International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Infrastructure, sustainability, and policy reform in Nigeria: An empirical study of sectoral contributions to economic growth

Olugbenga Francis Akomolehin [1,*], Ibukun Felix Olusegun [1] and Olubunmi Racheal Akomolehin [2]

[1] *Department of Finance, College of Social and Management Sciences, Afe Babalola University,Ado - Ekiti,Ekiti - State, Nigeria.*
[2] *Department of Mass Communication, School of Information and Management, Our Saviour Institute of Science Agriculture and Technology, Enugu, Enugu - State. Nigeria.*

International Journal of Science and Research Archive, 2025, 15(03), 545-561

Publication history: Received on 12 April 2025; revised on 05 June 2025; accepted on 07 June 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.15.3.1738

Abstract

This study examines the impact of infrastructural development on economic growth in Nigeria from 1999 to 2022, focusing on key sectors including education, health, transportation, information and communication technology (ICT), and energy. The primary objective is to assess both the short-run and long-run contributions of these infrastructure components to Nigeria's Gross Domestic Product (GDP). Using the Auto-Regressive Distributed Lag (ARDL) model and time-series data sourced from the Central Bank of Nigeria (CBN), World Development Indicators, and African Infrastructure Development Reports, the study employs the Augmented Dickey-Fuller (ADF) test to confirm variable stationarity and the bounds test to establish co-integration. The findings reveal a significant long-run relationship between infrastructural development and economic growth. In the long run, infrastructure in education, health, ICT, and transport exerted negative effects on GDP, suggesting inefficiencies and delayed returns on investment. Conversely, energy infrastructure—measured by electricity consumption—positively influenced growth. In the short run, only health infrastructure showed a positive contribution, while other sectors had negative or insignificant effects. Excluding energy, the infrastructure sectors have underperformed despite the increased investment, owing to inefficiencies and governance issues, the study suggests. These include improved policy implementation within all sectors, enhanced oversight over various policy implementation bodies, and improved allocation of resources especially in education, health and ICT. Developing energy infrastructure and employing public-private partnerships (PPPs) are key factors in sustainable economic growth as well.

Keywords: Infrastructural Development; Economic Growth; ARDL Model; Sectoral Analysis

1. Introduction

Everyone knows the importance of infrastructural development as a key driver of economic growth which is also observed in developing economies like Nigeria. Infrastructure refers to the basic systems and services that enable and support economic activity by lowering production costs and improving productivity in key sectors (World Bank, 2020). It is critical to connecting markets and providing access to trade and important services like education, health, transport, and energy. Therefore, Infrastructure spends are viewed as vital source of the long term growth in an economy and for sustainable development.

Notwith¬standing this acknowledged strategic value, Nigeria continues to grapple with enormous infrastructure deficits limiting its economic potential. Poor infrastructure across sectors (energy, transport, education, health) has constrained the country's ability to achieve sustainable economic development (African Development Bank, 2017). Notably, the energy sector has emerged as a pronounced constraint, given the high rate of power outages, and erratic

* Corresponding author: Olugbenga, Francis Akomolehin

electricity supply which has hampered industrial productivity and overall economic performance (Babatunde & Busari, 2021). Weakness in a transport and communication infrastructure raises transaction costs in addition to reducing access to markets and thus economic growth (Olufemi & Olayiwola, 2019).

Realising that infrastructure is a big driver of development, the Nigerian government has invested significantly in infrastructure projects in the last two decades. However, the economic impact of these investments remains a subject of debate, particularly due to limited empirical evaluations and a scarcity of oral-based or gesture-aligned assessment methodologies within corporate and policy environments (World Bank, 2020). To inform policy and resource allocation, it is important to understand the sector-specific contributions of infrastructural development to Nigeria's Gross Domestic Product (GDP)

1999-2022: A New Era For The Nigerian Nation? The transition from military rule to democratic governance in the early 2000s marked a significant turning point in Nigeria's political and economic landscape. This shift has had direct implications for infrastructure financing, as seen in the fluctuations in investment patterns over the years (Central Bank of Nigeria [CBN], 2022). The evolving political regime has played a central role in shaping how infrastructure projects are prioritized, funded, and executed.

During this time, several large-scale infrastructure projects were launched, including the much-touted National Integrated Power Project (NIPP) as a response to the ongoing energy crisis, as well as massive extensions of the road network by subsequent administrations. This raises important questions as the gap in infrastructure persists and the impact of such initiatives on long-term growth remains uncertain. Moreover, when examined from a sustainability perspective — including environmental impact, social equity, etc. — the investments' results are still approached (United Nations, 2017). Despite several ongoing infrastructure projects, Nigeria continues to rank lower than some other African countries on significant infrastructure indices, especially in the energy sector which is a major constraint to effective economic development as power supply remains largely erratic (African Infrastructure Development Report, 2021).

This study aims to analyze the role of infrastructural development in Nigeria's GDP growth for a period of over 23 years and assess which sectors have contributed the most, as well as find potential ways to improve the sustainability and inclusivity of future infrastructure investments.

Although Nigeria's economic development has been an airspace of extensive literature, seldom does it evaluate not just one infrastructure sector or generalized findings (Calderón & Servén, 2014) but the synergized effect of several infrastructural indicators cut across energy, transport, telecommunication, and water supply on GDP growth intertemporally. Whereas most previous studies have focused on the disaggregated focus of these sectors neglecting the interactive or cumulative effect (Babatunde & Busari, 2021). Moreover, there is a lack of empirical studies utilizing long-term datasets and integrating environmental and social sustainability aspects (Federal Ministry of Finance, 2019). This gap needs to be addressed for infrastructure policies to be designed to ensure effectiveness and necessity to Nigeria's broader development impenecessity to Nigeria's broader development imperatives.

1.1. Statement of the Problem

Despite the broad consensus on the importance of infrastructure in driving economic development, there remains a significant gap in understanding how various infrastructural components collectively contribute to Nigeria's GDP over time. Existing studies have predominantly focused on isolated sectors such as energy or transportation, offering a fragmented perspective on the infrastructure–growth nexus. This has led to an incomplete understanding of the cumulative impact of diverse infrastructural elements—including roads, electricity, water supply, and telecommunications—on economic growth in Nigeria.

Moreover, these studies rarely evaluate the sustainability of infrastructural investments in terms of environmental impact and social equity. Given Nigeria's persistent infrastructure challenges and the complexity of its development trajectory, there is a pressing need for a comprehensive study that not only examines sector-specific contributions but also investigates whether these investments align with long-term sustainable growth. The lack of longitudinal studies covering a substantial time frame—such as the 23-year period from 1999 to 2022—further underscores the need for empirical research that captures the dynamic interplay between infrastructure and economic growth within Nigeria's evolving socio-political context.

1.2. Research Questions

How has infrastructural development contributed to Nigeria's GDP between 1999 and 2022?

