International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 24-36 ISSN: 3048-6874
www.ijhssm.org

Assessing the Effect of Infrastructure and Income on Industrial Growth in Nigeria

[a]*Raymond Osi, Alenoghena; [b]Abayomi Oluwaseun, Japinye;[c]Segun Amos Adewale and [d]Joyce Sadiq
[a]Caleb University, Imota, Lagos, Nigeria
[b]Caleb University, Imota Lagos, Nigeria
[c]Central Bank of Nigeria
[d]Lagos State Ministry of Economic Budget, Planning and Statistics
**Corresponding author*

Date of Submission: 28-04-2025 Date of Acceptance: 07-05-2025

Abstract
Industrial growth is a fundamental driver of economic development, particularly in emerging economies like Nigeria. However, despite Nigeria's significant potential as Africa's largest economy, its industrial sector remains underdeveloped due to persistent structural challenges such as inadequate infrastructure and income inequality. Using a secondary dataset, this study critically evaluates the effects of infrastructure and income on industrial growth in Nigeria using a combination of econometric techniques. Gross Fixed Capital Formation (GFCF) serves as a proxy for infrastructure investment, while GDP per capita represents income levels. Key infrastructure components, including air transport, road transport, telecommunications, and energy consumption, are examined to assess their impact on industrial growth. Consequently, the World Bank Development Indicators, 2022 and the Nigerian Central Bank's statistical report will be the sources of the data. Inferential techniques were adopted in the analyses of data trends. Augmented Dickey Fuller (ADF) was utilized to test the stationarity of the variables. The results reveal that all variables are stationary at first difference. Using Fully-Modified OLS, the results indicate that infrastructure and Gross domestic product per capita have a negative and significant drive to industrial productivity. At the same time, gross fixed capital formation and trade openness are positively associated with industrial growth. The interaction between infrastructure and income shows a positive and is significant in the industrial output. The study concludes that comprehensive infrastructure investments and targeted policies addressing income disparities are critical for fostering sustained industrial development in Nigeria. Recommendations for policy and future research are provided, emphasizing the need for regional development, improved energy infrastructure, and enhanced telecommunications networks.

Keywords: Gross Fixed Capital Formation, Industrial growth, Infrastructure, Income, Trade Openness.

I. INTRODUCTION

Industrial growth is widely recognized as a fundamental driver of economic development, particularly in emerging economies such as Nigeria (Chete et al., 2014; Nwogo & Oriji, 2019; Ibitoye, Ogunoye and Kleynhans, 2022). Nigeria's economy, as Africa's largest, has the potential to catalyze structural transformation and diversify away from the primary sector. This transformation can create a conducive environment for the development of innovation, employment, and technological advancement. Job creation, in particular, is a significant aspect of this potential, as it can have a profound social impact. Despite the current situation where Nigeria contributes very little to GDP, the industrial sector can be a key player in achieving more sustainable growth and job creation (Ibitoye et al., 2022; Chukwu, 2023). The leading sectors are still the oil and agricultural, despite the potential in the industrial sector (Eromise et al., 2022; Ibitoye et al., 2022). This is a result of the persisting structural challenges. The problems include inadequate infrastructure and high-income disparity, which may hinder industrial development.

Infrastructure does not merely complement industrialization; it is its backbone, the sustaining and driving force for productive activities, the movement of goods and labour, and the integration of markets, domestic as well as foreign (Azolibe & Okonkwo, 2020). There is not enough emphasis. Inadequate infrastructure is a nagging issue which, given the urgency of our industrial development and market integration, needs to be tackled speedily. In particular, industrial growth depends on the availability of efficient transportation networks, reliable energy systems, and modern telecommunications infrastructure (Ubi & Udah, 2019). In the Nigerian context, however, the infrastructure landscape is characterized by significant deficiencies (Ojiodu & Aderinto, 2021). Road networks are underdeveloped and poorly maintained, air transport remains limited in capacity, and the energy sector is marred by frequent power outages and unreliable supply (Bennee & Okoye, 2021). These infrastructural gaps impose high transaction costs on industrial actors, disrupt production processes, and dissuade both domestic and foreign investment in the sector (Azolibe & Okonkwo, 2020).

Equally significant is the role of income in shaping industrial growth, as income levels, commonly represented by GDP per capita, directly influence both the consumption capacity of households and the investment potential of firms (Nwuju, Aiyedogbon and Aigbedion, 2022). In Nigeria, the high levels of income disparity between different regions and social classes present a formidable challenge to industrial expansion (Oyadeyi, 2023). Low-income households have limited purchasing power, which constrains demand for industrial goods and services. At the same time, firms in regions with lower GDP per capita often lack the resources needed to invest in technology, machinery, and infrastructure that would support industrial activities (Fagbohun & Adekoya, 2016). Furthermore, the concentration of wealth within specific segments of the population exacerbates these issues, as economic participation remains restricted for large portions of society, thereby stifling broad-based industrial growth (Keji, 2021).

This study seeks to critically evaluate the effects of infrastructure and income on industrial growth in Nigeria. The analysis employs gross fixed capital formation (GFCF) as a proxy for industrial growth (Anderu, 2023; Goswami & Goswami, 2023) and GDP per capita as a proxy measure of income (Mubarak, Suomi and Kantola, 2020; Uddin & Azam, 2023), while also examining key infrastructural components such as air transport, road transport, telecommunications, and energy consumption. The study aims to provide an in-depth understanding of the relationship between these variables and their cumulative impact on industrial development in Nigeria through a comprehensive econometric approach. Specifically, it addresses a gap in the existing literature concerning the joint effects of infrastructure and income on industrial growth. It offers insights into potential policy interventions required to overcome the barriers impeding Nigeria's industrial trajectory.

