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Infrastructure, Industrial Growth and Social Inclusion: An ARDL Cointegration Analysis of Nigeria

By
Joseph Nwabueze AMAEFULE Ph.D
McPherson University, Seriki Sotayo, Abeokuta, Nigeria
Department of Economics
https://orcid.org/0000-0001-7451-6905
amaefulejn@mcu.edu.ng; josephamaefule@gmail.com

&

Oluwatosin Adeola ABIOLA-BOLADE Ph.D

Babcock University, Ilisan Remo, Ogun State, Nigeria
Department of Economics
https://orcid.org/0009-0003-6723-8216
Adeleyeol@babcock.edu.ng; omolayo1933@gmail.com

Abstract

Understanding the dynamic relationship between infrastructure, industrial performance, and inclusive development remains a central concern in contemporary development economics. In many emerging economies, infrastructure investment is widely recognised as a key driver of productivity growth, structural transformation, and improved welfare. However, evidence on how infrastructural development simultaneously shapes industrial expansion and social inclusion remains limited, particularly within country-specific time-series contexts. This study provides an econometric assessment of the infrastructure–development nexus using a dynamic modelling approach. It applies the Autoregressive Distributed Lag (ARDL) cointegration framework to examine both short-run and long-run relationships among infrastructural development, manufacturing performance, and social inclusion. Nigeria offers a compelling case due to persistent infrastructure deficits, uneven industrial performance, and enduring social inequality. Using annual data from 1990 to 2023, the study evaluates how infrastructure influences manufacturing value added and inclusive development through dynamic adjustment mechanisms.

Keywords: Infrastructural Development, Industrial Growth, Social Inclusion, Economic Pathways

JEL Classification: O18, O14, I31, O10.

1. Introduction

Many developing economies face the urgent task of revitalizing industrial growth as a strategy for long-term economic transformation. Over the years, the reliance on commodity exports, coupled with a weak manufacturing base, has constrained value addition, reduced employment prospects, and exposed economies to external shocks (Olayemi, 2022). The industrial sector in several countries has struggled to expand due to structural inefficiencies, insufficient investment, and the absence of supporting systems that can enhance competitiveness (Mensah & Adom, 2020). These challenges have delayed the transition toward economies that are more diversified and resilient, weakening efforts to generate stable jobs and build domestic productive capacity (Adegbite, 2023).

Efforts to redirect economic pathways through industrialization have gained renewed attention, particularly in response to the volatility of global markets and the limits of resource-based growth (Khan & Roy, 2021). While strategies have been introduced to stimulate local production, attract investment, and support small and medium-scale enterprises, progress has often been uneven (Okonkwo & Bello, 2022). One major constraint has been the lack of essential infrastructure to support industrial activities. Without reliable energy, efficient transport systems, and logistics networks, industries remain limited in scale and output. Consequently, industrial growth remains slow, and many economies continue to underperform relative to their potential (Abiodun, 2020).

Addressing the weaknesses in economic structure also requires attention to the unequal distribution of development outcomes. In many countries, economic gains have not translated into broad-based improvements in living conditions or access to opportunities. High levels of unemployment, especially among youth and women, persist alongside urban-rural disparities and widespread poverty (Eze & Chukwu, 2021). These inequalities present serious risks to social cohesion and economic stability. Programs aimed at economic reform have not always succeeded in reaching vulnerable populations, creating gaps in participation and benefits that continue to widen (Akinyemi, 2024).

In Nigeria, these development challenges are especially pronounced. While the country has recorded episodes of economic growth, the benefits have not been evenly distributed across its population (Adegbite, 2023). Millions of Nigerians, particularly in rural and underserved regions, continue to experience limited access to quality education, healthcare, employment opportunities, and basic infrastructure (Eze & Chukwu, 2021). Unemployment and underemployment rates remain high, particularly among young people and women, and significant regional disparities persist between the north and the south (Akinyemi, 2024). These gaps have contributed to persistent poverty, insecurity, and weakened national cohesion.

The country's infrastructure deficit has contributed significantly to these outcomes. Poor road networks, unreliable electricity, inadequate water supply, and limited digital connectivity have left many communities disconnected from markets, institutions, and social services (Okonkwo & Bello, 2022). These deficits have widened socio-economic exclusion and constrained the potential of individuals and businesses to contribute to national development (Abiodun, 2020). Without deliberate and inclusive investment in infrastructure, efforts to reduce poverty and promote equitable growth will remain insufficient (Olayemi, 2022).

