



## Energy Consumption and Industrial Production in Nigeria

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### ABSTRACT

This study investigates the impact of energy consumption on industrial production in Nigeria from 1986 to 2024. Using secondary time-series data on total energy consumption, electricity consumption, petroleum product consumption, and the Industrial Production Index (IPI), the study applies the Johansen cointegration technique and Vector Error Correction Model (VECM) to examine both long-run and short-run dynamics. The results reveal a significant long-run positive relationship between total energy consumption and industrial output, highlighting the critical role of aggregate energy availability in driving industrial growth. Conversely, electricity consumption and petroleum product consumption exhibit significant negative long-run relationships with industrial production, reflecting structural inefficiencies, unreliable power supply, and high operational costs associated with self-generation and petroleum reliance. The short-run analysis identifies a significant error correction mechanism, indicating that industrial output adjusts to restore long-run equilibrium at a moderate annual speed of 15.5%. These findings underscore that while the quantity of energy is important, the efficiency, reliability, and cost of energy supply are decisive factors for industrial performance. The study concludes with recommendations for policy interventions to enhance energy infrastructure, promote alternative energy sources, and improve energy efficiency to foster sustainable industrial growth in Nigeria.

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## **INTRODUCTION**

### **Background to the Study**

Energy remains a critical driver of industrial development, serving as an essential input for production, transportation, communication, and technological innovation. Historically, Nigeria's industrial growth has been closely tied to the performance of its energy sector. In the post-independence era (1960s–1970s), industrial expansion benefited from relatively stable electricity supply provided by the National Electric Power Authority (NEPA) and investments in hydropower infrastructure such as the Kainji Dam, which supported the growth of manufacturing firms in textiles, food processing, cement, and steel. However, from the late 1970s through the 1980s, rapid population growth, mismanagement, and underinvestment in energy infrastructure led to persistent electricity shortages and system failures. The Structural Adjustment Programme (SAP) of 1986 further increased production costs by reducing subsidies, forcing firms to rely heavily on diesel and petrol generators for power. By the 1990s and early 2000s, frequent blackouts, aging transmission infrastructure, and limited generation capacity had become severe constraints on industrial productivity and competitiveness. For developing economies like Nigeria, the availability, reliability, and affordability of energy resources—such as electricity, petroleum products, natural gas, and renewable energy—are essential for stimulating industrial output and fostering economic growth (Adewuyi & Awodumi, 2023). Inadequate energy supply disrupts manufacturing activities, lowers capacity utilization, and weakens productivity. Nigeria's industrial sector has long faced challenges related to erratic electricity supply, high production costs due to heavy dependence on generators, infrastructural decay, and policy inconsistencies (Okoye & Udeh, 2024). Although Nigeria possesses substantial energy resources—including large natural gas reserves and significant renewable energy potential—its energy consumption patterns remain inefficient and insufficient to meet industrial demand (NBS, 2023). Consequently, many manufacturers rely on self-generated power, increasing costs and reducing competitiveness both locally and internationally. Over the years, the government has introduced several interventions to address the energy crisis, including the Electric Power Sector Reform Act of 2005, the unbundling of the Power Holding Company of Nigeria (PHCN), the National Renewable Energy and Energy Efficiency Policy (NREEEP), and more recent grid expansion initiatives. Despite these efforts, their impact on industrial output has remained inconsistent, largely due to infrastructural deficits, implementation challenges, and rising energy prices (Federal Ministry of Power, 2024). Therefore, understanding the relationship between energy consumption and industrial production is critical for designing effective policies that promote industrial performance, economic diversification, and sustainable development in Nigeria.

