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Infrastructure Development and Economic Growth Nexus: The Nigeria Experience

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Abstract: *This study examined the impact of government infrastructural development on transportation (IFDT), road (IFDR), water (IFDW) and telecommunication (ITEL) as they influence the growth process of the Nigerian economy, proxy by real GDP (RGDP), from 1990 to 2023. Data were sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin (various issues), World Development Indicators (WDI), and National Bureau of Statistics (NBS). Four models were estimated to capture the influence of infrastructure development on GDP growth. The Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests were conducted to ascertain the level of stationarity of the series. Descriptive statistics and econometric methods of Auto-Regressive Distributive Lag (ARDL) model and Granger causality estimation tests were conducted to examine the long run relationship of the series.The analysis revealed that infrastructure development on transport services (IFDT) was positive and significant in explaining changes in real GDP of Nigeria. However, Infrastructure development on road (IFDR), water (IFDW) and telecommunication (ITEL) were negative and not significant in explaining changes in Nigeria's real GDP within the study period. On this basis therefore, the study concludes that there is no long run relationship between the dependent variable (RGDP) and the explanatory variables (IFDT, IFDR, IFDW and ITEL). It was recommended that the government, in partnership with the private sector, should increase her investment in the provision of infrastructural facilities that are reliable, durable and affordable to the people, as this will not just reduce the cost of doing business but also attract foreign investors into the country. Proper and dedicated maintenance culture of existing infrastructure facilities should be prioritized as this will save government huge amount that can be channeled into other areas of development.*

Keywords: Infrastructure development on water, road, telecommunication, economic growth, Nigeria

INTRODUCTION

It is widely acknowledged that developing water infrastructure is essential to achieving the Sustainable Development Goals (SDGs). Infrastructure is one of the macroeconomic environment constituents with which regions drive economic activities in the economy. Infrastructure are the basic and necessary amenities and facilities that an economy needs to function properly (Agénor & Moreno-Dodson, 2016). It remains unarguably the key that unlock the progress of any region and ensure its growth. A country with a poor infrastructural profile finds it difficult to sustain growth. This may discourage economic activities, social - cultural and political activities that could influence the "take –off" activities of Nigeria's development process.

Given the far-reaching importance in the development process of a country, many African governments are working hard to upgrade and update their infrastructural profile by building airports, rail lines, and power plants. In fact, Ayua (2021) stressed the important roles of infrastructure in the growth process of every nation. The World Bank estimates of $95 billion is needed annually to build the infrastructure in Sub-Sahara Africa. Hence, the definition of infrastructure by the World Bank (1994) as a general term for various activities called social overhead capital; basically with technical, peculiar and economic characteristics or features. However, its development is of great concern to various countries whether developed, developing and underdeveloped. This concern makes it pertinent to be considered in certain research endeavors.

The development of infrastructure is a development art and plan that involves a consistent improvement and maintenance in the components of infrastructure, like roads, water, power, sanitation, Information Communication Technology (ICT) (Onah & Edame, 2008). Put in simpler form, it involves the development of infrastructure in any given country. Infrastructural development helps poor countries to scale up their economic activities, raise productivity and bring down cost of production. The development of infrastructure enables a country to determine its success in curbing population growth, production capacity, favourable trade, poverty alleviation and reducing environmental degradation (Anyanwu & Oaikhenan, 1997). Infrastructural development improves the economic fortune that includes any kind of foundation such as public utilities, public works, transportation, vitality, water, computerization, social and green foundation, clean water and sanctification, power etc.

The benefits of infrastructure development have renewed attention over the years. The study of Calderon and Serven (2021) and Estache (2020), opined that the development of infrastructure in relation to growth is traceable to the last two decades based on the the global development initiative. The first one was the retirement of the government since the mid-1980s in most industrial and developing countries from its sole position in the provision of infrastructure to private participation in infrastructure provision. This was aimed at encouraging private ownership and control of economics activities and other forms of partnership with the private sector.

In rural areas, Infrastructure development have the capacity to develop and serve as incentives toward attracting other forms of industrial activities and investment. With constant and affordable electricity, for example, rural farmers can easily process their harvested cassava roots to flour. The development of infrastructural is crucial to every developing economy because it serve as a major contributor to both nominal and real economic growth.

Infrastructure plays a fundamental role in the socioeconomic and environmental health which determine the nature and quality of human lives and economic growth. It is pertinent to recognize infrastructure as an interconnected 'system of systems' that provides the physical foundation for our society. Infrastructure development aids in the country's integration with global markets and low-cost global connectivity. Infrastructure are required to increase corporate productivity and production by reducing the level of production and transportation costs (Oliver et al, 2016).