Within this context, infrastructural development emerges as a vital strategy for reshaping Nigeria's economic pathways. Strategic investments in transport, energy, water, and ICT can improve industrial performance while also expanding access to essential services for marginalized populations (Okonkwo & Bello, 2022). Infrastructure that connects rural areas to urban centers can reduce regional inequalities, open up new economic opportunities, and enhance national productivity (Abiodun, 2020). The dual role of infrastructure in advancing both industrial growth and social inclusion makes it a powerful tool for building a more resilient and inclusive Nigerian economy (Khan & Roy, 2021).

This study, therefore, seeks to examine how infrastructural development can serve as a catalyst for industrial growth and social inclusion in Nigeria. By exploring the interconnections between infrastructure investment, industrial transformation, and equitable access to opportunities, the research aims to inform policies and practices that support sustainable, inclusive, and broad-based national development.

2. Literature Review

2.1 Conceptual Review

Khan and Roy (2021) describe reshaping economic pathways as a strategic reconfiguration of development models to support sustainability, resilience, and inclusive progress. This process involves shifting from resource-dependent and consumption-led patterns of growth to structures that emphasize innovation, productivity, and social equity. Adegbite (2023) adds that such transformation requires institutional reform and targeted investments that address long-standing structural imbalances, especially in developing economies where economic vulnerability is often systemic.

Industrial growth, according to Olayemi (2022), represents the expansion of manufacturing and industrial activity that adds value to raw materials, increases productivity, and contributes to national economic diversification. It is widely viewed as a driver of employment generation, technology transfer, and international competitiveness. Mensah and Adom (2020) further argue that sustainable industrial growth must be rooted in coherent industrial policy, infrastructure development, and the promotion of technological capabilities that empower local firms to participate effectively in both domestic and global value chains.

Social inclusion, as explained by Eze and Chukwu (2021), refers to the integration of marginalized and disadvantaged populations into the economic, political, and social systems of a country. This involves removing structural barriers that hinder equitable access to opportunities, services, and decision-making processes. Akinyemi (2024) emphasizes that social inclusion is not just about addressing poverty but also about ensuring equal participation in development processes, thereby enhancing the capabilities of all citizens to contribute meaningfully to national progress.

Infrastructural development underpins all these processes by enabling mobility, communication, production, and service delivery. Okonkwo and Bello (2022) argue that efficient infrastructure such as roads, power supply, and ICT reduces transaction costs, stimulates industrial expansion, and promotes regional integration. Abiodun (2020) notes that infrastructure also plays a critical role in bridging spatial inequalities, particularly by connecting underserved regions to national and global markets, facilitating industrial linkages, and supporting inclusive service provision. Collectively, these elements demonstrate how infrastructure acts not merely as a technical support system but as a catalyst for both economic efficiency and social justice.

2.2 Theoretical Review

The interconnections between infrastructural development, industrial growth, and social inclusion can be better understood through a synthesis of relevant economic and development theories. These theoretical perspectives provide a conceptual foundation for analyzing how infrastructure acts as a catalyst in reshaping economic trajectories toward both productive transformation and inclusive progress.

One useful lens is the Growth Pole Theory, introduced by François Perroux, which posits that economic advancement does not occur evenly across space but rather concentrates around dynamic centers where large-scale investments are made. Infrastructure within this framework functions as a magnet, attracting industrial enterprises and fostering both backward and forward linkages. Roads, energy systems, and ICT infrastructure, for example, can stimulate regional industrialization by concentrating economic activity in specific locations. Importantly, when such infrastructure is deployed inclusively across geographic regions, it helps extend economic benefits to historically marginalized areas, thereby enhancing social inclusion (Perroux, 1955).

Endogenous Growth Theory further elaborates on how internal factors, including infrastructure, human capital, and innovation, serve as engines for sustained economic growth. According to this theory, investments in critical infrastructure such as transportation networks, energy supply, and communication systems enhance productivity, reduce transaction costs, and support the spread of technology across sectors. These investments not only foster growth in manufacturing and services but also enable more equitable access to opportunities. Consequently, public infrastructure investment becomes a strategic tool to address social and spatial inequalities by integrating disadvantaged groups into the economic mainstream (Romer, 1990).

Structural Change Theory offers another important framework by emphasizing the transition of labour and capital from low-productivity sectors such as subsistence agriculture to more productive sectors like manufacturing and services. Prominent scholars such as Lewis and Chenery argue that such transformation is contingent upon the presence of enabling infrastructure that supports mobility, production, and market access. Infrastructure, in this sense, facilitates the structural reconfiguration of the economy by linking rural producers to urban markets and supporting industrial agglomerations. When this infrastructure is inclusive in design and implementation, it ensures that the benefits of transformation are broadly shared across different social groups, including women, youth, and rural populations (Lewis, 1954; Chenery, 1979).

