysia and Indonesia 28%, Thailand 34%, China 30%, Brazil 35%) but Nigeria's contribution is just 20%. For example, available statistics shows that manufacturing sector and its components have continued to rise in the last three decades under review. For instance, manufacturing sector has been fluctuating, it fluctuates from N 5,838.89 billion in 1981 to N 3,137.51 billion in 1986 further to N 3,825.61 billion in 1990 and N 2,990.69 billion in 1996. Manufacturing sector output was still N 3,050.51 billion in 2001 and N 3,268.55 billion in 2006 later rose to N 4,216.19 billion in 2011 to N 6,302.23 billion, N 6,291.59 billion and N 6,754.96 billion in 2016, 2020 and 2023 respectively. This might be as result of insufficient energy supply in the economy. However, this paper examined the impact of non-renewable energy on non-oil manufacturing sectors output in Nigeria, while the specific objectives are to:

i. Examine the impact of liquefied natural gas on non-oil manufacturing sector output in Nigeria.
ii. Investigate the impact of coal energy consumption on non-oil manufacturing sector output in Nigeria.
iii. Evaluate the impact of petroleum energy consumption on non-oil manufacturing sector output in Nigeria.

Literature Review

Conceptual Review

Non-renewable energy resources are finite. They cannot be easily replaced on human timescales, and we are exploiting them faster than they are being made. Non-renewable energy sources are exhaustible in nature if used continuously (Elijah & Nsikak, 2013). There are two main types of non-renewable energy: fossil fuels and nuclear energy (Geological Society Report, 2020). Burning fossil fuels generates heat and electricity, but also released carbon dioxide (CO2) gas. The CO2 in the Earth's atmosphere traps excess heat from the sun in a process known as the 'greenhouse effect'. Over the past 250 years, increasing amounts of CO2 (currently at 410 parts per million) have caused the Earth's atmosphere and oceans to heat up, this is known as global warming (Geological Society Report, 2020). Awodumi and Adewuyi (2020) posited that with trends of non-renewable energy such as petroleum and natural gas consumption, it could be argued that Angola and Nigeria are among the least consumers of petroleum in per capita terms among the World economies. However, Olarinde and Abraham (2018) reported that Nigeria has the Africa largest crude oil reserve and sixth largest in the world with an estimated oil reserve of about 36.2 billion barrels.

Coal energy is referring to fossil fuel energy that is generated from the combustion of coal. Coal is a black or brownish-black sedimentary rock that is composed of carbon, hydrogen, oxygen,

nitrogen, and sulfur. It is the most abundant form of fossil fuel available on earth. They were formed by the decay of old plants and animals several centuries ago. Coal is mostly found below the earth and is major source of fuel for electricity generation as of today. Most power stations on earth require huge reserves of coal to produce electricity continuously without break. When coal is burnt, it produces heat that is used to convert the water into stream. The steam is then used to move the turbines which in turns activate generators which produces electricity. Coal contains excessive amount of carbon. When it is burnt to produce power, it mixes up with oxygen to produce carbon dioxide. Carbon dioxide is one the gas responsible for global warming (Adegboyega *et al.* 2021).

Petroleum, also known as crude oil, is a non-renewable energy source that is extracted from the earth and refined into various fuels, chemicals, and products. Oil and gas were formed from the remains of plants and animals that once lived in the sea. For over millions of years these remains remained buried under mud and rock under great pressure and at high temperatures. Under these conditions marine biomass gradually changed into oil and gas. The global proven oil reserve was estimated to be 1147 billion barrels by the end of 2003. Saudi Arabia had the largest share of the reserve with almost 23%. (One barrel of oil is approximately 160 liters) (Statistical Review of World Energy, June 2004). Oil and gas are primarily found along geologically young tectonic belt at plate boundaries, where large depositional basins are more likely to occur (Chike *et al.* 2023).