### **Statement of the Problem**

Industrial production in Nigeria continues to underperform relative to its potential, partly due to persistent energy constraints. Frequent power outages, rising fuel prices, insufficient electricity generation, and unreliable distribution networks have significantly increased production costs for

manufacturers (Okoye & Udeh, 2024). Many industries operate below optimal capacity, leading to low output, reduced profitability, and limited competitiveness. Although government policies have attempted to address energy shortages, industrial productivity has remained volatile, raising questions about the effectiveness of energy-sector reforms. Empirical studies show mixed evidence on the energy–industry nexus in Nigeria. Some scholars find that increased energy consumption stimulates industrial growth (Adewuyi & Awodumi, 2023), while others argue that inefficiencies in energy utilization and poor infrastructural quality offset potential gains (Eze & Igwe, 2024). These inconsistencies highlight the need for a comprehensive empirical investigation covering recent periods characterized by rising industrial demand, fuel subsidy removal, and policy shifts toward renewable energy. Without understanding how energy consumption influences industrial output, policymakers may struggle to design strategies that effectively support manufacturing expansion and economic diversification.

### **Objectives of the Study**

The main objective of this study is to examine the impact of energy consumption on industrial production in Nigeria. The specific objectives are to:

1. Determine the relationship between total energy consumption and industrial production in Nigeria.
2. Evaluate the effect of electricity consumption on industrial output in Nigeria.
3. Examine the impact of petroleum product consumption on industrial production in Nigeria.

### **Research Questions**

1. What is the relationship between total energy consumption and industrial production in Nigeria?
2. How does electricity consumption affect industrial output in Nigeria?
3. What effect does petroleum product consumption have on industrial production in Nigeria?

### **Research Hypotheses**

H<sub>01</sub>: There is no significant relationship between total energy consumption and industrial production in Nigeria.

H<sub>02</sub>: Electricity consumption has no significant effect on industrial output in Nigeria.

H<sub>03</sub>: Petroleum product consumption has no significant impact on industrial production in Nigeria.

## **LITERATURE REVIEW**

### **Conceptual Literature**

Energy consumption refers to the use of various energy sources, including electricity, fuel, gas, and renewables, to drive productive and household activities. For industrial production, energy is a critical input for powering machines, operating factories, and enabling automation (Adewuyi & Awodumi, 2023). Efficient energy consumption enhances industrial productivity, reduces production costs, and improves output, while inadequate

or unreliable energy supply disrupts operations and lowers industrial capacity utilization (Eze & Igwe, 2024). Industrial production represents the total output of the manufacturing, mining, and utilities sectors. In Nigeria, it is commonly measured by the Industrial Production Index (IPI), which captures changes in manufacturing performance over time (NBS, 2023). The relationship between energy consumption and industrial output is anchored on the assumption that industrialization requires reliable and affordable energy, and production tends to increase as energy availability improves.

### **Theoretical Literature**

The relationship between energy consumption and industrial performance is grounded in several theoretical frameworks, notably the Energy-Led Growth Hypothesis, Endogenous Growth Theory, and Production Theory, each offering distinct insights into how energy shapes industrial output. Emerging from empirical observations in the 1970s and 1980s, the Energy-Led Growth Hypothesis argues that energy is a fundamental driver of economic and industrial expansion, meaning that increased energy consumption stimulates productivity and output, a strong point that highlights energy as a strategic input for industrialization; however, its weakness lies in assuming a unidirectional causality, which may overlook cases where industrial growth itself drives energy demand. The Endogenous Growth Theory, rooted in the works of Romer and Lucas, extends the meaning of growth by emphasizing internal factors such as technology, infrastructure, and human capital, asserting that adequate and reliable energy supply facilitates technological adoption and innovation within industries; its strength lies in explaining long-run productivity improvements, though it may underestimate short-term structural issues such as energy pricing and market failures. Production Theory, derived from microeconomic foundations, conceptualizes energy as a critical input alongside labour and capital, meaning that insufficient or costly energy raises marginal production costs and reduces output; while its strength is its simplicity and direct applicability to firm-level analysis, its weakness is that it does not fully capture external factors such as policy constraints or infrastructural inefficiencies. Together, these theories are highly relevant to the present study as they collectively explain how energy availability, cost, and efficiency influence Nigeria's industrial performance, providing a robust analytical foundation for examining the country's persistent energy constraints and their impact on industrial output.