The theoretical and empirical literature review in the next section of the research expands on the established links between infrastructure, income and industrial growth in Nigeria. The research design, a key component derived from the methodology section, provides a detailed guideline on the use of the econometric technique for the analysis of the relationships between selected independent variables like Gross Fixed Capital Formation (GFCF), Air transport, Road transport, Telecommunications and Energy consumption with the dependent variable GDP per capita. This design serves as a roadmap, guiding us through the analysis process. The results section comprises of descriptive statistics summarising the key variables to demonstrate the association between infrastructure investments, income levels and growth in Nigeria's industrial sector. The study presents a critical discussion of the findings, linking the results to the broader literature discussed in earlier sections before the concluding section.

II. LITERATURE REVIEW

2.1 Empirical Literature Review

2.1.1 Infrastructure and Industrial Development

Infrastructure is generally acknowledged as one of the essential drivers of industrial development, serving as the pivotal base upon which all industrial activities are hinged (Bennee & Okoye, 2021). Adequate and efficient infrastructure facilitates the functioning of productive activities through the transportation of goods, energy delivery and the communication and connectivity mechanism needed for business conduct (Chete et al., 2014). The infrastructure deficit is a significant constraint toward industrial development in Nigeria because it hinders the growth of a modern and diversified industrial base (Ojiodu & Aderinto, 2021). Increasing investment in infrastructure, government policies, and initiatives are towards ending these challenges.

Infrastructure for transport, including roads, railways and air transport, supports industrial development by ensuring that raw materials and intermediate goods and products can be moved from producers to consumers (Azolibe & Okonkwo, 2020). Inadequate transport infrastructure can create significant obstacles to industrial productivity by increasing the cost of transporting goods and lengthening lead times, thereby reducing the competitiveness of domestic industries in domestic and international markets (Hossain & Huggins, 2021). In Nigeria, underdeveloped road networks have been considered a significant constraint to industrial development (Ubi & Udah, 2019). Poorly maintained roads, traffic congestion, and limited access to key industrial zones hinder the efficient flow of goods and services, contributing to higher production costs and lower industrial output (Siyan et al., 2015).

Energy infrastructure is equally critical to industrial development (Edomah et al., 2016). Overall, industrial processes within the manufacturing, mining and heavy industries sectors invariably require a relatively steady and reliable energy supply (Renna & Materi, 2021). Nigeria's energy sector is plagued by chronic inefficiencies, including poor power supply, low generation capacity and overreliance on fossil fuels (Abam et al., 2014). To have a stable energy supply for production, industrial firms are usually compelled to purchase expensive alternative energy sources, such as diesel generators (Adeyanju et al., 2020). These sources make production costly, thus reducing their competitiveness and profitability. The importance of energy infrastructure to industrial growth cannot be overstated, as it directly affects the capacity of firms to operate at optimal levels, maintain production schedules, and invest in technology upgrades (Ojiodu & Aderinto, 2021).

Telecommunications infrastructure has also become increasingly important in industrial development, particularly in the context of the globalised economy (Sarangi & Pradhan, 2020). Reliable telecommunication networks are not just a convenience but a necessity for the digitalised industrial production processes, supply chains, and logistics systems. These networks ensure the secure and fast exchange of real-time information, communication processes, coordination, and data flow (Kobzev et al., 2021). The telecommunications sector in Nigeria has seen spectacular growth in recent decades, with the mobile subscriber market and internet penetration soaring (official data from Terna, 2019). However, for many industrial operations, the underdeveloped fixed-line telecommunications infrastructure is an ongoing problem ('Nigeria Is Neglected,' 2021). Nigeria's telecoms was the first African economic sector to become digitalised. However, the urgency of a comprehensively digitised industrial sector has yet to arrive.

Second, the importance of investing in infrastructure cannot be overstated. There is solid empirical evidence that growth in total factor productivity is closely tied to such investments (presumably, they are complements). Industrial growth is aided by investment in infrastructure (Du, Zhang & Han, 2022). Ansar et al. (2016) conclude that 'industrial growth is likely to be favoured in countries where there is quicker growth in total factor productivity' and is likely to be supported by higher infrastructure investment and, in turn, enhanced industrial growth, as well as improved efficiency in the movement of goods and a reduction in transaction costs. Similarly, Justman (1995) finds that improving infrastructure such as roads, rail, irrigation and water delivery through investment can lead to faster industrialisation. Justman (1995) adds that transport infrastructure facilitates industrialisation because improved connectivity allows firms to produce products that can be shipped to a larger market to improve demand, source inputs more cheaply and reduce production delays. However, infrastructure investment is not the sole answer to industrial growth – improving countries' institutions and their governance, along with investing in human capital and skills, helps to ensure that infrastructure investment results in industrial outcomes; as Seidu et al. (2020) stress that there are institutional, governance and people variables – beyond investment in infrastructure – that specify the institutional and governance conditions that are necessary for infrastructure investments to generate industrial growth.

2.1.2 Income and Industrial Development

The role of income in industrial development is well-established in economic literature (Han et al., 2020). Higher levels of GDP per capita are generally associated with increased investments in technology, infrastructure, and industrial capacity, as higher income enables firms and individuals to finance industrial activities (Sarangi & Pradhan, 2020). In this regard, income serves as both a driver of demand for industrial goods and services and a source of capital for investment in production processes (Uddin & Azam, 2023).

However, empirical studies on the impact of income inequality on industrial growth have shown that income distribution can significantly alter this relationship (Erman & Te Kaat, 2019). In Nigeria, income inequality is pervasive, with a large proportion of the population living below the poverty line (Mohammed Guza et al., 2020). Young (2019) argued that this income disparity reduces the positive effects of infrastructure investments on industrial growth. When income is concentrated in the hands of a few, industrial activities become geographically and socially isolated, with wealthier regions benefiting from infrastructure developments.

In comparison, poorer regions remain marginalised (Erman & Te Kaat, 2019). This geographic concentration of industrial activities limits the overall growth potential of the sector, as it restricts the ability of low-income households to participate in industrial production and consumption.