What is the impact of sector-specific infrastructural investments (e.g., energy, transportation, telecommunications) on sustainable economic growth in Nigeria, considering environmental sustainability and social equity?

1.3. Research Objectives

- To assess the contributions of infrastructural development to GDP growth in Nigeria from 1999 to 2022.
- To evaluate the impact of sector-specific infrastructural investments—particularly in energy, transportation, and telecommunications—on sustainable economic growth in Nigeria, with a focus on environmental sustainability and social equity.

1.4. Research Hypotheses

- H_{01}: Infrastructural development has no significant contribution to GDP growth in Nigeria from 1999 to 2022.
- H_{02}: Sector-specific infrastructural investments (e.g., energy, transportation, telecommunications) have no significant impact on sustainable economic growth in Nigeria, including considerations of environmental sustainability and social equity.

1.5. Scope of the Study

The research evaluates how infrastructure development affected Nigeria's economy from 1999 to 2022. The research demonstrates how education along with health facilities and transport and energy systems and information and communication technology (ICT) service infrastructure contribute to Nigeria's overall GDP. The research draws its secondary data from trustworthy information sources including CBN Statistical Bulletin and World Development Indicators (WDI) and African Infrastructure Development Reports. This paper addresses the time-lapsed effects of infrastructure investments on economic outcomes through an Auto-Regressive Distributed Lag (ARDL) model. This research concentrates on Nigeria exclusively to demonstrate infrastructure development impacts on the national economy.

1.6. Significance of the Study

This study provides important evidence bridging between academic and policy stress on infrastructure and economic growth in Nigeria. First, through an in-depth review across various infrastructure sectors over a long-term horizon, the study produces empirical evidence that can be utilized to allocate resources to maximize economic returns on investments.

Unlike many earlier studies that confine their analysis to one sector, this study takes an integrated view by analyzing energy, transportation, telecommunications, and water infrastructure together. Enabling a more sophisticated awareness of sector interdependencies, as well as how integrated infrastructure development can promote viable economic advancement (Federal Ministry of Finance, 2019).

In addition, the study analyzes the effects of infrastructural development on not only economic output but also on broader sustainability goals, such as environmental protection and social equity. This study is timely as Nigeria is poised to align its national development plans with the United Nations Sustainable Development Goals (SDGs) – notably, SDG 9 (industry, innovation and infrastructure) – and SDG 8 (decent work and economic growth) – (United Nations 2017).

The research findings may be of utility beyond Nigeria. The Nigerian experience can provide transferable lessons to developing countries around policy design, prioritisation of investment, and creating a road map for sustainable development, which will all play a role in improving infrastructure where country-specific circumstances are unique, but the broader challenge of infrastructure delivery is similar. By employing credible and long-time data sources and valid econometric methodologies, this research fills the gaps in the literature and brings terms to future work in the domain of the infrastructure economics.

2. Conceptual Review

2.1. Infrastructure and GDP Growth

The positive effect of infrastructural development on economic growth has been heavily discussed at both macro- and micro- scales around the world, with strong evidence indicating that optimally designed and efficiently executed infrastructure spending significantly contributes to GDP growth (Calderón & Servén, 2014; Esfahani & Ramírez, 2003).

Infrastructure is a key foundation of economic activity, enabling productivity, lowering transaction and production costs, improving the efficiency of markets and providing an enabling environment for trade and investment (World Bank, 2020).

Investment in infrastructure — including transport, energy, telecommunications and water systems — is viewed as critical to long-term economic development around the world. These investments enhance connectivity, lower logistical barriers, and facilitate the ease of doing business. Corruption, delays, cost overruns and poor maintenance lower the potential of infrastructure to bring positive impact (OECD, 2018), especially in low- and middle-income countries. The World Bank (2020) shows that countries which prioritize, deliver and monitor their projects end up delivering better projects and therefore stronger returns on those investments and stronger growth paths in terms of GDP.

Infrastructure is well-recognized as an important driver of economic performance in Nigeria. "However, the nation remains hampered by enormous infrastructure gaps, particularly in energy and transportation sectors, which have limited economic opportunity (AfDB, 2017)." Chronic electricity blackouts, poor road infrastructure and antiquated communications systems, for example, have increased the cost of doing business and diminished industrial efficiency. These bottlenecks raise operational costs and suppress economic output (AfDB, 2021). In addition, developments in Nigeria's infrastructure have been fragmented, heavily affected by oil revenues and political instability (Central Bank of Nigeria [CBN], 2020). Consequently, this has made the relationship between infrastructure and GDP growth in Nigeria to be uneven between investment and returns.

According to Olufemi and Olayiwola (2019), infrastructure has a positive and significant relationship with GDP growth in Nigeria despite its effect being diluted as a result of weak institutional capacity, public expenditure inefficiency, lack of maintenance, and mismanagement of resources. That highlights the importance of not only spending more on infrastructure, but also doing so with better institutional quality and governance frameworks.

2.1.1. Missing Infrastructure Is the Niche of Sustainable Development

Sustainable development is the ability to meet current needs without compromising the ability of future generations to meet theirs (Brundtland Commission, 1987). When designed and implemented sustainably, infrastructure contributes to the long-term economic, environmental and social development of communities. But if infrastructure is unsustainable (e.g., carbon-intensive power plants, poorly planned urban extensions, inefficient water systems), it can exacerbate environmental challenges and exacerbate social inequalities (United Nations, 2017).

Undoubtedly the most critical pillar of environment sustainability is definitely the infrastructure, as it controls the consumption and utilization of natural resources. Ensuring a focus on renewable energy, clean water systems, efficient transportation, and green building technologies where appropriate is needed to mitigate widescale footprints. The net impact of implementing such systems results in lower greenhouse gas emissions as well as better air and water quality and climate resilience in countries (World Bank, 2020; UN Environment Programme, 2019). Investment in solar and wind power, for instance, reduces reliance on fossil fuels and improves energy security (Babatunde & Busari, 2021; IEA, 2021).

In comparison, Nigeria's energy infrastructure is and remains heavily reliant on fossil fuels, especially oil and gas (African Union, 2021). Although this infrastructure helps facilitate economic activity, it also generates pollution, carbon emissions, and ecosystem degradation. Shifting to renewable energy sources—including solar, wind, and hydropower—would not only honor Nigeria's climate commitments; it would engender long-term environmental sustainability. Such a transition would call for intentional policy transformations, investment in green technologies, and engagement between the public and private sectors (Oyedepo, 2012).

Sustainable transport [infrastructure] also offers Nigeria avenues for a lower carbon footprint. Investing in green public transportation system (e.g., electric buses; rail networks) can decrease emissions, mitigate urban congestion and contribute towards more liveable cities (World Bank, 2018). Even if still at an early stage, Nigeria's adoption of sustainable transport solutions could present vital solutions to environmental and economic resilience.

