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Research Article

The Role of Natural Gas in Driving Industrial Growth in Nigeria: An ARDL Approach

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Abstract

This study examines the impact of natural gas utilization on Nigeria's industrial sector, aligning with the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure). Using an Autoregressive Distributed Lag (ARDL) model, the research analyzes the short-run and long-run dynamics between industrial output (LOG_IND_OP), natural gas supply (LOG_NG_SD), GDP (LOG_GDP), and inflation (LOG_INF). The findings reveal a significant short-run relationship, where a 1% increase in natural gas supply boosts industrial output by 0.33%, while GDP has a stronger positive effect (0.9%). Inflation, however, shows no short-term impact. The bounds test indicates no long-run cointegration, though weak evidence suggests a potential 1.32% industrial growth from increased natural gas supply at a 10% significance level. The study highlights the crucial role of natural gas in Nigeria's industrial expansion, supporting energy transition theories and the Environmental Kuznets Curve (EKC) hypothesis, which posits that the adoption of cleaner energy can enhance industrial productivity while mitigating environmental degradation. Policy recommendations emphasize stabilizing natural gas supply, investing in infrastructure, and adopting adaptive industrial policies to sustain growth. The absence of long-run equilibrium highlights the need for agile strategies that align with Nigeria's energy transition goals, ensuring industrial resilience against external shocks while fostering sustainable development.

Keywords

Natural Gas, Industrial Growth, ARDL Model, SDGs, Energy Policy, Economic Growth

1. Introduction

Nigeria, one of Africa's largest economies and most populous nation, is endowed with substantial natural gas reserves, estimated at 206 trillion cubic feet (TCF), the ninth largest globally [1]. Despite this vast resource, the country's industrial sector remains underdeveloped, contributing only 23.4% to the GDP in 2022 [2], which is significantly lower than that of emerging economies like South Africa (28.5%) and Egypt (32.1%). This underperformance is largely attributed to chronic energy shortages, with industries relying on expensive and polluting diesel generators due to unreliable grid electricity [3, 4].

Natural gas presents a sustainable alternative, offering cleaner combustion than coal and oil, aligning with the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure). However, despite Nigeria's Gas Master Plan (2008) and the Decade of Gas Initiative (2021-2030), utilization remains suboptimal due to infra-

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structure deficits, policy inconsistencies, and gas flaring [5-7].

Nigeria's industrial sector faces three critical challenges that hinder its growth and productivity: energy poverty, gas flaring, and policy inconsistencies. Energy poverty remains a major constraint, as manufacturers struggle with unreliable grid electricity. According to the Manufacturers Association of Nigeria [8], over 60% of manufacturing firms rely on self-generated power, primarily from diesel generators, which significantly increases operational costs and reduces competitiveness. This reliance on alternative power sources underscores the urgent need for improved energy infrastructure [9, 10].

Another pressing issue is gas flaring, which not only wastes valuable resources but also exacerbates environmental degradation. The Global Gas Flaring Reduction Partnership (GGFR, 2023) [11] reports that Nigeria flares approximately 7.4 billion cubic meters of gas annually, depriving the industrial sector of a cheaper and cleaner energy source. This waste gas could otherwise be harnessed to power industries, reduce production costs, and lower carbon emissions [12, 13].

Furthermore, policy inconsistencies have created an unstable business environment for the utilization of gas. Frequent changes in gas pricing regulations and inadequate infrastructure investment have discouraged private sector participation [14]. The lack of a coherent policy framework has also delayed critical gas pipeline projects, limiting industrial access to natural gas [15]. Addressing these challenges requires a multi-faceted approach, including regulatory reforms, infrastructure development, and incentives for gas-to-power initiatives [16, 17].

While the significance of natural gas utilization for industrial development and the constraints posed by accessibility and availability are well recognized, a clear literature gap remains in the area of sector-specific empirical analyses, particularly regarding the industrial sector in Nigeria. Most existing studies have explored the broader relationship between energy consumption and economic growth, often aggregating various energy sources without isolating the unique role of natural gas. For instance, [18, 19] primarily investigates energy consumption and its macroeconomic implications, with limited focus on industrial gas use. Similarly, [20] provides a comprehensive overview of gas production and utilization in Nigeria but does not disaggregate the sectoral impacts. [21] analyze gas production's contribution to economic growth but fall short of isolating industrial usage effects. Earlier works, such as [22, 23], employ the ARDL approach to establish a positive long-run relationship between natural gas consumption and GDP; however, these studies do not provide insights at the sectoral (industrial) level.