2.2 Gaps in Literature

While existing studies such as Bennee and Okoye (2021) and Mohammed Guza et al. (2020) have extensively examined the individual effects of infrastructure and income on industrial growth in Nigeria, there are notable gaps in the literature regarding their combined impact. Moreover, sectoral disparities in infrastructure investment have often been overlooked. For instance, while studies like Giwa et al. (2022) have analysed the role of road transport, there has been limited attention to the underdevelopment of air transport systems and their implications for industrial expansion. This study seeks to address these gaps by providing a comprehensive analysis of the effects of infrastructure and income on industrial growth in Nigeria, using the most recent available data. It integrates infrastructure components such as air transport, road transport, telecommunications, and energy consumption with income (GDP per capita) measures to assess their combined impact on industrial productivity. Through this approach, the study's insights can lead to the generation of policy interventions required to overcome the infrastructural and income-related barriers to Nigeria's industrial growth.

2.3 Theoretical Framework

The link between infrastructure and economic growth has occupied a central place in development economics (Irshad et al., 2022). In endogenous growth theory, infrastructure investment is said to boost productivity by improving the efficiency of resource allocation, reducing transaction and production costs, and increasing firms' ability to compete in the market (Acs & Sanders, 2021). This theory suggests that the availability and quality of infrastructure, such as transport, telecommunications, and energy systems, can directly influence industrial output by fostering economies of scale and enhancing labour productivity (Chandra, 2021). Infrastructure is seen as a public good that drives long-term economic growth by encouraging private and public sector investment (Andonov et al., 2021).

The Solow-Swan model of economic growth further reinforces this argument by emphasising the role of capital accumulation in short-term growth while recognising that technological progress, which is often facilitated by efficient infrastructure, drives sustained long-term growth (Gundlach, 2007; Enya & Ezeali, 2021). In this model, infrastructure investment boosts immediate industrial output and supports future growth by enabling technological advancements, facilitating innovation, and expanding productive capacity (Irshad et al., 2022). For industrial sectors in developing economies like Nigeria, infrastructure forms the backbone for achieving higher productivity levels and integrating into global value chains (Owusu-Manu et al., 2019).

Income levels, as measured through GDP per capita, serve as a direct indicator of economic welfare and industrial potential, although there are limitations that need to be acknowledged (Raghupathi & Raghupathi, 2017; Dědeček & Dudzich, 2022; Uddin & Azam, 2023). Higher income levels allow for more significant investments in industrial capacity, as firms and individuals have more financial resources to allocate toward production, technology, and infrastructure. Kuznets' theory of structural transformation provides further insight into the dynamic relationship between income and industrial growth (Kuznets, 1957). Kuznets posits that economic development typically involves a shift from agrarian economies, reliant on primary production, toward more industrialised economies that require significant infrastructure investment and income growth to support higher levels of output (Baymul & Sen, 2019). This theory highlights the importance of income in fostering industrial activities and financing the necessary infrastructure improvements that enable these activities (Baymul & Sen, 2020).

III. METHODOLOGY

3.1 Research Design

This study adopts a quantitative research design, using econometric techniques to explore the impact of infrastructure and income on industrial growth in Nigeria. Quantitative research is particularly well-suited to this analysis, as it allows for systematically examining relationships between variables and generating statistically robust conclusions (Rana et al., 2021). This ensures objectivity, replicability, and precision in evaluating the contributions of infrastructure components and income levels to industrial development. The study uses secondary data from authoritative sources, providing an empirical basis for assessing the research questions. A time-series approach is employed, allowing the analysis to account for dynamic changes over time and enabling the capture

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 24-36 ISSN: 3048-6874
www.ijhssm.org

of long-term trends in infrastructure investment, income fluctuations, and industrial growth.

3.1 Methodology

This study uses econometric approaches involving time series data to examine the effect of infrastructure and income on industrial growth in Nigeria. The independent variables in this study include Air Transport (Passenger Carried) (ATRSP), Fixed telephone subscriptions (per 100 people) (FTEL), Road Transport (RTRSP), Energy per Capita (ENERG) – proxy for infrastructure variable, Gross Fixed Capital Formation (GFCF), Trade Openness, Gross Domestic Product per capital and Industrial Growth serves as a proxy for the dependent variable (Sustainable Economic Development). All of these measures are used in the study to achieve this goal.

The study uses annual time series data with 33 observations from 1989 to 2022. Thus, the data's primary sources are the Nigerian Central Bank's statistics report and the World Bank Development Indicators, 2022.

3.2 Model Specification

In order to show the relationship between to examine Infrastructure, Income and Industrial Growth in Nigeria. In the model, the authors expressed output as a function of Infrastructure and Income, Industrial Growth and other variables. The following linear specification specification of the econometric model is shown in equation (1) as follows:

IPI = f(INFRA, GFCF, TOPEN, GDPPC) - - - - - (1)
IPI = f(INFRA, GFCF, TOPEN, GDPPC, INFRA*GDPPC) - - - (2)

Where,
IPI = Industrials Output
INFRA= INDEX=Principal component of Infrastructure
GFCF = Gross Fixed Capital Formation
TOPEN= Trade Openness
GDPPC = Gross domestic Product per Capita
Let's assume a basic long-run relationship among variables:

$$IPI_t = \beta 0 + \beta 1 INDEX_t + \beta 2 GFCF_t + \beta 3 TOPEN_t + \beta 4 GDPPC_t + u_t ....3$$

$$IPI = \beta 0 + \beta 1 INDEX_t + \beta 2 GFCF_t + \beta 3 TOPEN_t + \beta 4 GDPPC_t + \beta 5 INDEX * GDPPC + u_t ....4$$

u_t = error term
t = time period

3.3. Estimation Procedure

The estimation procedure adopted in this study is comprised of five steps. The first step entails the estimation of the principal component analysis to arrive at a single variable for infrastructure to be adopted among the other variables in the study. The second step involves the determination of the stationarity status of the variables affecting the estimation of the order of integration using the ADF - Fisher Chi-square statistic. The third step is the cointegration analysis using the ARDL cointegration technique. The fourth step comprises the regression analysis estimation using the ARDL technique to separate the long-run estimation from the short-run estimation over the sample period of the data from 1989 to 2022.