2.1.2. Infrastructure and Social Equity

Infrastructure is a driver of economic efficiency, but also a catalyst for social equity. Access to critical services, like education, health care, clean water and electricity, especially in deprived areas, is enhanced through inclusive infastructure (World Bank 2020). Equitable infrastructure development also improves poverty alleviation and inclusive growth by reducing disparities in geographic and income-based disparities (Calderón & Servén, 2014).

There are deep inequalities in Nigeria where urban areas vastly outpace rural communities that struggle with access to basic infrastructure. Lack of infrastructure, such as an inadequate water supply and scarce electricity in rural areas, limits economic outlets while also contributing to poverty (AfDB, 2017). According to Olufemi and Olayiwola (2019) providing infrastructure to rural communities can improve living standards, increase better health outcomes and thus decreasing income gap. Rural investments are essential — road networks, digital connectivity, health institutions and educational infrastructure help link disadvantaged communities to larger functioning economic systems.

In particular, education and health infrastructure is indispensable for supporting the development of human capital. Well-furnished schools with access to modern teaching aids drive educational outcomes, and healthcare infrastructure decrease morbidity and improves productivity (United Nations, 2017; WHO, 2020). Such social services not only work to improve individual welfare but also contribute to national development by ensuring a healthier and better educated workforce.

There needs to be venues through which targeted policies can come out to make sure infrastructure projects serve the unique needs of vulnerable populations. By ally with the private sector resources while being regulated by public stakeholders to guarantee equity and sustainability, public-private partnerships (PPPs) provide an approach to infrastructure that is more inclusive (Babatunde & Busari, 2021; Grimsey & Lewis, 2005). Embedding social equity targets in PPP agreements could play a part in the delivery of infrastructure that is inclusive, such as in Nigeria.

Gender equity is also an important part of the inclusive infrastructure. Inadequate infrastructure has been shown in the literature to disproportionately affect women and girls, especially related to water, sanitation, transport, and energy (World Bank, 2018). Gender Equity and Economic Empowerment — Better access to humanitarian agencies such as clean water and effective transportation can help women pursue education and economic activities leading to better gender equity and economic empowerment across communities.

2.1.3. Sustainable Infrastructure in Support of Achieving the SDGs

Sustainable development depends on infrastructural development because it enables effective delivery of development objectives specifically as per United Nations Sustainable Development Goals SDG 9 (Industry Innovation and Infrastructure) and SDG 11 (Sustainable Cities Communities). They emphasize constructing resilient structures together with promoting sustainable industrialization and encouraging innovation (UN, 2017). SDG-aligned infrastructure takes account of the environmental, social and economic dimensions. For example, SDG 9 calls for investment in resilient, sustainable infrastructure that supports inclusive development and industrial growth. In Nigeria, this means building energy-efficient buildings, increasing access to digital technologies, and developing projects that are resilient to climate-related shocks (World Bank, 2020). Likewise, goal 11 is focused on developing sustainable urbanism through affordable housing, efficient transport systems, and access to essential services.

Nevertheless, Nigeria is riddled with a number of issues that are weighing it down in its quest to build a sustainable infrastructure. One significant barrier is the financing gap, as sustainable infrastructure projects typically have high capital costs and long payback periods (African Union, 2021). While PPPs have been used with increasing frequency to fill this gap, there is ongoing criticism regarding governance, transparency, and project delivery (Grimsey & Lewis, 2005).

Other complexity is the absence of robust regulatory could articulate the nature of the environmental and social developers of infrastructure projects. With no presence of strong institutions, same infra investments could lead to negative externalities like environmental degradation and displacement of vulnerable communities (UN Habitat, 2020). Strengthening governance, increasing institutional capacity and accountability, therefore are necessary elements in ensuring infrastructure underpins long-term sustainability and inclusive development.

2.2. Theoretical Review

There are numerous theorists, models, and economic frameworks that establish the basis for the relationship between infrastructure development and economic growth. One offers a clean explanation: the growth accounting framework, which apportions GDP growth into contributions from labor, capital (including infrastructure), and total factor productivity. This models infrastructure as an element of capital input in the production function hence allowing for simultaneously estimation of direct and indirect effects of infrastructural investments on economic output. Research using this framework in Nigeria has found that infrastructure, especially energy and telecommunications, is a main driver of productivity gains and economic performance (Babatunde & Busari, 2021).

Another model commonly referenced is the Solow-Swan neoclassical growth model, which suggests that economic growth is driven by accumulation of capital, labor, and technological progress. In this context, infrastructure increases labor and capital productivity by lowering production and transaction costs. But in a country like Nigeria, infrastructural limitations like electricity deficit, bad road, and inadequate digital connectivity frequently restrict the efficient use of labor and capital and hinder significant growth in GDP (Central Bank of Nigeria [CBN], 2022). It stresses optimizing resource allocation and promoting productivity through infrastructure demand.

The theory of endogenous growth, developed by Barro (1990) and Romer (1994), offers an even more dynamic view by highlighting infrastructure as an engine for long-run growth through its potential to foster innovations, knowledge spills and human capital. It improves access to education and health services, enables efficient public service delivery, lowers transaction costs, and provides a more favorable environment for private sector development. Also, durable infrastructure gives rise to better institutional quality by providing better transparency and accountability functions. These dynamics reinforce sustained economic growth and form the theoretical foundation of this study collectively.

2.3. Empirical Review: Sectoral Insights on Infrastructure and Economic Growth

The relationship between infrastructure development and economic growth has been widely studied in both advanced and emerging economies. This topic is also a very individual one, as the nature and extent of this relationship tend to differ across industrial sectors, as evidenced by empirical studies that show varying degrees of impact, depending on the quality and type of investment, governance or country context. In China, Liu et al. (2020) based on panel data analysis of infrastructure investment from 1990 until 2018. They found that energy and transportation infrastructure had first-order effects in both GDP growth and private sector productivity. But the study also highlighted an increasing need for investments in digital infrastructure to ensure continuing growth and facilitate a transition to a knowledge-based economy. In Pakistan, Khan et al. (2021) used time-series regression to estimate the contribution of road infrastructure and energy supply to economic growth from 1990 to 2019. The findings indicated that both sectors had a positive influence on GDP, although inefficiencies in the energy sector — including supply bottlenecks and obsolete grid networks — dampened the aggregate impact. Studies on the link between electricity generation and GDP growth of Ghana came from Adom and Amakye (2019), who performed cointegration analysis on the 1995-2017 period. Despite the study disclosing a strong positive correlation between energy infrastructure, it only considered the energy sector, excluding how complementary sectors (such as transportation and ICT) may have contributed to the relationship.

For Bangladesh, several studies have explored the relationship between infrastructure and sustainable economic growth. For instance, Sultana and Jahan (2021) examined the period from 1990 to 2020 using an ARDL model, emphasizing the long-term benefits of investments in energy and health infrastructure, while noting the limited attention paid to ICT and education—both of which are increasingly central to contemporary development discourse.

