Foundations of Growth: Evaluating the Interplay Between Infrastructure and Economic Growth in Nigeria.

Noel Ebehung PhD, Owan Jacob Ogar PhD

Department of Economics University of Calabar, Calabar

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ABSTRACT

Infrastructure is a critical component of economic growth, as it enhances productivity, facilitates trade, and improves the quality of life. This study therefore employs a two-pronged analytical framework to investigate the extent to which infrastructure impact on economic growth in Nigeria. First, the Toda-Yamamoto causality test is used to determine the nature of causality among the study variables, while the Autoregressive Distributed Lag (ARDL) technique is utilized to investigate the short run and long run effects of infrastructure on economic growth. The study findings show that a 1 percent increase in telecommunications infrastructure contributes approximately 0.17 percent to the growth of the Nigerian economy. In contrast, the transport and power sectors demonstrate negligible long-term impacts on Nigeria's economic growth. Therefore, this study emphasizes the necessity for the federal government of Nigeria to expand public-private partnerships (PPPs) to mobilize resources for infrastructure development. Such partnerships are expected to leverage private sector expertise, improve project efficiency, and alleviate the financial burden on the government, thereby fostering economic growth in Nigeria.

Keywords- Infrastructure, Economic growth, ARDL, Telecommunication, Public-private partnerships

INTRODUCTION

Economic growth, a subject of rigorous analysis for centuries, hinges on the interplay of capital, labor, and technology. These fundamental production factors are crucial for achieving rapid and sustained economic growth. However, their effectiveness is largely contingent upon the quality of infrastructure within the economy [1], [2], [3], In fact, public infrastructures such as communication networks and paved highways are considered by scholars like [4] as core factors of production. Apart from infrastructure's role in the production process, they also streamline distribution, and create an environment conducive to efficient business operations.

These sentiments underscore the importance of infrastructure to the expansion and sustainability of economies, and more so, inspire the assignment of substantial budgetary allocation by states to the provision of public infrastructures. Nevertheless, available data suggest that the Nigerian government has not prioritized infrastructural development over the years. For instance, [5] reported that between 2009 and 2013, Nigeria managed an average investment of $664 per capita annually (3% of GDP) in infrastructural development, which is significantly lower than the $3,060 per capita (5% of GDP) invested by developed countries More so, Nigeria's public-private partnership investments in transport dwindled significantly from $2.9 billion in 2013 to about $1 billion in 2019 [6]. Apart from poor spending, there are also problems of poor maintenance of existing infrastructures, corruption, lack of accountability, and policy inconsistency across successive administrations [7]

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Consequently, infrastructure has seemingly been a drag on Nigeria's growth trajectory. This is evidenced by the poor contribution of infrastructure to GDP over the years. As seen in Table 1.1 below the transport sector's average contribution to GDP in the 1980s was only 3.1 percent. It depreciated by 24 percent in the 1990s to 2.5 percent. In the 2000s, the sector's contribution further fell to 1.5 percent of the national GDP, reflecting a depreciation of over 60 percent and a cumulative decrease exceeding 80 percent in a span of 20 years. The sub-sector did not record much improvement in the 2010s, as its total impact on the economy was only 1.6 percent. The communication sub-sector on the other hand performed better as it made up 11.16 percent of the GDP in the 1980s. Its average contribution to GDP however dwindled significantly to 3.33 percent in the 1990s, while in the 2000s and 2010s it rose to 7.68 and 10.6 percent respectively.

In the power sector, the average electricity consumption in Nigeria in terms of Kilowatt-hour per capita as seen in Table 1.2 shows that electricity consumption has been in the ascendency over the years, however, the volume of electricity consumption compared to that of South Africa suggests that it has been grossly inadequate in meeting the demands of households and business units. In the 1980s for instance the total electricity consumption in Nigeria in terms of Kilowatt-hour per capita was about 81.85 representing 15.81 percent of the total consumption in Sub-Sahara Africa which is really poor when compared to South Africa's 4051.7kwh. Between the 1990s and 2000s, a period spanning two decades the electricity consumption per capita of Nigeria had increased by only 46 percent to 117 kilowatt/hour per capita accounting for 22.67 percent of the total consumption within Sub-Saharan Africa while that of South Africa had risen to 4582.7. The 2010s recorded an increase in electricity consumption of 31 kilowatt-hours per capita in Nigeria to 148.5 while that of South Africa was 4354.0. In fact, as noted by [8], Nigeria's electricity output revolves around five thousand megawatts which is less than 3% of the recommended global sustainable development standard of one thousand megawatts per one million people.