### **Empirical Literature**

Adewuyi and Awodumi (2023) examined the relationship between energy consumption and manufacturing output in Nigeria using the ARDL approach and found that electricity consumption significantly enhances industrial output, although petroleum consumption exhibited mixed effects. Similarly, Okoye and Udeh (2024) observed that unreliable electricity supply and escalating fuel prices reduce industrial productivity by increasing production costs. Eze and Igwe (2024) analyzed the effects of energy efficiency on industrial performance and revealed that inefficiency rather than low energy consumption alone negatively impacts output, emphasizing the need for infrastructure modernization. Reports by the National Bureau of Statistics (NBS,

2023) further confirm that most Nigerian industries rely heavily on self-generated power, resulting in high operational expenses. Uzonwanne (2025) demonstrated that petroleum product consumption exerts a short-run positive effect on manufacturing output but turns negative in the long run due to sustained increases in energy costs. In a related study, Adebajo and Obi (2025) argued that enhanced investments in renewable energy have the potential to significantly improve industrial sustainability and resilience. Beyond Nigeria, international studies strengthen these findings. For instance, Sharma and Paul (2022), in a panel study of Asian developing economies, found that energy shortages and price volatility significantly constrain industrial growth. Likewise, Mensah and Adams (2023) reported that in Ghana, electricity unreliability led to reduced factory capacity utilization and lower manufacturing output. In South Africa, Moyo (2024) established that energy price shocks undermine industrial competitiveness, especially in energy-intensive sectors. These studies collectively reveal that an adequate, efficient, and affordable energy supply is critical for industrial performance across developing economies. Thus, the empirical evidence underscores the importance of examining how energy consumption patterns shape Nigeria's industrial output, particularly in the face of persistent supply challenges and rising energy costs.

#### **Summary and Gap in the Literature**

The empirical literature consistently establishes that energy consumption plays a critical role in determining industrial output, although the magnitude and direction of this impact vary across energy types, estimation techniques, and time periods. While numerous studies agree that electricity shortages, high petroleum costs, poor infrastructure, and energy inefficiencies undermine industrial productivity in Nigeria, several unresolved gaps remain. Most existing studies rely on ARDL or static regression methods, resulting in limited exploration of the joint long-run relationships among multiple energy variables, and few extend their analyses to recent years up to 2024 despite significant policy changes in the energy sector. Findings regarding the influence of petroleum product consumption also remain inconclusive, with evidence pointing to short-run gains but adverse long-run effects. Moreover, very few studies incorporate Nigeria's evolving reforms such as subsidy removal, sectoral deregulation, and increased investment in renewables within a comprehensive multivariate framework. Importantly, there is a methodological gap in the application of advanced dynamic techniques such as the Johansen cointegration approach and the Vector Error Correction Model (VECM), which allow for simultaneous estimation of long-run equilibrium relationships and short-run adjustments among multiple energy and industrial output indicators. This study fills these gaps by employing Johansen cointegration and VECM techniques to examine the dynamic interactions between electricity consumption, petroleum product use, total energy consumption, and industrial production in Nigeria using updated data from 1986–2024.

## METHODOLOGY

### Research Design

This study adopts an ex post facto research design, utilizing historical secondary data to analyze the relationship between energy consumption and industrial production in Nigeria. This design is appropriate because the variables under investigation have already occurred and cannot be manipulated by the researcher, making it suitable for assessing real-world trends and causality based on existing records.

### Sources of Data

The study will rely on secondary time-series data obtained from credible institutional sources, including the Central Bank of Nigeria (CBN) Statistical Bulletin (2024), National Bureau of Statistics (NBS) annual publications, World Bank Development Indicators (2024), and reports from the Energy Commission of Nigeria, covering the period 1986–2024. Additional data will be sourced from relevant government agencies and international energy databases where necessary to ensure completeness, reliability, and consistency of the variables used in the analysis.