Closely related is the theory of Spatial Inequality and Regional Development, which centers on disparities in development outcomes across geographic locations. This theory suggests that infrastructure plays a pivotal role in mitigating spatial inequality and promoting balanced regional development. Concentrating infrastructure investment in already developed urban centers tends to reinforce regional disparities. Conversely, strategic investments in underdeveloped regions can integrate these areas into the national economy, stimulate localized industrial development, and support inclusive growth. Thus, spatially equitable infrastructure policy becomes essential for enhancing both economic performance and social justice (Krugman, 1991; World Bank, 2009).

Modernization Theory also contributes to this discussion by portraying infrastructure as a cornerstone of the transition from traditional to modern societies. Infrastructure in transport, electricity, water, and telecommunications is seen as essential for industrialization, urbanization, and the diffusion of modern institutions and values. Moreover, the theory links infrastructure development to national cohesion and social integration. However, modernization efforts that exclude disadvantaged populations may inadvertently reinforce inequality. Hence, the theory underscores the necessity of designing infrastructure that is intentionally inclusive, ensuring that modernization benefits are equitably distributed across society (Rostow, 1960).

Taken together, these theories underscore the multifaceted role of infrastructure as not only a driver of economic growth and industrialization but also a tool for promoting social inclusion and spatial equity. A theoretically grounded approach to infrastructural development thus demands policies and investments that are both economically strategic and socially inclusive.

2.3 Empirical Review

Empirical studies have increasingly examined the role of infrastructure in transforming economic structures, especially in developing economies. Adebayo (2022) investigated the impact of infrastructure investment on industrial output in Nigeria between 2000 and 2020 using an autoregressive distributed lag (ARDL) model. The findings revealed a statistically significant long-run relationship between infrastructure expenditure, especially on electricity and transport, and increases in manufacturing output. The study emphasized that industrial growth was more responsive to improvements in energy infrastructure than other types, underscoring the critical role of power supply in productive activity.

Similarly, Nwankwo and Usman (2021) conducted a panel data analysis covering ten West African countries to explore how transport and communication infrastructure affect industrial competitiveness. The results showed that countries with higher levels of road density, port connectivity, and ICT access recorded faster industrial expansion. The authors concluded that infrastructural endowments explain the divergence in industrial growth patterns across the region and recommended infrastructure-led regional development strategies.

In another study, Ayoola (2023) assessed the causal linkage between infrastructure quality and inclusive development in Nigeria. Using data from the Nigeria Living Standards Survey (NLSS) and structural equation modeling, the study found that communities with better road and energy infrastructure reported higher employment levels, better access to markets, and reduced income inequality. The research highlighted the mediating role of infrastructure in linking economic growth to social inclusion, suggesting that infrastructure investment is not only an economic imperative but also a tool for addressing social disparity.

Empirical findings by Oladipo and Musa (2020) supported this connection, showing that inclusive access to ICT infrastructure improved youth participation in digital entrepreneurship in urban and peri-urban areas of Lagos State. Their logistic regression analysis indicated that digital infrastructure significantly raised employment outcomes for women and young people when supported by complementary education and policy frameworks. The authors argued that ICT development, when inclusively distributed, can reshape economic participation and improve developmental outcomes.

Meanwhile, Ibrahim and Dangana (2024) used time-series data from 1990 to 2022 to evaluate the effects of capital spending on roads and energy on industrial performance in Nigeria. Their vector error correction model (VECM) indicated a strong short- and long-run effect of capital expenditure on industrial value-added. However, the study also noted that regional disparities in infrastructure quality hindered uniform gains across the country, reinforcing the need for spatially balanced development initiatives.

A study by Eze and Akpan (2021) on social infrastructure and inclusive growth in Southeast Nigeria revealed that improved access to schools, health centers, and clean water was significantly associated with enhanced human capital and reduced poverty rates. The authors used a difference-in-differences approach to evaluate the outcomes of government interventions under the Social Investment Program (SIP) and found that inclusive infrastructure reduced vulnerability among low-income households, especially in rural areas.