Table 1.1 percentage contributions of transport and ICT sectors to GDP in Nigeria

Time/ Period	GDP	TR Billion ₦	ICT Billion ₦	% TR to GDP	% ICT to GDP
1980s	251.6537	7.696368	28.1	3.1	11.16
1990s	3210.754	80.52623	107.2	2.5	3.33
2000s	27207.28	413.2223	2089.7	1.5	7.68
2010s	98347.1	1560.927	10439.4	1.6	10.6

Source: Authors' computation

The consequences of Nigeria's weak infrastructure did not only result in its poor ranking of 132 out of 137 countries in the 2018 Global Competitiveness Index for infrastructure, but was also identified by several studies to be a major constraint to business growth, ultimately leading to annual losses of about 10.1 trillion naira [9], [10], [11], [12].

Previous studies have explored the relationship between infrastructure and economic growth, but many have not adequately addressed the complexity of this nexus. A common issue in assessing the infrastructure-growth relationship is simultaneity and reverse causality. This is because economic growth leads to the provision of more infrastructures, which in turn expands production frontiers [13]. Despite these arguments, some studies, including those by [14], [15] neglected to examine cross-causality. To address causality issues, some researchers have used the VAR or VECM and Engel-Granger methods, which allow for more flexibility in modeling cross-relationships. However, these studies have their shortcomings. For example, [16] did not show the magnitude of infrastructure's impact on economic growth.

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This study employs a two-pronged approach in evaluating the interplay between infrastructure and economic growth in Nigeria. First, the Toda-Yamamoto causality test is used to ascertain if improvements in infrastructure cause changes in economic growth, while the Auto Regressive Distributed Lag (ARDL) technique reveals how past investments in infrastructure influence current economic growth, accounting for both immediate and long term effects. Another distinguishing feature of this study is the use of three measures of infrastructure namely electricity, telecommunications, and transport, whereas previous studies, such as those by [17], [18], [19] considered only a single measure of infrastructure. By using multiple measures, this study aims to provide a more comprehensive evaluation of the impact of infrastructure on economic growth in Nigeria.

Table 1.2 Average electricity consumption in Kilowatt-hour per capita for Nigeria, percentage of Sub-Sahara Africa and South Africa

Time/	EC(kWh percapita)	% EC	EC(kWh percapita)
Period	Nigeria	SSA	South Africa
1980s	80.85	15.81	4051.7
1990s	86.27	16.64	4355.6
2000s	117	22.67	4582.7
2010s	148.5	29.87	4354

Source: Authors' computation

LITERATURE REVIEW AND THEORETICAL UNDERPINNING

Conceptual issues

The concept of infrastructure lacks consensus among scholars, with varied interpretations across civilizations and fields of study. This diversity of usage has led to a multitude of historical viewpoints, making it challenging to encapsulate the concept with a single set of words. [20] for instance defined infrastructure as a "capital good (provided in large units) in the sense that it is originated by investment expenditure and characterized by long duration, technical indivisibility and a high capital-output ratio" [21] delineate infrastructure as encompassing all the fundamental facilities and systems serving a country, city, or other area, including the services and facilities necessary for its economy to function. It typically includes roads, bridges, tunnels, water supply, sewers, electrical grids, telecommunications, and more. This study however agrees with **[22],** [14] and [3] who insisted on transport infrastructure, communication infrastructure and power as the basic facilities and services that are necessary for carrying out extensive economic activities leading to economic growth.

Empirical literature

The existing empirical evidence finds a strong connection between a country's infrastructure and the size of its economy. But this connection, according to [23], [24] depends largely on how developed the country is. They argue that only in countries with inadequate infrastructure would the link between infrastructure investment and economic growth be very strong. A similar view is held by [25] who posits that the impact of infrastructure investment on economic growth may vary depending on the threshold of infrastructure in the economy. In that regard, this study considers a study of the effect of infrastructure on the United States economy (well-developed infrastructure) carried out by [26] and the statistical evidence indicates that between 1950 and 1979 United States infrastructure investment in core areas grew at an average rate of 4%,

and correspondingly the overall economy expanded at an average rate of 4.1% during the same period. On the other hand, between 1980 and 2007 investment in public infrastructure fell significantly to 2.3% and average annual GDP also dropped to 2.9 percent over the same period. This clearly shows that growth was spurred by investment in infrastructure, which contradicts the position of [23] [24] but aligns with [27] that suggests that there is always growth in productivity in countries with good and efficient infrastructures. Similarly, [28] evaluated the influence of infrastructure investment on Spain's economy between 1850 and 1935. The study utilized the VAR technique and the results indicated that investments in infrastructure triggered economic growth within the study period.