3.4 Sources of Data and Variable Definition

The study uses annual time series data with 33 observations from 1989 to 2022. Thus, the data's primary sources are the Nigerian Central Bank's statistics report and the World Bank Development Indicators, 2022.

Table 1 A – Variable Definition and Measurements

Variable	Full Name	Measurement	Source
IPI	Industrial Production Index	Value added is the net output of Industrial sectors after adding up all outputs and subtracting intermediate inputs.	WDI
INDEX	Summarised Index for Infrastructure	Comprises of Air and Road Transport, Fixed Telephone and Energy use	CBN

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 24-36 ISSN: 3048-6874
www.ijhssm.org

CFGF	Gross Fixed Capital Formation	GFCF refers to land improvements (fences, ditches, drains, and so on); equipment purchases, plant, machinery; and the construction of railways, roads, and the like, including schools, offices, hospitals and the like. (Estimated as share of GDP)	WDI
TOPEN	Trade Openness	Trade Openness is measured by the ratio of the value of imports plus exports divided by GDP.	WDI
GDPPC	GDP Per Capita	GDP divided by population	WDI

Source: Compiled from WDI and CBN Reports (2022)

IV. EMPIRICAL RESULTS AND ANALYSIS

4.1 Principal component analysis of Infrastructure

The principal component analysis in this study is conducted to estimate a composite index that incorporates the features of the four selected infrastructure measures adopted in this study. The measures are defined as shown:

i) Air Transport (Passenger Carried) (ATRSP)
ii) Fixed telephone subscriptions (per 100 people) (FTEL)
iii) Road Transport (RTRSP)
iv) Energy per Capita (ENERG)

The level of correlations among these variables is shown in Table 4.1. There is a negative correlation between Air Transport and Energy per Capita (-0.59653), and there is also a negative correlation between Road Transport and its significance and Fixed telephone subscriptions (-0.10528). However, there is a positive correlation between Air Transport and Fixed telephone subscriptions, but it is not significant (0.048). However, air transport and road transport have a strong positive relationship and are highly correlated (0.7899). Another variable to consider is that there is a strong negative relationship between Energy per Capita and Road Transport (-089021). With these high positive correlations, it may not be proper to use the variables together in multiple regression equations, leading to multicollinearity.

Table 1 Ordinary Correlation of Infrastructure Variables

	ATRSP	ENERG	FTEL	RTRSP
ATRSP	1			
ENERG	-0.5965	1		
FTEL	0.0448	0.1026	1	
RTRSP	0.7899	-0.8902	-0.1053	1

Source: *Author`s Computation*

The average correlation among all the variables is estimated at 0.63.3, as shown in the principal component. The high correlation among the variables justifies the computation of a composite proxy for the variables with the method of principal component analysis

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 24-36 ISSN: 3048-6874
www.ijhssm.org

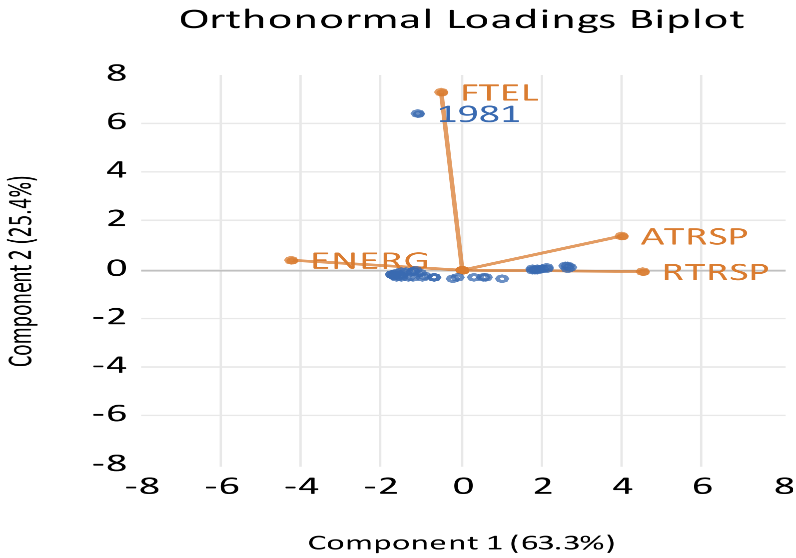

Table 2 gives the basis for the generation of the PCA variable data. The principal component one (PC1) equation is generated from the Eigenvectors (loading) shown in equation.

PC1 = 0.539ATRSP -0.572ENERG - 0.065FTEL + 0.615RTRSP

Further observation reveals reveal that PC1 alone comprises 0.6326 proportions of the total PCA components. This is over 63.26% of the total proportion of all the PCs. Therefore, PC1 is conveniently adopted as the variable for the PCA of this study.

Table 2 Eigenvectors (loadings) of Infrastructure Variables

Variable	PC 1	PC 2	PC 3	PC 4
ATRSP	0.538579	0.187731	0.755653	-0.32199
ENERG	-0.57208	0.050826	0.621931	0.532304
FTEL	-0.06491	0.98081	-0.17828	0.044887
RTRSP	0.615181	-0.0136	-0.10202	0.781639

Source: *Author`s Computation*

4.2 **Unit Root Test**

The unit root test result is shown in table 3.