Liquefied Natural Gas (LNG) has emerged as a cornerstone in the global energy landscape, playing a pivotal role in shaping energy security, economic development, and environmental sustainability. The global gas and LNG markets have witnessed significant transformations, driven by increasing demand, market volatility, and the implications of climate change policies (Botão *et al.* 2023). The surge in LNG's prominence is attributed to its versatility, cleaner-burning properties compared to other fossil fuels, and the ability to transport it across vast distances, making it a critical component in the energy mix of numerous countries (Nikhalat-Jahromi *et al.*, 2017). Technological advancements and strategic geopolitical shifts mark the historical evolution of the LNG industry. Initially, the industry relied heavily on long-term contracts to distribute volume and price risks, but the liberalization of gas markets has led to a significant migration of risks upstream, reshaping the business structure of the LNG trade (Nikhalat-Jahromi *et al.*, 2017). This shift has also fostered a move towards vertical integration within the industry, as suppliers seek to mitigate these risks.

Manufacturing sector output refers to the total value of goods produced by the manufacturing sector of an economy within a specific period, usually measured in terms of quantity, value, or index. According to Kwode (2020) pointed out that the manufacturing sector is involved in the production of two categories of goods; consumer goods and capital goods. The manufacturing sector in Nigeria therefore consists of firms that engage in the transformation of raw materials obtained from primary industries into semi-finished and finished products that could be sold locally or exported. Manufacturing firms that engage in the production of cement and food and beverages products are parts of the manufacturing sector of the Nigeria economy. Ohunakin *et al*. (2013) stated that in Nigeria, cement production grew rapidly from 2 million tons in 2002 to

17 million in 2011. The cement sub-sector, food and beverages and other sub-sectors of the manufacturing sector depend on energy supply for their production activities. This suggests the need to assess the extent of the impact of renewable energy on the selected manufacturing sector output on the growth level of this sector so that possible policy measures could be taken.

Theoretical Framework

The theoretical framework adopted for this paper is the Robert Solow and Trevor Swan formulated neoclassical growth theory in 1956. It was developed to introduce the model of long-run economic growth. Robert Solow and Trevor Swan in 1956 stipulated how a steady economic growth rate comes as a result of a combination of three driving forces labor, capital, and technology. The model first considered exogenous population increases to set the growth rate but, in 1957, Solow incorporated technology change into the model. The theory states that short-term equilibrium results from varying amounts of labor and capital in the production function. The theory also argues that technological change has a major influence on an economy, and economic growth cannot continue without technological advances. Neoclassical growth theory outlines the three factors necessary for a growing economy. These are labor, capital, and technology. However, neoclassical growth theory clarifies that temporary equilibrium is different from long-term equilibrium, which does not require any of these three factors.

This growth theory posits that the accumulation of capital within an economy, and how people use that capital, is important for economic growth. Further, the relationship between the capital and labor of an economy determines its output. Finally, technology is thought to augment labor productivity and increase the output capabilities of labor. Therefore, the production function of neoclassical growth theory is used to measure the growth and equilibrium of an economy. That function is $Y = AF(K, L)$.

Where:

Y denotes an economy's gross domestic product (GDP)
K represents its share of capital
L describes the amount of unskilled labor in an economy
A represents a determinant level of technology

However, because of the relationship between labor and technology, an economy's production function is often rewritten as $Y = F(K, AL)$. Increasing any one of the inputs shows the effect on GDP and, therefore, the equilibrium of an economy. However, if the three factors of neoclassical growth theory are not all equal, the returns of both unskilled labor and capital on an economy diminish. These diminished returns imply that increases in these two inputs have exponentially decreasing returns while technology is boundless in its contribution to growth and the resulting output it can produce.

Empirical Review

Alsulamy *et al.* (2025) investigates the asymmetric impact of non-renewable energy shocks on manufacturing output. Using yearly data from 1990 to 2022, this study finds that positive

shocks to non-renewable energy significantly enhance manufacturing output in both the short and long run, driven by the sector's reliance on cheap fossil fuels. On the contrary, negative shocks disrupt supply chains, increase energy costs, and reduce output over the same periods. In addition, this study reveals that renewable energy negatively affects manufacturing output due to transition costs and operational inefficiencies. However, gross fixed capital accumulation positively affects industrial production.