Adenikinju and Olomola's (2020) analysis focuses on the high economic costs incurred by unreliable power supply, lending strong empirical justification to electricity access as a crucial driver of industrial output. Building on this, Adedoyin et al. (2022) refine the understanding by demonstrating that while electricity infrastructure supports GDP growth, over-investment can incur diminishing returns, emphasizing the importance of optimal infrastructure thresholds in ARDL estimation.

Similarly, Ekperiware et al. (2023) provide compelling Nigerian evidence by affirming that investments in roads and rail have significant short term and long term benefits on economic performance. Their findings reinforce the selection of transport infrastructure as a strategic variable in both industrial and social inclusion models. Taiwo et al. (2021) contribute further by demonstrating that domestic credit to the private sector (DCPS) and electricity, when analysed via ARDL, exhibit strong long-run positive relationships with GDP, supporting the financial inclusion dimension in your theoretical structure.

While Isa and Adeniji (2015) deepen the empirical backing of telecommunications (TC) by illustrating in ARDL analysis how ICT infrastructure enhances GDP through improved teledensity and FDI attraction, validating the inclusion of digital access as a growth lever.

Furthermore, Mohammed (2023) analyzed how infrastructure deficits undermine Nigeria's industrial cluster development, particularly in Kano and Aba. Using qualitative interviews and firm-level data, the study found that unreliable electricity, poor road networks, and water scarcity were major constraints limiting economies of scale and industrial agglomeration. These findings align with earlier quantitative studies by Yusuf and Sanni (2020), who found that industrial zones with better infrastructure had higher productivity levels and greater resilience to economic shocks.

These empirical studies affirm that infrastructural development plays a crucial role in facilitating industrial growth and social inclusion. Infrastructure serves as a physical and institutional bridge that enables mobility, connects markets, reduces costs, and promotes equitable participation in the economy. However, the literature also highlights uneven access and regional disparities in infrastructure delivery, suggesting that targeted and inclusive investment strategies are essential to reshape economic pathways sustainably and equitably.

Despite the breadth of existing research, notable gaps persist in the literature. First, while many studies have focused on the relationship between infrastructure and aggregate economic growth, there is limited empirical evidence on how infrastructure specifically influences sectoral growth, particularly in industry, which is critical for structural transformation. This study addresses that gap by examining infrastructure's role in driving industrial expansion rather than aggregate economic indicators. Second, although infrastructure is often recognized for its economic value, relatively few studies have explicitly explored its link to social inclusion. The connection between infrastructural development and social inclusive outcomes such as employment, access to services, and poverty reduction remains under-researched, especially in Nigeria. This study seeks to bridge this gap by investigating how infrastructure can serve as a channel for both economic and social transformation.

3 Methodology

This study adopts an ex post facto research design, using secondary data from the period of 1990 to 2023. Annual data from 1990 to 2023, sourced from the World Development Indicators (WDI) (2024) were used to achieve the objective of the study. The estimation techniques employed were unit root test for stationarity and Autoregressive Distribution Lag Model (ARDL)..

3.1 Model Specification

This study adopts an endogenous growth framework in which infrastructure and financial development function as internal drivers of productivity expansion and structural transformation. The empirical specification models the dynamic relationship between infrastructural indicators, industrial output, and social inclusion using the Autoregressive Distributed Lag (ARDL) approach.

Two functional models are estimated.

Model 1: Industrial Growth Function

$$MVA_t = f(\ EA_t\ TRAN_t\ TC_t\ \ DCPS_t\ INF_t\ ) \qquad 1$$

Long-Run Structural (Levels) model

This represents the equilibrium relationship among the variables.

Model 1: $lnMVA_t = \propto_0 + \propto_1 lnEA_t + \propto_2 lnTRAN_t + \propto_3 lnTC_t + \propto_4 lnDCPS_t + \propto_5 INF_t + \in_t$ 2

Model 2: Social Inclusion Function

$SI_t = f(EA_t\ TRAN_t\ TC_t\ \ DCPS_t\ \ INF_t\ )$ 3

This also represents the equilibrium relationship among the variables in model 2.

$lnSI_t = \beta_0 + þ_1 lnEA_t + þ_2 lnTRAN_t + þ_3\ lnTC_t + þ_4\ lnDCPS_t + \Phi_5 INF_t + \in_t$ 4

These equations describe the long-run equilibrium relationship.