### Model Specification

This study adopts an Autoregressive Distributed Lag (ARDL) modelling framework, consistent with previous empirical studies such as Adewuyi and Awodumi (2023), Uzonwanne (2025), and Sharma and Paul (2022), who employed similar dynamic models to examine the impact of energy consumption on industrial and economic performance. Guided by these empirical foundations, the functional relationship for this study is specified as:

$$IPI_t = f(TEC_t, ELCT_t, PPC_t) \dots\dots\dots 3.1$$

Where:  $IPI_t$  represents the Industrial Production Index,  $TEC_t$  denotes Total Energy Consumption,  $ELCT_t$  is Electricity Consumption, and  $PPC_t$  refers to Petroleum Product Consumption. Translating the functional form into an econometric model, the baseline linear specification is expressed as:

$$IPI_t = \beta_0 + \beta_1 TEC_t + \beta_2 ELCT_t + \beta_3 PPC_t + \mu_t \dots\dots\dots 3.2$$

Where  $\beta_0$  is the intercept,  $\beta_1$ – $\beta_3$  are the slope coefficients measuring the effect of each energy variable on industrial output, and  $\mu_t$  is the stochastic error term. This model will later be extended into an ARDL framework to capture both short-run and long-run dynamics.

### Estimation Procedure

The study employs a comprehensive econometric approach anchored on the Johansen cointegration framework and the Vector Error Correction Model (VECM) to analyse both short-run and long-run dynamics between energy consumption and industrial production in Nigeria. Stationarity of the series is assessed using the Augmented Dickey–Fuller (ADF) unit root test, applying the decision rule that a variable is stationary when its test statistic is greater than the critical value in absolute terms or when its p-value is below 0.05. The optimal lag structure is selected using the Akaike Information Criterion (AIC), with preference given to the specification that yields the lowest AIC value. Johansen’s cointegration test is then applied to determine the presence and number of cointegrating vectors among the variables, with cointegration confirmed when the trace or maximum eigenvalue statistic exceeds the

corresponding 5% critical value. Upon establishing cointegration, the VECM is estimated to capture both equilibrium adjustments and short-run dynamics, with the error correction term expected to be negative and statistically significant ( $p < 0.05$ ), thus confirming convergence toward the long-run equilibrium. All estimations and diagnostics are conducted using EViews or Stata to ensure the reliability, accuracy, and validity of the empirical results.

### Data Presentation

This section presents the data and preliminary analyses used to investigate the relationship between energy consumption and industrial production in Nigeria from 1986 to 2024. The dataset comprises four key macroeconomic indicators. The dependent variable is the Industrial Production Index (IPI), which measures changes in industrial activity and serves as a proxy for industrial performance. The independent variables capture major dimensions of Nigeria's energy use: Total Energy Consumption (TEC) representing aggregate national energy demand, Electricity Consumption (ELC) reflecting grid-based energy supply essential for manufacturing productivity, and Petroleum Product Consumption (PPC) which captures industries' reliance on refined petroleum products such as diesel and petrol. These variables together provide a comprehensive framework for assessing how energy consumption patterns influence industrial output over time. The dataset covers annual observations from 1986 to 2024, enabling a robust long-term evaluation of the energy-industry nexus in Nigeria.

## RESULT AND DISCUSSION

### Augmented Dickey-Fuller (ADF) Unit Root Test

Table 1. ADF Unit Root Test Results (5% Significance Level)

Variable	ADF Statistic	5% Critical Value	p-value	Order of Integration	Decision
IPI	0.272762	-2.941145	0.9737	I (1)	Not stationary at level; stationary at 1st difference
TEC	-1.209095	-2.941145	0.6605	I (1)	Not stationary at level; stationary at 1st difference
ELC	-0.357466	-2.941145	0.9064	I (1)	Not stationary at level; stationary at 1st difference
PPC	-1.395307	-2.941145	0.5744	I (1)	Not stationary at level; stationary at 1st difference

Source: Researcher's computation using EViews (2025)