Eze and Chidumebi (2024) examined how gasoline and renewable energy use affects output in Nigeria's manufacturing sector from 1990 to 2022. It employed the Auto-Regressive Distributed Lag (ARDL) model for its analysis. The Bounds co-integration test revealed the presence of a long-term relationship among the variables selected for the study. The findings reveal that in the short term, gasoline consumption marginally boosts manufacturing output, but it significantly hampers it over the long term. On the other hand, renewable energy's influence on manufacturing output is negligible yet positive in both the short and long term. The study suggests that by shifting focus from gasoline to renewable energy sources, Nigeria can enhance the resilience, sustainability, and innovation of its manufacturing sector, thus aligning with international environmental objectives and boosting economic growth.

Awujola *et al.* (2023) examined the effect of non-renewable energy on selected manufacturing sector outputs in Nigeria on the use of annual time series data covering 1986- 2021. The study employed the ARDL regression technique. The findings also revealed that gas energy consumption (GEC) had significant positive effect on both cement manufacturing output (CMO) and food and beverages output. The paper concluded that gas energy has significant impact on selected manufacturing sector output in Nigeria and recommends that manufacturing sector reform measures should take into cognizance petroleum sector dynamics since rent seeking in the petroleum sector was found to affect the manufacturing sector negatively. Federal government should invest in alternative sources of energy such as solar and wind considering the fact that other energy sources were found to be important determinants of the output of the selected manufacturing sector in Nigeria.

Oni and Babatunde (2023) examined the effects of natural gas, renewable biofuels, fuel oil, gas/diesel, gasoline, and electricity on manufacturing production from 1990 to 2019. It employed an Autoregressive Distributed Lag (ARDL) model estimate technique. While the ARDL bound test reveals that there is cointegration among the variable in the long run. Renewable biofuels and fuel oil are the only variables that have a direct and statistically significant positive relationship with GDP manufacturing output. Therefore, increasing the use of these energy sources is likely to increase the output of GDP manufacturing in the long run. According to the Granger Causality Test, there is a bidirectional relationship between manufacturing output and both gasoline and renewable biofuel. In contrast, there is a Granger causality relationship between manufacturing output and gas/diesel and electricity. Furthermore, the test indicates that manufacturing GDP only has a Granger cause renewable biofuel.

Omri and Saidi (2022) examined the impact of renewable and non-renewable energy on carbon dioxide emissions for 14 Middle East and North Africa economies using Fully Modified Least-Squares and Vector Error Correction model techniques. The fully modified least-squares estimates show that renewable energy enhances environmental quality, whereas non-renewable energy deteriorates it. The article also find that the industry sector has the highest contribution to environmental degradation. The results of the Vector Error Correction model technique show a two-way linkage between CO_2 emissions and renewable energy and between CO_2 emissions and non-renewable energy in both short and long runs.

Oluwafemi, *et al.*, (2021) studied the impact of energy on economic in comparison of different flues in cement production in Nigeria. The Analysis of Variance (ANOVA) was used to determine the effectiveness, availability, cost, environmental, and health impact of energy. The findings revealed that coal is the cheapest energy source but environmental issues exonerate it from being the choice energy source, but Natural gas had better production output while minimizing pollution and health issues. The findings further showed that Factory B was the most energy efficient in terms of output and cost of production. This study is relevant to the present research because it concentrated on energy and cement production in Nigeria, but its major weakness is that it was o not delimited to non-renewable energy sources.