Building on Arjun et al, 2020 (2020) model, the adapted the model is further extended to ARDL model to accommodate the short run and long run for this study is:

Hence, the standard ARDL distributed lag model before reparameterization. is specified as:

Model 1:

$$\Delta lnMVA_t = \propto_0 + \sum_{i=1}^{p} \propto_0 \Delta lnMVA_{t-i} + \sum_{j=0}^{q1} \propto_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} \propto_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} \propto_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} \propto_{4m} \Delta lnDCPS_{t-m}\ _4 + \sum_{n=0}^{q5} \propto_{5n} \Delta INF_{\ t-n} + \in_t \qquad 5$$

Model 2:

$$\Delta lnIS_t = \beta_0 + \sum_{i=1}^{p} \gamma_0 \Delta lnIS_{t-i} + \sum_{j=0}^{q1} ¥_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} ¥_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} ¥_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} ¥_{4m} \Delta lnDCPS_{t-m}\ _4 + \sum_{n=0}^{q5} ¥_{5n} \Delta INF_{\ t-n} + \in_t \qquad 6$$

ARDL Unrestricted Error Correction Representation (UECM)

These models indicate the joint significance of the lagged level terms is tested using the ARDL bounds test.

Model 1:

$$\Delta lnMVA_t = \propto_0 + \sum_{i=1}^{p} \propto_0 \Delta lnMVA_{t-i} + \sum_{j=0}^{q1} \propto_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} \propto_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} \propto_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} \propto_{4m} \Delta lnDCPS_{t-m} + \sum_{n=0}^{q5} \propto_{5n} \Delta INF_{t-n} + \Phi_1 lnEA_t + \Phi_2 lnTRAN_t + \Phi_3 lnTC_t + \Phi_4 lnDCPS_t + \Phi_5 lnINF_t + \in_t \qquad 7$$

4

Model 2:

$$\Delta lnIS_t = \beta_0 + \sum_{i=1}^{p} \gamma_0 \Delta lnIS_{t-i} + \sum_{j=0}^{q1} ¥_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} ¥_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} ¥_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} ¥_{4m} \Delta lnDCPS_{t-m} + \sum_{n=0}^{q5} ¥_{5n} \Delta INF_{t-n} + þ_1 lnEA_t + þ_2 lnTRAN_t + þ_3 lnTC_t + þ_4 lnDCPS_t + \Phi_5 INF_t + \in_t \qquad 8$$

4

Error Correction Model (Short-Run Adjustment)

Once cointegration is confirmed, the model becomes:

Model 1

$$\Delta lnMVA_t = \propto_0 + \sum_{i=1}^{p} \propto_0 \Delta lnMVA_{t-i} + \sum_{j=0}^{q1} \propto_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} \propto_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} \propto_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} \propto_{4m} \Delta lnDCPS_{t-m} + \sum_{n=0}^{q5} \propto_{5n} \Delta INF_{t-n} + \gamma ECT_{t-1} + \in_t \qquad 8$$

4

Model 2:

$$\Delta lnIS_t = \beta_0 + \sum_{i=1}^{p} \gamma_0 \Delta lnIS_{t-i} + \sum_{j=0}^{q1} ¥_{1j} \Delta lnEA_{t-j} + \sum_{k=0}^{q2} ¥_{2k} \Delta lnTRAN_{t-k} + \sum_{l=0}^{q3} ¥_{3l} \Delta lnTC_{t-l} + \sum_{m=0}^{q4} ¥_{4m} \Delta lnDCPS_{t-m} + \sum_{n=0}^{q5} ¥_{5n} \Delta INF_{t-n} + \Psi ECT_{t-1} + \in_t \qquad 9$$

4

Where:

MVA: Manufacturing value added (Proxy industrial output)

SI: Social Inclusion (Principal Component Analysis (PCA) of employment in the industry, Enrolment in secondary school, poverty rate)

EA: Electricity Access

TC= Telecommunication

DCPS: Domestic Credit to Private Sector

INF: Inflation

ECT_{t-1} : Error correction term from the long-run equation (should be negative and significant)

γ and Ψ= speed of adjustment toward equilibrium

Expected: $-1 < \gamma \& \Psi < 0$

4. Results and Discussion

Table 1: Descriptive Statistics

	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
MVA	11.857	4.833	0.609	1.791	4.168	0.124
SI	-0.0055	1.430	0.228	1.791	2.364	0.307
EA	47.554	8.094	-0.598	2.401	2.534	0.282
TC	38.057	39.091	0.324	1.414	4.157	0.125
TRAN	33029.54	26439.83	0.410	1.337	4.868	0.088
DCPS	10.775	4.116	0.983	3.666	6.108	0.047
INF	18.278	15.902	2.180	6.855	47.994	0.000