Infrastructure development can also reduce transportation cost, promote the movement of man and goods, reduce the cost of doing business and encourage healthy competition among producers. In every nation, and continentals, the economy needs dependable and quality infrastructure that are capable of connecting supply chains in a more effective and efficient manner (Peter, 2016). Infrastructure is important for alleviating poverty in the country; especially, in Nigeria. The science and art of infrastructural development comprises a transformative process capable of providing a sustained economic and social values for all, generates a sustained prosperity and increase overtime the value and quantity of production in any given country and continents.

It is possible to increase the quantity and value of a country's production per man if and only if there is well developed infrastructure (Valerija, & Šišinački, 2006). Therefore, defining growth as a sustained increase in the market value of goods and services, adjusted for inflation, produced in a year could be appreciated better and made better in an environment where there is infrastructure development (Nwachukwu & Emoh, 2011). On this premise, to validate economic growth by the Classical theory, there is need for every nation or continent to have steady state in GDP growth and any deviation off of that steady state is temporary and will eventually propel to return by infrastructure development.

Economic growth, measured as an increase of people's real income, refers to a rise in the quantity of goods and services a given amount of money income of the consumer can purchase in a period of time (Odedokun, 2001). With quality infrastructure in place, economic growth increases a country's capacity to produce and supply goods and services. This will be an advantage because the government can generate more revenue, through tax, which can be utilized to provide public goods and services, education, healthcare, security and to mention a few (Ghani & O'Connell, 2014; Eminue, 2005). Infrastructure development has a two-way relationship with economic growth. Infrastructure promotes growth, and GDP growth brings about changes in infrastructure (Calderón, 2017). A country's infrastructure encourages the movement of goods and people, provides energy, water; good communication and supports human life. Output of infrastructure sectors such as water, power, security, transport, etc. are inputs for sectors like agriculture, manufacturing, etc. Therefore, insufficient availability of the former results in sub-optimal utilization of assets in the latter, thereby further affecting output. Infrastructure development such as transport improves productivity significantly.

Studies (see Odedokun, 2001; Peter,2016 and Perkins, Fedderke, & Luiz, 2005) have reported that infrastructure contributed 6.5% of the total value added in low-income countries. This proportion increases to 9% in middle income countries and 11% in high income countries. Hence, from the analysis above, the investment and development of a country's infrastructural base encourages GDP growth and also alleviates poverty. In the low-income countries like Nigeria, basic infrastructure like water, irrigation is more important. In Nigeria, the need for transportation has been on the rise. However, in developed nations telecommunication and power remain more important. As a result of the importance of infrastructure to growth, efficiency, competitiveness and growth of the economy hinges upon the state of development of the infrastructure sector. The study of Fan and Chan-Kang (2015) revealed that the government can achieve a rapid growth rate of about 1.8% with a 20% sustained increase in infrastructural investment. The estimates accompany a 0.2% decline in inflation rate with the rise in resulting income, leading to a 0.7 percentage point annual reduction in poverty in rural India. This reveals the capacity of the economy to achieve an 8-9% aggregate real GDP growth in the long run (Fan & Chan-Kang 2015). Given this improvement, one would have expected sub-Sahara Africa to also gain such improvement in infrastructure. This is on the assertion that the region gained GDP growth from the value of $1.92 trillion to $4.1 trillion (World Bank, 2022). On this basis therefore, this study evaluates the relationship and effects of infrastructure as it influences the growth of the Nigerian economy. This study's background is anchored on the assessment of government expenditure on transportation, road, energy and water; as proxies for infrastructure development, as it influences real GDP of Nigeria.

However, the reality is that Nigeria has not experienced rapid growth beyond a single-digit. This suggests that Nigeria's performance has been appallingly subpar and raises research concerns. As a result, this study is concerned about the economy's low performance in terms of economic growth, even though successive administrations have worked to build infrastructure in the areas of telecommunications, water utilities, transportation, and roads.