In Ethiopia, Abebe et al. (2019) statistics supported a cross-country regression of the infrastructure on GDP growth and poverty reduction over the period from 1995 to 2018. They found that they were key parts of economic growth, rural development and poverty alleviation (Kalugina, Arkhipenko & Ohnenko, 2016). But the absence of health and education infrastructure reduces the scope of its conclusions.

In the Nigerian context, there exists some relevant empirical evidence. Here are a few examples in the different sectors:

Using a Vector Error Correction Model (VECM), Mohammed and Okeke (2020) studied the long-run relation between public infrastructure investments and GDP for the period 2000 to 2018. Their study, which affirmed a positive long-run impact, pointed to short-run inefficiencies arising from delay in programme execution and bad governance. Sectoral Assessment of infrastructure using ADL model from 1999–2019 Tella and Adeoti (2021) employed the ARDL model to assess the sectoral impact of infrastructure from 1999 to 2019. They discovered that transport and energy infrastructure are key contributors to GDP, while health infrastructure was a less important factor. Ojo and Ogunleye (2021) studied the significance of ICT infrastructure on GDP using time-series regression and found a positive relationship between ICT infrastructure and GDP and that this was most evident through efficiency improvements in trade and banking. Despite increased investment, the benefits of infrastructure development have remained unevenly distributed, largely due to the persistent digital divide—particularly in rural areas. Omotosho and Akinwande (2023), in their study using a multivariate cointegration framework based on Nigerian data, found that investments in health infrastructure significantly enhanced labor productivity, thereby contributing to long-term economic growth. Similarly, Ali and Nwogu (2022), through an ARDL analysis covering the period 2000–2021, demonstrated that energy infrastructure also played a pivotal role in driving sustainable economic performance.

The findings confirmed both short- and long-term benefits on GDP, although only one in five respondents reported adequate electricity supply and two-thirds cited unreliable supply chains as significant constraints.

Taken together, these studies confirm that sector-specific infrastructure, especially energy, transportation, and ICT, continue to be a bedrock driver of economic development. But the scale of impact depends heavily on governance, the efficiency of investment, and how it aligns with broader development goals. The subsequent sections provide a detailed synthesis of the key sectors and opportunities vis-a-vis Nigeria's infrastructure-growth nexus.

2.3.1. Energy Infrastructure

Energy infrastructure, including systems for the generation, transmission, and distribution of electricity, is crucial to making the economy work. This energy is important for lowering production costs, running industries, and increasing people welfare. Chronic power shortages and overreliance on fossil fuels, however, have crushed industrial productivity in Nigeria. Due to the unreliability of the national grid, many Nigerian firms rely on expensive private generators (Babatunde and Busari, 2021). The African Development Bank (2017) claims that GDP can rise by 2% for every 10% increase in energy infrastructure, provided that they are efficient. Despite this investment, the quality of governance and sustainable policy frameworks are key for maximizing the economic returns of energy investments (Calderón & Servén, 2014).

2.3.2. Transportation Infrastructures

Transportation infrastructure — roads, railways, ports, airports — is essential for trade, market connectivity, and regional integration. In Nigeria, inefficient transportation results from bad roads, insufficient rail connectivity and port congestion, which raises transaction costs of goods and people. Improvements in road and railway infrastructure boost regional development and market accessibility (Olufemi and Olayiwola, 2019). At the continental level, the African Infrastructure Development Report (2021) estimated that efficient transport systems can boost GDP up to 1.5 percent a year . In low-capacity and low-investment settings, the World Bank (2020) also emphasizes the importance of leveraging private capital through a scaled-up role for public-private partnerships (PPPs) to finance and manage large-scale transport infrastructure.

2.3.3. Telecommunication infrastructure

In today's digital world, telecommunications infrastructure plays a crucial enabling role for both innovation, competitiveness and inclusive economic participation. With the growth of the mobile network and internet connectivity in Nigeria, many sectors (banking, commerce, education, health) can now expand. As noted by Babatunde and Busari (2021), rising mobile penetration facilitates financial inclusion and encourages the development of small and medium enterprises (SMEs). However, the digital divide — especially between urban and rural areas — continues to inhibit the full potential of the ICT sector to achieve inclusive development. According to African Union (2021), there is a demand for coherent digital strategies and investment in broadband infrastructure to overcome barriers of access and engender inclusive growth.

It is also important to understand that this does not automatically translate into economic growth as infrastructure building effectiveness depends on several factors, including institutional quality, cross-sectoral coordination and alignment with national development priorities. Of the public services proof of idea, we have seen them out perform particularly in energy, transport and telecommunications infrastructure but less so in health and education where issues of governance, delays and funding inefficiencies have proven tangible implementation challenges. To maximize the potential of infrastructure as an economic growth catalyst, Nigeria must pursue wide-ranging policy reform, improved public investment management and focused public-private partnership (PPP).

2.4. Gaps in the Literature

Numerous empirical studies focus on infrastructure's influence on economic growth but the literature still remains incomplete particularly for Nigeria. Research about the co-examined effects of multiple sectors including energy together with transport and ICT and health and water on long-term GDP performance remains scarce in the literature. Studies currently focus on individual sectors without considering their collective effects on macro-level economic performance.

The literature lacks sufficient examinations of how infrastructure development synchronizes with environmental sustainability goals alongside social equity targets that represent core parts of United Nations Sustainable Development Goals (SDGs). The lack of research about this connection remains problematic for Nigeria since it has made a promise to achieve sustainable growth with inclusivity. Further infrastructure investments by the country require a deep

understanding of their overall impacts on sustainable development according to World Bank (2020) and United Nations (2017).Third, there is often a focus on relatively short timeframes or datasets which may fail to incorporate structural changes in the economy, changes in political cycles, and shifts in demographics over time. A long-term analysis from 1999 to 2022 reveals more granular insight into infrastructure's changing role in Nigeria's development trajectory.

This study fills these gaps by assessing the long-run contributions of various infrastructure indicators to GDP growth in Nigeria and analysing their implications for environmental sustainability and social equity, yielding a more integrated and policy-relevant understanding of the infrastructure-growth nexus.

3. Methodology

3.1. Research Design and Model Specification

The examination of infrastructure development's important impact on Nigeria's economic growth is conducted through a time-series econometric model in this quantitative research study. The model quantifies real gross domestic product (RGDP) development through different infrastructure sectors from 1999 until 2022. The model refers to Ekiran and Olasehinde (2019) which showed that economic output depends on agricultural and natural resources (ANR) and road maintenance together with construction activities (RMC) and energy supply (ES) and transport and communication systems (TCS).

