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Rethinking the Effect of Infrastructural Development on Industrial Development in Nigeria: Mediating Role of Institutional Quality

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ABSTRACT

Extant studies indicate that effective policies to promote industrial growth in Nigeria are contingent upon addressing infrastructure issues. This study examines the interplay between infrastructural development, institutional quality, and industrial development, focusing on three objectives: the impact of overall infrastructure on industrial growth; the effects of individual infrastructure variables on industrial development; and the interactive relationship between institutional quality and infrastructure development on industrial development. Analysing annual data from 1981 to 2023 by employing the Autoregressive Distributed Lag (ARDL) regression technique. The results indicate that both short-run and long-run aggregate infrastructural development have a significant negative impact on industrial development in Nigeria. Similarly, air transport and telephone density also show significant negative relationships with industrial growth in both time frames. The only factors significantly influencing Nigeria's industrial growth during the studied period were air travel and telephone density, while other infrastructure aspects presented weak but positive impacts. Furthermore, the interactive effects of infrastructure development and institutional quality revealed negative relationships at lags one and two, though a positive relationship was noted in the short run when only institutional quality was considered. This study therefore concludes that the level of industrial development can only improve significantly if appropriate and efficient institutional quality complements infrastructure development in Nigeria.

Keywords: Infrastructure development, institutional quality, industrial development, autoregressive distributed lag model, Nigeria.

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1 INTRODUCTION

Infrastructure can be appreciated as an economic factor that cuts across all segments of the economy because of its significance to its proper functioning of any economy as a whole. This is an indisputable fact, as no economy can function efficiently without transport and telecommunication networks, some form of power supply, and amenities such as drainage or disposal systems, markets, homes and offices, schools, and the like (Umofia, et al., 2018). Jacobson and Tarr (1995) defined infrastructure as structures and systems which frame and keep an economy, thereby making provision for economic and social efficiency.

The connection shared by infrastructure and industrial sector growth is undeniable. The multiplier effect expressed by industrial output was due to infrastructure (for example, energy infrastructure) begs the need for infrastructural development in our great nation if there is any hope to enhance productivity (Agne, 2009). The developed and developing world alike, count industrialization as a significant dynamic for growth and development. The relationship between infrastructure and industrialization in any economy can be appreciated from the perspective of distribution of resources which include production inputs and outputs to and from industries. Thus, infrastructure and industrialization go hand in hand on the quest for sustainable development in any economy.

The deplorable situation of infrastructure occasion by inadequate funding from government for maintenance of these facilities, careless use, vandalisation, corruption and delays in construction. Poor infrastructure leads to low productivity because producers of goods and services are discouraged because of higher cost of production and sometimes, overall inability to get goods to the points of sale. This further leads to lower generation of income that led to the decline in industrial output (162.9 billion Naira in 1990, down to 131.8 billion Naira in 1998) and industrial capacity utilization increases by 13.3% in 1981, then decreases to 32.4% in 1998 (CBN,2000). It is noteworthy that the manufacturing subsector attains its historic peak contribution of 9.9% precisely in 1983. After 1983, its contributions fluctuated between 5.29% and 8.74%. The average annual contribution of the manufacturing sub-sector in the 1980s (8.19%) doubled its corresponding figures in the 1970s. The1990s was characterized by a fall in the contributions of the sub sector. Specifically, the contribution ranged between 5.54% in 1990 and 4.89% in 1999. Overall, the average share for the decade was 5% in the 1990s; in 2000-04, the share of manufacturing was at its lowest ebb of 4.12% (Shobande & Etukomen, 2017).

The Nigerian industrial output in 2004 was $14.81 accounting for10.86% of the nation's GDP; which continually drop in percentage of the total nations GDP from 2004-2018. However, its total value picked up from 2019 with $51.63billion accounting for 11.52 of total GDP and furthered increased in 2020 with a value of $54.76 billion (12.67% of total GDP). However, it is obvious the deplorable condition of infrastructure in Nigeria with poor delivery and its maintenance. Inadequate infrastructure has been a thorn in the flesh of industrialization in Nigeria. It has led to low productivity and output, translating into low-capacity utilization, higher production costs, and then inflation (Umofia, et al., 2018). Ogbonnaya (2010) demonstrated empirically that no matter how noble the policies or incentives to drive the industrial sector are, if the infrastructure problems are not fixed, the policy objective of accelerating the growth of the industrial sector may not be realized.

Nigeria is replete with several cases of inadequate infrastructure. These include irregular supply of electricity, shortage of piped borne water, fuel scarcity and bad roads. The current state of infrastructural facilities has had a very negative impact on industrial sector such as low production of goods and services, their efficient distributions as well as depleted economic growth and development. It has even led to some industries winding up, relocating to other countries or regions and hindering foreign investors from investing in the economy. This is why it is important to carry out research on the effect of aggregate infrastructural development index on industrial output growth. Also, added to that, the study examines disaggregated infrastructure (transportation networks, energy systems, and communication facilities) to a know the contribution of each of them and where they are lacking and to proffer adequate policy recommendation(s) for industrial development in Nigeria

Studies show a link between infrastructure development and industrialization in developing economies, but there's a gap in understanding how different infrastructure sectors interact to drive industrial growth, lacking comprehensive analysis. This is why this study move frontier of knowledge by examining if institutional quality index could mediate infrastructural development, and have any remarkable influence on industrial development in Nigeria. Institutional theory focuses on the role of formal and informal institutions in shaping economic behaviour and outcomes (North, 1991). This one of the gaps that this study intends to fill. As one of the objectives of this study that investigates the interactive effect of infrastructural development and institutional quality on industrial development in Nigeria.

2 LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 The Concept of Infrastructure

Infrastructure encompasses the structures and networks essential for economic and social activities, such as power supply, water, and telecommunications (Jacobson & Tarr, 1995). The World Bank (1994) elaborates on this definition, viewing infrastructure as critical for economic functions. Studies by Lanjow (1995) and the African Development Bank (ADB) (1999) highlight that sufficient infrastructure encourages investments in underdeveloped areas, fosters economic diversity through the mobility of people, goods, and information, and enhances environmental sustainability via improved waste management and sanitation.

2.1.2 The Concept of Development

Development is understood as improvement or transformation from an undesired to a preferred state. Kindleberger (1995) defines it as increased output along with technical and institutional changes that facilitate this growth, emphasizing that development encompasses more than just a rise in national income and production; it also involves examining the forces that drive this increase.

