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Telecommunication Infrastructure And Economic Growth Nexus: An Empirical Analysis For A Developing Economy

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Abstract

Telecommunication infrastructure plays a critical role in promoting economic growth by improving connectivity, reducing transaction costs, and supporting innovation. Despite recent improvements, Nigeria continues to experience gaps in telecommunication infrastructure development, which limit its economic potential. This study investigates the impact of telecommunication infrastructure development on economic growth in Nigeria over the period 1990–2022. Annual time-series data were obtained from the Central Bank of Nigeria, the National Bureau of Statistics, and the World Bank. The Autoregressive Distributed Lag (ARDL) model was employed to examine both short-run and long-run relationships among the variables. The results indicate the existence of a long-run relationship between telecommunication infrastructure development and economic growth. Findings further reveal that telecommunication infrastructure and capital formation have positive and statistically significant effects on economic growth in the long run, while transport and educational infrastructure show insignificant effects. The study recommends sustained investment in telecommunication infrastructure, improved regulatory frameworks, and efficient utilisation of resources to enhance Nigeria's long-term economic performance.

Keywords: Telecommunication Infrastructure, Economic Growth, Infrastructure Development, Nigeria, Telecommunications, Capital Formation, Transport Infrastructure

1. INTRODUCTION

Nigeria, as a developing country, continues to face several challenges in achieving sustainable economic growth, and one of the most critical among these is the state of its telecommunications infrastructure. Telecommunications infrastructure plays a central role in modern economic systems by enabling communication, information exchange, digital services, and connectivity across individuals, businesses,

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and government institutions. In today's digital economy, reliable and affordable telecommunications services are no longer optional; they are fundamental drivers of productivity, innovation, and national competitiveness.

Telecommunications infrastructure includes mobile and fixed broadband networks, internet services, data transmission systems, and digital communication platforms. These systems reduce transaction costs, improve access to information, support business operations, and connect local markets to global value chains. Effective telecommunications infrastructure also enhances financial inclusion, supports e-commerce, facilitates remote education and healthcare services, and improves overall quality of life. As a result, countries with well-developed telecommunications networks tend to experience faster economic growth and stronger integration into the global economy.

Government investment in telecommunications infrastructure is therefore essential for economic development. Increased spending on digital networks and communication technologies expands coverage, improves service quality, and lowers costs for users. This, in turn, boosts private sector activity by enabling businesses to operate more efficiently and reach wider markets. Telecommunications infrastructure also attracts foreign direct investment, as investors often prioritize countries with strong digital connectivity and reliable communication systems.

Despite its importance, the development of telecommunications infrastructure in Nigeria has been relatively slow and uneven. While urban areas have benefited from improved mobile network coverage and internet access, many rural and underserved communities still experience limited connectivity, poor service quality, and high costs. These disparities restrict economic participation, widen inequality, and limit the ability of small businesses and individuals to fully benefit from digital opportunities.

Several factors continue to constrain telecommunications infrastructure development in Nigeria. These include high deployment costs, long investment recovery periods, regulatory challenges, inadequate funding, and issues related to governance and transparency. In some cases, resources allocated for infrastructure development have not been efficiently utilized, reducing the overall impact of public and private investments. Rapid population growth and increasing demand for digital services further place pressure on existing telecommunications networks, making expansion and modernization even more urgent.

The Nigerian government has introduced various policies and initiatives aimed at improving telecommunications infrastructure, including reforms designed to encourage private sector participation and expand broadband penetration. Investments in digital connectivity and information and communication technologies have contributed to gradual improvements in network availability and access. However, progress has remained slower than required to meet the growing needs of the population and the demands of a digital-driven economy.

Inadequate telecommunications infrastructure continues to hinder economic activities such as e-commerce, online banking, digital entrepreneurship, and information sharing. These limitations reduce productivity and weaken Nigeria's ability to compete effectively in the global market. Strengthening telecommunications infrastructure is therefore critical not only for economic growth but also for innovation, employment creation, and inclusive development.

Given these challenges, there is a clear need to examine the role and impact of telecommunications infrastructure development on economic growth in Nigeria. Understanding how investments in digital connectivity influence productivity, business performance, and national output is essential for designing effective policies and ensuring that telecommunications infrastructure contributes meaningfully to

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long-term economic development.

This study focuses on the impact of telecommunication infrastructure development on economic growth in Nigeria. The emphasis on transport infrastructure is because it is the hallmark of economic activities. Good telecommunication networks facilitate the production and distribution of goods and services and thereby enhance economic growth. The study will focus primarily on secondary data between the periods of 1990-2022. Additionally, the study will specifically concentrate on Nigeria and may not capture the nuances of infrastructure development in other countries or regions. The data selection is based on the data's accessibility.

This involves assessing the influence of upgraded telecommunication networks on trade facilitation, reliable energy supply on industrial productivity, and improved telecommunications on business connectivity and innovation, which promotes economic growth. Such analysis is vital for policymakers and stakeholders to devise focused intervention and investment plans that optimize infrastructure's economic benefits.

Infrastructure deficits in Nigeria impede productivity, restrict access to vital services, and hinder economic diversification. Understanding the relationship between infrastructure investment and economic growth allows policymakers to prioritise projects that have the best chance of promoting sustainable development, alleviating poverty, and elevating living standards. Furthermore, infrastructure development enhances Nigeria's global competitiveness, enticing foreign investment and fortifying economic resilience.

Thus, the findings of the study on the impact of transport infrastructure on economic growth in Nigeria are pertinent to diverse stakeholders, including government agencies, private investors, development partners, and civil society groups. Government agencies like Ministry of education, Transportation, Budgets, health can utilize insights to prioritize projects and design policies promoting infrastructure sustainability. Private investors like UNDP, UNICEF, IMF, WHO etc. rely on evidence-based assessments for informed investment decisions. Development partners align support with Nigeria's priorities, while civil society advocates for inclusive development. Understanding how infrastructure investment affects economic activity, why it's vital for sustainable development, and its relevance to stakeholders facilitates evidence-based policymaking, fostering Nigeria's economic progress and societal well-being. Future researchers can also develop more on this for more findings as it can also serve as an insight.

The rest of the paper is structured into five sections. Section 1 contains the introduction; section 2 discusses the literature (conceptual, theoretical, and empirical); section 3 covers the methodology, which includes the types and sources of data, the analytical framework, model specification, and estimation techniques of the data; section 4 deals with the presentation of the results and analysis of the findings while section 5 includes conclusions, and policy inferences of the study.

2. LITERATURE REVIEW

The foundation upon which the economic structure is built is infrastructure. As long as the necessary physical components are there, infrastructure can include a wide range of systems and structures in both large- and small-scale organisational frameworks. The electrical grid that runs through a city, state, or nation, for example, is infrastructure based on the devices involved and the goal of providing a service to the regions it supports. Similar to this, the physical cables and parts that make up a company's data network in a particular location also serve as the infrastructure for the relevant business since they are essential to maintaining operations (Jorgenson & Landefeld, 2019).

It is fairly common to notice public funding, control, monitoring, or regulation of infrastructure since it frequently entails the establishment of either public commodities or commodities that lend themselves to production by natural monopolies. This frequently takes the form of direct government manufacture or fabrication by a monopoly that is heavily regulated, authorised by law, and frequently receives subsidies. At smaller scales, infrastructure can often take on the characteristics of club commodities or commodities that are most easily manufactured by localised monopolies. It can be provided by localised arrangements of formal or informal collective action, or it can be provided by a private firm that fabricates infrastructure for use within the firm (Pierre-Richard & ALFaslan, 2018). The facilities, operations, and services that facilitate the growth and functioning of other economic sectors are referred to in this study as economic infrastructure. Furthermore, infrastructures include things like roads, trains, ships, aeroplanes, and communication. Building and enhancing basic services with the intention of spurring economic expansion and improvements in living standards is known as infrastructure development (Faremo, 2015).

According to (Bairam, 1991) stated that infrastructure enhances efficiency of labor and capital, reducing production cost and increasing output. Similarly (Aschauer, 1989) demonstrated that public infrastructure significantly contributes to private-sector productivity, creating a “public capital multiplier.”

According to neoclassical growth theory, investing in infrastructure developments such as building communication networks, power generation systems, and transportation networks—effectively raises economic productivity and efficiency. As a result, increased infrastructure lowers transportation costs, makes it easier to move goods and services, and promotes greater connectivity across various regions. Consequently, this leads to a rise in economic activity, trade, and investment, which in turn drives economic growth (Aschauer, 1989). Because it identifies labour, capital, transportation, education, health, and telecommunication as the factors that influence economic growth, the theory is pertinent to the current investigation.