Table 4.1 shows the Augmented Dickey-Fuller (ADF) unit root test results for all variables in the model at the 5% significance level. The results indicate that IPI, TEC, ELC, and PPC are all non-stationary at level, as their

ADF statistics fail to exceed the critical values in absolute terms and their p-values are above 0.05, leading to the acceptance of the null hypothesis of a unit root. However, after first differencing, all variables become stationary with highly significant ADF statistics ( $p < 0.01$ ), confirming that they are integrated of order one, I (1). This uniform I (1) behaviour of the variables satisfies the fundamental requirement for Johansen cointegration analysis, which mandates that all variables must be integrated of the same order. The absence of any I(2) variable ensures that the model is free from spurious regression risks and validates the appropriateness of applying the Johansen cointegration technique followed by a Vector Error Correction Model (VECM) to investigate both long-run equilibrium relationships and short-run adjustment dynamics among the variables.

**Data Analysis**

Table 2. Johansson Cointegration Result Output

Date: 11/18/25 Time: 04:02  
 Sample: 1986 2024  
 Included observations: 39  
 Lags interval (in first differences): 2 to 2  
 Endogenous variables: IPI TEC ELC PPC  
 Deterministic assumptions: Case 3 (Johansen-Hendry-Juselius):  
 Cointegrating  
 relationship includes a constant. Short-run dynamics include a constant.

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.** Critical Value
None *	0.664674	76.92944	47.85613	0.0000
At most 1 *	0.399887	37.59397	29.79707	0.0052
At most 2 *	0.264043	19.21102	15.49471	0.0131
At most 3 *	0.203124	8.174027	3.841465	0.0043

Trace test indicates 4 cointegrating equation(s) at the 0.05 level

\* Denotes rejection of the hypothesis at the 0.05 level

\*\*MacKinnon-Haug-Michelis (1999) p-values

Source: Researcher’s computation using EViews (2025)

Based on the results presented in Table 4.2, the Johansen cointegration test reveals a significant long-run equilibrium relationship among the variables. The trace test identifies four cointegrating equations at the 5% significance level, as the null hypothesis of no cointegration (None) is strongly rejected (Trace Statistic = 76.93 > 47.86 Critical Value,  $p=0.0000$ ), and this rejection continues sequentially for the hypotheses of at most one, two, and three cointegrating equations, with all p-values below 0.05. This confirms the existence of multiple stable long-run relationships between the Industrial Production Index (IPI),

Total Energy Production (TEC), Electricity Consumption (ELC), and Petroleum Product Consumption (PPC) over the study period. This robust finding validates the use of a Vector Error Correction Model (VECM) to further analyze both the long-run dynamics and the short-run adjustment mechanisms that bind these variables together.

**Vector Error Correction Model**

Table 3. Short Run Test

Vector Error Correction Estimates

Date: 11/18/25 Time: 04:06

Sample (adjusted): 1989 2024

Included observations: 36 after adjustments

Standard errors in () & t-statistics in []

Lags interval (in first differences): 1 to 2

Endogenous variables: IPI TEC ELC PPC

Deterministic assumptions: Case 3 (Johansen-Hendry-Juselius): Cointegrating

The relationship includes a constant. Short-run dynamics include a constant.

Cointegrating Eq:	CointEq1			
IPI (-1)	1.000000			
TEC (-1)	0.224640 (0.04268) [5.26298]			
ELC (-1)	-8.632101 (2.39944) [-3.59755]			
PPC (-1)	-8.009671 (1.41874) [-5.64562]			
C	1222.397			
Error Correction:	D(IPI)	D(TEC)	D(ELC)	D(PPC)
COINTEQ1	-0.155099 (0.04126) [-3.75945]	0.289452 (0.82433) [0.35114]	0.005686 (0.01287) [0.44165]	0.052286 (0.06820) [0.76671]
D (IPI (-1))	-0.327581 (0.18310) [-1.78911]	-5.906648 (3.65845) [-1.61452]	0.019830 (0.05714) [0.34705]	-0.306555 (0.30266) [-1.01287]
D (IPI (-2))	0.081890 (0.20722) [0.39519]	2.421352 (4.14039) [0.58481]	0.003497 (0.06467) [0.05408]	0.170913 (0.34253) [0.49897]
D (TEC (-1))	-0.069117	0.436315	-0.002256	-0.035043