2.1.3 The Concept of Industrialisation

Industrialisation marks the shift from an agrarian to an industrial society, requiring major economic restructuring for manufacturing and often resulting in fossil fuel-related pollution. The rise of sustainable practices promotes cleaner technologies via technological leapfrogging. This economic growth, spurred by increased incomes, expands consumer markets, while family structures evolve from extended households. Industrialisation involves efficient value creation processes in the secondary sector, which is separate from the primary (agriculture) and tertiary (services) sectors.

2.1.4 The concept of institutions

This study explores the varying definitions of institutions in economic research, noting perspectives from Nelson and Sampat, who consider them "social technology," and Hodgson, who includes organizations in a broad definition. Douglass North's definition, describing institutions as the rules of the economic "game," is the most influential. The study emphasizes the impact of institutions on market behavior by shaping incentives, constraints, and reducing uncertainties through formal and informal rules, highlighting that high-quality institutions contribute to more predictable outcomes and lower transaction costs in trade.

2.2 Theoretical Review

2.2.1 Modernization theory

Modernization theory, emerging in the mid-20th century, argues that societies evolve through stages of development marked by industrialization, urbanization, and technological progress. It emphasizes that infrastructure development is vital for transitioning from traditional agrarian economies to industrialized ones. Specifically, it indicates that investments in infrastructure like transportation and energy are critical for fostering economic growth in developing economies.

2.2.2 Institutional Theory

Institutional theory emphasizes the influence of both formal and informal institutions on economic behavior and outcomes. In the realm of infrastructure development in developing economies, it posits that the success of infrastructure investments is tied not only to physical assets but also to the quality of governing institutions, including regulatory frameworks, property rights, and governance structures. This interplay is crucial in determining the effectiveness of infrastructure projects and their ability to foster industrialization.

2.3 Empirical Literature Review

Research emphasizes the crucial role of infrastructure in industrial output in middle-income nations, particularly Nigeria. Studies by Mesagan and Ezeji (2016) indicate that ICT enhances industrial performance, while the effects of electricity are negligible. Ijaiya and Akanbi (2009) and Adenikinju (1998) demonstrate a long-term relationship between infrastructure and industrialization, with transportation advancing faster than other facilities. Patel and Wu (2023) argue that strong governance and regulatory frameworks improve the impact of infrastructure investments on industrial growth, urging for comprehensive governance reforms to ensure sustainable industrial development.

Amarachi (2024) analyzed the impact of infrastructure development on industrialization in Nigeria using secondary data. The study emphasized education's critical role in promoting technological innovation and economic growth, recommending the use of modernization, dependency, and institutional theories for further research. It suggested creating evidence-based decision-support systems for infrastructure investments and improving regulatory capacity through governance reforms. Similarly, Appiah, Onifade, and Gyamfi (2024) found a positive link between institutional quality and infrastructure growth in sub-Saharan Africa, with industrialization being a significant factor in infrastructural transformations, underscoring the need for robust policy frameworks to support governance and infrastructure development in the region.

2.4 Theoretical Framework

The study's theoretical framework combines production function and growth approaches, aligning with Barro (1990) and Futagami et al. (1993). It posits that public investment in infrastructure is crucial for maximizing growth, indicating that optimal infrastructure levels enhance industrial sector growth, while insufficient levels hinder it.

3 METHODOLOGY

3.2 Specification of Models

Following the aforementioned framework, the model is specified as follow. Aggregate output produced using infrastructure capital at time *t* is expressed as:

$$Y_t = f(A_t, K_t, L_t, Infi_t) \qquad 3.1$$

where: at time *t*, *Y* is the total output of the industrial sector (Later substituted as INV), *K is* capital stock, *L* is labour, θ is a vector of infrastructure variables and ϕ is a control variable (real interest rate). For simplicity, this study assumes that capital fully depreciates at each period and savings rate (*s*) is constant.

Thus, testing the possibility of constant return to scale, equation (3.2) in Cobb-Douglas production form and including (*A*) as a measure of total productivity yields: $Y_t = A_t, K_t^a, L_t^b, Infi_t^c, Insq_t^d$

3.2

Taking first differences of equation (5) and including the stochastic term yields:

$$A \ln Y_t = \alpha + aA \ln K_t + bA \ln L_t + cA \ln Infi_t + dInR \text{int}_t + \varepsilon_t \qquad 3.3$$

The elasticity of industrial output with respect to infrastructure *c* is the main variable of interest in this study. The other production elasticities: *a*, *b* and *d* are of interest mainly in order to assess the shape of the production function.

3.2.1 Effect of Aggregate Infrastructural Development on Industrialization in Nigeria

The study analyzes the effect of infrastructural development on industrial development in Nigeria by creating a composite index using various infrastructure indicators. It employs Principal Component Analysis (PCA) to establish this index, utilizing six key variables: Telephone lines per thousands (TEL), Electric power consumption (kWh per capita) (ELEC), Road (total network in km) (ROAD), Air transportation (million ton-km) (AIR), Railway density per thousands (RAIL) and Water transport (WATER). The analysis is conducted using econometric software E-Views 12 and Stata. The model is as stated below:

$$\ln Y_t = \alpha_0 + a \ln K_t + b \ln L_t + c_t \ln Infi_t + d \ln Insq + eR\text{int}_t + \varepsilon_t \qquad 3.4$$

Where: at time *t*, *Y* is the total output of the industrial sector, *K* is capital stock, *L* is labour, Infi is index of total infrastructure variable and Rint is a control variable which is real interest rate.