Effiong and Inyang (2020) investigated the relationship between electricity consumption and manufacturing sector performance in Nigeria over the period 1981 to 2018. The paper utilized Granger causality test, and the Vector Autoregressive (VAR) approach. The Granger causality test indicated that a unidirectional causality flows between electricity consumption per capita and manufacturing value added. This therefore supports the feedback thesis. Meanwhile, the VAR result indicated that both electricity consumption and manufacturing value added were strongly endogenous. That is, they significantly predict themselves. However, electricity consumption is weakly exogenous in predicting manufacturing value added rather, manufacturing value added is strongly exogenous in predicting electricity consumption in Nigeria.

Femi *et al.*, (2020) assessed the relationships between various energy sources and manufacturing output. The study used Autoregressive Distributed Lag (ARDL) technique. The results showed that hydroelectricity and gas have positive and statistically significant long run relationships with manufacturing output in Nigeria, while coal, although had a positive relationship with manufacturing output, is statistically significant at 10% level. The short run results reported positive and significant relationships between the contemporaneous values of hydroelectricity, coal, gas and manufacturing output in Nigeria but the previous year value of hydroelectricity had a significant negative relationship with manufacturing output. The study recommended among others that Nigerian manufacturing firms should make use of them as their main energy input.

Mandara and Sungau (2020) examined the role of energy resource to production output in cement companies in Tanzania using time series data for 2005 to 2014. The study used the Multiple OLS technique of analysis. The findings revealed that energy resources have positive

and significant effect on production output in cement organizations and recommended that cement organizations should consider energy resource as a key and an important resource in production of cement. The strength of this study lies on the inclusion of cement companies and the use of time series data, but its weakness is that it used OLS technique that does not take into cognizance lag values of the variables and the study Area was Tanzania, not Nigeria.

Nwatu (2020) estimated the relationship between energy consumption, carbon (iv) oxide emission and industrial production for Nigeria and South Africa. The Autoregressive Distributed Lag (ARDL) was applied in the model estimation. The results coefficients for energy consumption and carbon (iv) oxide emission were obtained for short and long run for Nigeria and for only short run for South Africa. Conclusions and policy recommendations were then made to the government in line with the results of the model estimation. Top of the list is the regulation of energy consumption and carbon footprint via policies in the effort to increase industrial production.

Onwe and King (2020) examined electricity consumption and manufacturing sector output in Nigeria from 1981 to 2019. By employing the Autoregressive Distributed Lagged Model (ARDL) estimation technique. The study found a stable long-run relationship amongst the variables ARDL Wald Test. Estimated results shows that electricity consumption has a positive relationship with manufacturing sector output in the short-run and a negative relationship in the long run. However, there is a significant impact of electricity consumption and manufacturing sector output in Nigeria.

Ibrahim *et al.* (2017) examined the symmetric relationship between the electric consumption, manufacturing output and financial development in Nigeria from 1981 until 2015. The result indicates the co-movement in the variable over long time horizon, meaning that any inefficiency in electricity supply would impedes industrial output. Moreover, the Granger causality test based on Vector Error Correction framework shows the presence of causality between power utilization of manufacturing firms and economic growth without feedback. The result of variance decomposition further indicates that the variation in the industrial output responds more to shocks in the electricity supply than its own shock. This finding suggests that energy is the engine of manufacturing sector in Nigeria.

Danmaraya and Hassan (2016) examined the effect of energy consumption, capital and labour on manufacturing industry performance using panel data for the sample of seven low-income sub-Saharan Africa (SSA) countries during the period 1990-2012. The panel cointegration test provided evidence of cointegration among the variables for the seven-low income-income SSA countries. The Fully Modified Ordinary Least Square (FMOLS) result indicated that energy consumption and capital formation are positively significant variables in explaining the performance of the manufacturing industry in the seven low-income SSA countries. Conversely, labour was insignificant in explaining manufacturing industry performance. For that, strong energy policy that will enhance efficient and sustainable energy supply should be put in place to enhance energy consumption in SSA countries.