REVIEW OF RELATED LITERATURE

Conceptual Issues

The Concept of Infrastructure

In its literal sense, infrastructure refers to the fundamental facilities that enable operations. The words "infra" and "structure" are combined to form the word. An interrelated collection of components that support an economy's structure is referred to as infrastructure. It is used to describe permanent installations that are utilized for an extended length of time. Although the phrase has many different meanings in different sectors, it is most commonly used to refer to the fundamental infrastructure and systems that support a nation, city, or region, such as schools, hospitals, water and power lines, and transportation and communication networks (Olowononi, 2019). Therefore, infrastructure refers to the fundamental facilities that are necessary for elementary, secondary, and post-secondary activities to function at their best. Economic development cannot occur without infrastructure, which is seen as a vital component of economic development. The basic physical systems that comprise an economy or region include things like power, water, roads, hospitals, education, and communication. Infrastructure is the term used to describe these systems. Although these systems are usually costly investments, they are crucial to the development and prosperity of a country. Public-private partnerships, the private sector, or the government can all provide funding for infrastructure improvement initiatives (Ezeani, 2016).

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Government Expenditure on Infrastructure Development in Nigeria

Government actions in Nigeria have caused infrastructure to deteriorate, resulting in a near-strange economic performance. This deterioration has been marked by irregular power supplies, ineffective telecommunication, and inadequate road networks. (BPE, 2003). Road, water, sanitation, shipping, transportation, power, energy, information, and telecommunications deficiencies and inefficient delivery of social services have resulted in crippling transaction costs that have impacted trade and decreased the competitiveness of the nation's products in the global market. However, public spending call for its prioritizing on growth and enhancing the different sectors of which infrastructure are of utmost necessity.

Road Infrastructure in Nigeria

Road infrastructure involves to all the physical systems and assets that supports roads (highways, streets, e.t.c.), signs (signage, traffic lights, e.t.c), parking spaces, bridges and tunnels, walkways and cycle paths. Road infrastructure has been a major driver of urban and regional development in Nigeria. One way to boost growth in Nigeria is the development of basic infrastructure, especially in economically underdeveloped areas. This is due to the fact that road infrastructure is essential for the effective transportation and for facilitating access to a wide range of social and commercial activities. The primary aim of the roads Infrastructure development for Nigeria is to improve economic competitiveness by improving the quality and capacity of strategic national roads, improving road safety and increasing the efficiency, quality and transparency of works procurement and implementation in road plans.

Road infrastructure is important for reducing hunger, poverty alleviation, and improving human life quality. Road transportation provides door-to-door delivery, making it an excellent option for delivering completed items to customers (Odedokun, 2001). Road infrastructure can potentially unlock the potential of rural areas by converting small scale farming to a dynamic, commercial farming system. For road infrastructure projects to be managed effectively, it is essential to comprehend the circumstances in which more or new road infrastructure does, in fact, promote economic growth.

Water Infrastructure in Nigeria

Building water infrastructure is essential to achieving sustainable development, particularly for energy generation, agricultural development, health and sanitation, and water supply. Nigeria, however, confront particular difficulties with regard to fragmented infrastructure types, systematic and recurring malfunctions, and infrastructure finance. All of the natural and man-made elements that transport and purify water are included in a region's water infrastructure. It is convenient to conceive about infrastructure in relation to storm water, wastewater, and drinking water, even if everything is a part of the same system. The main goals of water infrastructure are to build sanitation and water facilities in the nation's high priority areas and to sustainably increase the sector's resilience. It is a distinct program for investment and institutional building that directly supports ongoing initiatives in Nigeria to enhance water security and raise living standards in local communities (Olaluku, 2022). The three main pillars of water infrastructure are program management, capacity building, and assistance for sanitation and water infrastructure to increase resilience.