The Pesaran et al (2001) autoregressive distributed lag model was used by the researcher to illustrate a long-run relationship between infrastructure development and industrialization in Nigeria. The model is as stated below in equation 5:

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} a_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i} \Delta \ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i} \Delta \ln L_{t-i} + \sum_{i=0}^{q_3} d_{4i} \Delta \ln Infi_{t-i} + \sum_{i=0}^{q_4} e_{5i} \Delta \ln Insq_{t-i} + \sum_{i=0}^{q_5} f_{6i} \Delta Rint_{t-i} + \gamma_1 \ln Y_{t-1} + \gamma_2 \ln K_{t-1} + \gamma_3 \ln L_{t-1} + \gamma_4 \ln Infl_{t-1} + \gamma_5 \ln Insq_{t-1} + \gamma_6 Rint_{t-1} + \mu_t \qquad 3.5$$

Δ is the difference operator. The summation a_1, b_2, c_3, d_4, e_5 and f_6 represent the short run dynamics of the model, the coefficients γ_1 to γ_5 indicate the long run relationship, and μ is the serially uncorrelated disturbance term with zero mean and constant variance. Following confirmation of cointegration between the variables, the following long run model for Y was estimated:

$$\ln Y_t = \alpha + \gamma_1 \ln Y_{t-1} + \gamma_2 \ln K_{t-1} + \gamma_3 \ln L_{t-1} + \gamma_4 \ln Infi_{t-1} + \gamma_5 \ln Insq_{t-1} + \gamma_6 Rint_{t-1} + \mu_t \qquad 3.6$$

The lag orders of the variables were selected using the appropriate Information Criterion to find the ideal structure of the ARDL specification, and the following error correction model was developed to forecast the short run dynamics:

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} a_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i} \Delta \ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i} \Delta \ln L_{t-i} + \sum_{i=0}^{q_3} d_{4i} \Delta \ln Infi_{t-i} + \sum_{i=0}^{q_4} e_{5i} \Delta \ln Insq_{t-i} + \sum_{i=0}^{q_5} f_{6i} \Delta Rint_{t-i} + \theta ECM_{t-1} \qquad 3.7$$

Where the adjustment value is assumed to be less than zero and the short run parameters range from a_1, b_2, c_3, d_4, e_5 and f_6. The calculated cointegration model of the equation yields the delayed error correction term, or ECM.

As Autoregressive Distributed Lag Model (ARDL) was chosen method to achieve all the three objectives of this study, the following diagnostics tests were used for the said three objectives of this study. The Jacque-Bera test for normalcy, serial correlation tests, and residual tests for heteroscedasticity were also performed. Additionally, the Ramsey RESET test was used to determine whether the model estimates were accurate. on determine if the long run and short run coefficients were stable and whether the two statistics remained below the 5% significant threshold, the CUSUM and CUSUMSQ tests on the residual equation were applied.

3.2.2 Effect of Disaggregated/Sectoral/Individual Infrastructural Development on Industrialization in Nigeria

For isolating the impact of infrastructural development on industrialization in Nigeria, six infrastructure measures are utilized, addressing both physical and social needs. Telephone density reflects telecommunication access, facilitating communication among production agents. Energy consumption is critical for industry growth, lowering production costs. Increased capital expenditure on transport and water facilitates the import of heavy machinery for industrial output. The variables analyzed include road network length, air and railway transport capacity, water transportation, telephone lines, energy use, and electric power consumption per capita, with a focus on determining each infrastructure sector's contribution to industrialization. Is as stated below:

$$\ln Y_t = \alpha + a\ln K_t + b\ln L_t + c_1\ln Road_{1t} + c_2\ln Rail_{2t} + c_3\ln Water_{3t} + c_4\ln Tel_{4t} + c_5\ln Elec_{5t} + c_6\ln Air_{6t} + d\ln Infi_{7t} + eInInsq_t + fR\text{int}_t + \varepsilon_t \qquad 3.5$$

As a result, the study used Pesaran et al (2001) autoregressive distributed lag model was employed to establish a long-run relationship between financial development and poverty levels in Nigeria.

The following is the model:

$$\begin{aligned}\Delta\ln Y_t = {} & \alpha_0 + \sum_{i=1}^{p} a_{1i}\Delta\ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i}\Delta\ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i}\Delta\ln L_{t-i} + \sum_{i=0}^{q_3} c_{4i}\Delta\ln Road_{t-i} \\ & + \sum_{i=0}^{q_4} c_{5i}\Delta\ln Rail_{t-i} + \sum_{i=0}^{q_5} c_{6i}\Delta\ln Water_{t-i} + \sum_{i=0}^{q_6} c_{7i}\Delta\ln Tel_{t-i} \\ & + \sum_{i=0}^{q_7} c_{8i}\Delta\ln Elec_{t-i} + \sum_{i=0}^{q_8} c_{9i}\Delta\ln Air_{t-i} + \sum_{i=0}^{q_9} d_{10i}\Delta\ln Infi_{t-i} + \sum_{i=0}^{q_{10}} e_{11i}\Delta\ln Insq_{t-i} \\ & + \sum_{i=0}^{q_{11}} f_{12i}\Delta Rint_{t-i} + \gamma_1 lnY_{t-1} + \gamma_2 ln\mathrm{K}_{t-1} + \gamma_3 ln\mathrm{L}_{t-1} + \gamma_4 ln\mathrm{Road}_{t-1} + \gamma_5 ln\mathrm{Rail}_{t-1} \\ & + \gamma_6 ln\mathrm{Water}_{t-1} + \gamma_7 lnTel_{t-1} + \gamma_8 lnElec_{t-1} + \gamma_9 lnAir_{t-1} + \gamma_{10}\mathrm{lnInfl}_{t-1} \\ & + \gamma_{11} ln\mathrm{Insq}_{t-1} + \gamma_{12}\mathrm{Rint}_{t-1} + \mu_t \qquad 3.9\end{aligned}$$

Δ is the difference operator. The summation a_1, b_2, c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9, e_5 and f_6 represent the short run dynamics of the model, the coefficients γ1 to γ12 indicate the long run relationship, and μ is the serially uncorrelated disturbance term with zero mean and constant variance. The following long run model for Y was estimated:

$$\begin{aligned}\ln Y_t = {} & \alpha\,\gamma_1 lnY_{t-1} + \gamma_2 ln\mathrm{K}_{t-1} + \gamma_3 ln\mathrm{L}_{t-1} + \gamma_4 ln\mathrm{Road}_{t-1} + \gamma_5 ln\mathrm{Rail}_{t-1} + \gamma_6 ln\mathrm{Water}_{t-1} \\ & + \gamma_7 lnTel_{t-1} + \gamma_8 lnElec_{t-1} + \gamma_9 lnAir_{t-1} + \gamma_{10}\mathrm{lnInfl}_{t-1} + \gamma_{11} ln\mathrm{Insq}_{t-1} \\ & + \gamma_{12}\mathrm{Rint}_{t-1} + \mu_t \qquad 3.10\end{aligned}$$

The lag orders of the variables were selected using the appropriate Information Criterion to find the ideal structure of the ARDL specification, and the following error correction model was developed to forecast the short run dynamics:

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} a_{1i}\Delta \ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i}\Delta \ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i}\Delta \ln L_{t-i} + \sum_{i=0}^{q_3} c_{4i}\Delta \ln Road_{t-i} + \sum_{i=0}^{q_4} c_{5i}\Delta \ln Rail_{t-i} + \sum_{i=0}^{q_5} c_{6i}\Delta \ln Water_{t-i} + \sum_{i=0}^{q_6} c_{7i}\Delta \ln Tel_{t-i} + \sum_{i=0}^{q_7} c_{8i}\Delta \ln Elec_{t-i} + \sum_{i=0}^{q_8} c_{9i}\Delta \ln Air_{t-i} + \sum_{i=0}^{q_9} d_{10i}\Delta \ln Infi_{t-i} + \sum_{i=0}^{q_{10}} e_{11i}\Delta \ln Insq_{t-i} + \sum_{i=0}^{q_{11}} f_{12i}\Delta Rint_{t-i} + \theta ECM_{t-1} \quad 3.11$$

Where the adjustment value is assumed to be less than zero and the short run parameters range from a_1, b_2, c_3, e_5 and f_6. The calculated cointegration model of the equation yields the delayed error correction term, or ECM.

3.2.3 The Interactive Effect of Infrastructural Expenditure and Institutional Quality on Industrialization in Nigeria

This study validates the mediating role of institutional quality on infrastructural development and on industrialization in Nigeria. This section focuses on if institutional quality is interacted with infrastructure expenditure what would likely be the effect on industrialization in Nigeria. Following equation 4 above, the model is as follows:

$$\ln Y_t = \alpha + a\ln K_t + b\ln L_t + c_t(\ln Infi_t * \ln Insq_t) + dInR\text{int}_t + \varepsilon_t \quad 3.12$$

The Pesaran et al (2001) autoregressive distributed lag model was used by the researcher to illustrate a long-run relationship between infrastructure development and industrialization in Nigeria. The model is as stated below in equation 13:

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} a_{1i}\Delta \ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i}\Delta \ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i}\Delta \ln L_{t-i} + \sum_{i=0}^{q_3} d_{4i}\{\Delta \ln Infi_{t-i} * \Delta \ln Insq_{t-i}] + \sum_{i=0}^{q_5} e_{5i}\Delta Rint_{t-i} + \gamma_1 lnY_{t-1} + \gamma_2 ln K_{t-1} + \gamma_3 ln L_{t-1} + \gamma_4[\ln Infl_{t-1} * ln Insq_{t-1}] + \gamma_5 Rint_{t-1} + \mu_t \quad 3.13$$

Δ is the difference operator. The summation a_1, b_2, c_3 and d_4 represent the short run dynamics of the model, the coefficients γ_1 to γ_5 indicate the long run relationship, and μ is the serially uncorrelated disturbance term with zero mean and constant variance. Following confirmation of cointegration between the variables, the following long run model for Y was estimated:

$$\ln Y_t = \alpha + \gamma_1 \ln Y_{t-1} + \gamma_2 \ln K_{t-1} + \gamma_3 \ln L_{t-1} + \gamma_4[\ln Infi_{t-1} * \ln Insq_{t-1}] + \gamma_5 Rint_{t-1} + \mu_t \quad 3.14$$

The lag orders of the variables were selected using the appropriate Information Criterion to find the ideal structure of the ARDL specification, and the following error correction model was developed to forecast the short run dynamics:

$$\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} a_{1i}\Delta \ln Y_{t-i} + \sum_{i=0}^{q_1} b_{2i}\Delta \ln K_{t-i} + \sum_{i=0}^{q_2} c_{3i}\Delta \ln L_{t-i} + \sum_{i=0}^{q_3} d_{4i}\{\Delta \ln Infi_{t-i} * \Delta \ln Insq_{t-i}] + \sum_{i=0}^{q_5} e_{5i}\Delta Rint_{t-i} + \theta ECM_{t-1} \quad 3.15$$

Where the adjustment value is assumed to be less than zero and the short run parameters range from a_1, b_2, c_3 and e_5. The calculated cointegration model of the equation yields the delayed error correction term, or ECM.

3.3 A Priori Expectation

The text outlines the expected relationships between various independent variables and Industrial Value Added (IVA). Key factors such as labour supply, capital, infrastructure development, institutional quality, telecommunications, energy consumption, transportation networks, and water transport are anticipated to positively influence industrial outputs. Conversely, it is expected that a higher Real Interest Rate will negatively affect industrial development.

3.4 Sources of Data, Description and Measurement of Variables

The study identifies and measures various variables relevant to its objectives. The endogenous variable is Industry value added (% of GDP) (INV), with several exogenous variables including labour supply (L), Capital (K), Infrastructure Index (INFI) (It was computed using Principal Component Analysis (PCA) with the of Stata 15 Software, Institutional Quality (INV) , Telephone lines per thousands (TEL), Electric power consumption (kWh per capita) (ELEC), Road network length (km) (ROAD), Air transportation (million ton-km) (AIR), Railway density per thousands (RAIL), and Water transport (WATER). The control variable is Real Interest Rate (RINT), based on annual data for this analysis. All the variables were sourced from World Development Indicator Database (2025) with exception of Institutional Quality (INV) which was sourced from The Fraser Institute's Institutional Quality Index, also known as the Economic Freedom of the World Index Database (2025).

3.1 Measurement of Variables

4.1 Unit root results

It was established in this study that the order of integration of our variables were mixture of I(1) and I(0) using the Augmented Dickey-Fuller (ADF).

Table 4.1: Optimal Augmented Dickey-Fuller Unit Root Test with Structural Break

Variables	Level	First Difference	Break Date	Order of Integration
Log INV		-7.3207***[b]	2016	I (1)
Log GFCF	-4.3315***[a]		2005	I(0)
Log LAB	-10.7937***,[b]		2000	I(0)
RINT	-10.1967***[b]		1995	I(0)
Log INSQ		-7.3207***[b]	2016	I(1)
Log ROAD		-7.4019***[b]	2017	I(0)
Log RAIL		-13.0432***,[b]	1994	I(1)
Log AIR	-6.0991***[a]		1993	I(0)
Log TEL	-12.0881***[a]		2000	I(0)
Log ELEC	-7.0018***[a]		2000	I(0)
INFI*INSQ		-8.5313***[b]	2019	I(1)
Log WAT	-4.7965***[b]		2016	I(0)

Note: Intercept = a, Intercept and Trend =b. ADF is Augmented Dickey Fuller unit root tests while ***, ** and * represent 1%, 5% and 10% levels of significance, respectively. I(0) and I(1) represent stationary at levels and first difference respectively.
Source: Author's Computation (2025).