Table 3: Augmented Dickey Fuller Unit Root Test Results

	LEVEL			FIRST DIFFERENCE			
Variables	**T-Stat**	**Critical Values 5%**	**P-Values**	**T-Stat**	**Critical Values 5%**	**P-Values**	**Order of Integration**
IPI	1.6670	2.9370	0.4398	6.5331	2.9604	0.000	I(1)
INDEX	0.2448	2.9350	0.9723	6.7278	2.9370	0.000	I(1)
GFCF	1.7524	3.5236	0.7092	4.5570	2.9370	0.007	I(1)
TOPEN	0.9530	3.5578	0.9367	5.6070	2.9390	0.000	I(1)
GDPPC	1.1379	2.9370	0.6913	4.1121	2.9379	0.0026	I(1)

Source: *Author`s Computation*

Note: * indicates signifies at 5 percent; 95% critical values are reported in parentheses below each test value.

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 24-36 ISSN: 3048-6874
www.ijhssm.org

The findings of the Augmented Dickey-Fuller (ADF) unit root test, with a t-statistic of 6.5331, show that the IPI is stationary at first difference because the t-statistic is higher than the 5% threshold value, which is 2.9604. The probability value is less than 5%, or 0.000 INDEX is not stationary at the level since the t-statistics is less than the critical values, and the probability values are greater than 0.05. Still, it is stationary at first difference because the t-statistic of 6.7278 is greater than the critical value at 5% of 2.9370 with 0.000 as the probability value. GFCF is stationary at first difference because the t-statistic of 4.5570 is more than the 5% critical value of 2.9370 with the probability value of 0.007. Still, it is not stationary at the level because the t-statistic is less than the 5% critical value. Moreover, with a 0.000 probability value, the TOPEN is stationary at the first difference since the t-statistics are larger than the critical value of 5%, which is 5.6070 and 2.9390, respectively.Additionally, GDPPC is not stationary at the level since the t-statistics is less than the critical value of 2.9370 with a P-value of 0.6913. Still, it is stationary at first because the t-statistics of 4.1121 is greater than the critical value of 2.9379 with probability values of 0.0026.

The unit-roots examine the stationarity of the variables, as was previously discussed, to avoid erroneous findings. According to the results, all the variables are stationary at the first difference. For this reason, fully modified OLS will be employed as a method to assess the effect of infrastructure and income on industrial growth in Nigeria.

4.4. **Cointegration Test**

The normalized auto-correlation coefficient (termed the z-statistic) and the Johansen Cointegration Test combine to reject the null hypothesis that there is no cointegration at the 5% level of significance (refer to Tables 4 and 5).

Johansen cointegration test findings are displayed in Tables 4 and 5, respectively, showing the presence of two (Trace) and one (Maximum Eigenvalue) cointegrating ranks. Another test was required to determine whether the non-stationary variables were cointegrated because nearly all of the variables were stationary at the initial differencing. At the five per cent significance level, the hypotheses were essentially evaluated to confirm the rank of the cointegrating correlations among the variables. This suggests that there was proof that the variables had a long-run association.

Table 4 Johansen Cointegration Rank Test (Trace)

Hypothesized			0.05	Prob **
No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value	Critical Value
None *	0.5456	87.28722	69.81889	0.0011
At most 1 *	0.459253	55.73613	47.85613	0.0076
At most 2 *	0.327749	31.14395	29.79707	0.0348
At most 3	0.23205	15.25903	15.49471	0.0542
At most 4 *	0.11081	4.697779	3.841465	0.0302

Source: *Author`s Computation*

Trace test indicates 3 cointegrating equation(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values

Table 5: Johansen Unrestricted Cointegration Rank Test (Max-eigenvalue)

Hypothesized		Max-Eigen	0.05	Prob.**
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Critical Value
None	0.5456	31.55109	33.87687	0.0924
At most 1	0.459253	24.59219	27.58434	0.1153
At most 2	0.327749	15.88492	21.13162	0.2317
At most 3	0.23205	10.56125	14.2646	0.1776
At most 4 *	0.11081	4.697779	3.841465	0.0302

Source: *Author`s Computation*

Therefore, considering the application of the Fully Modified Least Squares (FMOLS) would enable us to track the long-run relationship between the variable, since all variables are stationary at first difference and there is co-integration, and we have confirmed the long-run relationship.

4.5 Assessing the Effect of Infrastructure and Income on Industrial Growth in Nigeria.

The FMOL investigation of the effect of infrastructure and income on industrial growth in Nigeria is shown in Table 6. The results of the FMOLS test indicate that the principal component index of infrastructure and gross fixed capital formation, trade openness and gross domestic product per capita are statistically significant in affecting industrial growth at a 5% level of confidence with 0.013,0,0.003, and 0.01 probability values, respectively.

In addition, the effects of the principal component of infrastructure and gross domestic product per capita have a negative impact on industrial growth. In contrast, gross fixed capital formation and trade openness are positive. In specific terms, there is a 10% change in the principal component of infrastructure and a 22.4% change in industrial growth in the reverse direction. Moreover, a 10% change in gross domestic product per capita stimulates a 0.03% change in industrial growth in the reverse direction.

Table 6: Assessing the Effect of Infrastructure and Income on Industrial Growth in Nigeria.

Dependent Variable: IPI				
Method: Fully Modified Least Squares (FMOLS)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INDEX	-2.24406	0.898034	-2.49886	0.0173
GFCF	0.289187	0.036151	7.999521	0.0000
TOPEN	0.109407	0.03518	3.109935	0.0037
GDPPC	-0.00252	0.000935	-2.69226	0.0108
INDEX*GDPPC	0.002088	0.000441	4.740186	0.0000
C	17.0029	2.523996	6.736501	0.0000
R-squared	0.760295	Mean dependent var		29.44751
Adjusted R-squared	0.726051	S.D. dependent var		5.045487
S.E. of regression	2.640814	Sum squared resid		244.0865
Long-run variance	4.42623			

Source: *Author`s Computation*

Substituted Coefficients:

=========================

IPI = 17 – 2.2441*INDEX+ 0.2802*GFCF + 0.1094*TOPEN – 0.0025*GDPPC + 0.0021* INDEX*GDPPC

4.6 Examining the Interacted Effect infrastructure and Income on Industrial Growth.

The interaction effect between income and infrastructure has positively and statistically significantly impacted industrial growth. This implies that during the reviewed period, the proportion of infrastructure development made possible by GDP per capita has favourably impacted industrial expansion. The probability value supports the robustness of this association by confirming statistical significance at the 5% level.