More recent studies, such as [24], explored the nexus between gas supply, pricing, taxation, and economic growth, emphasizing structural constraints in the gas market but not providing disaggregated evidence relevant to industrial uptake. Similarly, [25] established a positive linkage between overall energy consumption and GDP but treated energy as a composite variable, thereby masking the unique contribution of natural gas to industrial output.

Although studies like [26] have examined the impact of natural gas on Nigeria's economic growth and confirmed its significance, their findings are framed at the national level, with no focus on how gas consumption drives sectoral productivity, especially in the industry sector. [27] addressed optimization strategies in gas utilization. They highlighted infrastructural and regulatory challenges, but their analysis remained cross-sectoral and did not provide empirical evidence specific to the industrial sector. Additionally, while [28] applied the ARDL approach to analyze the effect of natural gas utilization on Nigeria's power sector, no comparable methodological investigation has yet focused on the industrial sector.

This persistent gap in the literature underscores the need for empirical research that directly evaluates the relationship between natural gas utilization and industrial growth in Nigeria. Such an approach not only strengthens the policy relevance of gas-sector studies but also aligns with current national priorities around energy transition and industrial development. Accordingly, this study adopts the ARDL model to fill this gap by providing a sector-focused empirical analysis of the role of natural gas in driving industrial growth in Nigeria.

This study investigates the impacts of natural gas utilization on industrial output in Nigeria, employing the Autoregressive Distributed Lag (ARDL) model to examine the short- and long-run relationship. The study's objectives include assessing the short- and long-term effects of natural gas usage in the industrial sector, as well as the economic implications of increased gas utilization. The findings revealed that industrial output has a significant and positive relationship in the short term, as the bound test indicated no co-integration at the 5% level. However, the F-stat proximity to the 10% lower bound suggests weak evidence of a long-run relationship, based on this outcome, policy recommendations include focusing on short-term measures that can adapt to changes in energy supply and economic conditions, as well as promoting technological innovation and diversification, which can help create more sustainable industrial growth.

The study is built on Endogenous Growth Theory [29] which posits that energy infrastructure (e.g., gas pipelines) enhances industrial productivity, the Environmental Kuznets Curve (EKC) states that gas adoption can reduce industrial emissions while sustaining growth [30] and the Energy Economics Models which stipulates that stable energy supply reduces production costs [31].

The research advocates gas-to-industry policies aligned with SDGs 7 and 9, advances ARDL applications in energy-industrial studies, and guides firms on gas-based energy transition strategies.

2. Materials and Methods

2.1. Materials

This study analyzes empirical findings derived from secondary annual time-series data obtained from various online databases. Information pertaining to Nigeria's domestic natural gas production, distribution (including exports and local supply), was extracted from the International Energy Agency (IEA). Additionally, industrial output and macroeconomic indicators such as gross domestic product (GDP), inflation rates, and unemployment figures were retrieved from the World Bank on the Macrotrends online platform. Prior to analysis, the collected data were standardized to ensure consistency in variable units and compatibility with EViews software for further processing. Links for research data used and data sources are provided in the Supplementary Materials Section.

2.2. Time Series Analytical Model

This study employs the Autoregressive Distributed Lag (ARDL) Model, a robust cointegration technique suitable for analyzing variables with mixed integration orders, stationary at the level (I(0)) or first difference (I(1)) [32]. The methodology entails estimating both long-run and short-run dynamics through Equations (1) and (2), while adhering to ARDL model assumptions, including diagnostic checks for residual properties and stability. Upon confirming cointegration, the long-run coefficients are derived using the ARDL framework specified in Equation (1)

$$I_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i P_{t-i} + \sum_{j=0}^{q} \beta_j G_{t-j} + \sum_{k=0}^{r} \gamma_k X_{t-k} + \epsilon_t \quad (1)$$

Where:

1) I_t (Industrial sector Output) is the dependent variable.
2) G_t (Natural Gas Utilization) is the independent variable
3) X_t Represents control variables (GDP and Inflation).
4) $I_{t-\mathrm{i}}, G_{t-j}$ & $X_{t-\mathrm{k}}$ represents the variables lagged by $(\mathrm{i}, j$ & $k)$ Periods.
5) (α_i), (β_j) and (γ_k) are the coefficients of the lagged dependent and independent variables, respectively.
6) (ϵ_t) is the error term.