Ndegwa (2016) studied bordered on non-renewable energy was assessed in Kenya's cement sub-sector for the period 2004 to 2014. Data Envelopment Analysis (DEA) and Tobit regression analysis were employed to analyze the data. DEA results revealed that firms could improve their level of energy use efficiency, but the scope for improving energy use efficiency varied across different firms. The Tobit regression indicated that only quality of the labour force had a positive and significant effect on energy efficiency score. The strength of this literature is that it uses energy and cement firms in Kenya. There is need to domesticate the study on non-renewable energy in Nigeria; an oil producing economy by estimating its potentials for stimulating the growth of the currently feeble manufacturing sector in the country using the ARDL technique.

Methodology

This paper adopted *ex-post* research design to use secondary data to empirically examine the impact of non-renewable energy on oil and non-oil manufacturing sector output in Nigeria over the period 1986 to 2024. The *ex-post* facto design is particularly suited for studies aiming to decipher statistical associations between dependent and independent variables, primarily to establish cause and effect relationships.

The Autoregressive Distributed Lag Model (ARDL) was used in this study to examined the long-term and short-term effects. A modified model developed by Awujola *et al.* (2023) titled effect of non-renewable energy on selected manufacturing sector outputs in Nigeria serves as the foundation for the model adapted for this study. The original model is stated as:

$$CMO = f(HEC, PEC, GEC) \quad \ldots\ldots (1)$$

Where: CMO = Cement Manufacturing output as a sub-sector of the manufacturing sector output
FBO = Food and Beverages output as a sub-sector of the manufacturing sector output, HEC = Hydroelectric energy consumption, PEC = Petroleum Energy consumption, GEC = Gas energy consumption**.** However, the model was modified by including relevant non-renewable energy indicators.

This model is restricted to few-selected manufacturing sector. This limits the pass-through effect of non-renewable energy on non-oil manufacturing sector output. Hence, this study improves on its model by modifying it. Thus, these models are:

$$NMS_t = \beta_0 + \beta_1 CEC + \beta_2 PEC + \beta_3 LNG + U_t \quad \ldots\ldots (2)$$

Where;
NMS = Non-oil manufacturing sector
CEC = Coal energy consumption
PEC = Petroleum energy consumption,
LNG = Liquefied natural gas
U = Error term

t = Time period (annually)
β_0 = Intercept of the parameter
$\beta_1 - \beta_3$ = Coefficient of the variables

A priori Expectations
Furthermore, the a priori expectations of the parameters to be estimated are as expressed below:
$\alpha_1 > 0$; The coefficient of coal energy consumption is expected to be positive and have a positive impact on non-oil manufacturing sector;
$\alpha_2 > 0$; The coefficient of petroleum energy consumption is expected to be positive and have a positive impact on non-oil manufacturing sector; and
$\alpha_3 > 0$; The coefficient of liquified natural gas is expected to be positive and have a positive impact on non-oil manufacturing sector

ARDL Model
The unrestricted ARDL model adopted for this paper is specified as:

$$lnNMS = \beta o + \sum_{t=i}^{p}(\beta 1\Delta \text{lnNMSt} - \text{i}) + \sum_{t=i}^{p}(\beta 2\Delta \text{lnCECt} - \text{i}) + \sum_{t=i}^{p}(\beta 3\Delta \text{lnPECt} - \text{i}) + \sum_{t=i}^{p}(\beta 4\Delta \text{lnLNGt} - \text{i}) + \lambda 1\text{lnNMSt} - \text{i} + \lambda 2\text{lnCECt} - \text{i} + \lambda 3\text{lnPECt} - \text{i} + \lambda 4\text{lnLNG} + \varepsilon \text{t} \ldots\ldots\ldots (3)$$

ln = Natural Log
Δ = First difference
β_0= Constant parameter
$\beta_1 - \beta_4$ = Coefficient of the shot run parameter
$\lambda_1 - \lambda_4$ = Coefficient of the long run parameter

Results and Discussions
Descriptive Statistics Results
Descriptive statistics offers a preliminary understanding of the distribution, central tendencies, variability of the variables used in this paper. It helped to summarize the key characteristics of the dataset and provide insight into patterns and behavior of the variables.