Additionally, a positive association is shown by the fact that a 10% increase in the interaction coefficient of infrastructure and income leads to a 0.02% increase in industrial growth. Furthermore, the model's explanatory variables account for almost 73% of the overall variation in industrial growth, according to the R-squared value of 0.76 and the modified R-squared of 0.73. This demonstrates how well the model explains the main factors influencing industrial growth.

V. CONCLUSIONS AND RECOMMENDATIONS

This study set out to critically evaluate the effects of infrastructure and income on industrial growth in Nigeria, employing a combination of econometric techniques to analyze the relationships between key infrastructure components, income levels, and industrial development.

Infrastructure, which comprises Air Transport, Fixed telephone subscriptions, Road Transport, and Energy per Capita, shows a positive relationship with Industrial growth; likewise, other independent variables have a significant impact on Industrial growth.

The findings show that the effects of the principal component of infrastructure and gross domestic product per capita have a negative impact on industrial growth. The interaction effect between income and infrastructure has been positively and statistically significant in impacting industrial growth.

Based on the findings of this study, several policy recommendations are put forward to enhance industrial growth in Nigeria:

i. Strengthen Energy Infrastructure: Given the critical role that energy availability plays in industrial productivity, the Nigerian government should prioritize investments in energy infrastructure. This includes expanding the generation capacity, improving the reliability of the grid, and reducing the country's reliance on costly alternative energy sources. Policies aimed at improving energy efficiency, particularly in industrial sectors, should also be encouraged.

ii. Enhance Telecommunications Networks: Telecommunications has proven to be a significant contributor to industrial growth. The government and private sector should invest in expanding fixed-line telecommunications and internet infrastructure, especially in rural and underdeveloped areas, to ensure broader connectivity. This will not only enhance industrial operations but also integrate Nigeria more effectively into global value chains.

iii. Address Inefficiencies in Transport Infrastructure: The negative impact of air and road transport on industrial growth underscores the need for more strategic investments in transport infrastructure. Maintenance of existing roads, improvement of road networks, and expansion of air transport capacity are crucial. The government should consider public-private partnerships to fund and manage large-scale transport infrastructure projects and ensure efficient use of resources.

iv. Reduce Income Inequality: Income disparities in Nigeria are hindering the full benefits of infrastructure investments. Policies aimed at wealth redistribution, such as progressive taxation, social safety nets, and region-specific development programs, should be implemented to reduce income inequality. This will increase the purchasing power of a larger segment of the population, enabling more widespread industrial growth.

v. Promote Regional Development: Regional disparities in infrastructure development and income levels need to be addressed to foster balanced industrial growth. The government should implement regionally tailored infrastructure projects that address the specific needs of underdeveloped areas, ensuring that all parts of the country benefit from industrial activities.

References

[1]. Abam, F.I., Nwankwojike, B.N., Ohunakin, O.S. and Ojomu, S.A. (2014). Energy Resource Structure and on-going Sustainable Development Policy in Nigeria: a Review. *International Journal of Energy and Environmental Engineering*, 5(2-3). doi:https://doi.org/10.1007/s40095-014-0102-8.

[2]. Acs, Z. and Sanders, M. (2021). Endogenous Growth Theory and Regional Extensions. *Handbook of Regional Science*, pp.615–634. doi:https://doi.org/10.1007/978-3-662-60723-7_13.

[3]. Adeyanju, G.C., Osobajo, O.A., Otitoju, A. and Ajide, O. (2020). Exploring the potentials, Barriers and Option for Support in the Nigeria Renewable Energy Industry. *Discover Sustainability*, 1(1). doi:https://doi.org/10.1007/s43621-020-00008-5.

[4]. Anderu, K.S. (2023). Industrial Output Growth and Foreign Direct Investment in Nigeria. *Future Business Journal*, 9(1). doi:https://doi.org/10.1186/s43093-023-00225-0.

[5]. Andonov, A., Kräussl, R. and Rauh, J. (2021). Institutional Investors and Infrastructure Investing. *The Review of Financial Studies*, 34(8), pp.3880–3934. doi:https://doi.org/10.1093/rfs/hhab048.

[6]. Ansar, A., Flyvbjerg, B., Budzier, A. and Lunn, D. (2016). Does Infrastructure Investment Lead to Economic Growth or Economic fragility? Evidence from China. Oxford Review of Economic Policy, 32(3), pp.360–390. doi:https://doi.org/10.1093/oxrep/grw022.

[7]. Azolibe, C.B. and Okonkwo, J.J. (2020). Infrastructure Development and Industrial Sector Productivity in Sub-Saharan Africa. *Journal of Economics and Development*, 22(1), pp.91–109. doi:https://doi.org/10.1108/jed-11-2019-0062.

[8]. Baymul, C. and Sen, K. (2020). Was Kuznets Right? New Evidence on the Relationship between Structural Transformation and Inequality. *The Journal of Development Studies*, 56(9), pp.1–20.

doi:https://doi.org/10.1080/00220388.2019.1702161.

[9]. Baymul, Ç. and Sen, K. (2019). Kuznets Revisited: What Do We Know about the Relationship between Structural Transformation and Inequality? *Asian Development Review*, 36(1), pp.136–167. doi:https://doi.org/10.1162/adev_a_00126.

[10]. Bennee, E. and Okoye, P. (2021). Infrastructural Development and Economic Growth of Nigeria. *African Journal of Business and Economic Development* |, [online] 1, pp.2782–7658. Available at: https://www.ijaar.org/articles/ajbed/v1n12/ajbed-v1n12-Dec21-p11228.pdf.