Empirical Literature

Perkins (2005) was the first of a series of studies attempting to address these particular challenges. This study used the PSS ARDL technique to focus on the causality between the variables and found that public sector investment in infrastructure and fixed capital stock positively influence GDP growth. Adeniran, Daniell, and Pittock (2021) studied water infrastructure in Nigeria, in relation to size, trend, and purpose. In other to calculate the magnitude of the link between output and infrastructure, they adopt a multivariate co-integration model that examines the long-term interaction between several variables, allowing for the possible ambiguous causal relationships. GDP, capital stock, public sector capital stock (monetary indicators of infrastructure), total road length, and generation capacity of electricity are all included in this model. They conclude that an indirect relationship exist between GDP and infrastructure stock, with growing infrastructure stock stimulating fixed capital investment and raising GDP. GDP's elasticity in relation to fixed capital stock is 0.06, while infrastructure's elasticity in relation to fixed capital stock is 1.37. Accordingly, a 1% increase in infrastructure raises fixed capital stock by 1.37%, whereas a one percent rise in fixed capital stock raises GDP by 0.06%.
Agenor and Moreno-Dodson (2006) examined public infrastructure and growth. The study argues that electricity generation directly affects GDP with an elasticity of 0.2 (that is, a percentage increase in electricity generation capacity directly increases GDP by 0.2%). Some of these results, however, are not robust to the replacement of total road length by other infrastructure measures. They also introduced a control for property rights to test for the role of institutions in the infrastructure-growth relationship. Incorporating this control preserves the indirect relationship through fixed capital stock while also revealing a strong positive direct association with elasticity ranging from 0.4 to 0.5. Olaluku, (2022) examined social and economic infrastructure in a study. Additionally, he tests the direction of causality using the PSS ARDL technique and examines the relationship between his two infrastructure indicators, private investment and Gross Value Added (GVA), using a VECM model. He made room for the idea that there could be a direct or indirect relationship between infrastructure and growth through private investment by incorporating this variable. He discovered that social infrastructure triggers economic infrastructure, private investment, and GVA using physical measures of economic and social infrastructure (built from road and classroom data, respectively). Odedokun (2007) reports that there are ambiguous causal relationships between economic infrastructure and both private investment and GVA. He uses the VECM model to find that GVA responds to social infrastructure spending with an elasticity of 0.06 and the private investment rate responds to economic infrastructure spending with an elasticity of 0.02 (GVA, in turn, responds to private investment with an elasticity of 2.5.) Even though a positive relationship was found between infrastructure growth, he explicitly tested for the probability of a non-linear relationship that infrastructure spending initially boosts growth. His findings shows a positive relationship for both social and economic infrastructure for all values of investment in infrastructure recorded in South Africa in the last thirty years. This finding is of substantial importance when interpreting the other South African empirical studies, as it suggests that their results are not compromised because they do not take into account the possibility of a nonlinear correlation between growth and infrastructure.

MATERIALS AND METHODS

Nature and Sources of Data

Time series data on Infrastructure Development on Transport (IFDT), Infrastructure Development on Road (IFDR), Infrastructure Development on Water (IFDW), Infrastructure Development on Telecommunications (ITEL) and Real Gross Domestic Product (RGDP) were sourced from the UNESCO Institute for Statistics, Central Bank of Nigeria (CBN) Statistical Bulletin (Various issues), Government expenditure on infrastructure is measured as percentages of real gross domestic product.

Models Specification

Using four models, the impact of infrastructure development on economic growth in Nigeria can be functionally expressed as:

Real Gross Domestic Product - Infrastructure Development on Transport

$$RGDP_{it} = f\,(,IFDT_{it}) \quad (3.1)$$

Transforming equation (3.1) into its explicit form;

$$RGDP_{it} = a_o + a_1\,IFDT_{it} + \mathcal{E}_{it} \quad (3.2)$$

Model 2: Real Gross Domestic Product - Infrastructure Development on Road

$$RGDP_{it} = f\,(IFDR_{it}) \quad (3.3)$$

Transforming equation (3.3) into its explicit form;

$$RGDP_{it} = \beta_0 + \beta_1\,IFDR_{it} + \mathcal{E}_{it} \quad (3.4)$$

Model 3: Real Gross Domestic Product - Infrastructure Development on Water

$$RGDP_{it} = f\,(IFDW_{it}) \quad (3.5)$$

Transforming equation (3.5) into its explicit form;

$$RGDP_{it} = \alpha_0 + \alpha_1\,IFDW_{it} + \mathcal{E}_{it} \quad (3.6)$$

Model 4: Real Gross Domestic Product - Infrastructure Development on Telecommunication

$$RGDP_{it} = f\,(ITEL_{it}) \quad (3.7)$$

Transforming equation (3.7) into its explicit form;

$$RGDP_{it} = \alpha_0 + \alpha_1\,ITEL_{it} + \mathcal{E}_{it} \quad (3.8)$$

In order to estimate equations (3.2, 3.4, 3.6 & 3.8), we can translate these into the following:

$$RGDP = B_o + B_1\,IFDT + B_2\,IFDR + B_3\,IFDW + B_4\,ITEL + e_t \quad (3.9)$$

Where B_o is the drift component, the term, B_1 *to* B_4 are the coefficients of the model, the variables are as explained earlier and E_t represents the error term.