4.3 Effect of aggregated infrastructural development on industrial development in Nigeria

Empirical findings on the effect of aggregated infrastructural development on industrial develo pment in Nigeria. The industry (including construction), value added (% of GDP) was the model's dependent variable. The first step is to check for long-term relationship.

4.3.1 ARDL bounds test

The ARDL Bounds Test results indicate a long-term relationship between Nigeria's aggregate infrastructural development and industrial development. The F-statistic of 8.045169, significant at the 5% level, surpassed the distribution's threshold values, rejecting the null hypothesis of no cointegration as shown in Table 4.3.1.

Table 4.3.1 Result on Bounds Test

F-statistic	8.045169
K	5
Upper Bounds	3.38
Lower Bounds	2.37

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
K is the number of exogenous variables in the model
Source: Author's computation (2025)

An autoregressive distributed lags model assessed the short and long-run coefficients, revealing that the cointegrated variables maintain a stable long-term relationship. The results indicated a statistically significant negative coefficient for the error correction term (-0.8748), demonstrating that 87.48 percent of the aftershock influences the long-run equilibrium rate, confirming the effectiveness of the error correction term at a 5% significance level.

Table 4.3.2 indicates that in the short run, aggregate infrastructural development significantly influences industrial development in Nigeria, albeit negatively. This finding contradicts the theoretical expectation that industrial development should correlate positively with infrastructural development. In term of the results sizes, in the short run, 1% changes in aggregate infrastructural index (INFI) led to a 3.9 decrease in industrial development. Likewise, in the long run, 1% change in aggregate infrastructural index led to 6.91 decrease in industrial development in Nigeria given the period under consideration. The results align with modernization theory, which posits that societies progress through phases of urbanization, industrialization, and technological advancement (Rostow, 1960). This theory emphasizes the importance of infrastructure in transitioning from agrarian to industrial societies, asserting that investments in infrastructure, such as energy and transportation networks, can foster economic growth in developing nations (Inglehart & Welzel, 2018).

The results indicate that the labour force participation rate significantly affects industrial development in Nigeria. In the short run, there is a positive relationship at lag one and lag two, while in the long run, a negatively significant relationship is observed. Meaning that in the short run give lag of one, a 1% change in labour force participation led to 669.8 % increase in industrial development in Nigeria at 1% level of significance. Also, at lag two, a 1% change in labour force participation rate led to a 267% increase in industrial development at 1% significance level. However, in the long, a 1% change in labour force supply resulted to a decrease of 949.97 (at 1% level of significance decrease) in industrial development in Nigeria given the study period. By implication, enough labour supply has already been attained in the short run. In the long run diminishing returns has already set in, that was why negative and significant link was found in the long run.

Table 4.3.2: ARDL Short Run Result on Infrastructure Development and Industrial Development. Dependent Variable: LnINV (3, 3, 0, 4, 1, 0) AIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGINV(-1))	0.2803	0.0823	3.4047	0.0025
D(LOGINV(-2))	-0.1898	0.0865	-2.1926	0.0392
D(LOGLAB)	2.0075	1.2006	1.6720	0.1087
D(LOGLAB(-1))	6.6980***	1.7113	3.9138	0.0007
D(LOGLAB(-2))	2.6700**	1.3152	2.0301	0.0546
D(INSQ)	0.0091	0.0088	1.0301	0.3141
D(INSQ(-1))	0.0466***	0.0113	4.1279	0.0004
D(INSQ(-2))	0.0573***	0.0115	4.9885	0.0001
D(INSQ(-3))	0.0410***	0.0110	4.1060	0.0005
D(INFI)	-0.0393***	0.0066	-5.965910	0.0000
D(RINT)	-0.0010	0.0006	-1.612722	0.1211
LOGGFCF	0.1584	0.10737	1.474831	0.1544
CointEq(-1)	-0.8748	0.1033	-8.466117	0.0000

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author's computation (2025)

Table 4.3.3 ARDL Long Run Result on Infrastructure Development and Industrial Dependent Variable: LnINV (3, 3, 1, 2, 4, 3) SIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGLAB	-9.4997***	1.6464	-5.7698	0.0000
LOGGFCF	0.1810	0.1211	1.4943	0.1493
INSQ	-0.0606***	0.0109	-5.5572	0.0000
INFI	-0.0691***	0.0114	-6.0513	0.0000
RINT	-0.0011	0.0008	-1.4375	0.1646
C	16.2715	3.2035	5.0793	0.0000

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author's computation (2025).

4.3.4 Residual diagnostic test results

The diagnostic test results, shown in Table 4.3.4, evaluated the accuracy of estimations using several tests including the Jarque-Bera normality test, serial correlation test, heteroscedasticity test, Ramsey Reset test, and cumulative sum tests. The Jarque-Bera test confirmed normal error distribution, while serial correlation LM tests showed no evidence of serial correlation at a 5% significance level. Heteroscedasticity tests did not affect parameter accuracy, and the Ramsey Reset test suggested all model estimations were valid. The parameter stability of the ARDL model was corroborated by the CUSUM and CUMUSQ tests, indicating reliable long-run coefficients against short-run dynamics, confirming the ARDL model's robustness.

Table 4.3.4 Residual diagnostic test results

Breusch-Godfrey Serial Correlation LM Test	0.7405
	(0.4895)
Heteroskedasticty Test (BPG)	0.7087
	(0.7576)
Normality Test	3.4176
	(0.1811)
Ramsey RESET'S Test	1.0050
	(0.3275)

Note: p-values are in the parentheses.
Source: Author's computation (2025).