Source: Authors' compilations, 2025

The descriptive statistics as reported in Table 1, indicated that the mean value of Manufacturing Value Added (MVA) is 11.857 with a standard deviation of 4.833, a Jarque-Bera probability of 0.124, suggesting that the variable is a normal distribution at the 5% level. Social Inclusion (SI) shows a negative mean value of -0.0055 and a standard deviation of 1.430, and with Jarque-Bera probability of 0.307 confirms normality of this variable. Electricity Access (EA) has a relatively high mean of 47.554 and moderate dispersion (standard deviation of 8.094), with a Jarque-Bera p-value of 0.282, Telecommunications (TC) and Transport Investment (TRAN) also conform to expectations with Jarque-Bera values for of 0.125 and 0.088, respectively confirm the assumption of normality of the variables. More notable, however, is the behaviour of Domestic Credit to Private Sector (DCPS) and Inflation (INF) with Jarque-Bera p-values of 0.047 and 0.000, indicating that the variables are not normally distributed.

Table 2: Correlation Matrix

Correlation	MVA	SI	EA	TC	TRAN	DCPS	INF
MVA	1.000						
SI	0.831	1.000					
EA	-0.887	0.868	1.000				
TC	-0.802	0.881	0.545	1.000			
TRAN	-0.725	0.762	0.453	0.134	1.000		

DCPS	-0.686	0.730	0.445	0.571	0.429	1.000	
INF	0.519	-0.422	-0.422	-0.291	-0.271	-0.3280	1.000

Source: Authors' compilations, 2025

Table 2 presents the correlation matrix among the key variables. A particularly strong negative relationship is observed between MVA and the variables EA (-0.887), SI (-0.831), TC (-0.802), and TRAN (-0.725), while DCPS also shows a strong negative correlation with MVA (-0.686). This inverse relationship suggests that higher access to electricity, telecommunications infrastructure, and transport investment, along with increased credit to the private sector, may not linearly translate to increased manufacturing value added. This unexpected negative correlation may be interpreted as a reflection of structural inefficiencies It may also signal that investment gains are diverted or disproportionately absorbed by other sectors. Conversely, inflation exhibits a moderate positive correlation with MVA (0.519), suggesting that periods of industrial expansion may be associated with upward price pressures, possibly due to supply-side constraints or increased demand. The correlations between SI and other variables (EA, TC, DCPS, TRAN) are positive and strong, highlighting that improvements in infrastructure and financial access are directly associated with enhanced social inclusion. However, inflation shows a negative correlation with SI, EA, TC, and TRAN, implying that rising inflation undermines inclusiveness and infrastructure performance, which aligns with macroeconomic theory on inflationary erosion of real access and purchasing power.

Table 3 Unit root test results

Var	ADF		PP		Remark
	Level	First Diff	Level	First Diff	
MVA	-0.697	-3.114**	-0.747	-6.140	I(1)
SI	-1.863	-3.623**	-1.543	-3.014**	I(1)
EA	-2.864**	-	-3.863**	-	1(0)
TC	-3.501**	-	-4.314***	-	1(0)
TRAN	-0.879	-5.119***	-0.824	-6.316***	1(1)
DCPS	-4.498***	-	-4.784***		1(0)
INF	-2.178	-4.645***	-2.461	-4.632***	1(1)

Note "*", "**" and "***" represent the probability values of 10%, 5% and 1% respectively

Source: Authors' compilation, 2025

The stationarity properties of the variables are reported in Table 3, where both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied. MVA is non-stationary at level but becomes stationary at first difference, implying it is integrated of order one, I(1). Similarly, SI, EA, TRAN, and INF also exhibit I(1) behaviour, becoming stationary only after first differencing. In contrast, TC and DCPS are stationary at level and therefore integrated of order zero, I(0). This mixture of integration orders across variables validates the adoption of the Autoregressive Distributed Lag (ARDL) bounds testing approach for cointegration, which is robust under such conditions. The mixed order of integration ensures that none of the series is I(2), which would have violated the underlying assumptions of ARDL methodology.

Table 4 Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-41.74241	NA	1.08e-06	3.292580	3.575468	3.381177
1	100.8372	216.3276	7.38e-10	-4.057736	-2.077515*	-3.437556
2	147.1970	51.15562*	5.14e-10*	-4.772204*	-1.094650	-3.620440*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Source: Authors' compilations, 2026

Table 4 details the results of the lag length selection using various information criteria, including Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn (HQ). The optimal lag length is identified as 2 based on the lowest values of AIC and HQ. The selection of an appropriate lag length is critical in dynamic modeling to capture the true temporal effects without introducing over-parameterization or omitted variable bias. The choice of lag 2 ensures that short-run dynamics are adequately represented while preserving degrees of freedom and avoiding spurious regressions.