The expected relationship among the variables are as follow:

$$\frac{dRGDP}{dIFDT} > 0; \frac{dRGDP}{dIFDR} > 0; \frac{dRGDP}{dIFDW} > 0; \frac{dRGDP}{dITEL} > 0$$

Methods of Data Estimation

This research made use of Eviews 10.0 econometrics software package to carry out regression analysis and performed various tests on the equations and four models estimated.

Autoregressive Distributed Lag (ARDL) Model
The Autoregressive Distributed Lag model is a standard least square regression that uses both its endogenous and exogenous variables as regressors with lags (Trochim, 2005). The ARDL based approach to estimation is asymptotically valid when regressors are all I(0) and I(1) and when a mixed order of integration. A general ARDL equation with a deterministic trend is expressed as:

$$Y_t = \lambda_{oi} + \sum_{i=1}^{p} \alpha_i Y_{t-1} + \sum_{i=0}^{q} \beta_t^1 X_{t-i} + \mu_{it} \qquad (3.10)$$

Where;
Y_t is the independent variable, X_t is the dependent variable, λ is a constant, α and β are co-efficient of variable Y and X respectively, $i = 1, \dots \dots, k$; 'p and q are optimal lag order (where p is the optimal lag for the dependent variable, q is the optimal lag for the independent variable) and μ_{it} represents the error term.The ARDL long-run and bound test co-integration technique recommended first by Pesaran and Shin cited in Uzomba (2015) and upheld by Pesaran, Shin, and Smith (2001) is used to estimate the long-run relationship among the independent and dependent variable in this study.

RESULTS AND DISCUSSION

Correlation Matrix Test
Table 4.1 shows the direction and strength of the existing relationship between the series. relation matrix test. Positive numbers indicate positive relationship while negative numbers indicate negative relationship between variables.

Table 4.1: Result of Correlation Matric Test

	RGDP	IFDT	IFDR	IFDW	ITEL
RGDP	1	0.1149	0.1620	-0.2296	0.0683
IFDT	0.1149	1	0.9517	0.2018	0.9559
IFDR	0.1620	0.9517	1	0.1668	0.9590
IFDW	-0.2296	0.2018	0.1668	1	0.1877
ITEL	0.0683	0.9560	0.9590	0.1877	1

Source: Author's Computation, 2024.

Table 4.1 reports the correlation matric test results conducted on all the study variables. The result reveals that RGDP is perfectly correlated, maintains a positive correlation with IFDT, IFDR and ITEL at the values of 0.1149, 0.1620 and 0.0683 respectively; but has a negative correlation with IFDW at the value of -0.2296. IFDT is positively correlated with the explanatory variables with values of 0.9517, 0.2018 and 0.9560 for IFDR, IFDW and ITEL respectively. IFDR has positive correlation with IFDW and ITEL with values of 0.1668 and 0.9590 respectively; lastly, IFDW has a positive correlation with IFDT at the value of 0.1877.

Unit Root Test
The unit root test results are presented for in tables 4.3 and 4.4 which represent ADF and Phillips Perron unit root results at level and at first difference.

Table 4.2: Result of Augmented Dickey-Fuller (ADF) Unit Root Test

Variables	At Level			1st Difference			2nd Difference			OI	Remarks
	t-stat	5% Stat	Prob.	t-stat	5% Stat	Prob.	t-stat	5% Stat	Prob.		
RGDP	-0.526540	-2.938987	0.8750	-5.356745	-2.938987	0.0001	-9.907225	-2.941145	0.0000	*I* [1]	Stationary at 1st differencing
IFDT	-0.061366	-2.938987	0.9466	-8.330265	-2.938987	0.0000	-9.079917	2.943427	0.0000	*I* [1]	Stationary at 1st differencing
IFDR	0.342378	-2.936942	0.9777	-7.447644	-2.938987	0.0000	-9.142637	-2.943427	0.0000	*I* [1]	Stationary at 1st differencing
IFDW	-4.240604	-2.936942	0.0018	-6.539637	-2.941145	0.0000	-6.148548	-2.948404	0.0000	*I* [0]	Stationary at level
ITEL	-0.175873	-2.936942	0.9334	-6.017497	-2.938987	0.0000	-7.695796	-2.943427	0.0000	*I* [1]	Stationary at 1st differencing

OI = Order of Integration

Source: Author's Computation, 2024.