The Error Correction Model (ECM) is estimated to capture the short-run dynamics and speed of adjustment towards long-run equilibrium. This is given by equation (2).

$$\Delta P_t = \lambda_0 + \sum_{i=1}^{p-1} \lambda_i \Delta P_{t-i} + \sum_{j=0}^{q-1} \delta_j \Delta G_{t-j} + \sum_{k=0}^{r-1} \theta_k \Delta X_{t-k} + \phi ECT_{t-1} + \epsilon_t \quad (2)$$

Where ECT_{t-1} is the error correction term derived from the long-run relationship.

The research variables comprise Industrial Sector Output (I_t) proxied by Industrial Output (IND_OP) in US$ (billion) as the dependent variable, Domestic Natural Gas Utilization (G_t) proxied by Natural Gas Supply (NG_SD) in trillion standard cubic feet (Tscf) as the independent variable and the control variable (X_t) Including relevant variables that may impact the dependent variables, such as economic growth (GDP – US$ Billion) and inflation (INF) in percentage terms.

2.3. Methodology

This study examines annual time-series data spanning 2000 to 2022, applying the Autoregressive Distributed Lag (ARDL) model to assess both short-term and long-term impacts of natural gas utilization within Nigeria's industrial sector. The analytical procedure began by clearly defining the research aim, scope, and objectives, followed by data processing and refinement. Descriptive statistics were then computed to summarize key characteristics of the variables, including measures of central tendency (mean, median), dispersion, and distributional properties (skewness, kurtosis, and normality tests). Time-series plots were subsequently generated to visualize trends and potential correlations among variables. Finally, econometric techniques were implemented to empirically evaluate and quantify the influence of natural gas utilization on power sector performance. All statistical and econometric analyses were conducted using EViews 12.0 software.

3. Results

3.1. Descriptive Statistics

From Table 1, the descriptive statistics for the variables NG_SD, GDP, IND_OP, and INF reveal moderate variability and general symmetry across the dataset of 23 observations. Mean values range from 12.63 (INF) to 333.05 (GDP), with GDP showing the highest standard deviation (156.99), indicating notable economic fluctuations. All variables display near-normal skewness and platykurtic distributions, with kurtosis values below 3. The Jarque-Bera test results confirm normality for all series, with p-values exceeding 0.05, supporting the assumption of normal distribution. These characteristics suggest the dataset is suitable for time series modeling using the ARDL approach. However, given the observed variability, especially in GDP and IND_OP, stationarity tests are necessary to determine the integration order of the variables before applying the ARDL bounds test for co-integration. Overall, the descriptive results indicate that the data quality is sufficient for further econometric analysis, supporting the application of the ARDL methodology in examining the long-run relationships among the variables.

Table 1. Descriptive Statistic Result.

Descriptive Statistics	NG_SD	GDP	IND_OP	INF
Mean	166.8296	333.0534	32.87435	12.62557
Median	178.5100	375.7457	29.72175	12.53780
Maximum	260.9300	574.1838	64.40968	18.87360
Minimum	74.00000	69.17145	9.637935	5.388000
Std. Dev.	55.18395	156.9997	17.59244	3.809059
Skewness	-0.109850	-0.450042	0.372230	-0.047953
Kurtosis	1.868292	1.895209	1.927141	2.158512
Jarque-Bera	1.273654	1.946103	1.634195	0.687412
Probability	0.528968	0.377928	0.441712	0.709137
Sum	3837.080	7660.228	756.1101	290.3882
Sum Sq. Dev.	66995.91	542275.7	6808.867	319.1964
Observations	23	23	23	23

NOTE: ***, ** and * indicate significance at 1%, 5% and 10% level of significance.

3.2. Time Series Plot

The time-series graph of Figure 1 illustrates the trends in domestic natural gas supply (NG_SD), GDP, industrial output (IND_OP), and inflation (INF) from 2000 to 2022, with major global events highlighted. During the 2008 Global Financial Crisis (green zone), GDP and industrial output experienced a downturn, while inflation spiked slightly. Post-crisis recovery is evident, peaking around 2014. However, the period between 2014 and 2016 (purple zone), marked by a global oil supply surge and U.S. shale production boom, shows a sharp decline in GDP and industrial output, suggesting economic vulnerability to global energy shocks. The blue-shaded area reflects the COVID-19 pandemic era (2020–2022), during which GDP and industrial output gradually recovered, while inflation remained relatively stable. Throughout the period, the domestic natural gas supply shows a steady upward trend, largely unaffected by global disruptions. This trend underscores the growing importance and resilience of natural gas in the domestic energy mix, despite macroeconomic and geopolitical shocks.