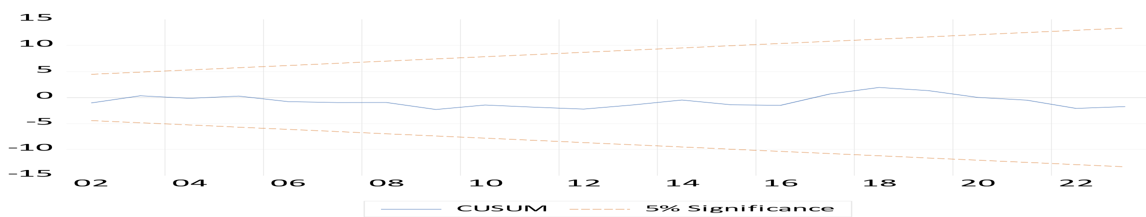

Figure 4.3.1 Cumulative Sum Test
Source: Author's computation (2025)

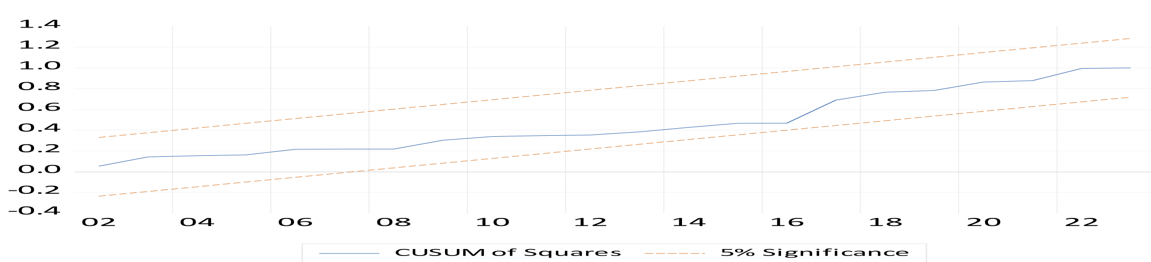

Figure 4.3.2 Cumulative Sum Squares Test
Source: Author's computation (2025)

4.4 Effect of individual infrastructure variable on industrial development in Nigeria

Verifying the contributions of Nigeria's infrastructure sectors is crucial for identifying strengths and deficiencies. This will enable the formulation of appropriate policies to address deficiencies and promote industrial development. Before discussing empirical findings on individual infrastructure's impact on industrial development, it is necessary to establish a long-term relationship between the variables of interest using ARDL Bounds tests. The dependent variable in the model is the industry value added as a percentage of GDP.

4.4.1 ARDL bounds test

The ARDL Bounds Test results indicate a long-term relationship between industrial development and Nigeria's infrastructure development. According to the finding of the in Table 4.4.1 F-statistic of 5.1262 surpassed both the upper and lower threshold values at the 5% significance level, rejecting the null hypothesis of no cointegration.

Table 4.4.1 Result on Bounds Test

F-statistic	5.1262
K	10
Upper Bounds	3.24
Lower Bounds	2.06

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
K is the number of exogenous variables in the model
Source: Author's computation (2025)

The analysis utilized an autoregressive distributed lags model to determine coefficients for both short and long runs. The ARDL results indicated a negative and statistically significant error correction term, suggesting cointegration and a stable long-term relationship between the variables. Specifically, the coefficient of -0.9800 reflects a rapid adjustment to equilibrium, highlighting that 98 percent of changes in the long-run equilibrium rate were attributed to aftershocks. The error correction term's significance at 5% underscores its effectiveness.

According to the results of effect of individual infrastructural variables on industrial development in Nigeria. Both the short and long runs results of air transport and telephone density are negatively and significantly related to industrial development in Nigeria given the period under investigation. In the short run, a 1% change in air transportation and telephone density brought about a 6.92% and 6.24% (both at 10% significant level) decrease in industrial value added, respectively. Also, in the long, a 1% in both air transport and telephone density led to decrease of 7.06% and 6.37% (both at 1% and 5% significant levels) in industrial output respectively in Nigeria during the study's period. These did not follow theoretical postulations that more infrastructural development leads to boost in industrial development. The study Garcia and Nguyen (2019) offered factual proof of how telecommunications infrastructure can revolutionise access to technology, information, and markets and this is not in tandem with this study. In order to clarify the complex relationships between the growth of telecommunications infrastructure and industrialisation in various emerging nations. The finding of physical capital is the same as in the first model result. A 1% change in physical capital led to an increase of 22.82% in industrial output in Nigeria. But the result in the short was positive but insignificant.

Air transport and telephone lines significantly contributed to Nigeria's industrial growth during the study period, while rail, road, water transportation, and electricity supply did not. The influence of foreign investors is evident in air and telecommunications. Policymaking should prioritize improvements in other infrastructure sectors in Nigeria.

Table 4.4.2 ARDL short run results of individual effect of infrastructure development on industrial development in Nigeria

Dependent Variable: LnINV (2, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0) SIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.6849	0.0761	8.9944	0.0025
D(LOGINV(-1))	0.4491	0.1013	4.4322	0.0392
D(LOGLAB)	2.0204	1.3017	1.5521	0.1087
D(LOGGFCF)	0.2237	0.1339	1.6707	0.1089
D(LOGINSQ)	0.1378	0.1466	0.9400	0.3574
D(LOGAIR)	-0.0692*	0.0258	-2.6817	0.0136
D(LOGELEC)	0.0011	0.0382	0.0296	0.9767
D(LOGRAIL)	0.0213	0.0205	1.0383	0.3104
D(LOGROAD)	0.0783	0.0892	0.8771	0.3899
D(LOGTEL)	-0.0624*	0.0257	-2.4289	0.0238
D(LOGWAT)	-0.1357	0.1001	-1.3561	0.1889
D(RINT)	-0.0013	0.0009	-1.6085	0.1220
CointEq(-1)	-0.9800	0.1082	-9.0565	0.0000
R-squared	0.9091			

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author’s computation (2025)

Table 4.4.3 ARDL long run results of individual effect of infrastructure development on industrial development in Nigeria

Dependent Variable: Ln INV (2, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0) SIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGLAB	-1.2355	1.8449	-0.6696	0.5101
LOGGFCF	0.2282*	0.1272	1.7939	0.0866
LOGINSQ	0.1406	0.1445	0.9730	0.3411
LOGAIR	-0.0706***	0.0223	-3.1674	0.0045
LOGELEC	0.0012	0.0390	0.0295	0.9767
LOGRAIL	0.0217	0.0194	1.1238	0.2732
LOGROAD	0.0798	0.0984	0.8113	0.4259
LOGTEL	-0.0637**	0.0278	-2.2955	0.0316
LOGWAT	-0.1385	0.1048	-1.3212	0.2000
RINT	-0.0013	0.0009	-1.4953	0.1490

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author’s computation (2025).