Economists like Paul Romer (1986) developed the endogenous growth theory, which highlights the importance of internal factors, especially technological innovation and human capital, in promoting long-term economic growth. Robert Lucas (1988) expanded on Romer's theory by highlighting the importance of human capital accumulation in maintaining long-term economic growth. The endogenous growth theory, which differs from the neoclassical growth theory, contends that internal economic factors also have an impact on economic growth in addition to external ones like labour and capital.

The endogenous growth theory highlights the importance of infrastructure as a driving force behind technical breakthroughs and knowledge diffusion in relation to economic growth. Infrastructure fosters an atmosphere that is favourable to innovation and technological advancement. Infrastructure, such as research and development establishments, educational institutions, and information and communication technology networks, nurtures an environment conducive to innovation and technological progress. Consequently, this leads to an escalation in productivity, efficiency gains, and long-term economic growth (Romer, 1986).

The need to provide empirical evidence supporting the importance of infrastructure investment in the global economy has prompted economic research to place a greater emphasis on the significance of infrastructure development. As academic research continues to advance, several authors have attempted to determine the empirical relationship between physical or social infrastructure investment and overall production. Negative growth effects like excessive public debt and misallocated resources might arise from an infrastructure deficiency. (Ansar et al., 2014). Improvements in transport, energy, telecommunications, and water infrastructure positively impact economic growth across African countries (Chakamera & Alagidede, 2018). Reduction in transportation costs allows for greater market integration, as producers gained access to larger markets and consumers benefited from more diversified goods (Donaldson, 2010). Infrastructure improvement in rural areas not only benefits agricultural sectors but it also stimulates non-agricultural rural industries, which leads to boosting regional economic growth (Fan & Zhang, 2004). Infrastructure has a positive significant relationship between infrastructure investments and economic growth in SSA (Kodongo & Ojah, 2016). (Lewis, 1998), (Shi et al., 2017). These authors establish that infrastructure investment could be a precursor to economic development, which is in accordance with the proposition that infrastructure stimulates heightened productivity and thus prompts increasing income from a wider variety of products (Donaldson, 2010). Infrastructure has a positive significant relationship with economic growth in SSA (Kodongo & Ojah, 2016). Improvements to rural infrastructure not only benefit agricultural sectors but also stimulate non-agricultural rural industries, which boost regional economic growth (Fan & Zhang, 2004). (Shi et al., 2017; Lewis, 1998). In line with the idea that infrastructure promotes increased productivity, which in turn leads to rising wealth, these authors demonstrate that infrastructure investment may be a precondition for economic development.

Nonetheless, other scholars argue that the economic impact of infrastructure depends on how far along an economy is (Esfahani & Ramírez, 2003; Sanchez-Robles, 1998). For instance, in mature economies, infrastructure may not be a barrier to economic advancement because improvements to the infrastructure may not have an effect on economic growth. However, the relationship between infrastructure investment and economic growth might be significant when considering less developed economies, where the absence of infrastructure impedes economic expansion.

Ogbaro and Omotoso (2017) used the Cobb-Douglas production model and the ordinary least squares approach to assess the impact of infrastructure development on economic growth in Nigeria in light of the empirical presentation in the literature. The study's conclusions showed that infrastructure related to rail lines, power, communication, and air transportation has significant and beneficial effects on economic growth. Given these results, it is advised that the Nigerian government create an atmosphere that supports and facilitates the use of laws like Public-Private Partnership, which are meant to build infrastructure. Similarly, Kabiru (2016) found that Nigeria's infrastructure capital budget and spending allocation and sufficiency offer significant promise in promoting socioeconomic growth. This is because infrastructure facilities and services help produce both intermediate consumption goods for businesses and final consumption goods for households.

A research by Onakoya et al. (2012) investigates how infrastructure affects Nigeria's economic expansion. The results, which were obtained using the three-stage least squares methodology, show that infrastructure investments significantly impact economic output, both directly through their impact on industrial output and indirectly through their influence on other sectors such as manufacturing, oil, and other services. Infrastructure, however, does not seem to have an impact on the agricultural sector. Similarly, Fasoranti (2012) looked into how infrastructure for the expansion of the Nigerian economy was affected by disaggregated government spending. The findings show that government spending in a number of sectors, including education, housing and the environment, health care, water resources, inflation, agriculture, security, transportation, and communication, is correlated with economic growth over the long run.

Akinlabi et al. (2011) investigate how public infrastructure investments affect poverty reduction and, in turn, Nigeria's economic growth. Using the Cointegration and Granger causality test between 1981 and 2006, they found that, although fiscal deficit has no such influence, public infrastructure is a Granger cause for GDP. Dissou and Didic (2011) revealed that the crowding out impacts of public infrastructure in Benin are largely reliant on the financing mechanism chosen by the government. Their results generally imply that infrastructure spending by the government can sustain capital accumulation and encourage private investment. Infrastructure finance channels including public-private partnerships and subcontracting are responsible for the favourable impact of public investment on private investment, which in turn promotes the growth of private investment.

Babatunde (2018) looked into Nigerian government expenditures on infrastructure and economic expansion. Only government spending on transportation and communication, education, and health infrastructure has a significant long-term impact on economic growth, according to a study using macroeconomic time series data on variables like GDP, public spending on agriculture and natural resources, transportation and communication, and healthcare between 1980 and 2016. Babatunde, however, advocated for government investment in infrastructure, which guarantees effectiveness and fairness in public administration.

With a focus on the impact of planned investments in economic, communal, and societal facilities on the reduction of poverty and income inequality, OEwubare (2019) investigated the role of economic strategising in achieving sustainable progress in Nigeria. The results showed that basic economic planning metrics play a significant impact in predicting Nigeria's long-term development. Africa's rapid consolidation and growth, technological transformation, trade, and advancement will be supported by essential infrastructure needs like clean water and sanitation, as well as access to affordable, reliable, and modern energy services, according to the African Development Bank (2014), the African Union, and the United Nations (2015).

As a result, few writers have shown how infrastructure spending may impact low-income households' income levels. For example, (Calderón & Chong, 2004) investigate the relationship between physical infrastructure stocks and using data from over 101 nations worldwide between 1960 and 1997. These authors demonstrate that infrastructure stock and inequality are negatively connected, suggesting that more infrastructure stock leads to slower growth, using cross-country and GMM statistics on dynamic panel data. The relationship is stronger in low-income economies. As the study was being expanded to include 121 economies and the time frame was extended from 1960 to 2000, the comparable

According to Calderon and Serven's (2004) research, income inequality is reduced by both the number and quality of infrastructure stocks. From 1960 to 2005, a comparable study was conducted in SSA, a region with limited economic development (Calderón & Servén, 2010). It has also been established that greater access to infrastructure services—such as more and better infrastructure—may lessen regional wealth disparity. By creating a general equilibrium growth model and taking into account four different public investment financing options (capital income tax, labour income tax, lump-sum tax, and consumption tax), Chatterjee and Turnovsky (2012) investigate how investments affect income inequality. Spending on infrastructure (public capital) would have various short- and long-term effects, according to the authors' model. Public investment reduces income inequality in the near term, but as time goes on, the trend weakens and eventually causes income inequality to worsen (increase).

Hooper et al. (2018) evaluate the relationship between infrastructure and income inequality in the United States from 1950 to 2010 using state-level panel data. The authors demonstrate that the lowering of inequality (per capita income) is more strongly impacted by improvements in highways (physical infrastructure). It is said that US states with a higher Gini coefficient at the bottom 40 percent experienced less infrastructure investment over the past ten years. According to these experts, infrastructure spending is a common component of both rich and developing nations' efforts to reduce poverty and income disparity. Similarly, (Sasmal & Sasmal, 2016) examine the influence of public investment in reducing poverty in India using panel data analysis. According to their findings, Indian states that invest more in the development of infrastructure (such as roads, transportation, power, irrigation, and communication services) also have greater per capita incomes and lower rates of poverty. Chotia & Rao (2017) investigate the impact of infrastructure development on poverty reduction in India from 1991 to 2015 using the autoregressive distributed lag (ARDL) bounds test approach. Infrastructure principal component analysis is used to calculate the development indicator, which is represented by indices for the transportation, water, sanitation, and energy and telecommunications sectors. According to this authors' research, there is a positive and unidirectional causal relationship between infrastructure development and poverty alleviation in India. Furthermore, Chotia and Rao (2017) examine the relationship between poverty, rural-urban income inequality, and infrastructure development in the BRICS nations (Brazil, the Russian Federation, India, China, and South Africa) using Pedroni's panel co-integration test and the panel dynamic ordinary least squares (PDOLS) technique. It has been discovered that while economic growth and infrastructure development may help the BRICS countries become less impoverished, rural-urban income inequality may make poverty worse.