Table 1: Descriptive Statistics

	NMS	**CEC**	**PEC**	**LNG**
Mean	8.313211	-3.496466	2.447357	2.194896
Maximum	8.816967	-2.465104	2.995732	2.862201
Minimum	7.955916	-5.298317	1.749200	1.115142
Std. Dev.	0.320329	0.797784	0.380376	0.584333
Skewness	0.481177	-0.832195	-0.113196	-0.385589
Kurtosis	1.574129	2.509217	1.962472	1.800490
Jarque-Bera	4.808755	4.767521	1.832543	3.304503
Probability	0.090322	0.092203	0.400008	0.191618
Observations	39	38	39	39

Source: Researcher's Computation Using E-views 10 (2025)

The descriptive statistics for non-oil manufacturing sector (NMS) revealed the mean value of 8.31% indicating on average, non-oil manufacturing sector (NMS) contribution to the Nigerian economy over the study period. The maximum and minimum values were found to be 8.82% and 7.96% respectively indicating a significant variation in the performance of non-oil manufacturing sector. The standard deviation was found to have 0.32% indicating a minimal volatility in non-oil manufacturing sector. The positive skewed 0.48 indicates that the distribution of non-oil manufacturing sector is right skewed. The kurtosis value is 1.57 implies a platykurtic (flat and short tailed) distribution. The Jarque-Bera statistics value was 4.81 and probability value 0.09 implies that the data are approximately normally distribution at 5%.

The coal energy consumption (CEC) has the mean value of -3.49, maximum value of -2.47 and the minimum value of -5.30, which are very weak in contributing to the economy for the period of study. The standard deviation has the value of 0.80 revealed the minimal volatility in coal energy consumption. The negative skewness -0.83 indicates that the distribution of coal energy consumption is left-skewed while the kurtosis value of 2.51 implies a platykurtic (flat and short tailed) distribution. The Jarque-Bera statistics value was 4.77 and probability value 0.09 implies that the data are approximately normally distribution at 5%.

Similarly, the mean value of petroleum energy consumption (PEC) was 2.45 indicating the average contribution of petroleum energy consumption to the Nigerian economy over the study period. The maximum and minimum values of petroleum energy consumption were 3.00 and 1.75 respectively, indicating a significant variation in petroleum energy consumption over time. The standard deviation was found to have 0.38 indicating a minimal volatility. The negative skewed -0.11 indicates that the distribution of petroleum energy consumption is left skewed. The kurtosis value is 1.96 implies a platykurtic (flat and short tailed) distribution. The Jarque-Bera statistics value was 1.83 and probability value 0.40 implies that the data are approximately normally distribution at 5%.

Lastly, the mean value of liquefied natural gas (LNG) was found to be 2.19 showing the average contribution to the economy for the period of study. The maximum value of 2.86 and the minimum value of 1.12, which implies the significant variation in the liquefied natural gas over time. The standard deviation revealed the value of 0.58 indicating a minimal volatility. The negative skewed -0.39 indicates that the distribution of liquefied natural gas is left skewed. The kurtosis value is 1.80 implies a platykurtic (flat and short tailed) distribution. The Jarque-Bera statistics value was 3.30 and probability value 0.19 implies that the data are approximately normally distribution at 5%.

Table 2: Unit Root Test Results

Variables	ADF Test Statistics	Critical ADF Test	Order of Integration
NMS	-4.891381	-2.943427**	*I* (1)
CEC	-3.123510	-2.945842**	*I* (0)
PEC	-6.568347	-2.943427	*I* (1)
LNG	-6.325658	-2.945842	*I* (1)

*Note: *** significant at 5%*

Source: Authors Computation, (Eviews-10), 2025

The results in table 2 revealed that non-oil manufacturing sector (NMS), petroleum energy consumption (PEC) and liquified natural gas (LNG) were not found to be stationary at level, as their ADF statistic values are lesser than their critical value with their probabilities greater than 5% level of significance. However, they became stationary at first difference as their ADF test statistics were more negative than the critical value and their p-values which were less than 5% significant of level. This implies that non-oil manufacturing sector (NMS), petroleum energy consumption (PEC) and liquified natural gas (LNG) were integrated at order one [I (1)].