Table 4.2 presents results of the unit root test conducted using Augmented Dickey-Fuller (ADF) estimator. Evidence from the result revealed that variables are stationary at first difference and integrated of order one [*I*(1)]; except IFDW that is statitonary at level and is integrated to order zero. This is revealed by the t-stat values at level which are greater than 5% critical values; hence they are not statistically significant from their probability values. Consequently, reject the null hypothesis and accept the alternative hypothesis – which postulates the absence of unit root associated with the series at those order of integration. In furtherance of the test, it is revealed that t-stat values are less than the 5% critical values for all the variables in the first difference stage; hence the null hypothesis is rejected, and the alternative is accepted.

Table 4.3: Result of Philip-Perron (PP) Unit Root Results

Variables	At Level			1st Difference			2nd Difference			OI	Remarks
	t-stat	5% Stat	Prob.	t-stat	5% Stat	Prob.	t-stat	5% Stat	Prob.		
RGDP	0.237827	-2.936942	0.9717	-5.333372	-2.938987	0.0001	-11.34119	-2.941145	0.0000	*I* [1]	Stationary at 1st differencing
IFDTS	-0.065585	-2.936942	0.9463	-8.419163	-2.938987	0.0000	-23.79440	-2.941145	0.0001	*I* [1]	Stationary at 1st differencing
IFDR	0.436696	-2.936942	0.9821	-7.547127	-2.938987	0.0000	-24.00669	-2.941145	0.0001	*I* [1]	Stationary at 1st differencing
IFDW	-4.194489	-2.936943	0.0020	-12.31285	-2.938987	0.0000	-67.12995	-2.941145	0.0001	*I* [0]	Stationary at level
ITEL	-0.242123	-2.936943	0.9245	-6.020911	-2.938987	0.0000	26.78435	-2.941145	0.0001	*I* [1]	Stationary at 1st differencing

OI = Order of Integration

Source: Author's Computation, 2024.

As a confirmation to the ADF unit root test result, the PP unit root test was conducted on all the study variables. From the result, it is evident that the series are equally stationary at first differencing and integrated of order one [*1*(1)]; except IFDW that is stationary at level and integrated of order one. This is just like we have in the ADF unit root. With this confirmatory test, it is evident that the data are suitably reliable to use for other analyses and to address the research questions and testing the tenability of the null hypotheses as done and reported in the following tables.

Presentation of Results of Actual Estimation Tests

Test for Dynamic Relationship between the Research Variables

According to Pesaran and Pesaran cited in Trochim, (2005) having confirmed that the unit root test reports results that have mixed order of cointegration, the three tests required in ARDL estimation are; Wald test, ARDL short-run dynamic tests and ARDL long run dynamics. Following this direction, the three tests are analyzed and reported in tables 4.5, 4.6 and 4.7 respectively.

Table 4.4: Lag Length Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: RGDP IFDT IFDR IFDW ITEL
Exogenous variables: C
Date: 12/13/23 Time: 07:43
Sample: 1990 2022
Included observations: 39

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-884.1838	NA	4.38e+13	45.59917	45.81245	45.67569
1	-721.7419	274.9017*	3.85e+10*	38.55087*	39.83053*	39.01000*
2	-707.8093	20.00581	7.26e+10	39.11843	41.46447	39.96017
3	-686.5684	25.05332	1.05e+11	39.31120	42.72364	40.53555

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Computation, 2024.

Table 4.4 presents the result of the ARDL lag length selection criterion carried out on all the variables. This was carried out through the process iteratively increasing the lag length to about lag 3 and beyond to where there seems to be no improvement in the choice of lag length. The results from the table show that the entire lag length selection criteria suggests a maximum of one lag for the ARDL model for the study. A key assumption in the ARDL Bound testing methodology of Pesaran cited in Iganiga and Uzomba (2019) is the errors of the equation must be serially independent. The validity of the chosen one lag length for the study was therefore tested using the Lagrange multiplier (LM) test of serial correlation as reported below. This is a justification that our data analysis method is suitable to proving empirical answers to the research questions raised in the study.

Tale 4.5 presents the estimated results of the ARDL Wald Bound Test.

Table 4.5: Results of ARDL Wald Bound Tests

Variables	**T-statistics**		**F-statistics**		**Chi-square**		**Wald**	**Remark**
	Value	**Prob.**	**Value**	**Prob.**	**Value**	**Prob.**	**Stat**	
RGDP	0.602284	0.5524	0.362746	0.5524	0.362746	0.5470	0.0880	Accept H_0
IFDT	2.026215	0.0535	4.105547	0.0535	4.105547	0.0427	0.2791	Accept H_0
IFDR	1.273771	0.2145	1.622493	0.2145	1.622493	0.2027	0.3265	Accept H_0
IFDW	-0.395719	0.6957	0.156594	0.6957	0.156594	0.6923	-0.125	Accept H_0
ITEL	-0.351545	0.7281	0.123584	0.7281	0.123584	0.7252	-0.109	Accept H_0

Note: Restrictions are linear in coefficient.