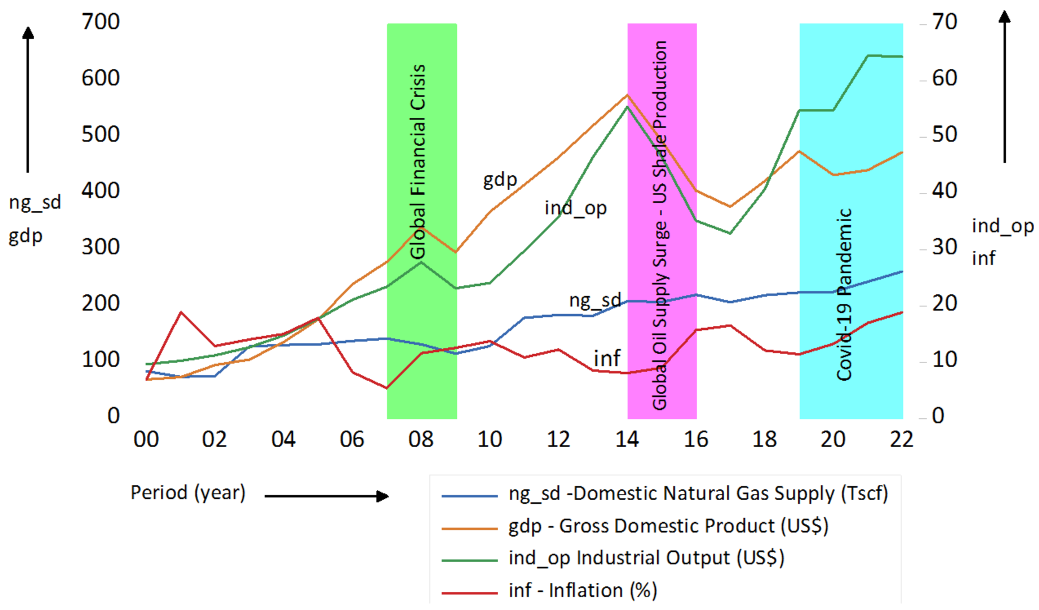

Figure 1. Correlation between Natural Gas Supply and Key Macroeconomic Variables.

3.3. Stationarity Consideration & Lag Length Selection

The stationarity analysis using the Augmented Dickey-Fuller (ADF) test indicated that the examined variables exhibit a combination of integration orders, with some stationary at level I(0) and others at first difference I(1). Furthermore, the optimal lag structure determination using the Unrestricted Vector Autoregressive (UVAR) Lag Length Selection Criteria suggested appropriate lag lengths of 1 and 2 for the model variables, as presented in Table 2.

Table 2. *ADF - Unit Root Test and Lag Length Selection Results.*

S/N	Variables	ADF Unit Root Test Result	Order of Integration	Optimal Lag Length
1	NG_SD	NG_SD is only stationary at 1st Diff @ C & C&T only	Order of integration is 1, I(1)	1
2	GDP	GDP is only stationary at 1st Diff @ C only	Order of integration is 1, I(1)	1
3	IND_OP	IND_OP is stationary at Level @ C&T and 1st Diff @ C only	Integration Order is 0, I(0)	2
4	INF	INF is stationary at 1st Diff @ C and C&T only	Order of integration is 1, I(1)	1

Note: C – Intercept; C & T - Intercept & Trend

3.4. ARDL Model Specification

The ARDL model examines short-run and long-run relationships. The model is given by the function in equation (3)

$$\text{LOG\_IND\_OP(t)) = f(LOG \_NG\_SD(t), LOG \_GDP(t), LOG \_INF(t))} \quad (3)$$

From equation (3), the ARDL Model is given by equation (4)

$$LOG\_IND\_OP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i LOG\_IND\_OP_{t-i} + \sum_{j=0}^{q_1} \beta_{1_j} LOG\_NG\_SD_{t-j} + \sum_{j=0}^{q_2} \beta_{2_j} LOG\_GDP_{t-j} + \sum_{j=0}^{q_3} \beta_{3_j} LOG\_INF_{t-j} + \epsilon_t \quad (4)$$