Poor countries on the other hand record low stock of infrastructure which is not altogether surprising since they lack the adequate resources to deliver and maintain widespread and sustainable infrastructures. The situation is even more worrisome as research shows that poor countries experience high population growth rate which demands constant maintenance, expansion and update of the existing infrastructure to serve the needs of the expanding population. Considering these sentiments this study considers the work of [29] who carried out a pair wise causality test and the ARDL model for cointegration to ascertain the nature of relationship between economic growth, investment in infrastructure and employment in South Africa, and the result designated the presence of long-run equilibrium affiliation between the variables. In a similar study [2] utilized the Granger causality and OLS technique to explore the relationship between infrastructural and economic growth in Nigeria. The result that ensued shows that changes in infrastructure was instrumental to growth. Likewise, [30] studied the interrelationship between infrastructural spending, economic growth and employment in Nigeria using Granger causality and the VAR technique. The outcome of the study indicated a strong causality between infrastructural investment and economic growth in Nigeria, while the bounds test signaled the presence of long-run relationship between economic growth and investment in infrastructure. In a related study, [31] examined the impact of infrastructure on economic growth using the simultaneous equation analysis. And the result of the study shows that infrastructure effected business productivity and growth within the study period. [14] examined the role of infrastructure development in Nigeria economic growth for the period spanning 1980 to 2015.The study result indicated a significant effect of infrastructure on economic growth. [32] considered the influence of private and public investment on infrastructures and its attendant impact on the Nigeria's economy. The ECM was employed to establish the long run relationship, and the results indicated that infrastructure components exerted positive influence on Nigeria's economy, while the reverse was the case for domestic investment on infrastructure and total labor. [33] on the other hand attempted both primary and secondary data to investigate spending on infrastructure by the government and its impact on the economy of Nigeria. Co-integration test was done to ascertain the long-term relationship among the variables, while the formulated hypothesis was tested using a parsimonious error correction method. The outcome from the study shows that the spending of government on communication and transport infrastructure significantly influenced growth of Nigeria's economy.

[17], [18], investigated the effect of road infrastructure on economic growth. The results indicated a positive impact of the transport sector on the Nigerian economy. On the other hand [15] studied the effects of infrastructure on the industrial sector of Nigeria, with particular attention on the electricity consumption using the OLS method of data analysis and the result disclosed that electricity consumption was positive but insignificantly related to industry value-added.

Similarly, [19] investigated the impact of telecommunication infrastructure on economic growth in Nigeria using mixed-methods approach that combined quantitative data analysis with qualitative insights. Their findings revealed that enhanced telecommunications infrastructure significantly boosts economic growth by facilitating improved business operations and expanding market access. The study emphasizes that increased connectivity reduces transaction costs and enhances productivity across various sectors, underscoring the critical role of telecommunications investment in driving sustainable economic development in Nigeria.

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Theoretical underpinnings

The theory of long-run development developed by [1] posits that public infrastructure serves as a fundamental determinant of economic performance. According to this theory, the state's investments in infrastructure and health services are essential for raising labor productivity, thus laying the foundation for economic growth. A key aspect of this theory is the recognition of the network effects of infrastructure, wherein the effectiveness of infrastructure is indirectly related to the size of public capital, potentially leading to multiple equilibriums. The theory establishes infrastructure as the focal point for technological assimilation and utilization, which drives economic growth. In a country with inadequate infrastructure, the adaptation of production processes by firms may be slower compared to those with sufficient infrastructure. Conversely, when infrastructure reaches a certain threshold, firms can more seamlessly adapt to new technologies and consequently reap the benefits of technological advancements. Agenor's theory emphasizes the significance of infrastructure in facilitating technological assimilation and utilization and also underscores the urgency of addressing infrastructure gaps to promote economic resilience and competitiveness.

Equally relevant to this study is the [34] growth theory of capital accumulation, which was lauded by [35] as the preeminent framework for understanding economic growth. This theory explicates how economic expansion is driven by capital accumulation, labor, and technology. In this model, increased savings by individuals result in greater investment, thereby fostering economic growth. However, long-term growth is primarily ascribed to continuous technological progress, which is exogenously determined. Thus, the Solow-Swan model demonstrates how growth can be catalyzed through savings and capital accumulation, particularly when directed towards essential network infrastructures like power, telecommunications, and paved highways that bolster economic production.

In contrast to the exogenous factors emphasized by the Solow-Swan model, the endogenous growth model first developed by [36] and refined by scholars such as [37], [38] diverges clearly from the neoclassical claim that external factors such as technological progress are the main determinants of an economy's growth. The endogenous growth model argue that growth in an economy results from its internal mechanisms, i.e., through endogenous forces. The model however like the neoclassical theory encourages capital investment in infrastructures like telecommunications, education, health, and other high-tech infrastructure that generate increasing returns to scale.