Degree of Freedom (df) = 25 for all the study variables
Null Hypothesis: H_0*: Coefficient = 0;* H_1*: Coefficient* $\neq 0$
Chosen Alpha Value: Five percent (5%= 0.05)

Decision Rule:
(i) If f-statistic value is more than 5% (0.05), we cannot reject the H_0*.*
(i) If f-statistic value is less than 5% (0.05), we reject the H_0*.*

Decision Rule:
We reject the H_0*, when Wald Statistic is more than the Chi-square value*
We cannot reject the H_0*, when Wald Statistic is less than the Chi-square value*
Source: Author's Computation, 2024.

The Wald test conducted and reported in Table 4.5 was an effort made to ascertain the degree of importance each variable is in the model. In other words, it is to find out how each of these variables make significant contributions to the model. Through the Wald test, the null hypothesis is tested to ascertain if the series are equal to some values. In our four estimated models, the null hypothesis states that our two coefficients of interest are simultaneously equal to zero. Implying that it can be used to find out if β^ is significantly different from β0 (null hypothesis: β0 = 0), it suggests that estimate of β significantly improves model fit and the variable is significant. The Wald test can be adopted to simultaneously test many parameters. In the top form, it can be negative, if our estimated parameter is less than the null value; but in the bottom form it will always be positive.

From the results in Table 4.5 it is evidently clear that all the Wald statistics are less than the Chi-square values. As a confirmation, it is equally revealed that f-statistics are all more than the 0.05 chosen alpha level. To this end therefore, we cannot reject but accept the null hypothesis that the coefficients of the independent variables of are simultaneous equal to zero – implying that they make significant or meaningful contributions to the improvement of the fitness of the model.

Table 4.6: Result of Granger Causality Test

S/N	Null Hypothesis:	Obs	F-Statistic	Prob.	Nature of Causality	Remark	Decision
1.	IFDT does not Granger Cause RGDP		0.29471	0.7466	IFDT ≠ RGDP	IFDT does not Granger cause RGDP	Retain H_0
	RGDP does not Granger Cause IFDT	33	0.46039	0.6348			
2.	IFDR does not Granger Cause RGDP		0.38964	0.6802	IFDR ≠ RGDP	IFDR does not Granger cause RGDP	Reject H_0
	RGDP does not Granger Cause IFDR	33	0.60920	0.5494			
3.	IFDW does not Granger Cause RGDP		3.22523	0.0518	IFDW ≠ RGDP	IFDW does not Granger cause RGDP	Retain H_0
	RGDP does not Granger Cause IFDW	33	1.62936	0.2106			
4.	ITEL does not Granger Cause RGDP		0.86918	0.4281	ITEL ≠ RGDP	ITEL does not Granger cause RGDP	Retain H_0
	RGDP does not Granger Cause ITEL	33	0.53942	0.5879			

***Source**: Author's Computation, 2024.*

Table 4.6 presents the result of Granger causality test conducted on all the variables of study. The analysis is conducted in such manner that the endogenous variable was used against the four dependent variables. From the result it is evident that none of the independent variables granger causes the dependent variable; hence the null hypothesis is retained. This is all their probability values are greater than 0.05 chosen alpha level.

Results of Post Estimation Tests – Residual Diagnostics Test

The post estimation test results are presented in table 4.7 below.

Table 4.7: Result of Post Estimation Test

Equations / Models	Post Estimation Tests			
	Normality of Distribution.	Breusch-Godfrey Serial Correlation LM Test.	Heteroskedasticity Test: Breusch-Pagan-Godfrey.	Remark
	Jarque-Bera	Prob. F(2,23)	Prob. F(13,25)	
RGDP Model	11.28967	1.860801	0.002896	Robust Estimation

***Source**: Author's Computation, 2024.*

Table 4.7 presents results of post estimation tests conducted on the RGDP model where IFDT, IFDR, IFDW and ITEL are the four regressors. The result shows that Jarque-Bera value of 11.28967, which indicates a goodness-of-fit test and measures the skewness and kurtosis of the series that are similar to a normal distribution. The Jarque-Bera test statistic is always positive, and not zero, showing that data is normally distributed. This is confirmed by the Breusch–Godfrey test which helps to detect serial autocorrelation. It is evident from the result that the probability F-stat value is 1.860801; which is significant. Therefore, the null hypothesis of no serial correlation of any order in the series, distribution and model is retained. Further, the Breusch Pagan test is conducted to detect if there is heteroscedasticity in our estimated models. The probability value of the result is 0.002896; which is significant. This therefore means that the null hypothesis of the absence of heteroscedasticity is accepted – indicating that there is no heteroscedasticity in the regression models used in the study.