	(0.03135)	(0.62646)	(0.00978)	(0.05183)
	[-2.20448]	[0.69648]	[-0.23061]	[-0.67615]
D (TEC (-2))	-0.064504	-0.026640	0.001565	0.016229
	(0.02826)	(0.56471)	(0.00882)	(0.04672)
	[-2.28232]	[-0.04717]	[0.17745]	[0.34739]
D (ELC (-1))	-7.881717	-2.123070	-0.093884	-3.025434
	(2.66958)	(53.3406)	(0.83308)	(4.41281)
	[-2.95242]	[-0.03980]	[-0.11269]	[-0.68560]
D (ELC (-2))	-3.005084	-10.44258	0.155531	1.601920
	(2.45038)	(48.9608)	(0.76468)	(4.05047)
	[-1.22638]	[-0.21328]	[0.20339]	[0.39549]
D (PPC (-1))	1.197907	-2.932179	0.019917	0.914118
	(0.66368)	(13.2609)	(0.20711)	(1.09706)
	[1.80495]	[-0.22111]	[0.09617]	[0.83324]
D (PPC (-2))	0.796267	-0.112287	-0.047881	-0.385571
	(0.54301)	(10.8498)	(0.16945)	(0.89759)
	[1.46641]	[-0.01035]	[-0.28256]	[-0.42956]
C	20.23677	101.3400	0.743793	5.517128
	(4.37108)	(87.3381)	(1.36406)	(7.22539)
	[4.62970]	[1.16032]	[0.54528]	[0.76358]
R-squared	0.443683	0.211429	0.099113	0.268997
Adj. R-squared	0.251112	-0.061538	-0.212733	0.015957
Sum sq. resids	850.8956	339709.1	82.86474	2324.996
S.E. equation	5.720730	114.3054	1.785247	9.456370
F-statistic	2.303993	0.774559	0.317826	1.063062
Log likelihood	-108.0117	-215.8237	-66.08822	-126.1050
Akaike AIC	6.556203	12.54576	4.227123	7.561387
Schwarz SC	6.996070	12.98562	4.666990	8.001254
Mean dependent	3.011111	122.9167	0.666389	3.611111
S.D. dependent	6.610631	110.9428	1.621122	9.532734
Determinant residual covariance (dof adj.)	660819.5			
Determinant residual covariance	179790.3			
Log likelihood	-422.1190			
Akaike information criterion	25.89550			
Schwarz criterion	27.83091			
Number of coefficients	44			

Source: Researcher's Computation using EViews (2025)

The Vector Error Correction Model estimates presented in Table 4.3 elucidate the short-run dynamics and the speed of adjustment back to the long-run equilibrium established by the cointegration test. The key finding is the statistically significant and negative error correction term (ECT) for the

industrial production (D(IPI)) equation, with a coefficient of -0.155 (p-value < 0.05). This confirms a valid long-run causal relationship, indicating that approximately 15.5% of any short-run deviation from the equilibrium is corrected within one year, driving industrial output back towards its long-run path. The long-run cointegrating equation itself reveals that Total Energy Production (TEC) has a significant positive relationship with IPI, whereas Electricity Consumption (ELC) and Petroleum Product Consumption (PPC) exhibit significant negative long-run coefficients, a finding that may reflect inefficiencies or structural issues within the energy sector. In the short run, industrial growth is negatively influenced by its own first lag and past changes in TEC and ELC, highlighting complex temporal interdependencies. The adjusted R-squared of 0.25 for the IPI equation suggests that the model accounts for a moderate portion of its short-run variation, while the insignificant ECTs in the other equations confirm that IPI is the adjusting variable in the system, bearing the burden of restoring equilibrium.