Table 5: ARDL Bounds Test

Model 1						**Model 2**					
Test Stat.	Value	k	Critical Value Bounds			Test Stat.	Value	k	Critical Value Bounds		
F-stat.	4.921	5	Sign.	I0 Bound	I1 Bound	F-stat	5.357	5	Sign	I0 Bound	I1 Bound
			10%	2.26	3.35				10%	2.26	3.35
			5%	2.62	3.79				5%	2.62	3.79
			1%	3.41	4.68				1%	3.41	4.68

Source: Authors' compilations, 2025

The bounds test for cointegration reported in Table 5 provides the F-statistic value of 4.921 for Model 1 (where MVA is the dependent variable) and 5.357 for Model 2 (where SI is the dependent variable). When compared to the critical value bounds at the 5% significance level (2.62 for I(0) and 3.79 for I(1)), the F-statistic exceeds the upper bound, confirming the presence of a long-run cointegrating relationship among the variables in both models. This result affirms that MVA and SI are each dynamically linked to their respective regressors, justifying the estimation of long-run and short-run coefficients via ARDL cointegration framework.

Table 6: ARDL model estimation on the relationship between the variables

Model 1: Dependent Variable: LNMVA				**Model 2: Dependent Variable**: LNSI		
Short Run Coefficients						
Variable	Coef	Std. Error	t-Stat	Coef	Std. Error	t-Stat
D(LNEA)	0.782	0.355	2.204**	0.322	0.095	3.396**
D(LNTC)	-0.011	0.015	-0.748	0.238	0.072	3.306**
D(LNTRAN)	0.126	0.059	2.140**	-0.182	0.169	-1.077
D(LNDCPS)	0.196	0.084	2.329**	0.755	0.061	12.377***
D(LNDCPS(-1))	-0.198	0.076	-2.589**	-	-	-
D(LNINF)	-0.024	0.034	-0.727	0.517340	0.152030	3.403**
ECM(-1)	-0.372	0.101	-3.683**	-0.305751	0.056	-5.489***
Long Run Coefficients						
Variable	Coef.	Std. Error	t-Stat	Coef	Std. Error	t-Stat
LNEA	4.541	1.927	2.357**	-0.171	0.036	-4.752***
LNTC	-0.063	0.064	-0.983	0.451	0.235	1.926
LNTRAN	0.697	0.286	2.437**	0.596	0.120	4.978***
LNDCPS	0.669	0.720	0.928	0.322	1.328	0.243
LNINF	-0.442	0.110	-4.018***	0.057	0.507	0.112
C	14.791	6.166	2.399	5.309	1.412	3.760**

Source: Authors' compilations, 2025

Table 6 presents the ARDL cointegration and error correction estimates for both models. In Model 1, The ARDL model indicates that electricity access (EA) and transport infrastructure (TRAN) have statistically significant and positive effects on manufacturing value added in both the short run and long run. The long-run coefficients (LNEA = 4.541; LNTRAN = 0.697) are especially noteworthy, affirming that investments in energy and transport infrastructure are critical for industrial productivity. The findings of this study confirm the critical role that infrastructural development plays in fostering industrial growth in Nigeria. The Autoregressive Distributed Lag (ARDL) model reveals that electricity access and transport infrastructure reveal statistically significant positive effects on manufacturing value added in both the short and long run. This supports the theoretical assertion of the endogenous growth model that infrastructure constitutes a vital internal driver of productivity and economic expansion. The results align with the work of Adedoyin et al. (2022), who, using ARDL and VECM methods, established that energy infrastructure significantly enhances GDP growth in Nigeria, though with attention was given against over-investment. In the same vein, Adenikinju and Olomola (2020) demonstrated that inadequate electricity supply imposes high costs on firms and undermines productivity, providing practical validation for the significant coefficient observed for electricity in this study.

Transport infrastructure also exhibited long-run significance, corroborating the findings of Ekperiware, Adeniran, and Adeyeye (2023), who found that investments in road and rail transport are positively linked to GDP growth in Nigeria. Their research, like this study, highlights the multiplier role of transport in improving industrial output. In contrast, while telecommunications and financial development indicators such as credit to the private sector showed positive short-run effects on both industrial output and social inclusion, their long-run coefficients were not statistically significant. This outcome suggests that while finance and digital infrastructure may offer immediate gains, their long-term influence may be constrained by structural rigidities or inefficiencies in policy execution. This finding aligns with Taiwo et al. (2021), who noted that although domestic credit and electricity both contribute to economic growth in Nigeria, the impact of credit is often weakened by institutional bottlenecks and misallocation of resources.