DISCUSSION OF THE MAJOR FINDINGS

Development of Infrastructure on Road and Real GDP

Infrastructure development on road has a positive impact on the real GDP of 2.2 % within the study period. The development of Infrastructure on roads significantly impacts on real GDP in Nigeria. A study by Kularatne (2006) looks at both social and economic infrastructure, analysing the relationship between Gross Value Added and private investment. His findings revealed that social infrastructure directly influences economic infrastructure, private investment, and GVA.

Infrastructure Development on Water and Real GDP

The development of Infrastructure on water has positive impact on real GDP GDP with 0.17 % within the study period. The development of infrastructure on water does not significantly impact real GDP in Nigeria. by corroborating our study's results, Adeniran, Daniell, and Pittock (2021) studied the development of water infrastructure in Nigeria. According to the study, in calculating the magnitude of the existing relationship between output and infrastructure. They adopted a multivariate co-integration model that examines the long-term interaction between several variables and found that a long run relationship exists between infrastructure and real GDP.

Infrastructure Development in Telecommunication and Real GDP

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The development of infrastructure on telecommunication has positive impact on the real GDP with 0.3 % within the study period. Telecommunication, port and airport infrastructure and some railway infrastructures, however, are driven by GDP growth.

Summary, Conclusion and Recommendations

Summary of the Major Findings

The summary of the statistical results are as follows:

(i) Infrastructure development on transport service positively impacted real GDP growth by 32 % within the study period.
(ii) Infrastructure development on road positively impacted real GDP growth by 2.2 % within the study period.
(iii) Infrastructure development on water positively impacted real GDP growth by 0.17 % within the study period.
(iv) Infrastructure development on telecommunication positively impacted real GDP growth by 0.3 % within the study.
(v) Infrastructure development on transport service does not significantly impact real GDP growth within the study period.
(vi) Infrastructure development on roads significantly impacts real GDP growth in Nigeria.
(vii) Infrastructure development on water does not significantly impact real GDP growth in Nigeria.
(viii) Infrastructure development on telecommunication does not significantly impact real GDP growth in Nigeria.
(ix) In general, no long run relationship exist between the endogenous variable (RGDP) and explanatory variables (IFDT, IFDR, IFDW and ITEL).

CONCLUSION

The incessant marginal growth in real GDP growth in Nigeria necessitated this study to assess the infrastructure development on GDP growth in Nigeria. Four models were specified and estimated that guided the researchers achieved the stated objectives. Anchoring on Wagner, Frischmann infrastructure and neo-classical economic growth theories, the study adopted a descriptive statistical and econometric methods of Auto-Regressive Distributive Lag (ARDL) and Granger causality estimation tests and robustness and stability tests.

The analysis revealed that infrastructure development, measured in terms of IFDT, has significant impact on real GDP growth but IFDR, IFDW and ITEL do not have same impact on real GDP growth within the study period. On this basis therefore, the study concludes that there is no long run relationship between the dependent variable (RGDPG) and explanatory variables (IFDT, IFDR, IFDW and ITEL).

Recommendations

(i) The government should increase investment and provide massive reliable and affordable transport services so as to make it continue to impact positively on the real GDP of Nigeria. However, the existing infrastructure on transport should be properly maintained and cost effective.
(ii) Critical and dedicated investment should be made in roads infrastructure so as to increase its contributions to real GDP growth in Nigeria. Existing bad roads linking major commercial cities should be prioritized and maintained to enable the smooth transportation of staple food crops.
(iii) Water resources infrastructure should be developed and massively invested upon for the benefit of the Nigerian populace. The government in collaboration with the private sector should construct more dams, treatment plants, reservoirs and wastewater facilities in areas prone to drought.
(iv) The government should increase budgetary allocation to telecommunication infrastructural facilities to enable adequate contribution to real gross domestic product in Nigeria. The government in partnership with the private sector provide more core networks, maintain existing telecommunication masts, transmission networks, electromagnetic spectrum and data centres.

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