The bound test results in Table 3 indicated no co-integration, implying the absence of long-run relationships since the F-statistic (2.750743) < the lower bound I(0) (2.79), equally, R-squared (0.98) and Adj. R-squared (0.97) explains 98% and 97% variability in LOG_IND_OP by the independent variable, indicating an excellent fit. Equally, from the model parameter fitness results, the F-statistic (138.76) is significant at the 1% level, meaning the independent variables have a strong impact on LOG_IND_OP. The Durbin-Watson Stat. (1.6732) value is close to 2, suggesting no significant autocorrelation in the residuals.

From Table 4, the intercept value of -1.8090 in the ARDL model represents the baseline level of industrial output (LOG_IND_OP) when all independent variables (LOG_NG_SD, LOG_GDP, LOG_INF) are held at zero. This negative intercept implies that, in the absence of natural gas supply, GDP, and inflation, short-run industrial output would be negative. This highlights a high dependency on macroeconomic factors and suggests underlying structural weaknesses in the economy.

In the short run, the coefficients of the logged independent variables indicate their immediate impacts on industrial output. LOG_NG_SD (0.3309) and LOG_GDP (0.9004) are both positive and statistically significant, suggesting that a 1% increase in natural gas supply or GDP increases industrial output by 0.33% and 0.90%, respectively. Conversely, LOG_INF (0.0224) is statistically insignificant, indicating that inflation does not exert a meaningful short-run effect.

Regarding long-run dynamics, the co-integration test result (F-statistic = 2.7507) falls just below the I(0) critical value (2.79), indicating no statistically significant long-run relationship at the 5% level. However, its proximity to the 10% lower bound (2.618) suggests weak evidence of a long-run relationship. The long-run coefficients indicate that LOG_NG_SD (1.3192) is positive and weakly significant at the 10% level, while LOG_GDP (0.6178) is positive and significant at the 5% level, suggesting sustained positive effects. LOG_INF (0.0891), though positive, remains statistically insignificant.

The error correction term (-0.2508) is negative and significant, confirming that about 25% of short-run disequilibrium is corrected each period, reflecting a gradual adjustment toward long-run equilibrium.

Table 3. *Bound Test and Model Fitness Result.*

Bound Test **Null Hypothesis (H_0): No Co-integration**			
F-Stat Value	**Signif. Level**	**Lower Bound I(0)**	**Upper Bound I(1)**
2.750743	10%	2.37	3.2
	5%	2.79	3.67
	2.5%	3.15	4.08
	1%	3.65	4.66

Model Parameter and Fitness Result			
R-Sqd	**Adj. R-Sqd**	**F-Stats**	**D-W Stat.**
0.9835	0.9764	138.7592***	1.6732

Note:
1) D-W Stat: Durbin-Watson Statistics; F-Stat: F-Statistics.
2) F-Stat (2.7507) < I(0) (2.79), implies no co-integration exists.
3) ***, ** and * indicate significance at 1%, 5% and 10% level of significance.

Table 4. *ARDL Model Analysis Test Result.*

Model	**Variable**	**Coefficient**	**t-Statistic**	**Prob.***
S-R	LOG_IND_OP(-1)	1.018589	6.668280	0.0000
	LOG_IND_OP(-2)	-0.269437	-1.843715	0.0865
	LOG_NG_SD	0.330928	2.557052	0.0228
	LOG_GDP	0.900369	4.960036	0.0002
	LOG_GDP(-1)	-0.745395	-3.692378	0.0024
	LOG_INF	0.022358	0.282224	0.7819
	C	-1.809017	-3.233283	0.0060
L-R	LOG_NG_SD	1.319239	2.108820	0.0535
	LOG_GDP	0.617800	2.331402	0.0352
	LOG_INF	0.089131	0.294946	0.7724
	C	-7.211605	-2.682658	0.0179

Note: L.R – Long Run; S.R – Short Run; C – Constant (Intercept); (-1) – Coefficient of the lag 1; (-2) – Coefficient of the lag 2; prob* - Probability (p-value)

3.5. Residual Diagnostic Results

The results presented in Table 5 and the histogram normality plot in Figure 2 show a Jarque-Bera statistic of 0.8260, with an associated p-value of 0.6617, which exceeds the 0.05 threshold. This confirms that the model residuals follow a normal distribution. Furthermore, the Breusch-Godfrey Serial Correlation LM test (Obs*R-squared = 0.2168; p-value = 0.8973) also exceeds the 0.05 significance level, indicating the absence of serial correlation in the residuals. Additionally, the Breusch-Pagan-Godfrey test for heteroskedasticity yields an Obs*R-squared value of 10.5484 and a p-value of 0.1034, suggesting that the residuals are homoscedastic. Collectively, these diagnostic tests support the validity of the model's assumptions, confirming that the residuals are normally distributed, free from serial correlation, and exhibit constant variance.