Rioja (1999) showed that investments in public infrastructure might result in a significant rise in GDP. Boisso et al. (2000) make an effort to quantify how changes in the availability of public infrastructure affect the slowdown in American productivity. The effect of public infrastructure provision on economic development in certain Chinese regions is examined by Lin (2001). The distinction between the immediate and long-term impacts of public infrastructure has been attempted by Moreno et al. (2002). Salinas-Jimenez (2004) estimated a translog cost function to examine how infrastructure investment affects productivity and efficiency in Spanish regions. In their attempt to quantify the role of public infrastructure in the Philippine agricultural sector, Teruel & Kuronda (2005) came to the conclusion that public infrastructure has increased productivity in the Philippines' agricultural sector by lowering production costs.

Public spending and private sector productivity are found to be positively correlated by Aschauer (1989a), Morrison and Schwartz (1996b), and Wylie (1996), but Holz-Eakin (1994) and Holz-Eakin and Schwartz (1995) find conflicting results based on the four investigation methodologies: no relationship if the estimation of production functions uses the

There is a substantial correlation when typical methods to account for unobserved (i.e., state-specific) features are excluded. Evans and Karras (1994) find no evidence of the productivity of public investment in other sectors, but they find substantial evidence in the education sector. Morrison and Schwartz (1996b) conclude that infrastructure investment increases productivity and yields a considerable return for manufacturing enterprises. However, depending on the costs of infrastructure investment and the relative growth rates of infrastructure and output, the net social benefits of infrastructure investment could be either positive or negative.

Ogun (2010) uses secondary data for the years 1970:1–2005:4 to investigate the relationship between Nigeria's economic growth and infrastructure development using the structural vector autoregressive (SVAR) technique. Real capital spending on social and community services serves as the indication of infrastructure development, whereas real capital expenditure on economic services (such as roads, transit, and communication) serves as the indicator of physical infrastructure. Real consumer expenditure per capita is used as a measure of poverty. The author concludes that poverty has decreased as a result of infrastructure improvement. Therefore, it is hypothesised that significant investments in urban social infrastructure could result in a sharp decline in urban poverty.

Subsequent African governments have failed to adequately prioritise infrastructure development in emerging nations, and the Nigerian government is not exempt from this. Some academics, including Wheeler and Moody (1992), Loree and Guisinger (1995), Richard et al. (1999), Morisset (2000), Asiedu (2000), and Sekkat et al. (2004), have even acknowledged the significant role that infrastructure plays in attracting foreign direct investment. They contend that infrastructural development is a prerequisite for foreign investors to operate successfully because inadequate infrastructure raises costs for businesses. Therefore, by lowering the costs of investment for foreign investors and raising their return on investment

(ROI), infrastructure should enhance the investment climate for FDI. As the

A stable political system combined with the availability of adequate infrastructure—such as roads, railroads, highways, ports, communication networks, and electricity—would boost productivity and draw more foreign direct investment, which would spur economic growth.

2.1 Theoretical Framework

In order to achieve the objectives of this study, the work is anchored on a triangulation approach (endogenous growth model and social infrastructural model) which is regarded as technological progress (solo and swam,1956) because the major variables are the independent variables. GDP is in line with the endogenous growth model which can be determined by the variables of social infrastructure (education and health expenditure) and other independent variables of the production function, such as labour and capital formation. We used a production function model in quantitative analysis, using the econometric model specification from Iheanacho (2016) and Atolia et al. (2017). The production function is used because it establishes the positive importance of infrastructures to economic growth in any economic system by connecting the physical quantity of inputs to outputs in any sector. This research paradigm is based on new models of sustainable development that focus on the three sustainability processes—social, economic, and environmental—that are brought about by physical development activities.

While significant research has explored how infrastructure influences economic growth, there are still several notable gaps in the literature related to the interplay of infrastructure with other factors like governance, human capital, and environmental sustainability

3. METHODOLOGY

3.1 Data

The CBN Statistical Bulletin (2022), the World Bank (2021), and the National Bureau of Statistics (2022) provided the annual secondary data collection, which covered the 33-year period from 1990 to 2022. Real Gross Domestic Product is the dependent variable, and labour force participation and capital formation are the independent variables. The capital expenditures for transportation, education, telecommunication, and health are the independent variables.

3.1.2 Model Specification

An estimating equation or function is used to express the endogenous model, which is frequently used to test or explain how the independent factors affect the dependent variable. In order to measure economic growth, the macroeconomic variables that will be used are real gross domestic product (RGDP), which is also the dependent variable while the Infrastructure development variables will be proxy as; Transport Infrastructure Development (TPID), Educational Infrastructural Development (EDID), Telecommunication Infrastructure development (TCID) and Health Infrastructure Development (HTID) and Labour Force (LP) which represents our exogenous variables. This study adapted and modified the model developed by Ogbaro and Omotoso (2017):

$$GDP = f(TPID, EDID, TCID, HTID, LP, KP) \quad \ldots\ldots 3.1$$

TPID = Transport Infrastructure Development

EDID = Educational Infrastructural Development

TCID = Telecommunication Infrastructure development

HTID = Health Infrastructure Development

LP = Labour Force

KF = Capital Formation LINEAR MODEL

$$GDPt = \beta_0 + \beta_1 TPID_t + \beta_2 EDID_t + \beta_3 TCID_t + \beta_4 HTID_t + \beta_5 LP_t + \beta_6 KFt + \mu_t \text{ ……}3.2$$

Where:

GDP = GROWTH RATE

$TPID_t$ = Transport Infrastructure Development

$EDID_t$ = Educational Infrastructural Development

$TCID_t$ = Telecommunication Infrastructure development

$HTID_t$ = Health Infrastructure Development

LP_t = Labour Force

KF_t = Capital Formation

β = Intercept

β_1- β_6 = Coefficient of the independent variables (Parameters to be estimated)

μ = stochastic variable or error term incorporating other factors that are not considered in the

A ”prior expectation

For the duration of the study, the factors in equation (3.2) are expected to have a favourable impact on Nigeria's economic growth.

3.2 Methods of Data Analysis

3.2.1 Descriptive Statistics

In this study, terms like mean, minimum, maximum, standard deviation, and Jarque-bera will be utilized to describe the nature or raw attributes of the data features and characteristics.

3.2.2 Unit Root Test

A formal system for testing for non-stationarity was developed by Dickey and Fuller (1979, 1981) (Asteriou and Hall, 2011). Their justification for testing for non-stationarity is similar to that of the unit root test. The unit root test in the time arrangement test, which is an enlarged version of the Dickey Fuller test for the larger and more complex arrangement of time arrangement models, is known as the Dickey Fuller test. The negative number represents the Augmented Dickey Fuller (ADF) insights used in the test. At some level of certainty, it is shown that the more negative it is, the more firmly the idea that there is a unit root is rejected. An autoregressive model's unit roots were examined using the Dickey–Fuller test. To prevent false and inconsistent regression results, the unit root and differencing tests were conducted. The Augmented Dickey-Fuller test (ADF) was used to test for autocorrelation, and then the test for the null hypothesis (H) was conducted (Dickey & Fuller, 1979).

The unit root test estimation formula is:

$$\Delta y_t = \omega + \delta y_{t-1} + \sum_{i=1}^{m} \theta_i \Delta y_{t-i} + \mu_t \text{ ……}3.3$$

Where: Δ is the first difference operator; y_t is a time series variable at current time (t); ω is the drift term; y_{t-1}; is lagged value of y_t; δ is the coefficient of y_{t-1}; Δy_{t-i} is the lagged value of the first difference of y_t; m is the maximum lag length; θ_i is the coefficients of

Δy_{t-1}; and μ_t is the white noise error term. The null hypothesis is such that the time series contains a unit root which implies that δ=0. The null hypothesis is rejected if δ is negative and statistically significant. Unit root test is based on t-statistic test

Hypothesis for Unit Root Test:

H_0: $\delta = 0$ (Variable has unit root i.e., time series is non-stationary) $\delta < 0$ (Variable do not have unit root i.e., time series is stationary)

Decision Rule:

(i) If t^*> ADF critical value in absolute terms, reject the null hypothesis

(ii) If t^*< ADF critical value in absolute terms, accept the null hypothesis.