GDP=f(ANR,RMC,ES,TCS)

As to the reasons of the variables being replaced, it is to align better with the above-mentioned objectives of the present study, and more specifically the focus on human capital and technological infrastructure, hence even agriculture and natural resources have been traded for more contemporary variables. These consist of education, health, information technology, and electricity consumption, which are key infrastructure sectors that

3.2. Modified Model Specification

The modified functional form of the model is specified as:

$$RGDP=f(SEG,SHG,TCSG,ICSG,ECPC)$$

Where:

- RGDP: Real Gross Domestic Product
- SEG: Share of Education in GDP
- SHG: Share of Health Infrastructure in GDP
- TCSG: Share of Transportation and Communication in GDP
- ICSG: Share of Information and Communication Technology in GDP
- ECPC: Electricity Consumption per Capita

This model posits that real GDP is a function of investments in critical infrastructure sectors—education, health, transport and communication, ICT, and electricity. These variables are selected based on their documented influence on industrial productivity, human capital development, and technological innovation (Barro, 1990; World Bank, 2020).

3.3. Linearized Econometric Model

For estimation purposes, the model is linearized as follows:

$$GDP_t=\beta_o+\beta_1 SEG_t+\beta_2 SHG_t+\beta_3 TCSG_(t+) \beta_4 ICSG_t+\beta_5 ECPG_t+\epsilon_t\text{----}3.8$$

Where:

- β_o: Constant term
- $\beta_1 \ldots \beta_5$: Coefficients of infrastructural components
- εt: Error term

This specification allows for the quantification of the individual effects of infrastructure components on GDP, both in the short and long run.

3.4. Estimation Technique: Auto-Regressive Distributed Lag (ARDL) Model

The examination of infrastructure development's important impact on Nigeria's economic growth is conducted through a time-series econometric model in this quantitative research study. The model quantifies real gross domestic product (RGDP) development through different infrastructure sectors from 1999 until 2022. The model refers to Ekiran and Olasehinde (2019) which showed that economic output depends on agricultural and natural resources (ANR) and road maintenance together with construction activities (RMC) and energy supply (ES) and transport and communication systems (TCS).

$$\Delta InRGDP_t=\beta_0+\sum_{i=1}^{n}\beta_{5i}\Delta InRGDP_t+\sum_{i=1}^{n}\beta_{2i}\Delta SEG_t+\sum_{i=1}^{n}\beta_{3i}\Delta InSHG_t+\sum_{i=1}^{n}\beta_{4i}\Delta InTCSG_t+\sum_{i=1}^{n}\beta_{5i}\Delta InICSG_t+\sum_{i=1}^{n}\beta_{6i}\Delta InECPG_t+\delta_7 InRGDP_{(t-i)}+\delta_8 InSEG_{(t-i)}+\delta_9 InSHG_{(t-i)}+\delta_{10} InTCSG_{(t-i)}+\delta_{11} InICSG_{(t-i)}+\delta_{12} InECPG_{(t-i)}+U_t \quad \text{----------3.6}$$

Where:

- Δ: First difference operator
- In: Natural logarithm of variables
- $\beta_0 ... \beta_6$: Short-run coefficients
- $\delta_7 ... \delta_{12}$: Long-run coefficients
- U_t: Error term

The ARDL model facilitates the separation of short-run dynamics from long-run equilibrium relationships, providing comprehensive insights into how infrastructure affects GDP over time.

Table 1 Definition of Variables

Variable	Definition	Expected Impact
SEG	Share of education expenditure in GDP	Positive
SHG	Share of health infrastructure in GDP	Positive
TCSG	Share of transportation and communication infrastructure in GDP	Positive
ICSG	Share of information and communication technology in GDP	Positive
ECPC	Electricity consumption per capita	Positive
RGDP	Real Gross Domestic Product (dependent variable)	—

Each of these variables is expected to significantly and positively influence GDP growth, reflecting their strategic role in economic transformation, human development, and industrial efficiency (Calderón & Servén, 2014).

3.5. Estimation Procedure

This study employs a quantitative time-series approach using secondary data covering the period 1999 to 2022, sourced from credible and authoritative repositories, including:

- Central Bank of Nigeria (CBN) Statistical Bulletin
- World Development Indicators (WDI)

3.5.1. African Infrastructure Development Reports

The study utilizes an estimation process which analyzes both immediate and lasting effects of infrastructure improvements on Nigerian economic development. The research follows this method sequence:

The study uses the Augmented Dickey-Fuller test named ADF for stationarity testing.The first methodology checks the time-series characteristics of different variables to identify integration levels. The ADF unit root test provides essential criteria to verify whether variables exist at level [I(0)] or first difference [I(1)] because this condition enables ARDL methodology implementation.

3.5.2. ARDL Bounds Test for Cointegration

The examination for the long-run equilibrium relationship between variables employs the ARDL bounds testing approach after confirming they have mixed integration levels. The analysis of infrastructural indicators and GDP cointegration involves this vital step to determine their relationship within the sample period.

3.5.3. Estimation of Long-Run and Short-Run Coefficients

Once cointegration is established, the ARDL model is estimated to obtain both long-run and short-run coefficients. This allows the study to capture immediate as well as sustained impacts of sectoral infrastructure on economic growth.

3.5.4. Error Correction Model (ECM)

An ECM is derived to quantify the speed of adjustment back to long-run equilibrium following any short-run disequilibrium. The coefficient of the lagged error correction term is expected to be negative and statistically significant, validating the model's convergence properties.

3.5.5. Post-Estimation Diagnostics

To ensure the robustness and reliability of the estimated model, the following diagnostic tests are conducted:

- Jarque-Bera Test for normality of residuals
- Breusch-Pagan-Godfrey Test for heteroscedasticity
- Breusch-Godfrey Serial Correlation LM Test for autocorrelation

These diagnostic checks validate the statistical adequacy of the model, confirming that the residuals are normally distributed, homoscedastic, and serially uncorrelated—key conditions for drawing credible inferences from the ARDL framework. Through this comprehensive estimation procedure, the study provides a rigorous empirical foundation for assessing the dynamic effects of infrastructural development on Nigeria's GDP growth, both in the short and long

3.6. A Priori Expectations

Based on economic theory and prior empirical evidence, the expected signs of the coefficients are positive for all independent variables. The rationale is that improvements in each infrastructure component are anticipated to enhance productivity, reduce transaction costs, improve human capital, and boost industrial output—thus driving economic growth.

This expectation can be represented as:

d(RGDP) d(RGDP), d(RGDP), d(RGDP) >0

d(SHG), d(TCSG) d(ICSG) d(ECPC)

This means that any positive change in the infrastructural components—education, health, transportation and communication, ICT, and electricity consumption—is expected to result in a corresponding increase in real GDP.

4. Analysis and Interpretation

4.1. Overview

In this chapter, we show the empirical results of the study which evaluates the effect of infrastructural development on economic growth in Nigeria. Most studies of similar genre have placed focus on the juxtaposing of socio-environmental variables while retaining its statistical relevance.

4.2. Unit Root Test (Stationarity Test)

To denote the stationarity of the above time series data, we conduct the "Unit Root Test" with a postulation that we shall not reject the null hypothesis.