Table 5. Residual Diagnostic Test Results.

	Histogram Normality Test Jaeque Bera (Prob)	Breusch-Godfrey Serial Correlation LM Test: Obs*R-sqd (Prob)	Heteroskedasticity Test Obs*R-sqd (prob)
Results	0.8260 (0.6617)	0.216808 (0.8973)	10.54839 (0.1034)

Note:
1) Histogram Normality - Null hypothesis: Residuals are normally distributed
2) Serial Correlation LM Test – Null hypothesis: No serial correlation
3) Heteroskedasticity Test - Null hypothesis: Homoskedasticity
4) Prob = Probability = value in parenthesis = p-value
5) If the p-value < 0.05, we reject null hypothesis
6) If the p-value > 0.05, we cannot reject null hypothesis

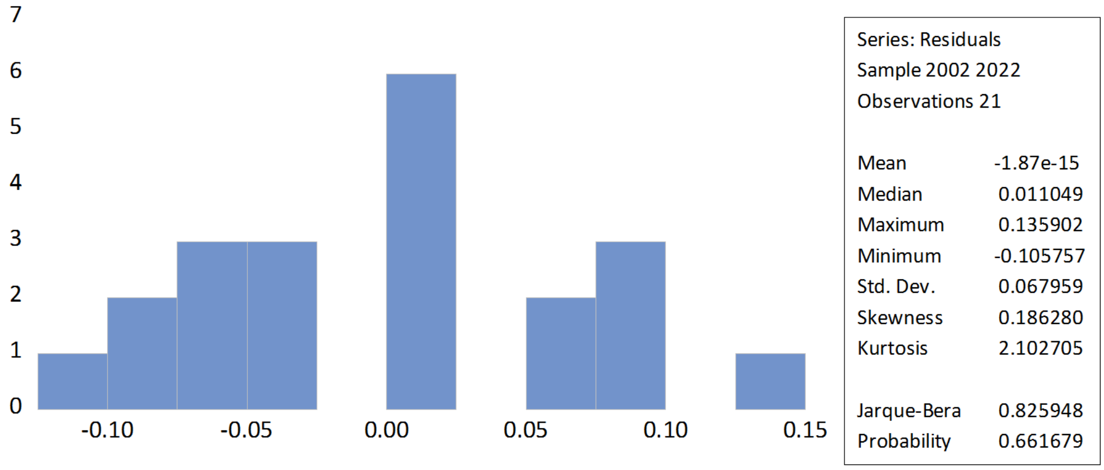

Figure 2. Histogram Normality Plot.

3.6. Stability Diagnostics

The stability tests include the CUSUM of Square (CUSUMSQ) Test and the CUSUM Test.

The CUSUMSQ line, as shown in Figure 3, falls entirely within the 5% significance bounds throughout the sample period (2009-2022), indicating no evidence of structural breaks or instability in the model parameters during this period. Hence, the CUSUMSQ line plot indicated that the model is stable, with no significant structural changes or breaks in the relationship between the variables from 2017 to 2022.

The CUSUM test results presented in Figure 4 demonstrate that the cumulative sum of recursive residuals remains within the 5% critical boundaries across the entire observation period (2009-2022). This graphical evidence suggests the absence of significant structural changes or parameter instability in the estimated model. The stability test outcomes confirm that the regression coefficients remain consistent over time, thereby validating the reliability of the model specification for the studied timeframe.