[11]. Boamah, J., Adongo, F.A., Essieku, R. and Lewis Jr., J.A. (2018). Financial Depth, Gross Fixed Capital Formation and Economic Growth: Empirical Analysis of 18 Asian Economies. *SSRN Electronic Journal*. doi:https://doi.org/10.2139/ssrn.3424688.

[12]. Bosede, A., Abalaba, B. and Afolabi, D. (n.d.). *Transport Infrastructure Improvement and Economic Growth in Nigeria*. [online] Available at: https://www.ijhssi.org/papers/v2%288%29/Version-1/D081026031.pdf [Accessed 12 Sep. 2024].

[13]. Chandra, R. (2021). Paul Romer and Modern Endogenous Growth Theory. *Palgrave Studies in Economic History*, pp.251–281. doi:https://doi.org/10.1007/978-3-030-83761-7_9.

[14]. Chete, L.N., Adeoti, J.O., Adeyinka, F.M. and Ogundele, O. (2014). *Industrial Development and Growth in Nigeria: Lessons and Challenges*. [online] Available at: https://www.brookings.edu/wp-content/uploads/2016/07/L2C_WP8_Chete-et-al-1.pdf.

[15]. Chukwu, B.C. (2023). Impact of Industrial Sector on Economic Growth in Nigeria (1981–2020). *SSRN Electronic Journal*. doi:https://doi.org/10.2139/ssrn.4426683.

[16]. Dědeček, R. and Dudzich, V. (2022). Exploring the Limitations of GDP per Capita as an Indicator of Economic development: a cross-country Perspective. *Review of Economic Perspectives*, 22(3), pp.193–217. doi:https://doi.org/10.2478/revecp-2022-0009.

[17]. Du, X., Zhang, H. and Han, Y. (2022). How Does New Infrastructure Investment Affect Economic Growth Quality? Empirical Evidence from China. *Sustainability*, [online] 14(6), p.3511. doi:https://doi.org/10.3390/su14063511.

[18]. Edomah, N., Foulds, C. and Jones, A. (2016). Energy Transitions in Nigeria: The Evolution of Energy Infrastructure Provision (1800–2015). *Energies*, 9(7), p.484. doi:https://doi.org/10.3390/en9070484.

[19]. Enya, F.O. and Ezeali, B.O. (2021). Public Investment in Infrastructure and Economic Growth in Nigeria (1980-2020). *African Journal of Economics and Sustainable Development*, 4(3), pp.1–22. doi:https://doi.org/10.52589/ajesd-0jm1vber.

[20]. Erman, L. and te Kaat, D.M. (2019). Inequality and growth: Industry-level Evidence. *Journal of Economic Growth*, 24(3), pp.283–308. doi:https://doi.org/10.1007/s10887-019-09169-z.

[21]. Eromise, M.S., Gatawa, N.M. and Olarinde, M.O. (2022). Industrial Development and Economic Growth Nexus in Nigeria. *Review of innovation and competitiveness*, 8(1), pp.21–39. doi:https://doi.org/10.32728/ric.2022.81/2.

[22]. Fagbohun, A. and Adekoya, O.M. (2016). Investment as a Determinant of Per-Capita Income Growth in Nigeria: An Empirical Analysis. *European Journal of Business and Management* , [online] 8(11). Available at: https://www.iiste.org/Journals/index.php/EJBM/article/viewFile/29907/30719 [Accessed 12 Sep. 2024].

[23]. Ghouse, G., Rehman, A.U. and Bhatti, M.I. (2024). Understanding of Causes of Spurious Associations: Problems and Prospects. *Journal of Statistical Theory and Applications*. doi:https://doi.org/10.1007/s44199-024-00072-0.

[24]. Giwa, O.M., Olorunnimbe, R.O., Fagbenro , A.H. and Oguntimehin , A. (2022). Road Transport Infrastructure Planning Study: Panacea for Nigeria Economy Development. *Developing Country Studies*, 12(4). doi:https://doi.org/10.7176/dcs/12-4-04.

[25]. Goswami, V. and Goswami, L. (2023). An Examination of Economic Growth Determined by Foreign Direct Investment and the Institutional environment: a Subnational Perspective. *South Asian Journal of Business Studies*. doi:https://doi.org/10.1108/sajbs-12-2022-0409.