For the ARDL approach to be credible, we need to investigate the order of integration of the variables which can be ascertained using Augmented Dickey-Fuller (ADF) test. The test result for LGDP and LECPC in Table 4.1 shows they are stationary (integrated of order five, I(0)) while others are non-stationary and become stationary after first differencing (Integration of order one, I(1)).

Table 2 ADF Unit Root Test Results

Variable	T-Statistic	Prob.	1st Difference	Integration Order
LGDP	-4.4773	0.0026	N/A	I(0)
LSEG	-1.2162	0.6482	-5.1331	I(1)
LSHG	-0.4892	0.9811	-4.7421	I(1)
LTCSG	-0.5315	0.8669	-4.7124	I(1)
LICSG	-2.8207	0.0716	-3.6689	I(1)
LECPC	-11.8005	0	N/A	I(0)

Source: Author's computation using EViews 10, 2024

The mixed order of integration validates the application of the ARDL bounds testing approach.

4.3. Bounds Test for Co-integration

To examine the existence of a long-run relationship between infrastructural development and economic growth, the ARDL bounds test was conducted. The result in Table 4.2 reveals that the F-statistic (9.13) exceeds the upper bound critical value (3.79) at the 5% significance level, confirming the presence of a long-run relationship.

Table 3 ARDL Bounds Test for Co-integration

Test Statistic	Value	Significance Level	I(0)	I(1)
F-statistic	9.13016	10%	2.26	3.35
k (number of regressors) = 5	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Source: Author's computation using EViews 10, 2024

4.4. Lag Selection Criteria

The optimal lag order for the ARDL model was selected using information criteria. Although all criteria initially selected lag order 1, this specification yielded a spurious model due to a high Durbin-Watson statistic. Consequently, lag order 2 was selected for model estimation.

Table 4 Lag Order Selection Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	30.1791	NA	0.005318	-2.41791	-2.11919	-2.3596
1	39.0115	11.4820*	0.002459*	-3.20115*	-2.85264*	-3.13311*
2	39.0587	0.0566	0.002749	-3.10587	-2.70757	-3.02812

Source: Author's computation using EViews 10, 2024

4.5. ARDL Long-Run Estimates

The long-run coefficients from the ARDL model are presented in Table 4.4. The results indicate that LGDP(-1) has a statistically significant and positive effect on current GDP, while LSEG(-1), LSHG(-1), LTCSG(-1), and LICSG(-1) exert negative effects. LECPC(-1) contributes positively to GDP, although the effect is statistically insignificant at the 5% level.

Table 5 ARDL Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.133	1.834	-2.253	0.074
LGDP(-1)	0.854	0.322	2.655	0.045*
LSEG(-1)	-0.189	0.069	-2.733	0.041*
LSHG(-1)	-0.214	0.066	-3.243	0.023*
LTCSG(-1)	-0.095	0.09	-1.059	0.338
LICSG(-1)	-0.343	0.124	-2.765	0.040*
LECPC(-1)	0.24	0.121	1.98	0.105

Source: Author's computation using EViews 10, 2024

4.6. ARDL Short-Run Dynamics

Table 4.5 presents the short-run coefficients. The error correction term CointEq(-1) is positively signed (0.854) and significant, suggesting instability in returning to long-run equilibrium, which is typically expected to be negative. Variables such as LSEG, LICSG, and LECPC negatively affect GDP in the short run, while LSHIG and LTCSG exhibit positive effects.

Table 6 ARDL Short-Run Coefficients - Significance level at 5%

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.133	0.399	-10.354	0.000*
D(LGDP(-1))	-0.492	0.117	-4.196	0.009*
D(LSEG)	-0.577	0.09	-6.416	0.001*
D(LSHIG)	-0.315	0.051	-6.22	0.002*
D(LSHIG(-1))	0.083	0.012	6.643	0.001*
D(LTCSG)	0.036	0.07	0.509	0.632
D(LTCSG(-1))	0.102	0.05	2.063	0.094
D(LICSG)	-0.071	0.032	-2.19	0.08
D(LECPC)	0.05	0.016	3.155	0.025*
D(LECPC(-1))	-0.123	0.017	-7.365	0.001*
CointEq(-1)	0.854	0.082	10.472	0.000*

R^2 = 0.958, Adj. R^2 = 0.916, F-statistic = 22.917, Prob (F-stat) = 0.000, D.W. = 2.116; Significant at 5% level; Source: Author's computation using EViews 10, 2024

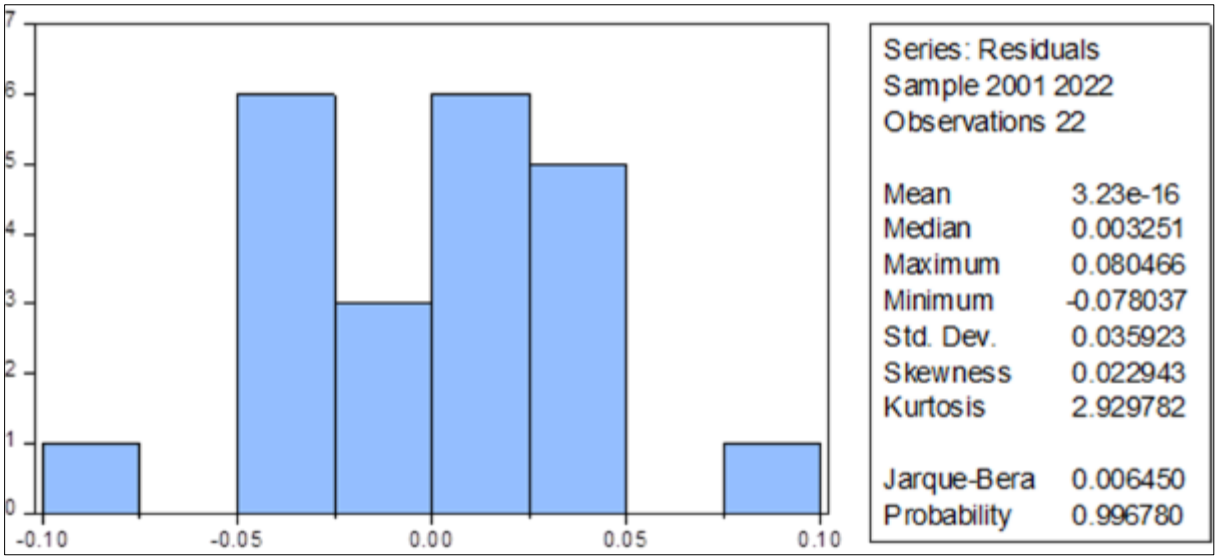
4.7. Post-Estimation Diagnostics

The robustness of the model was verified using the Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey heteroskedasticity test, and Jarque-Bera test for normality. The results in Table 4.6 confirm that the residuals are free from serial correlation, have constant variance, and are normally distributed.