3.3 Cointegration test

Co-integration is used in the study primarily because it offers a formal framework for evaluating and estimating both short-term and long-term correlations between the economic variables. Therefore, the cointegrating relationship between the variables was assessed using the Engle-Granger, Phillips-Ouliaris, and bounds tests for cointegration. To make sure the cointegration results were robust, all three of these tests were employed.

The ARDL method, developed by Pesaran, Shin, and Smith (2001), was used to estimate the long-term and short-term estimations of the link between infrastructure and economic growth. This method expresses economic development as a function of the present and lagged values of the explanatory variables as well as the lagged value of itself.

Using lagged variables to account for both short-term and long-term effects, the following equation illustrates how changes in infrastructure variables—such as labour, capital, transportation, education, health, and communication—affect changes in GDP.

$$\Delta GDP_t = \alpha + \beta_1 \Delta GDP_{t-1} + \beta_1 \Delta GDP_{t-2} + \cdots + \beta_p \Delta GDP_{t-p} + y_1 \Delta \text{Transportation}_t + y_2 \Delta \text{Education}_t + y_3 \Delta \text{Health}_t + y_4 \Delta \text{Communication}_t + y_5 \Delta \text{Labour}_t + y_6 \Delta \text{Capital}_t + £_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.4$$

Where

$\Delta \text{GDP}t, represents\ the\ change\ in\ GDP\ at\ time\ t$

$\Delta \text{GDP}t - i, represents\ the\ change\ in\ GDP\ at\ time\ t$

$\Delta \text{Transportation}t + \Delta \text{Education}t + \Delta \text{Health}t + \Delta \text{Communication}t + \Delta \text{Labour}t + \Delta \text{Capital}t,$

Represent the changes in transportation, education, health, communication, labor, and capital at time *t* respectively.

$\gamma 1, \gamma 2, \gamma 3, \gamma 4, \gamma 5, \gamma 6$, are the coefficients representing the effects of changes in transportation, education, health, communication, labor, and capital on GDP.

$\beta 1, \beta 2, \ldots, \beta p\ are\ the\ coefficients\ of\ the\ lagged\ changes\ in\ G$

α Is the intercept term.

p Is the lag length for GDP, which can be determined using statistical techniques or domain knowledge.

$£_t$ is the error term representing the random disturbance in the model

$$\Delta \mathrm{GDP}_t = a_0 + \sum_{p=1}^{n} b_p \Delta \mathrm{GDP}_{t-p} + \sum_{p=1}^{n} c_p \Delta \mathrm{TPID}_{t-P} + \sum_{p=1}^{n} b_p \Delta \mathrm{EDID}_{t-p} + \sum_{p=1}^{n} b_p \Delta \mathrm{TCID}_{t-p} + \sum_{p=1}^{n} b_p \Delta \mathrm{AGID}_{t-p} + \sum_{p=1}^{n} b_p \Delta \mathrm{LP}_{t-p} + GDP_{t-1} + \beta_2 TPID_{t-1} + \beta_3 EDID_{t-1} + \beta_4 TCID_{t-1} + \beta_5 AGID_{t-1} + \beta_6 LF_{t-1} + \mu_t \quad \text{..................3.5}$$

Where; Δ is the first difference operator; the parameters, where β_1 to β_5 are the respective long run multipliers; the parameters b, c, d, e, f were the short run by dynamic coefficients of the underlying ARDL model in the equation; and μ is the white noise error term. The Bounds co-integration test involves estimating the above equation and restricting the parameters of the lag level variables to zero.

4. RESULTS

4.1 Descriptive Statistics

Descriptive statistics must be used to demonstrate how the variables employed in the investigation behave. This emphasises not just choosing the best course of action but also making sure the suitable methods are applied for the research. Descriptive statistics, unit root tests, the NARDL limits test, and the outcome shown in table 4.1.1 were used to achieve this.

4.1.1 Variable Descriptive Analysis.

Descriptive Analysis of Variables

STATISTICS	RGDP	TPID	EDID	TCID	HTID	LF	KF
Mean	52098.99	23.57667	771.0221	3948.674	284.1327	49.48964	11828.68
Maximum	199336.0	51.15000	1519.660	12323.04	529.9900	73.27234	65227.13
Minimum	489.7700	3.660000	293.5300	222.7500	127.1000	31.93659	262.7700
Skewness	1.017969	0.447497	0.484596	0.608963	0.407120	0.324314	2.109019
Kurtosis	2.921858	1.635179	1.526936	1.992957	1.463039	2.114090	6.732239
Jarque-Bera	5.707834	3.662657	4.275219	3.434032	4.159698	1.657637	43.61700
Probability	0.057618	0.160201	0.117936	0.179601	0.124949	0.436565	0.000000
Sum	1719267.	778.0300	25443.73	130306.2	9376.380	1633.158	390346.5
Sum Sq. Dev.	1.06E+11	9208.497	7396775.	4.82E+08	704512.1	4435.441	8.30E+09
Observations	33	33	33	33	33	33	33

Source: Author, Computed using E-View 10.

Table 4.1.1's results showed that all of the variables' mean values were positive, indicating that they were all rising with time. With the highest overall mean values of 52098.99 and 11828.68, respectively, Real Gross Domestic Product (RGDP) and Capital Formation (KF) are the variables most impacted by infrastructure development shocks, according to the mean value findings, while Transport Infrastructural Development (TPID) has the lowest average value of 23.57 revealing that (TPID) is the less affected variables in the study.

The minimum (min) and maximum (max) are fundamental measures used to describe the range of values in a dataset. The range between the minimum and maximum values provides

insight into the spread or variability of the dataset. The wider range (larger difference between max and min) suggests greater variability in the data, while smaller difference between max and min indicates less variability. Greater variability in the data is indicated by a wider range (bigger difference between max and min), whereas less variability is shown by a smaller difference between max and min. According to the results, Nigeria's RGDP and KF fluctuated consistently during the study period. The highest and widest ranges of these variables were 199336.0 and 65227.13, with minimum values of 489.7700 and 262.7700, respectively. This illustrates the degree of RGDP and KF's venerability as a result of shocks to Nigeria's infrastructure development over the research period. Additionally, the chart showed that GDP has the biggest standard deviations (57551.22), suggesting that it is the variable most impacted by shocks related to infrastructure development.

The asymmetry of the series' distribution around its mean is measured by the test's skewness, which is 0 for a normal distribution. A distribution with a long left tail is negatively skewed, and one with a long right tail is positively skewed. This indicates that the mean is higher than the medium and mode and that the majority of the data points are concentrated on the left side of the mean. According to the positive sign, all of the variables visually exhibit a long right tail (positively skewed). demonstrating that every variable has been rising during the study's duration and reacting favourably to shocks to Nigeria's infrastructure development.

Kurtosis describes the tailedness or sharpness of the peak of a distribution; it provides insights into the likelihood of extreme values (outliers) in the data. The series is said to be platykurtic if the distribution is less than 3, meaning variables are spread far from the mean and it is leptokurtic when it is greater than 3, meaning variables are concentrated around the mean. From the distributions of the data of this study, most of the variables are said to be leptokurtic except for KF that is platykurtic in nature. Meaning the variables are normal in analyzing infrastructure development on economic growth in Nigeria.

To ascertain whether the data's skewness and kurtosis match those of a normal distribution, the Jarque-Bera test is employed. It's especially helpful for verifying a dataset's assumption of normalcy. With the exception of KF, which is statistically significant based on its probability value being more than 0.05 at the 5% level of significance, the Jaque-Bera statistics in this study indicate that nearly all of the variables are not statistically significant at the 5% level. This suggests that while the other variables are not significant at the selected 5% level of significance and are therefore not normally distributed, the null hypothesis that the variables are normally distributed is rejected. This indicates that the majority of the variables are abnormal and can be utilized to determine how infrastructure development affects Nigeria's economic growth.

4.2 Unit Root Test Results

The ADF test is used to look at the unit root of the variables, and the results are displayed in Table 4.2. To determine whether or not the variables in the study are stationary, the unit root test, also known as the stationarity test, is utilised. The study looked at a number of methods to make the variables stationary in the event that they weren’t, otherwise, the results would be erroneous. No variable integrated of order 2, or I(2), may be employed in the analysis as required by the ARDL bounds testing. Thus, for every variable used to determine the degree of stationarity, table 4.2 displays both the Augmented Dickey-Fuller (ADF) and unit root tests.