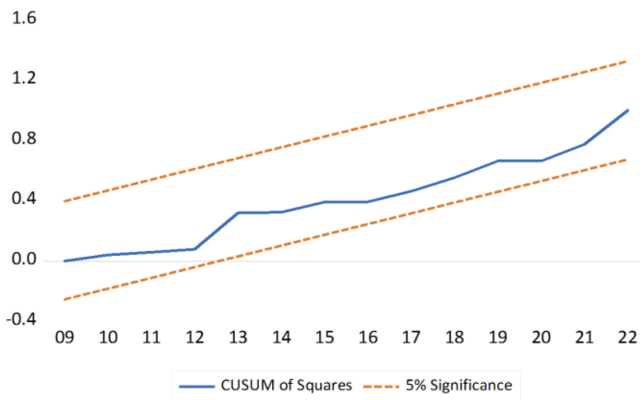

Figure 3. CUSUM of Square Test Plot.

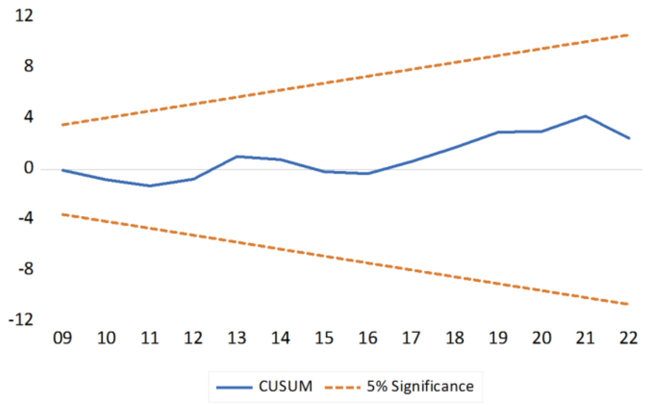

Figure 4. CUSUM Test Plot.

4. Discussions

The ARDL model results reveal strong short-run dynamics with industrial output (LOG_IND_OP) significantly influenced by natural gas supply (LOG_NG_SD) and GDP (LOG_GDP), while inflation (LOG_INF) remains statistically insignificant. The high R-squared (0.98) and adjusted R-squared (0.97) values indicate that the independent variables explain a substantial proportion of the variation in industrial output. The model also passes diagnostic tests, confirming normality, absence of serial correlation, and homoscedasticity in the residuals. Although the F-statistics from the bounds test (2.7507) falls just below the 5% lower bound, its proximity to the 10% threshold suggests weak evidence of a long-run relationship. Long-run coefficients support this, with GDP and natural gas supply having positive effects on output; however, only GDP is statistically significant at the 5% level. The negative and significant error correction term (-0.2508) implies that the system corrects deviations from equilibrium at a rate of 25% per period. Overall, the model reflects a robust short-run relationship with limited long-run linkages, highlighting the importance of energy supply and macroeconomic performance in sustaining industrial growth in the short term.

4.1. Effect of Control Variables on the Result

In the ARDL model, the control variables GDP (LOG_GDP) and inflation (LOG_INF) exert varying influences on industrial output. LOG_NG_SD and LOG_GDP emerged as key short-run determinants, with coefficients of 0.3309 and 0.9004, respectively, both of which are statistically significant. This indicates that a 1% increase in either variable boosts industrial output by 0.33% and 0.90%, respectively, underscoring the critical role of energy availability and economic expansion in short-term industrial performance. Conversely, inflation (LOG_INF) exhibits a positive but statistically insignificant short-run coefficient (0.0224), indicating a limited or no immediate impact. In the long run, LOG_GDP remains positively significant (0.6178), affirming GDP's sustained influence on output, while LOG_NG_SD (1.3192) is only weakly significant at the 10% level. Inflation remains statistically insignificant in the long run as well. These results indicate that while energy and economic growth are crucial for both short- and long-term industrial performance, inflationary trends do not significantly constrain or drive output, possibly due to effective inflation management or cost pass-through mechanisms within the sector.

4.2. Comparison with Existing Literature

The findings of this study align with previous empirical evidence that highlight the importance of energy supply and macroeconomic indicators in determining industrial output performance. [33] found a strong positive relationship between energy consumption and industrial output in Nigeria, highlighting the pivotal role of energy access in driving industrial growth. Similarly, [34] confirmed that electricity consumption has a positive influence on economic growth, which indirectly supports increased industrial activity, in line with this study's short-run and weak long-run effects of natural gas supply on output.

A study reinforced this perspective, establishing a significant link between electricity consumption and economic performance in Nigeria, echoing the importance of energy variables observed in the current analysis [35]. Moreover, the observed insignificance of inflation in influencing industrial output aligns with the findings of [19], who argue that inflation's impact may be muted due to structural adjustments or inflation-targeting policies.