Table 7 Post-Estimation Diagnostic Tests

Test	Statistic	Prob.
Breusch-Godfrey LM Test (χ^2)	2.323	0.313
Heteroskedasticity Test (χ^2)	6.372	0.973
Scaled Explained Sum of Squares	0.754	1

Source: Author's computation using EViews 10, 2024



Source :Author's Computation using Eviews 10, 2024

Figure 1 Histogram of Residuals

5. Discussion

The findings from the ARDL model reveal a significant long-term relationship between infrastructural development and economic growth in Nigeria. However, the direction and significance of the impact vary across sectors.

In the long run, sectors such as education, health, ICT, and transport exhibited negative effects on GDP, suggesting inefficiencies, misallocation of resources, or delays in returns on investment. Conversely, electricity consumption had a positive impact, highlighting the importance of energy infrastructure for productivity and industrial output.

In the short run, health infrastructure (LSHIG) positively influenced GDP, likely due to improved labor productivity. However, education and ICT infrastructure had negative short-term impacts, possibly reflecting time lags in translating infrastructure into tangible growth or systemic inefficiencies.

The error correction term was significant but positively signed, indicating divergence from long-run equilibrium. This unexpected result implies possible macroeconomic instability or misalignment in infrastructure policy execution.

The model demonstrated strong explanatory power (R^2 = 95.8%) and was statistically significant overall (F-statistic = 22.917, $p < 0.05$), with robust residual diagnostics confirming its reliability.

6. Summary

Using the Auto-Regressive Distributed Lag (ARDL) model, this study examined the effect of infrastructural development on economic growth in Nigeria for the period 1999–2022. The study covered five crucial infrastructural elements: education, health, transport and communication, information and communication technology (ICT), and electricity use. The aim was to observe the short-run and the long-run impact of these variables on real gross domestic product (RGDP).

Instead, the results showed a complex nexus between infrastructure and economic growth. In the long run, the shares of education, health, the share of transport and communication, and the share of ICT infrastructure in GDP were found to negatively impact economic growth, implying inefficiencies, delayed project results or misallocation of resources in these sectors. On the other hand, electricity consumption positively and significantly affected long-run GDP growth, highlighting the critical importance of energy infrastructure for Nigeria's economic performance.

We find that in the short-run, while health infrastructure contributed positively to economic growth, other sectors had negative effects (or non-significant effects). Although statistically significant, the error correction term was positive, indicating that there was divergence, not convergence, towards long-term equilibrium, a finding which could indicate macroeconomic instability or inefficiency in infrastructure implementation.

The model had strong explanatory power (adjusted R^2 = 91.6%), and the F-statistic of the entire model was highly significant, which confirmed the validity of the model. The results from the diagnostic tests (the Breusch-Godfrey test for serial correlation, Breusch-Pagan test for heteroscedasticity and Jarque-Bera test for normality (not shown)), confirmed the model specification with normality, independence, and homoscedasticity of the residuals.

7. Conclusion

The study concludes that infrastructural development exerts a mixed and complex influence on Nigeria's economic growth. While electricity infrastructure demonstrated a positive and statistically significant long-term contribution to GDP, other critical sectors—education, health, transport, and ICT—exhibited negative long-run effects. These findings suggest that while infrastructure is fundamental to economic growth, its impact is contingent on effective planning, implementation, and governance.

In the short term, only health infrastructure contributed positively to growth, reflecting its immediate effect on labor productivity and human capital. The negative short-run effects of sectors like education and ICT may be attributed to the time lag between investment and impact, or underlying institutional and operational inefficiencies.

The positive error correction mechanism (ECM) coefficient highlights a concerning trend: the system tends to move away from equilibrium over time, indicating that infrastructure investments may not currently be producing the intended stabilizing effects. This underscores the urgent need for structural reforms to enhance the effectiveness of infrastructure-led growth strategies in Nigeria.

Recommendations

Based on the evidential outcomes, this study proffers a coherent package of policy recommendations to reinforce the role of infrastructural development in promoting sustainable economic growth in Nigeria.

The first is an urgent need to reassess and optimize investments in education and health infrastructure. This negative long-run effect of these sectors on GDP growth calls attention to inefficiencies in public expenditure, project execution and mismatch between investment priorities and development outcomes. In order to prevent this from happening, government agencies should carry out value-for-money audits and sectoral needs assessments to ensure resources are used efficiently and transparently. Any investments must be guided by measurable development indicators and directed towards high-impact projects that will build human capital, enhance productivity, and complement Nigeria's wider socioeconomic objectives.

Second, it is important to strengthen governance and institutional oversight in infrastructure development. Systemic weaknesses in project management, corruption, and lack of accountability lead to persistent inefficiencies in all sectors. This will ensure all infrastructure projects are delivered on time and within budget, with real economic impact through improved institutional capacity across all levels of government and the establishment of stringent monitoring and evaluation frameworks. To avoid abuse of public resources and restore public trust in infrastructure service delivery, transparent procurement systems and enforceable accountability mechanisms need to be institutionalized.

Third, considering its multiplier effect on long-term economic growth, Nigeria must expand and modernize its energy infrastructure. Easier access to reliable electricity will lower production costs, boost industrial output and boost the competitiveness of small and medium-sized enterprises (SMEs). Policymakers should support investments to upgrade the national electricity grid; investing in energy diversification through renewable energy sources such as solar, wind, and hydro; and investments to ensure equitable energy access — particularly in underserved rural communities.

Further, reform steps on energy pricing, governance, and regulation will be required to attract private investment and ensure long-term sustainability.

Building Nigeria's ICT sector also needs to be done strategically. We note that while the study did find a negative relationship between ICT infrastructure and economic growth, this would likely indicate underutilization and access inequalities rather than lack of potential. Addressing the digital divide through targeted investment in broadband infrastructure and mobile coverage — especially in rural regions — could create opportunities for labour productivity gains on a large scale. The deployment of integrated digital solutions for key sectors like education, healthcare, and commerce, the promotion of digital literacy and innovation ecosystems will strengthen the transformative power of ICT and recalibrate Nigeria for accelerated participation in the global digital economy.

In addition to fiscal reform, the government must also work to deepen the use of public-private partnerships (PPPs) to fill the country's significant infrastructure funding gap. A stable regulatory environment, with transparent rules of the game and adequate risk-sharing and investment incentives, can promote private sector participation and infrastructure delivery. Coupled with institutional reforms to strengthen contract enforcement, fiscal accountability, and public participation in PPP processes, this can make PPPs more effective.

Lastly, infrastructure development in Nigeria must be closely links with a long-term national plan and sustainability endeavours. We should strengthen the evidence-based planning frameworks that guide the selection of projects to put in place the hard infrastructure to stimulate the economy, so investments in hard infrastructure are not only economically sustainable but also socially inclusive and environmentally sound. To avoid redundancy and fragmentation, a national infrastructure master plan that encompasses regional priorities and incorporates inter-sectoral synergies is key. Infrastructure projects should also rank based on the degree of inclusive growth, decrease inequality and the Nigeria obligations under Sustainable Development Goals (SDGs).