On the other hand, the table 2 revealed that coal energy consumption (CEC) was found to be stationery at level as its ADF statistic value was found to be greater than its critical value with its probabilities greater than 5% level of significance. Therefore, coal energy consumption (CEC) was integrated at level [*I (0*)].

Table 3: The Result of Bound Test - Co-integration Analysis

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	10.25976	10%	2.72	3.77
K	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

Source: Authors Computation, (Eviews-10), 2025

From the co-integration test captured in table 3, it could be seen that F-statistic value of 16.83199 is greater than the lower bound [*I* (0)] and upper bound [*I* (1)] critical values of 3.23 and 4.35 respectively at 5% level of significant. This indicates that the variables were found to be co-integrated, and as such, there is a long-run equilibrium relationship between non-renewable energy and non-oil manufacturing sector in Nigeria for the period under review.

Table 4: ARDL Model Results of the Short-Run, Long-Run ECM
Dependent Variable: NMS

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.944122	0.288224	6.745171	0.0000
D(LPEC)	0.278428	0.064132	4.341482	0.0002
D(LPEC(-1))	0.291443	0.069722	4.180093	0.0003
D(LPEC(-2))	0.079272	0.065450	1.211189	0.2363
CointEq(-1)*	-0.250061	0.037031	-6.752699	0.0000
R-squared	0.704013			
Adjusted R-squared	0.664548			
F-statistic	17.83895			
Prob(F-statistic)	0.000000			
Durbin-Watson stat	1.877278			

LONG

Source: Authors Computation, (Eviews-10), 2025

The table 4 revealed the results of the Auto-Regressive Distributed Lag (ARDL) model, focusing on both the short-run and the long-run relationship between the dependent variable non-oil manufacturing sector (NMS) and independent variables: petroleum energy consumption (PEC) and liquified natural gas (LNG) and Error Correction Model (ECM). The error correction term CointEq(-1) in the ARDL model captures the speed at which short run deviations from the long run equilibrium are corrected. The coefficient of the error correction term is -0.250061 which is significant with the t-statistics value of -6.752699 and p-value of 0.0000, this implies a strong statistical significance at 5% level. The negative sign of ECM revealed the existence of long run relationship among the variables and shows how the system will adjust back to equilibrium aftershocks. The coefficient of ECM been -0.250061 implies the average speed of 25.01% of any deviation in the long-run equilibrium in non-renewable energy and non-oil manufacturing sector to corrected within one period.

Discussion of Findings

The long run results in table 4 revealed that coal energy consumption has a positive and statistically significant impact on non-oil manufacturing sector output in Nigeria. The positive coefficient implies that a unit increase in coal energy consumption will lead to 0.265972 in increase in non-oil manufacturing sector output in Nigeria in the long run. The outcome of the paper is consistent with the *a priori expectation* of the model of this paper. This finding is in line with other findings like: Femi *et al*., (2020) whose study found that coal had a positive relationship with manufacturing output.

Similarly, the result in table 4 revealed that petroleum energy consumption has a positive but statistically insignificant impact on non-oil manufacturing sector output in Nigeria. The positive coefficient signifies that an increase in petroleum energy consumption will lead to an increase in non-oil manufacturing sector output in Nigeria in the long run. The outcome of the paper is consistent with the *a priori expectation* of the model of this paper. This finding is in line with other findings like: Awujola *et al.* (2023) whose findings revealed that gas energy consumption (GEC) had a positive effect on manufacturing output.

Lastly, the findings in table 4 revealed that liquified natural gas has a positive but statistically insignificant impact on non-oil manufacturing sector output in Nigeria. The positive coefficient implies that an increase in liquified natural gas will lead to an increase in non-oil manufacturing sector output in Nigeria in the long run. The outcome of the paper is consistent with the *a priori expectation* of the model of this paper. This finding is in line with other findings like: Oluwafemi, *et al*., (2021) who found out that Natural gas had better production output while minimizing pollution and health issues.