Table 4.2.1: Results of the Augmented-Dickey Fuller (ADF) Test.

Table 4.2.1: Augmented–Dickey Fuller (ADF) Test Results

Variables			ADF Statistics	Remark
	Level	First Difference	5% Critical Value	
RGDP	11.15064	2.129951	-2.963972	I(1)
TPID	-2.963972	-2.963972	-5.057460	I(1)
EDID	1.604067	-1.621040	-2.963972	I(1)
TCID	1.779685	-2.314341	-2.963972	I(1)
HTID	0.071715	-2.294797	-5.847284	I(1)
LF	2.019748	-2.724223	-2.967767	I(1)
KF	4.432681	1.103198	-2.963972	I(1)

Note: ** At the 5% significance level, the null hypothesis that the unit root exists is rejected, as indicated. Source: E-Views 9 program was used for computation. See Appendix II.

Every variable has a unit root at level, according to the ADF test results, and becomes stationary after the first difference I(I). All of the variables in the ADF value are greater than their respective critical values at the 5% level, as demonstrated by the comparison of the ADF value with each critical value at the significant 5% level. There might be a long-term link between the variables, based on the order of integration I(0) and I(1). At least one of the variables in our system must be stationary I(0) at level in order to employ long run limitations inside the ARDL framework (King and Watson, 1997).

4.3 Results of Cointegration Tests

Three cointegration tests (Bounds test, Engle-Granger and Phillips-ouliaris) were conducted and the results are shown in Table 4.3.3

Table 4.3.3 Results of Cointegration Tests

	Engle-Granger				Philips-Ouliaris			
Variables	tau-statistic	Prob.*	z-statistic	Prob.*	tau-statistic	Prob.*	z-statistic	Prob.*
RGDP	-6.594920	0.0083	-38.34870	0.0048	-6.927930	0.0043	-34.04534	0.0256
LP	-3.431406	0.7044	-15.40708	0.8213	-3.488914	0.6804	-15.46142	0.8188
KP	-9.148716	0.0000	-46.98077	0.0000	-10.72592	0.0000	-41.80190	0.0009
HTID	-4.506752	0.2718	52.70096	0.9999	-3.853079	0.5205	-19.08155	0.6175
EDID	-7.957789	0.0005	-44.52780	0.0002	-8.678439	0.0001	-39.96637	0.0022
TCID	-4.807439	0.1795	-48.11925	0.0000	-4.126813	0.4028	-19.69229	0.5792
TPID	-3.497598	0.6768	-17.90033	0.6891	-3.602474	0.6316	-18.73215	0.6391

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	F-Bounds Test	Null Hypothesis: No levels relationship		
				Critical values
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	14.87887	10%	1.99	2.94
K	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99

Sources: Author‟s Computation E-Views 9.0

The p-values for Ouliaris are less than 5%, indicating that they are statistically significant.

0.05. Additionally, the bounds tests' F-statistic (14.8) is higher than the upper bound's critical value (3.28). This shows that the null hypothesis has been rejected. As a result, the findings demonstrate that the variables in the model exhibit cointegration. This suggests that the factors being studied have a long-term link.

4.4 ARDL Regression

Table 4.4.4 ARDL Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short run				
DLOG(LP)	-1.495000	0.803274	-1.861133	0.0756
DLOG(KP)	0.417062	0.180147	2.315114	0.0299
DLOG(HTID)	-0.702994	0.265951	-2.643316	0.0145
DLOG(EDID)	0.434130	0.271668	1.598020	0.1237
DLOG(TCID)	0.147215	0.103250	1.425814	0.1674
DLOG(TPID)	0.066918	0.091310	0.732871	0.4710
CointEq(-1)	-0.382863	0.121166	-3.159826	0.0044
		Long run		
LOG(LP)	-3.904787	1.511158	-2.583970	0.0166
LOG(KP)	1.089323	0.284273	3.831963	0.0009
LOG(HTID)	-1.836147	0.539054	-3.406239	0.0024
LOG(EDID)	1.133904	0.562162	2.017040	0.0555
LOG(TCID)	0.732831	0.128512	5.702418	0.0000
LOG(TPID)	0.174784	0.226723	0.770913	0.4486
Constant	12.887441	2.931140	4.396734	0.0002
R-squared	0.998206	Mean dependent var		9.949343
Adjusted	0.997582	S.D. dependent var		1.697708

R-squared			
S.E. of regression	0.083473	Akaike info criterion	-1.896322
Sum squared resid	0.160259	Schwarz criterion	-1.484083
Log likelihood	39.34115	Hannan-Quinn criter.	-1.759676
F-statistic	1600.011	Durbin-Watson stat	1.722199
Prob(F-statistic)	0.000000		

Source: Author, Computed using E-Views 10.0

While LP and HTID are negatively signed, KP and HTID are statistically significant in the short term, while the remaining variables are positively signed and statistically insignificant in the short term at the 5% level of significance, according to the results in Table 4.4. This suggests that KP and HTID have a positive and inverse connection with the dependent variables, respectively, suggesting that both factors may have an impact on economic growth in the near future if they are completely utilized. This suggests that a rise in KP will result in a rise in the

In the short term, economic expansion and an increase in HTID will cause economic growth to slow down in the present period.

With the exception of EDID and TPID, which are statistically insignificant at the 5% level, all of the variables are statistically significant in the long run, according to the ARDL long-run estimations. Additionally, given that each of their p-values is less than 0.05 at the 5% threshold of significance, LP, KP, HTID, and TCID are statistically significant over the long term. In other words, if fully utilised in various ways, LP, KP, HTID, and TCID have the potential to have an impact on economic growth in the long run. The findings imply that both LP and HTID are negatively signed, meaning that whereas a policy change on EDID and TPID will have a direct impact on economic growth over the long term in Nigeria, a positive policy adjustment on LP and HTID will have an inverse effect on economic growth. This is consistent with the underlying theory and our a-priori anticipation.

About 99% of the variation in foreign direct investment in Nigeria can be explained by the independent variables, according to the R-2 of 0.99. The remaining five percent is ascribed to variables not included in the model but to other factors that actually impact economic growth. The error term in the study captures this. The absence of serial correlation is indicated by the Durbin-Watson value of 1.7. Thus, we can reject the null hypothesis (HO1) based on these findings.

The outcome shows how infrastructure development affects Nigeria's economic growth in dynamic ways. Over a lengthy period, Nigeria's infrastructure development has a sustained and notably positive impact on economic growth. This suggests that positive economic growth in the nation is correlated with negative LP and HTID. Nonetheless, in Nigeria, the effects of LP and HTID typically need a lag period before becoming asymptotic to the steady state over the course of the time horizon. Nigeria's economic growth is significantly impacted by the development of its infrastructure. This is to be expected since all investors prefer to put their money into economies with more predictable infrastructure development.