Inflation (INF), on the other hand, shows a significant negative long-run effect on MVA (-0.442), validating economic theory that macroeconomic instability undermines productivity. This finding is supported by Ayoola (2023) who found that inflation erodes infrastructure-led development gains, especially where price volatility hampers private investment in manufacturing.

Model two explores the effect of infrastructural indicators on social inclusion, proxied through a PCA composite of industrial employment, secondary school enrolment, and poverty rates. The social inclusion model further reinforces the importance of infrastructure. Electricity access and transport infrastructure again emerged as key determinants, significantly influencing the composite social inclusion index in the long run. These results agree with the conclusions of Isa and Adeniji (2015), whose ARDL analysis confirmed the growth-enhancing role of telecommunications infrastructure through increased ICT penetration and connectivity. Their findings also support the positive but statistically weaker relationship observed in this study between telecommunications and inclusion outcomes. In addition, the inflation variable exhibited a negative long-run effect on industrial output, affirming theoretical expectations that macroeconomic instability reduces investment incentives and erodes productive capacity. This is consistent with the broader literature, including Ayoola (2023), which highlights how inflation undermines infrastructure-led development gains by diminishing investor confidence and increasing operating costs.

Generally, the findings in the two models affirm that infrastructure, particularly electricity and transport, plays a foundational role in shaping Nigeria's industrial and inclusive development trajectory. The evidence also highlights the differentiated effects of financial and digital infrastructure, which though important, require complementary institutional support to generate sustained impact. These findings are consistent with a growing body of empirical literature and reinforce the need for strategic, well-targeted infrastructure policies aimed at unlocking Nigeria's industrial potential and advancing equitable economic transformation.

Table 7: Post Estimation

Estimation	F-statistic	Prob	Decision
Normality (Jarque-Bera)	0.283	0.868	Normal distribution
Breusch-Godfrey Serial Correlation LM Test	0.127	0.564	No evidence of serial correlation
Heteroskedasticity Test: Breusch-Pagan-Godfrey	1.076135	0.419	residuals have constant variance

Source: Authors' compilation, 2025

The validity of the models is confirmed by post-estimation diagnostic tests, as presented in Table 7. The Jarque-Bera test for normality yields a p-value of 0.868, indicating that the residuals are normally distributed, a necessary condition for valid inference. The Breusch-Godfrey LM test shows no evidence of serial correlation (p = 0.564), while the Breusch-Pagan-Godfrey test for heteroskedasticity (p = 0.419) confirms that the residuals have constant variance. These findings collectively demonstrate that the models are well specified, statistically sound, and free from major violations of classical linear regression assumptions.

This results support the conclusion that infrastructure development, particularly in electricity and transport, plays a critical role in enhancing both manufacturing productivity and social inclusion. However, inflation exerts a long-term drag on industrial output while simultaneously showing short-term benefits to social inclusion, possibly through fiscal redistributions or wage adjustments. Financial access, although significant in the short run, requires structural alignment to generate sustained long-term impacts. These findings underscore the importance of coordinated policy efforts that balance macroeconomic stability, infrastructure investment, and financial sector reforms to achieve inclusive and sustainable industrial development.

5. Conclusion and Recommendations

This study has empirically examined the role of infrastructural development in reshaping Nigeria's economic pathway through its impact on industrial growth and social inclusion. The findings confirm that access to electricity and transport infrastructure significantly boosts manufacturing productivity and promotes equitable social outcomes. Although short-term gains are evident from improved financial access and telecommunications, their long-term effectiveness remains limited without supportive structural and institutional reforms. The study concludes that infrastructure is not merely a physical asset but a strategic driver of industrial transformation and social equity. Therefore, by strengthening and equitably distributing energy and transport systems, Nigeria can address historical development challenges and transition toward a more inclusive and resilient economic model, making infrastructural development central to its long-term industrial and social advancement strategies.

Based on this conclusion, it is recommended that the government and stakeholders should allocate greater investments on electricity and transport networks, especially in underserved industrial and rural regions, to enhance inclusive industrial growth in Nigeria. Also, infrastructure development must be spatially and socially inclusive, targeting areas and groups historically excluded from development gains, like the rural communities, youths, and women.

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