[26]. Gundlach, E. (2007). The Solow Model in the Empirics of Growth and Trade. *Oxford Review of Economic Policy*, 23(1), pp.25–44. doi:https://doi.org/10.1093/oxrep/grm002.
[27]. Han, X., Su, J. and Thia, J.P. (2020). Impact of Infrastructure Investment on Developed and Developing Economies. *Economic Change and Restructuring*. doi:https://doi.org/10.1007/s10644-020-09287-4.
[28]. Hossain, Md.A. and Huggins, R. (2021). The Environmental and Social Impacts of Unplanned and Rapid Industrialization in Suburban Areas: The Case of the Greater Dhaka Region, Bangladesh. Environment and Urbanization ASIA, 12(1), pp.73–89. doi:https://doi.org/10.1177/0975425321990319.
[29]. Hu, X. (2023). Using Ordinary Least Squares in Higher Education Research: A Primer. Higher education, pp.1–77. doi:https://doi.org/10.1007/978-3-031-32186-3_13-1.
[30]. Ibitoye, O.J., Ogunoye, A.A. and Kleynhans, E.P.J. (2022). Impact of Industrialisation on Economic Growth in Nigeria. Journal of Economic and Financial Sciences, 15(1). doi:https://doi.org/10.4102/jef.v15i1.796.
[31]. Irshad, R., Mehr-un-Nisa and Ghafoor, N. (2022). Infrastructure and Economic Growth: Evidence from Lower Middle-Income Countries. Journal of the Knowledge Economy, 14. doi:https://doi.org/10.1007/s13132-021-00855-1.
[32]. Johnson, A.O., Olabisi.I, A.I. and Folake, B.-O.R. (2021). An Empirical Study of the Telecommunication and Economic Growth in Nigeria. Journal of Progressive Research in Social Sciences, [online] 11(1), pp.7–21. Available at: https://www.scitecresearch.com/journals/index.php/jprss/article/view/2008 [Accessed 12 Sep. 2024].
[33]. Justman, M. (1995). Infrastructure, Growth and the Two Dimensions of Industrial Policy. The Review of Economic Studies, 62(1), p.131. doi:https://doi.org/10.2307/2297845.
[34]. Keji, S.A. (2021). Human Capital and Economic Growth in Nigeria. Future Business Journal, 7(1). doi:https://doi.org/10.1186/s43093-021-00095-4.
[35]. Kobzev, V., Izmaylov, M. and Germann, M. (2021). Digital Technologies in Modern Logistics and Supply Chain Management: Key Opportunities, Prospects. XIV International Scientific Conference ‘INTERAGROMASH 2021’, pp.685–693. doi:https://doi.org/10.1007/978-3-030-81619-3_76.
[36]. Kuznets, S. (1957). Quantitative Aspects of the Economic Growth of Nations: II. Industrial Distribution of National Product and Labor Force. Economic Development and Cultural Change, 5(S4), pp.1–111. doi:https://doi.org/10.1086/449740.
[37]. Mohammed Guza, G., Ishak, S., Bani, Y. and Dankumo, A. (2020). The Determinants of Income Inequality in Nigeria: An Autoregressive Distributive Lag Approach. International Journal of Innovation, Creativity and Change. www.ijicc.net, [online] 11, p.2020. Available at: https://ijicc.net/images/vol11iss12/111213_Guza_2020_E_R.pdf [Accessed 12 Sep. 2024].
[38]. Mubarak, F., Suomi, R. and Kantola, S.-P. (2020). Confirming the Links between socio-economic Variables and Digitalization worldwide: the Unsettled Debate on Digital Divide. Journal of Information, Communication and Ethics in Society, ahead-of-print(ahead-of-print). doi:https://doi.org/10.1108/jices-02-2019-0021.
[39]. Nwogo, J.E. and Oriji, J.O. (2019). Impact of Industrialization on Economic Growth in Nigeria. IOSR Journal of Economics and Finance (IOSR-JEF), 10(5).
[40]. Nwuju, O.C., Aiyedogbon, O.J. and Aigbedion, M. (2022). Impact of Selected Macroeconomic Variables on per Capita Income in Nigeria (1990-2022). International Journal of Advanced Research in Accounting, Economics and Business Perspectives, 8(1).
[41]. Ojiodu, E. and Aderinto, E. (2021). Effect of Infrastructural Development on Nigeria’s Industrial Sector. ESCAE Journal of Management and Security Studies (EJMSS), 1(2).
[42]. Owusu-Manu, D.-G., Jehuri, A.B., Edwards, D.J., Boateng, F. and Asumadu, G. (2019). The Impact of Infrastructure Development on Economic Growth in sub-Saharan Africa with Special Focus on Ghana. Journal of Financial Management of Property and Construction, 24(3), pp.253–273. doi:https://doi.org/10.1108/jfmpc-09-2018-0050.

[43]. Oyadeyi, O. (2023). Financial development, Real sector, and Economic Growth in Nigeria. SN Business & Economics, 3(8). doi:https://doi.org/10.1007/s43546-023-00526-0.

[44]. Raghupathi, V. and Raghupathi, W. (2017). Innovation at country-level: Association between Economic Development and Patents. Journal of Innovation and Entrepreneurship, 6(1). doi:https://doi.org/10.1186/s13731-017-0065-0.

[45]. Rana, J., Gutierrez, P.L. and Oldroyd, J.C. (2021). Quantitative Methods. Global Encyclopedia of Public Administration, Public Policy, and Governance, pp.1–6. doi:http://dx.doi.org/10.1007/978-3-319-31816-5_460-1.

[46]. Renna, P. and Materi, S. (2021). A Literature Review of Energy Efficiency and Sustainability in Manufacturing Systems. Applied Sciences, 11(16), p.7366. doi:https://doi.org/10.3390/app11167366.

[47]. Sarangi, A.K. and Pradhan, R.P. (2020). ICT Infrastructure and Economic growth: a Critical Assessment and Some Policy Implications. DECISION, 47(4), pp.363–383. doi:https://doi.org/10.1007/s40622-020-00263-5.

[48]. Seidu, R.D., Young, B.E., Robinson, H. and Ryan, M. (2020). The Impact of Infrastructure Investment on Economic Growth in the United Kingdom. Journal of Infrastructure, Policy and Development, 4(2), p.217. doi:https://doi.org/10.24294/jipd.v4i2.1206.

[49]. Siyan, P., Rita, E. and Makwe, E. (2015). The Impact of Road Transportation Infrastructure on Economic Growth in Nigeria. International Journal of Management and Commerce Innovations, 3(1).

[50]. Terna, P. (2019). Mobile Broadband and Economic Growth In Nigeria. Oradea Journal of Business and Economics, [online] 4(1), pp.65–78. Available at: https://ideas.repec.org/a/ora/jrojbe/v4y2019i1p65-78.html [Accessed 12 Sep. 2024].

[51]. Ubi, P. and Udah, E. (2019). Impact of Governance and Road Infrastructure on Industrial Growth in Nigeria. Nigerian Journal of Economic and Social Studies, [online] 61(1). Available at: https://www.njess.org/journal/njess/download-article?id=24 [Accessed 10 Sep. 2024].

[52]. Uddin, I. and Azam, M. (2023). Global Evidence on the Impact of Globalization, Governance, and Financial Development on Economic Growth. Journal of the Knowledge Economy. doi:https://doi.org/10.1007/s13132-023-01656-4.

[53]. Young, A.O. (2019). Growth Impacts of Income Inequality: Empirical Evidence From Nigeria. Research in World Economy, 10(3), p.226. doi:https://doi.org/10.5430/rwe.v10n3p226.