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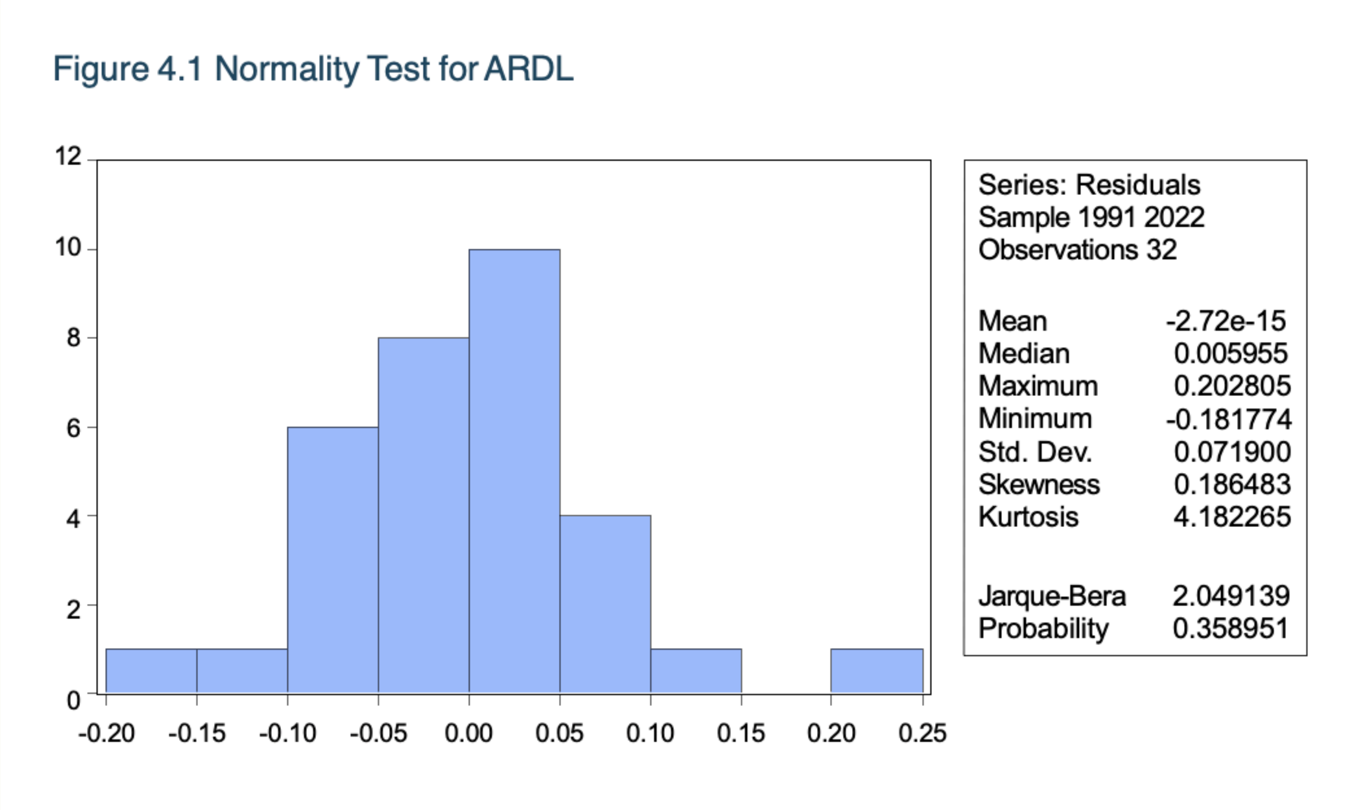
Figure 4.1 Normality Test for ARDL



Sources: ***Author's Computation 2024***

The outcome of the figure. 4.1 shows that, at the 5% level of significance, the probability value of the Jarque-Bera statistics is not significant. Nonetheless, the null hypothesis was approved, indicating that the residuals follow a normal distribution. It should be noted that the histogram normality test's null hypothesis asserts that the series' distribution is identical to the normal distribution.

T-test statistic decision rule:

Accept H if the P-value is greater than 0.05 Accept H reject H_1 if the P-value is less than 0.05

Table 4.6 shows that the t-test is 1.600599 and the p-val is 0.0437. Decision Rule: We accept the alternative hypothesis and reject the null hypothesis since the p-value is less than 0.05 and conclude that Telecommunication Infrastructure Development has significant impact on Economic Growth.

Table 4.6 shows that the p-value is 0.5713 and the t-test is = -0.573942. The null hypothesis is accepted and the alternative hypothesis is rejected according to the decision rule, which states that there is no discernible relationship between health infrastructure development and economic growth because the p-value is higher than 0.05.

5. DISCUSSION

The ARDL model's conclusions offer important new information about the connection between economic growth and infrastructure development, as well as the implications for policymaking. The study's main conclusions fall into three categories: econometric, statistical, and economic findings.

The economic findings paint a nuanced picture of how infrastructure development affects Nigeria's economic expansion. Both Transport Infrastructure Development (TPID) and Educational Infrastructural Development (EDID) have not sufficiently contributed to economic growth over the research period, in contrast to the anticipated positive contribution. In Nigeria, there is an inverse link between economic growth and labour force (LP) and health infrastructure development. Specifically, a 1% rise in LP and HTID reduces economic growth by 3.9% and 1.8%, respectively. This points to possible inefficiencies or poor administration of the money allotted to these areas, which is consistent with research by Aschauer (1989), who emphasised the declining returns of poorly managed infrastructure projects.

On the other hand, there is a favourable correlation between economic growth and the development of telecommunications infrastructure and capital formation (KP). Economic growth increased by 0.18 percent and 0.73%, respectively, for every 1% increase in these variables. These results corroborate those of Barro (1991) and Mankiw, Romer, and Weil (1992), who highlighted the critical role that technology, capital formation, and human capital play in promoting economic progress. A research by Onakoya et al. (2012) investigates how infrastructure affects Nigeria's economic expansion. The results show that infrastructure spending has a significant impact on economic output, both directly through its influence on industrial output and indirectly through its influence on other industries including manufacturing, oil, and other services.

With p-values less than 5%, the t-statistics show that capital formation, labour force participation, health infrastructure development (HTID), and telecommunication infrastructure development all have statistically significant effects on economic growth in Nigeria. For these variables, the alternative hypothesis is thus accepted and the null hypothesis is rejected. However, the null hypothesis is accepted because the p-values for Educational Infrastructural Development (EDID) and Transport Infrastructure Development (TPID) are higher than 5%. These statistical results highlight how different infrastructure improvements affect economic growth to differing degrees.

Numerous studies that emphasise the benefits of infrastructure expenditures conflict with the detrimental effects of LP and HTID on economic growth (Calderón & Servén, 2004). Nonetheless, it is consistent with research by Holtz-Eakin and Schwartz (1995), who noted that the effectiveness and calibre of infrastructure spending are essential to its growth-promoting effects. This implies that although investments in infrastructure are vital, their immediate financial benefits might not be as noticeable in the absence of effective management and use.

Lastly, given that capital formation (KF) Granger Causes RGDP and TCID Granger Causes TPID, as well as LF with TPID, KF with EDID, and KF with TPID Granger Cause each other, the Granger Casualty Test also demonstrates that the main infrastructure investment variables used in the study Granger Cause Economic Growth in Nigeria. This demonstrates how well infrastructure development contributes to Nigeria's economic growth. The results of this study, meanwhile, are consistent with those of a study by Ogbaro and Omotoso (2017) on The Impact of Infrastructure Development on Economic Growth in Nigeria, which used the Cobb-Douglas production model and was calculated using the ordinary least squares method. The results of the

Research has shown that the infrastructure of rail lines, power, communication, and air transportation has significant and favourable effects on economic growth. According to Kabiru (2016), Nigeria's infrastructure capital budget and spending allocation and adequacy show significant promise for promoting socioeconomic development.

5.1 Policy Recommendations

Based on the results, the following suggestions are put forth to increase the beneficial effects of infrastructure development on Nigeria's economic growth. This will guarantee that the regulatory and policy frameworks are appropriately created and put into place for efficient policies, as well as that infrastructure projects are properly planned, carried out, and maintained.

1. According to the report, the Nigerian government should make a commitment to good governance and make sure that public infrastructures are properly maintained, administered, and protected. Future and ongoing developments should be actively watched while making sure that projects are awarded based on merit and that realistic deadlines are set and rigorously adhered to. In order to significantly enhance human capital development—which is essential for sustained economic growth—governments at all levels must also boost their investments in educational infrastructure.
2. Boost communication effectiveness and facilitate a range of economic endeavours by fortifying the telecommunications infrastructure.
3. In an effort to improve transport infrastructure, more roads should be built and existing ones should be properly maintained. This is especially important for roads that have already been overtaken by gully erosion, as this will reduce firm production and make it impossible for businesses to transport intermediate and final consumables from rural to urban areas. Additionally, by making sure that resources are allocated appropriately and enhancing project management, the intended beneficial effect on economic growth can be achieved.
4. The development of health infrastructure should be reformed to remove inefficiencies and better distribute funds in order to enhance health outcomes and promote economic expansion. Government health facilities should be used effectively and efficiently and administered properly. In light of this,

Health programs that have been abandoned should be revived, while less impactful projects should be reduced if needed. In order to secure private participation for the management of these projects, PPP is anticipated to be a feasible option.