### Hypothesis Testing

1. Hypothesis 1 ( $H_{01}$ ): There is no significant long-run relationship between Total Energy Production (TEC) and the Industrial Production Index (IPI) in Nigeria.

The normalized cointegrating equation in Table 4.3 shows that the long-run coefficient for Total Energy Production (TEC) is 0.224640 with a t-statistic of [5.26298]. This highly significant value (p-value < 0.05) leads to the rejection of the null hypothesis. This confirms a statistically significant positive long-run relationship between total energy production and industrial output. The result indicates that a one-unit increase in total energy production (Quad Btu) is associated with an approximate 0.22-unit increase in the industrial production index in the long run, underscoring the critical role of domestic energy supply as a fundamental driver of industrial capacity and economic growth.

2. Hypothesis 2 ( $H_{02}$ ): There is no significant long-run relationship between Electricity Consumption (ELC) and the Industrial Production Index (IPI) in Nigeria.

As presented in the cointegrating equation of Table 4.3, the coefficient for Electricity Consumption (ELC) is -8.632101 with a t-statistic of [-3.59755], which is statistically significant at the 5% level. Therefore, we reject the null hypothesis. This reveals a significant but counterintuitive negative long-run relationship between electricity consumption and industrial production. While contrary to conventional expectation, this result may reflect profound structural inefficiencies within the power sector, such as high transmission losses, unreliable supply forcing industries to rely on costly self-generation, or a situation where increased electricity use does not translate into proportional productive output, thereby acting as a drag on industrial efficiency.

3. Hypothesis 3 ( $H_{03}$ ): There is no significant long-run relationship between Petroleum Product Consumption (PPC) and the Industrial Production Index (IPI) in Nigeria.

Table 4.3 indicates that the long-run coefficient for Petroleum Product Consumption (PPC) is -8.009671 with a t-statistic of [-5.64562], which is highly

significant. Consequently, we reject the null hypothesis. This establishes a statistically significant negative long-run relationship between petroleum product consumption and industrial performance. This finding potentially points to the adverse effects of Nigeria's reliance on imported refined products, including the heavy fiscal burden of subsidies, price volatility, and recurrent supply disruptions. These factors can increase operational costs for industries and divert national resources away from productive investment, thereby constraining industrial growth despite high fuel consumption.

The findings from the empirical analysis reveal a complex and nuanced relationship between energy consumption and industrial production in Nigeria, confirming the critical role of energy while also highlighting significant structural inefficiencies. The identification of a significant long-run cointegrating relationship among the variables affirms that industrial production, total energy supply, electricity consumption, and petroleum product consumption move together in equilibrium over time, as established by the Johansen test. This validates the central premise of the study that energy factors are fundamental to industrial performance. The long-run cointegrating equation provides the most critical insights. The significant positive relationship between Total Energy Production (TEC) and the Industrial Production Index (IPI) aligns with the Energy-Led Growth Hypothesis and empirical expectations (Adewuyi & Awodumi, 2023). This suggests that the aggregate availability of energy resources is a fundamental enabler of industrial activity in Nigeria. A robust domestic energy base provides the necessary foundation for scaling industrial output and supports the theoretical notion of energy as a primary factor in the production function. However, the significant negative long-run coefficients for both Electricity Consumption (ELC) and Petroleum Product Consumption (PPC) present a paradox that is central to understanding Nigeria's industrial challenges. The negative relationship with grid electricity consumption is not entirely unexpected given the well-documented inefficiencies in the power sector. This finding corroborates the views of Okoye and Udeh (2024) and Eze and Igwe (2024), who attribute this to erratic supply, high transmission losses, and the resulting high cost of self-generation. It implies that increased consumption from the national grid may be symptomatic of systemic inefficiencies rather than productive use, as industries are forced to consume more power to compensate for poor voltage and unreliable supply, thereby increasing costs without commensurate gains in output. Similarly, the negative long-run impact of Petroleum Product Consumption (PPC) underscores the severe burden that reliance on refined petroleum products places on the industrial sector. This finding resonates with Uzonwanne (2025), who noted adverse long-run effects due to rising costs. The removal of subsidies, reliance on expensive imported diesel and petrol for generators, and associated price volatility significantly increase production costs, eroding profitability and constraining expansion. This turns a potential input for growth into a drag on industrial performance. The short-run dynamics from the VECM further enrich this narrative. The significant and correctly signed error correction term for the IPI equation confirms that