Conversely, while [36] identified a strong causal relationship between energy consumption and economic growth, their study reported a more apparent long-run association than is observed here. This divergence may stem from differences in model specifications or the periods considered. Nonetheless, the consensus across these studies confirms that energy supply and macroeconomic growth are integral to Nigeria's industrial expansion.

4.3. Impact of Global Crisis on Results

The analysis, covering 2009–2022, captures the influence of major global crises, including the post-2008 financial recovery, the 2014–2016 oil price crash, and the COVID-19 pandemic. These events introduced volatility into key macroeconomic indicators such as GDP, inflation, and energy supply, all of which significantly affect industrial output. Notably, the COVID-19 pandemic led to global supply chain disruptions and reduced energy demand. However, the CUSUM and CUSUMSQ tests confirm no structural breaks, indicating the model's parameters remained stable despite these shocks.

The absence of long-run co-integration may reflect the disruptive and lingering effects of these crises, which likely distorted equilibrium relationships, delayed investment responses, and altered industrial behavior. The relatively weak significance of long-run gas supply effects, in contrast to strong short-run responsiveness, suggests that global crises primarily impacted short-term industrial dynamics. Nevertheless, the model's robustness, demonstrated by excellent fit statistics, stable residuals, and gradual error correction, highlights the sector's adaptive capacity. Overall, global crises influenced industrial output volatility but did not undermine the structural stability of the model or the resilience of the industrial sector during the study period.

5. Conclusions

This study, titled "The Role of Natural Gas in Driving Industrial Growth in Nigeria: An ARDL Approach," examined the impact of natural gas utilization (proxied by natural gas supply) on industrial output using time series data and the ARDL methodology. The findings indicate that, in the short run, both natural gas supply and GDP have a significant and positive influence on industrial output, while inflation exerts no meaningful impact. Although the bounds test suggests no firm evidence of a long-run co-integration relationship at the 5% level, weak support for long-run association is observed at the 10% level. Long-run coefficients further affirm the positive influence of natural gas and GDP on industrial output. The error correction mechanism confirms that approximately 25% of deviations from equilibrium are corrected each period, signaling a moderate speed of adjustment toward long-run equilibrium. Diagnostic tests confirmed that the model is robust, stable, and free from serial correlation, heteroskedasticity, and structural instability. These results underscore the strategic role of natural gas as a critical driver of Nigeria's industrial development. A key contribution of this study lies in its empirical validation of natural gas as a viable energy resource for industrial growth in Nigeria, aligning with the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure). However, a major limitation is the exclusion of other potential determinants of industrial development, such as exchange rate volatility, foreign investment, or policy variables. The paper recommends that the government invest in natural gas infrastructure, encourage private sector participation, provide tax incentives for the use of natural gas to enhance industrial productivity, and ensure macroeconomic stability to sustain and promote industrial growth. Future research should incorporate broader variables and sector-specific dynamics for deeper insights.

Abbreviations

1st Diff	First Difference
ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
C	Intercept
C & T	Intercept & Trend
COVID-19	Coronavirus 2019 Pandemic
CUSUM	Cumulative Sum
CUSUMSQ	Cumulative Sum of Squares
ECM	Error Correction Model
EKC	Environmental Kuznets Curve
GDP	Gross Domestic Product
GGFR	Global Gas Flaring Reduction Partnership
IEA	International Energy Agency
IND_OP	Industrial Output
INF	Inflation
LOG	Natural Logarithms
L-R	Long – Run
MAN	Manufacturer Association of Nigeria
NG_SD	Domestic Natural Gas Supply
NNPC	Nigerian National Petroleum Company Limited
Prob*	Probability (p-value)
SDG	Sustainable Development Goal (United Nations)
S-R	Short Run
Stat	Statistics
TCF	Trillion Cubic Feet
TSCF	Trillion Standard Cubic Feet
US	United States
UVAR	Unrestricted Vector Autoregressive

Supplementary Material

The supplementary material can be accessed at https://doi.org/10.11648/j.jenr.20251403.11

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Author Contributions

Ugbede Mathew Oduka is the sole author. The author read and approved the final manuscript.

Data Availability Statement

The data for this paper is available in the supplementary material link provided.

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Conflicts of Interest

The author declares no conflicts of interest.

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Biography

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