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APPENDICES

APPENDIX I: Data

	BILLIONS(₦)				
YEAR	GDP	TRANSPORTATION	EDUCATION	HEALTH	COMMUNICATION
1990	489.77	3.66	293.53	127.1	222.75
1991	584.25	3.72	296.64	129.95	226.9
1992	897.12	3.97	305.17	137.58	237.98
1993	1244.8	4.37	314.01	140.62	253.3
1994	1751.28	4.96	318.49	140.26	263.7
1995	3069.43	5.76	318.3	138.09	279.21
1996	4045.32	6.62	327.52	141.1	298.83
1997	4374.5	7.61	333.18	143.41	327.34
1998	4756.71	9.14	338.84	147.5	369.7
1999	5426.47	10.97	344.51	150.27	421.27
2000	6990.62	11.84	350.17	157.23	462.5
2001	8150.02	13.03	355.83	160.23	821.72
2002	11383.66	15.18	383.83	163.35	953.87
2003	13418.01	15.18	410.83	166.43	1083.72
2004	17938.38	16.08	455.4	184.49	1459.29
2005	22884.9	17.03	503.44	203.06	1775.49
2006	30063.96	18.07	557.67	224.14	2223.8
2007	34318.67	19.18	617.78	247.44	2811.95
2008	39542.43	20.36	684.31	273.16	3587.62
2009	43012.51	21.48	752.79	300.74	4610
2010	54612.26	22.65	826.67	330.96	5955.06
2011	62980.4	26.96	1087.67	374.12	6083.05
2012	71713.94	33.39	1105.9	390.3	6268.51
2013	80092.56	39.14	1278.41	427.72	6783.07
2014	89043.62	44.69	1391.95	472.63	7257.06
2015	94144.96	47.11	1498.71	484.34	7708.11
2016	101489.49	46.58	1518.93	475.69	7858.7
2017	113711.63	46.68	1507.98	474.24	7776.9
2018	127736.83	47.6	1507.56	472.7	8527.66
2019	144210.49	48.87	1519.66	474.17	9309.92

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2020	152324.07	46.55	1313.39	484.74	10537.14
2021	173527.66	48.45	1303.55	508.63	11227.07
2022	199336.04	51.15	1321.11	529.99	12323.04

APPENDIX II: Statistic Analysis Result

STATISTICS	RGDP	TPID	EDID	TCID	HTID	LF	KF
Mean	52098.99	23.57667	771.0221	3948.674	284.1327	49.48964	11828.68
Median	30063.96	18.07000	557.6700	2223.800	224.1400	48.84677	6997.620
Maximum	199336.0	51.15000	1519.660	12323.04	529.9900	73.27234	65227.13
Minimum	489.7700	3.660000	293.5300	222.7500	127.1000	31.93659	262.7700
Std. Dev.	57551.22	16.96365	480.7798	3881.024	148.3779	11.77317	16109.74
Skewness	1.017969	0.447497	0.484596	0.608963	0.407120	0.324314	2.109019
Kurtosis	2.921858	1.635179	1.526936	1.992957	1.463039	2.114090	6.732239
Jarque-Bera	5.707834	3.662657	4.275219	3.434032	4.159698	1.657637	43.61700
Probability	0.057618	0.160201	0.117936	0.179601	0.124949	0.436565	0.000000
Sum	1719267.	778.0300	25443.73	130306.2	9376.380	1633.158	390346.5
Sum Sq. Dev.	1.06E+11	9208.497	7396775.	4.82E+08	704512.1	4435.441	8.30E+09
Observations	33	33	33	33	33	33	33

Source: Author, Computed using E-View 9 software. Note: RGDP =Real GDP, TPID = transport infrastructural development, EDID = education infrastructural development,

APPENDIX III: ADF Test Result

Variables	Level	First Difference	5% Critical Value	Remarks
RGDP	11.15064	2.129951	-2.963972	I(1)
TPID	-2.963972	-2.963972	-5.057460	I(1)
EDID	1.604067	-1.621040	-2.963972	I(1)
TCID	1.779685	-2.314341	-2.963972	I(1)
HTID	0.071715	-2.294797	-5.847284	I(1)
LF	2.019748	-2.724223	-2.967767	I(1)
KF	4.432681	1.103198	-2.963972	I(1)

APPENDIX IV: Cointegration Tests

	Engle-Granger				Philips-Ouliaris			
Variables	tau-statistic	Prob.*	z-statistic	Prob.*	tau-statistic	Prob.*	z-statistic	Prob.*
RGDP	-6.594920	0.0083	-38.34870	0.0048	-6.927930	0.0043	-34.04534	0.0256
LP	-3.431406	0.7044	-15.40708	0.8213	-3.488914	0.6804	-15.46142	0.8188
KP	-9.148716	0.0000	-46.98077	0.0000	-10.72592	0.0000	-41.80190	0.0009
HTID	-4.506752	0.2718	52.70096	0.9999	-3.853079	0.5205	-19.08155	0.6175
EDID	-7.957789	0.0005	-44.52780	0.0002	-8.678439	0.0001	-39.96637	0.0022
TCID	-4.807439	0.1795	-48.11925	0.0000	-4.126813	0.4028	-19.69229	0.5792
TPID	-3.497598	0.6768	-17.90033	0.6891	-3.602474	0.6316	-18.73215	0.6391

ARDL Cointegrating And Long Run Form

Dependent Variable: LOG(RGDP)

Selected Model: ARDL(1, 0, 0, 0, 0, 1, 0)

Date: 08/06/24 Time: 17:25

Sample: 1990 2022

Included observations: 32

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(LP)	-1.495000	0.803274	-1.861133	0.0756
DLOG(KP)	0.417062	0.180147	2.315114	0.0299
DLOG(HTID)	-0.702994	0.265951	-2.643316	0.0145
DLOG(EDID)	0.434130	0.271668	1.598020	0.1237
DLOG(TCID)	0.147215	0.103250	1.425814	0.1674
DLOG(TPID)	0.066918	0.091310	0.732871	0.4710
CointEq(-1)	-0.382863	0.121166	-3.159826	0.0044

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Cointeq = LOG(RGDP) - (-3.9048*LOG(LP) + 1.0893*LOG(KP) -1.8361 *LOG(HTID) + 1.1339*LOG(EDID) + 0.7328*LOG(TCID) + 0.1748 *LOG(TPID) + 12.8874)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(LP)	-3.904787	1.511158	-2.583970	0.0166
LOG(KP)	1.089323	0.284273	3.831963	0.0009
LOG(HTID)	-1.836147	0.539054	-3.406239	0.0024
LOG(EDID)	1.133904	0.562162	2.017040	0.0555
LOG(TCID)	0.732831	0.128512	5.702418	0.0000
LOG(TPID)	0.174784	0.226723	0.770913	0.4486
C	12.887441	2.931140	4.396734	0.0002

APPENDIX V: The Pair-wise Granger Causality Test Results

Pairwise Granger Causality Tests

Date: 06/01/24 Time: 18:44

Sample: 1990 2022

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
TPID does not Granger Cause RGDP	31	2.16825	0.1346
RGDP does not Granger Cause TPID		1.60165	0.2208

EDID does not Granger Cause RGDP	31	3.18921	0.0577
RGDP does not Granger Cause EDID		1.17307	0.3253
TCID does not Granger Cause RGDP	31	0.81550	0.4534
RGDP does not Granger Cause TCID		2.89239	0.0734
HTID does not Granger Cause RGDP	31	1.81748	0.1825
RGDP does not Granger Cause HTID		1.31608	0.2855
LF does not Granger Cause RGDP	31	1.21477	0.3131
RGDP does not Granger Cause LF		1.55267	0.2307
KF does not Granger Cause RGDP	31	4.88436	0.0158
RGDP does not Granger Cause KF		1.56579	0.2280
EDID does not Granger Cause TPID	31	0.21093	0.8112
TPID does not Granger Cause EDID		1.49209	0.2435
TCID does not Granger Cause TPID	31	6.82986	0.0041
TPID does not Granger Cause TCID		0.18861	0.8292
HTID does not Granger Cause TPID	31	5.62509	0.0093
TPID does not Granger Cause HTID		0.15113	0.8605
LF does not Granger Cause TPID	31	8.09676	0.0018

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TPID does not Granger Cause LF		6.63291	0.0047
KF does not Granger Cause TPID	31	7.51798	0.0027
TPID does not Granger Cause KF		4.30905	0.0242
TCID does not Granger Cause EDID	31	2.68145	0.0873
EDID does not Granger Cause TCID		0.08405	0.9196
HTID does not Granger Cause EDID	31	5.55871	0.0098
EDID does not Granger Cause HTID		2.30398	0.1199
LF does not Granger Cause EDID	31	4.04711	0.0295
EDID does not Granger Cause LF		1.80855	0.1839
KF does not Granger Cause EDID	31	3.83438	0.0347
EDID does not Granger Cause KF		9.49400	0.0008
HTID does not Granger Cause TCID	31	0.20089	0.8193
TCID does not Granger Cause HTID		5.42016	0.0108
LF does not Granger Cause TCID	31	4.17874	0.0267
TCID does not Granger Cause LF		0.79025	0.4643
KF does not Granger Cause TCID	31	2.79769	0.0793
TCID does not Granger Cause KF		0.43955	0.6490