industrial output bears the burden of adjustment to restore long-run equilibrium following a shock, with about 15.5% of the disequilibrium corrected annually. This moderate speed of adjustment indicates that the industrial sector is responsive but faces significant frictions in adapting to energy-related disruptions. The mixed and often negative short-run impacts of lagged energy variables suggest complex temporal interdependencies and adjustment costs that industries face in responding to changes in their energy inputs. In conclusion, the study demonstrates that while the overall quantity of energy (TEC) is a positive driver, the specific forms and efficiency of energy consumption (ELC and PPC) are critically important. The negative relationships for ELC and PPC are not indications that energy is unimportant, but rather powerful evidence of how structural failures, inefficiencies, and high costs in the energy sector have perverted its role from a driver of industry into a constraint. This underscores the urgent need for policies that not only increase energy production but, more importantly, address the fundamental issues of reliability, cost, and efficiency in Nigeria's energy supply chain to unlock the sector's potential for industrial transformation.

## CONCLUSIONS AND RECOMMENDATIONS

This study investigated the impact of energy consumption on industrial production in Nigeria from 1986 to 2024 using the Johansen cointegration technique and Vector Error Correction Model (VECM). The analysis yielded several critical findings: Total Energy Production (TEC) exhibited a positive and statistically significant long-run relationship with the Industrial Production Index (IPI). Conversely, Electricity Consumption (ELC) showed a significant negative long-run relationship with industrial production. Similarly, Petroleum Product Consumption (PPC) demonstrated a significant negative long-run impact, reflecting the cost burdens and supply chain disruptions associated with refined petroleum reliance. The short-run dynamics revealed a significant error correction mechanism, with industrial output adjusting to restore long-run equilibrium at a speed of 15.5% annually following shocks.

This study examined the impact of energy consumption on industrial production in Nigeria from 1986 to 2024. Motivated by the persistent underperformance of the industrial sector despite Nigeria's abundant energy resources, the research aimed to unravel how the availability, reliability, and cost of energy influence industrial output. Using the Johansen cointegration test and VECM, the study confirmed the existence of a long-run equilibrium relationship among the variables. The findings revealed that while aggregate energy production positively drives industrial performance, the effects of electricity and petroleum product consumption are paradoxically negative due to systemic inefficiencies, high costs, and unreliable supply. The study concludes that the quality, efficiency, and affordability of energy rather than mere consumption levels are critical determinants of industrial productivity. Addressing structural bottlenecks in the energy sector is, therefore, essential for harnessing Nigeria's industrial potential and achieving sustainable economic diversification.

Based on the findings, this study recommends that policymakers and government agencies, such as the Ministry of Power and the Energy Commission of Nigeria, prioritize investments in energy infrastructure to enhance the reliability and efficiency of electricity supply. This includes upgrading transmission networks, reducing technical and commercial losses, and incentivizing private sector participation in power generation and distribution.

Secondly, to mitigate the adverse effects of petroleum product consumption, the government should accelerate the refurbishment of domestic refineries and promote the use of alternative energy sources, such as natural gas and renewables, for industrial processes. Policies that stabilize fuel prices and ensure consistent supply will reduce production costs and enhance industrial competitiveness.

Lastly, industrial firms should adopt energy-efficient technologies and practices to optimize energy use and reduce dependence on expensive self-generation. Future research should explore the role of technological innovation, regulatory frameworks, and renewable energy integration in reshaping the energy-industry nexus in Nigeria.

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