4.4.4 Residual diagnostic test results

The Jarque-Bera test indicated normal distribution of errors, and the serial correlation LM test confirmed the model's absence of serial correlation at a 5% significance level. The Breusch-Godfrey test showed that heteroscedasticity did not impact the accuracy of parameter estimates as shown in Table 4.4.4. Additionally, the ARDL model's parameter stability was validated through cumulative sum (CUSUM) and cumulative sum squares (CUSUMSQ) tests as shown in Figures 4.4.1 and 4.4.2., with all results falling within significant limits, indicating consistent long-run coefficients amidst short-run dynamics. The Ramsey Reset Test further supported the accuracy of all estimations made by the model.

Table 4.4.4 Residual Diagnostic Test Results

Breusch-Godfrey Serial Correlation LM Test	0.7092
	(0.4092)
Heteroskedasticty Test (BPG)	1.5338
	(0.1821)
Normality Test	0.4048
	(0.8168)
Ramsey RESET'S Test	0.0407
	(0.8420)

Note: p-values are in the parentheses.
Source: Author's computation (2025).

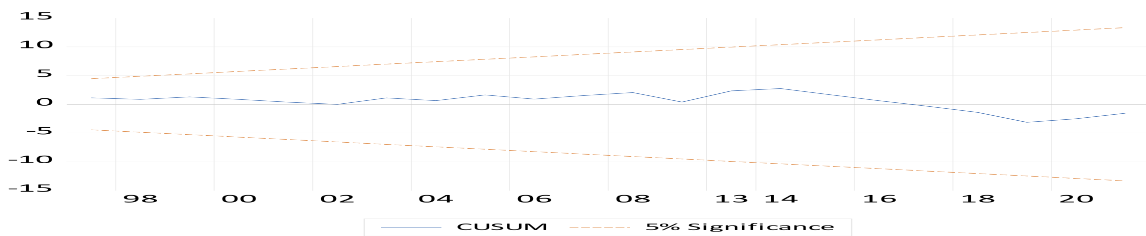

Figure 4.4.1 Cumulative Sum Test
Source: Author's computation (2025)

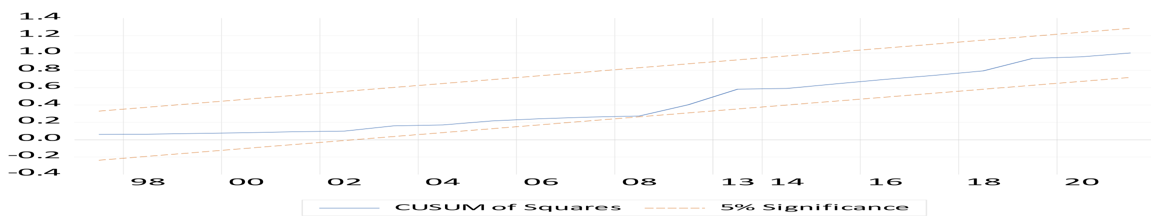

Figure 4.4. 2 Cumulative Sum Squares Test
Source: Author's computation (2025)

4.5 Interactive effect of infrastructural index and institutional quality index on industrial development in Nigeria

It is essential to verify the effect of when infrastructural index and institutional quality index are interacted on industrial value added whether or not a positive and significant contribution is going to be in Nigeria. Prior to empirical results analysis, the interaction of the infrastructural index and institutional quality index with industrial value added in Nigeria is introduced. The ARDL Bounds tests findings necessitate the examination of a long-term relationship between the variables, with industrial value added as a percentage of GDP being the dependent variable in the model.

4.5.1 ARDL bounds test

The ARDL Bounds Test results indicate a long-term relationship among the variables analyzed as shown in the results in Table 4.5.1. Specifically, the F-statistic of 6.8593 surpassed the critical values at the 5% significance level, rejecting the null hypothesis of no cointegration. This highlights the long-term connection between Nigeria's infrastructure development, institutional quality, and industrial development.

Table 4.5.1 Result on Bounds Test

F-statistic	6.8593
K	5
Upper Bounds	3.38
Lower Bounds	2.39

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
K is the number of exogenous variables in the model
Source: Author's computation (2025)

An autoregressive distributed lags model results in Table 4.5.2 revealed that the variables are co-integrated, indicating a stable long-term relationship as evidenced by a significant negative coefficient of the error correction term (-0.6666). This suggests that a 66.67 percent change in the long-run equilibrium rate is influenced by the aftershock, confirming the error correction term's efficacy at a 5% significance level.

According to the findings in Tables 4.5.2 and 4.5.3 that show both the short and long results. In the short run, significant and positive relationship was established between institutional quality and industrial growth in Nigeria, albeit at lag one and two. A 1% change in institutional quality led to a 3.13% significantly positive increase industrial development, though at one lag. Also, at lag two a 1% change in institutional quality brought an increase of 5.34% in industrial growth in Nigeria. However, in the long run, a significant but negative relationship was established. A 1% change in institutional quality brought about 6.19% decrease in industrial growth. In the short run, the findings of interactive effect of infrastructure index and institutional quality index were significant at level and lag one but negative at 1% and 5% respectively. A 1% change in the short run, led to a reduction of 0.68% and 0.27% at level and lag one respectively. In the long run, the findings of interactive effect of infrastructure index and institutional quality index was significant but negative at 1% significance level. By implication, in the short run when considering only the state of institutional quality ($t = 0.0313$, $t = 0.0534$, $t = 0.0259$ and $p < 0.05$) in Nigeria it was good, but in the long run, the quality of institutions turned negative and bad. The infrastructure in Nigeria is currently inadequate and deteriorating, suggesting that better maintenance of past quality institutions could have enhanced the country's infrastructure facilities.

Also, a positive and significant relationships were found between physical capital and industrial output growth in Nigeria, with a 1% increase in physical capital resulting in a 19.27% rise in industrial growth in the short run and 28.9% in the long run. Conversely, there was a significant negative relationship between the real interest rate and industrial growth, where a 1% change in real interest rate caused a 0.13% reduction in growth in the short run and a 0.2% reduction in the long run, both statistically significant at 5% and 10% levels.