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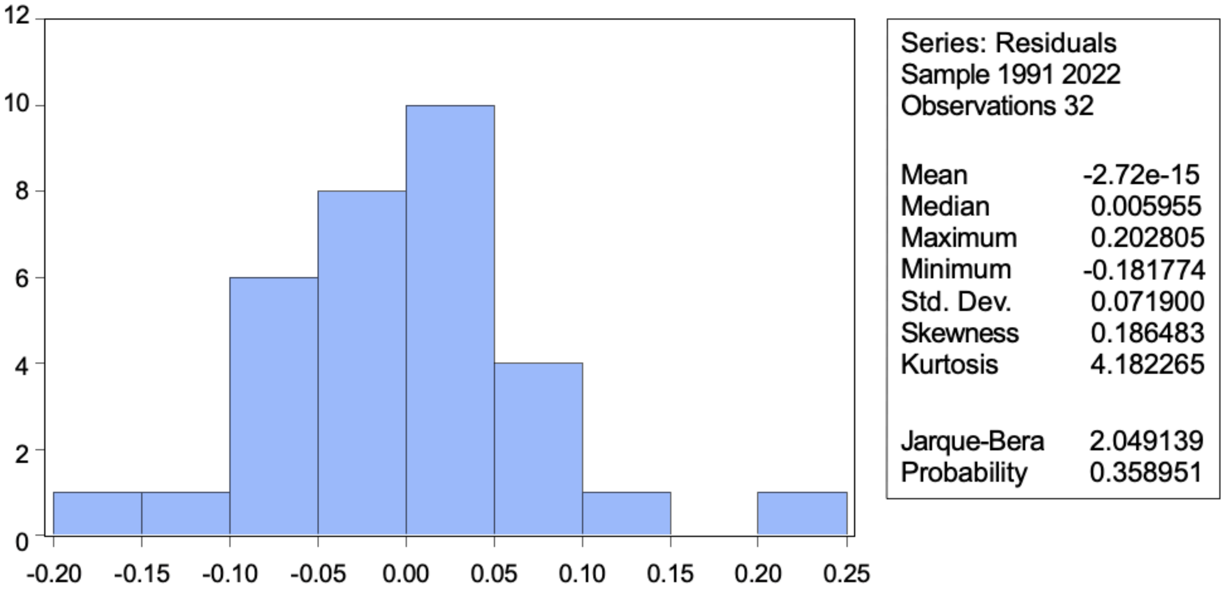
LF does not Granger Cause HTID	31	24.1282	1.E-06
HTID does not Granger Cause LF		0.88011	0.4267
KF does not Granger Cause HTID	31	1.33207	0.2813
HTID does not Granger Cause KF		4.41696	0.0223
KF does not Granger Cause LF	31	0.76426	0.4759
LF does not Granger Cause KF		0.24323	0.7859

APPENDIX VI: Normality Test for ARDL

Figure 4.1 Normality Test for ARDL



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.248662	Prob. F(2,21)	0.7821
Obs*R-squared	0.740296	Prob. Chi-Square(2)	0.6906

Heteroskedasticity Test: White

F-statistic	0.984616	Prob. F(8,23)	0.4727
Obs*R-squared	8.163434	Prob. Chi-Square(8)	0.4177
Scaled explained SS	6.710192	Prob. Chi-Square(8)	0.5682

APPENDIX VII: ARDL Result

Dependent Variable: LOG(RGDP)

Method: ARDL

Date: 08/06/24 Time: 17:25

Sample (adjusted): 1991 2022

Included observations: 32 after adjustments

Maximum dependent lags: 1 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (2 lags, automatic): LOG(LP) LOG(KP) LOG(HTID) LOG(EDID) LOG(TCID) LOG(TPID)

Fixed regressors: C

Number of models evaluated: 729

Selected Model: ARDL(1, 0, 0, 0, 0, 1, 0)

Note: final equation sample is larger than selection sample

HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

No d.f. adjustment for standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(RGDP(-1))	0.617137	0.121166	5.093316	0.0000
LOG(LP)	-1.495000	0.803274	-1.861133	0.0756
LOG(KP)	0.417062	0.180147	2.315114	0.0299
LOG(HTID)	-0.702994	0.265951	-2.643316	0.0145
LOG(EDID)	0.434130	0.271668	1.598020	0.1237
LOG(TCID)	0.147215	0.103250	1.425814	0.1674
LOG(TCID(-1))	0.133359	0.083396	1.599115	0.1234
LOG(TPID)	0.066918	0.091310	0.732871	0.4710
C	4.934129	1.794790	2.749140	0.0114

R-squared	0.998206	Mean dependent var	9.949343
Adjusted R-squared	0.997582	S.D. dependent var	1.697708
S.E. of regression	0.083473	Akaike info criterion	-1.896322
Sum squared resid	0.160259	Schwarz criterion	-1.484083
Log likelihood	39.34115	Hannan-Quinn criter.	-1.759676
F-statistic	1600.011	Durbin-Watson stat	1.722199
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

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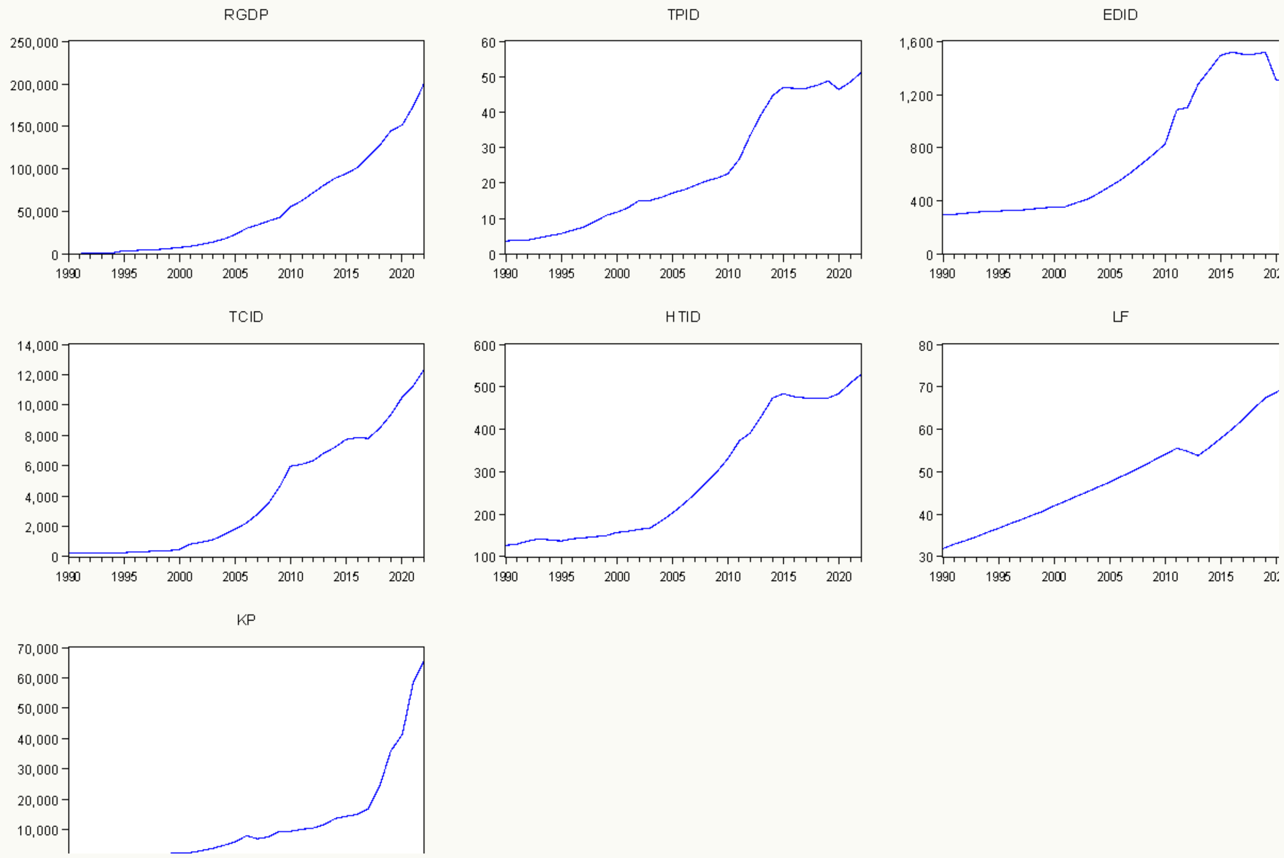
APPENDIX VIII: Trend Analysis



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