7.1. Final Remark

In order for Nigeria to reap the full dividends of infrastructure-driven economic growth, there needs to be a paradigm shift from the previous emphasis on quantity of infrastructure to a new focus on quality and efficiency of infrastructure delivery. It is not just the quantity of investments that counts as much as whether the infrastructure projects are adequately designed, implemented and maintained. With these measures, Nigeria could help infrastructure realize its potential as a driver of sustainable and long-term prosperity.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Abebe G, McMillan M, Serafinelli M. Foreign direct investment and knowledge diffusion in poor locations: Evidence from Ethiopia. Am Econ Rev. 2019;109(7):2225–2269. https://doi.org/10.1257/aer.20171765

[2] Adom PK, Amakye K. Electricity consumption and economic growth: Evidence from Ghana using causality analysis. Energy Econ. 2019;80:580–591. https://doi.org/10.1016/j.eneco.2019.02.010

[3] African Development Bank. African economic outlook 2021: From debt resolution to growth. 2021. Available from: https://www.afdb.org/en/documents/african-economic-outlook-2021

[4] African Development Bank. Nigeria: Country strategy paper 2017–2021. 2017. Available from: https://www.afdb.org

[5] African Union. African Union Agenda 2063: The Africa we want. African Union Commission. 2021. Available from: https://au.int/en/agenda2063

[6] African Union. Infrastructure development in Africa: An overview. 2021. Available from: https://au.int/en

[7] Ahmed M, Yousuf T. Infrastructure and sustainable development: Evidence from Bangladesh using ARDL bounds testing. Sustain Dev Rev. 2022;30(2):45–63.

[8] Ali M, Nwogu C. Energy infrastructure and economic growth in Nigeria: ARDL approach. J Energy Dev Stud. 2022;29(1):17–34.

[9] Babatunde MA, Busari DT. Infrastructure investment and economic development in Nigeria: Evidence from sectoral analysis. Niger J Econ Policy. 2021;28(2):89–109.

[10] Barro RJ. Government spending in a simple model of endogenous growth. J Polit Econ. 1990;98(5):S103–S125. https://doi.org/10.1086/261726

[11] Brundtland Commission. Our common future. Oxford University Press; 1987.

[12] Calderón C, Servén L. Infrastructure, growth, and inequality: An overview. World Bank Policy Res Work Pap. 2014;No. 7034. https://doi.org/10.1596/1813-9450-7034

[13] Central Bank of Nigeria. Statistical bulletin. 2022. Available from: https://www.cbn.gov.ng

[14] Ekiran O, Olasehinde A. Infrastructure development and inclusive growth in Nigeria. J Infrastruct Sustain Dev. 2019;5(1):22–36.

[15] Esfahani HS, Ramírez MT. Institutions, infrastructure, and economic growth. J Dev Econ. 2003;70(2):443–477. https://doi.org/10.1016/S0304-3878(02)00105-0

[16] Federal Ministry of Finance. Nigeria's Economic Recovery and Growth Plan: Implementation progress report. Abuja: Federal Government of Nigeria; 2019.

[17] Grimsey D, Lewis MK. Are public–private partnerships value for money? Evaluating alternative approaches and comparing academic and practitioner views. Account Forum. 2005;29(4):345–378. https://doi.org/10.1016/j.accfor.2005.01.001

[18] International Energy Agency (IEA). Net zero by 2050: A roadmap for the global energy sector. 2021. Available from: https://www.iea.org/reports/net-zero-by-2050

[19] Kalugina OA, Arkhipenko AP, Ohnenko DI. PPP as a mechanism for improving infrastructure development in Russia. J Econ Econ Educ Res. 2016;17(2):178–186.

[20] Khan MA, Ahmed S, Akhter N. Infrastructure development and GDP growth: Evidence from Pakistan. Pak J Econ Stud. 2021;4(1):75–98.

[21] Liu Y, Li X, Wang Q. Infrastructure investment and economic growth: Evidence from China. Econ Res J. 2020;55(3):44–61.

[22] Mohammed U, Okeke I. Infrastructure investment and economic growth in Nigeria: A VECM approach. Afr J Econ Policy. 2020;27(1):52–67.

[23] Ojo A, Ogunleye O. ICT infrastructure and economic performance in Nigeria. Telecomm Policy. 2021;45(6):102145. https://doi.org/10.1016/j.telpol.2021.102145

[24] Olufemi B, Olayiwola S. Transport infrastructure and economic development in Nigeria. J Transp Dev. 2019;145(2):1–10. https://doi.org/10.1061/JTPDCE.0000229

[25] Omotosho AB, Akinwande T. Health infrastructure and GDP growth in Nigeria: A cointegration analysis. Health Econ Policy J. 2023;11(1):35–50.

[26] Organisation for Economic Co-operation and Development (OECD). Financing climate futures: Rethinking infrastructure. OECD Publishing; 2018. https://doi.org/10.1787/9789264308114-en

[27] Oyedepo SO. Energy and sustainable development in Nigeria: The way forward. Energy Sustain Soc. 2012;2(1):1–17. https://doi.org/10.1186/2192-0567-2-15

[28] Pesaran MH, Shin Y, Smith RJ. Bounds testing approaches to the analysis of level relationships. J Appl Econometrics. 2001;16(3):289–326. https://doi.org/10.1002/jae.616

[29] Romer PM. The origins of endogenous growth. J Econ Perspect. 1994;8(1):3–22. https://doi.org/10.1257/jep.8.1.3

[30] Sultana N, Jahan S. Infrastructure investment and sustainable economic growth in Bangladesh: An ARDL bounds testing approach. J Econ Dev Policy. 2021;23(2):45–61.

[31] Tella A, Adeoti JO. Sectoral infrastructure investment and economic growth in Nigeria: An ARDL analysis. Niger J Econ Soc Stud. 2021;63(1):1–24.

[32] UN-Habitat. World cities report 2020: The value of sustainable urbanization. United Nations Human Settlements Programme; 2020. https://unhabitat.org/wcr/

[33] United Nations. Transforming our world: The 2030 agenda for sustainable development. 2017. Available from: https://sdgs.un.org/2030agenda

[34] United Nations Environment Programme (UNEP). Global environment outlook 6: Healthy planet, healthy people. Cambridge University Press; 2019. https://www.unep.org/resources/global-environment-outlook-6

[35] World Bank. World development indicators. 2018. Available from: https://databank.worldbank.org

[36] World Bank. Infrastructure for development: Building inclusive and sustainable economies. 2020. Available from: https://www.worldbank.org

[37] World Health Organization (WHO). Health in 2019: Annual report of the Director-General. 2020. Available from: https://www.who.int/publications/i/item/9789240005105