Conclusion and Recommendations

The paper used the ARDL technique to examined the impact of non-renewable energy on non-oil manufacturing sector in Nigeria from 1986 - 2024. The ARDL bounds test revealed that there is a long-run equilibrium relationship among the variables. The result revealed that coal energy consumption was found to have a positive influence on non-oil manufacturing sector in the long run. Similarly, petroleum energy consumption revealed to have a positive impact on

non-oil manufacturing sector Lastly, liquified natural gas was found to have a positive influence on non-oil manufacturing sector in the long run.

Based on the results of this paper, the paper therefore recommended that:

1. The Nigerian Coal Corporation (NCC) and the Nigerian Electricity Regulatory Commission (NERC), in collaboration with the National Assembly, should prioritize the development of coal energy in Nigeria by allocating increased funding to the sector. This is essential given it demonstrated positive impact on the output of the non-oil manufacturing sector during the period under review.
2. The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) should prioritize enhancing the efficiency of petroleum energy supply in Nigeria. Additionally, increased investment and funding in the sector are essential, given the significant influence of petroleum energy consumption on the output of the non-oil manufacturing sector.
3. The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) should work towards improving the efficiency of liquefied natural gas (LNG) utilization in Nigeria. Furthermore, increased investment and funding in the LNG sector are recommended, considering its significant impact on the performance of the non-oil manufacturing sector.

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APPENDIX B

Years	Non-oil manufacturing sector (₦' Billions)	Liquified Natural Gas (BCM)	Coal Energy Consumption (BCM)	Petroleum Energy Consumption (MT)
1986	3,117.85	3.20	0.067	5.96
1987	3,651.80	3.05	0.07	6.10
1988	4,204.74	3.26	0.065	5.75
1989	3,525.66	3.77	0.076	6.25
1990	3,783.09	3.50	0.071	7.00
1991	4,120.06	4.00	0.075	7.50
1992	4,623.32	5.00	0.050	11.00
1993	3,806.41	5.60	0.010	10.00
1994	3,321.23	5.65	0.025	7.50
1995	2,852.40	5.56	0.020	8.00
1996	2,939.34	5.65	0.085	9.70
1997	3,001.38	6.00	0.010	10.00
1998	2,862.87	6.02	0.012	9.50
1999	2,928.18	6.20	0.018	9.60
2000	2,933.67	7.90	0.005	10.00
2001	2,913.73	7.50	0.005	12.00
2002	3,465.40	7.00	0.045	13.00
2003	3,065.28	8.02	0.014	12.00
2004	3,017.46	11.05	0.009	11.90
2005	3,075.27	11.40	0.009	13.00
2006	3,084.89	11.50	0.009	11.00
2007	3,069.48	12.00	0.020	9.00
2008	3,147.32	11.00	0.035	11.00
2009	3,253.45	9.80	0.036	9.00
2010	3,323.48	11.00	0.038	12.00
2011	3,945.19	15.50	0.032	11.00
2012	4,560.14	15.70	0.048	11.50
2013	5,481.65	15.00	0.049	17.00
2014	6,372.83	16.00	0,048	20.00
2015	6,385.74	16.05	0.047	18.00
2016	6,096.27	17.00	0.046	18.50
2017	6,139.98	17.50	0.047	18.80
2018	6,277.59	17.00	0.046	19.00
2019	6,371.72	16.50	0.044	18.70
2020	6,254.53	17.50	0.045	18.20
2021	6,482.96	17.30	0.046	18.70
2022	6,650.18	16.90	0.045	18.40
2023	6,747.77	17.10	0.048	18.65
2024	6,626.97	17.10	0.046	18.58

Sources: CBN Statistical Bulletin 2024, IEA World Energy Balances 2024