4.5.2 ARDL short run results on interactive effect of infrastructural expenditure and institutional quality on industrial development in Nigeria

Dependent Variable: Ln INV (3, 0, 2, 4, 2, 0) SIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGINV(-1))	0.1777	0.0911	1.9503	0.0640
D(LOGINV(-2))	-0.3005	0.0857	-3.5054	0.0020
D(LOGGFCF)	0.1927*	0.1086	1.7746	0.0898
D(LOGLAB)	1.9393	1.2225	1.5863	0.1269
D(LOGLA(-1))	4.4294**	1.4393	3.0774	0.0055
D(INSQ)	0.0151	0.0091	1.6512	0.1129
D(INSQ(-1))	0.0313**	0.0105	2.9895	0.0068
D(INSQ(-2))	0.0534***	0.0114	4.6839	0.0001
D(INSQ(-3))	0.0259**	0.0096	2.7010	0.0130
D(INFI_INSQ)	-0.0068***	0.0012	-5.7815	0.0000
D(INFI_INSQ(-1))	-0.0027**	0.0013	-2.0989	0.0475
RINT	-0.0013**	0.0006	-2.2385	0.0356
CointEq(-1)	-0.6666	0.0853	-7.8173	0.0000
R-squared	0.8276			

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author's computation (2025).

4.5.3 ARDL long run results on interactive effect of infrastructural expenditure and institutional quality on industrial development in Nigeria

Dependent Variable: Ln INV (3, 0, 2, 4, 2, 0) SIC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGGFCF	0.2890*	0.1561	1.8519	0.0775
LOGLAB	-8.3252***	1.9652	-4.2363	0.0003
INSQ	-0.0619***	0.0144	-4.3145	0.0003
INFI_INSQ	-0.01157***	0.0026	-4.4647	0.0002
RINT	-0.0020*	0.0011	-1.7767	0.0894
C	12.7962	3.5919	3.5626	0.0017

NOTE: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively.
Source: Author's computation (2025).

4.5.4 Residual diagnostic test results

The diagnostic test results, detailed in Table 4.5.4, assessed the accuracy of estimations. The Breusch-Godfrey Serial Correlation LM Test confirmed no impact from heteroscedasticity, indicating absence of serial correlation at the 5% significance level. Normality tests via Jarque-Bera indicated error normality, while the Ramsey Reset Test showed no significant results, affirming accurate estimations. CUSUM and CUSUMSQ plots in Figures 4.5.1 and 4.5.2 confirmed the ARDL model's parameter stability, with long-run coefficients remaining constant amidst short-run dynamics.

Table 4.5.4 Residual diagnostic test results

Breusch-Godfrey Serial Correlation LM Test	**0.8122**
	(0.4580)
Heteroskedasticty Test (BPG)	1.2548
	(0.3054)
Normality Test	1.7482
	(0.4172)
Ramsey RESET'S Test	0.0571
	(0.8134)

Note: p-values are in the parentheses.
Source: Author's computation (2025).

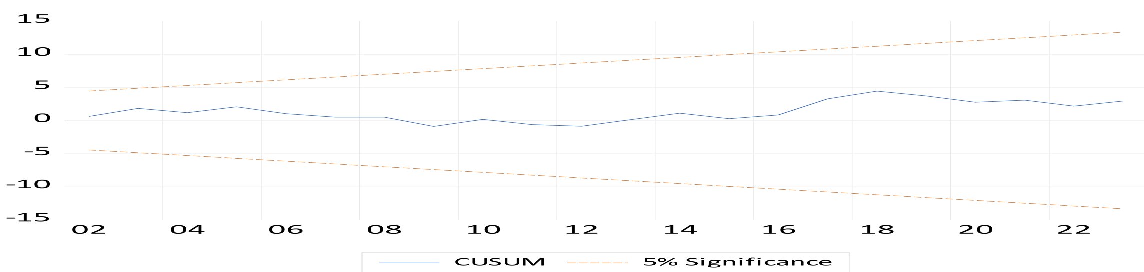

Figure 4.5.1 Cumulative Sum Test
Source: Author's computation (2025)

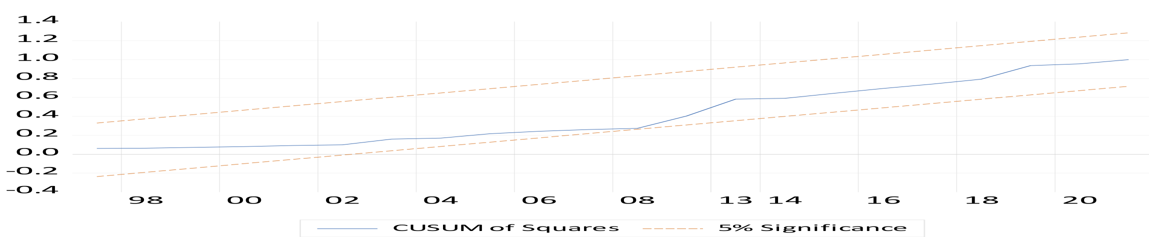

Figure 4. 5.2 Cumulative Sum Squares Test
Source: Author's computation (2025)

5 Summary, Conclusion and Recommendations

5.1 Summary

Over the period of 1981 to 2023, the study examined the impact of infrastructural and institutional development on Nigeria's industrial development. The study found that both short and long-term infrastructural development negatively correlates with industrial development, contrary to theoretical expectations. The study suggests that an appropriate mix of infrastructure is necessary to enhance industrial development in Nigeria. Both air transport and telephone density have a positive and significant impact on industrial development in Nigeria during the study period, while other infrastructures, such as energy and various transportation modes, do not. Foreign investors significantly influence Nigerian telecommunications and aviation sectors. There is a need for better policies to enhance other infrastructure in Nigeria.

5.2 Conclusion

In Nigeria, the interaction between infrastructural and institutional quality indexes shows a positive short-term relationship with industrial growth, but a negative long-term relationship. Initially, institutional quality was effective, but over time it deteriorated. The inadequacy of infrastructure has worsened, indicating that sustained high institutional quality could have jointly fostered industrial development if better infrastructure had been maintained.

5.3 Recommendations

The research, on the other hand, suggests that infrastructural development and institutional quality can make a significant contribution to improve the level of industrial development in Nigeria. Along with raising the calibre of institutions, investments in social and physical infrastructure are essential to promoting industrial development. This entails creating dependable transportation networks (roads, trains, and public transportation), making sure energy sources are steady and reasonably priced, and modernising communication systems. Also, encouraging transparency, fighting corruption, and promoting good governance are essential for allocating resources efficiently and drawing in investments.

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