Challenges of infrastructural development in Nigeria

Infrastructure development in Nigeria has evolved rather slowly compared to other African countries like South Africa and Egypt. While the average electricity consumption in kilowatt-hour per capita for Egypt and South Africa were as high as 6739.412 and 4354 KW/h per capita respectively between 2000 and 2014, that of Nigeria was only 148.5 KW/h per capita. Nigeria's current infrastructure stock constitutes only 30% of GDP – far below the World Bank's benchmark of 70%, which ranks Nigeria behind 23 other African countries on the African Development Bank's Africa Infrastructure Development Index [39] Moreover, private investment in Nigerian infrastructure has been disappointingly low, totaling just $8.4 billion from 2013 to 2023, in stark contrast to South Africa's $17.2 billion during the same period [39] This lack of investment exacerbates the existing infrastructure challenges and hampers economic growth, sustainable development, and poverty alleviation efforts. [40] attributes the infrastructural deficits to the relative challenges in the Nigerian economic and sociopolitical environment such as corruption, bad governance, paucity of funds for infrastructural development, shortage of foreign exchange and policy summersault

As noted by [41], public infrastructure is inherently costly to construct and maintain, which typically necessitates state involvement due to its financial capacity. Unfortunately, Nigeria, like other less developed nations, is increasingly hindered by a shortage of available funds, compounded by substantial debt servicing

obligations. This financial strain severely impacts the government's ability to provide essential public infrastructure. To address these challenges effectively, Nigeria must explore innovative financing solutions that mobilize private capital while ensuring sustainable outcomes. Traditional funding sources such as government allocations and loans from multilateral institutions have proven insufficient. The government has historically operated as the primary provider of critical infrastructure, but this model is no longer viable given the current fiscal constraints and the need for greater participation from the private sector

Infrastructure development in Nigeria also suffers from the challenge of foreign exchange deficit. Presently, a dollar exchanges for as high as 1,660 naira in the black market [42] while the official exchange rate stands at 1500.7800 naira to 1 dollar [43] A lot of materials used in the construction of public infrastructure, construction equipment and even diesel used by machines are procured outside the country and depend on foreign exchange which has become scarce. Hence paucity of foreign exchange is bound to diminish the acquisition of imported machineries including buses, aero planes and trains for public transportation, heavy machineries used in road construction, and even bitumen used for road construction.

Bad governance and the lack of visionary leadership are significant challenges hindering infrastructure development in Nigeria. Good governance is crucial for ensuring the effective and efficient provision of infrastructure, as it aligns resource allocation with national development priorities. In contrast, poor leadership often results in inadequate needs assessments, leading to inefficient allocation of public infrastructure among competing societal demands. Corruption further exacerbates these issues, acting as a major barrier to both infrastructure development and economic growth. [7] highlight that the infrastructural deficit in Nigeria is not solely due to a lack of capital; rather, it is significantly influenced by the pervasive corruption within the country. This corruption inflates project costs, diminishes the quality of infrastructure, and ultimately undermines economic returns on investments. The interplay between bad governance and corruption creates an environment where infrastructure projects are often poorly planned or executed. To address these challenges, Nigeria must prioritize visionary leadership that emphasizes accountability, transparency, and strategic planning. By fostering governance framework that encourages public participation and prioritizes infrastructural needs based on thorough impact assessments.

Lastly, the persistent issue of policy somersault in Nigeria has significantly hindered the nation's growth trajectory. This phenomenon, as defined by [40] refers to the abrupt changes or abandonment of policies midway through their implementation, often resulting from a lack of consistency, commitment, or understanding among policymakers. The implications are profound: substantial resources and energy are expended on initiating infrastructural projects that are frequently left incomplete or abandoned, leading to wasted investments and missed opportunities for development. A glaring example of this trend is the Ajaokuta Steel Company, which has remained largely inactive since its inception in 1979. Report by [44] suggests that despite continuous financial injections aimed at revitalizing this integrated steel complex, it has never operated at optimal capacity and often remains entirely shut down. Such instances highlight not only the inefficiencies within Nigeria's policy framework but also the broader consequences of neglecting the intricate web of interactions necessary for successful policy implementation. Moreover, the lack of a coherent approach to policy design and execution often results in a disconnect between governmental intentions and actual outcomes, while it may also deter foreign direct investment (FDI), further exacerbating Nigeria's developmental challenges.

MODEL SPECIFICATION

To estimate the impact of three types of infrastructure on economic growth in Nigeria, the study utilizes an econometric model based on the Cobb-Douglas production function. This model allows us to examine how different inputs (infrastructures in this case) contribute to economic output (GDP).

The Cobb-Douglas production function is given by: $Y= AK^{\alpha}L^{\beta}$ …… (1)

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For our purposes, we can extend this to include infrastructure variables. Let's denote:

Y= GDP (economic output)

K= Capital stock

L= Labor force

TR= Transport infrastructure

TE=Information and Telecommunication infrastructure

P = power infrastructure

A= Total factor productivity

The extended Cobb-Douglas production function becomes

$Y_t=A_tK_t^{\alpha}L_t^{\beta}TR_t^{\gamma}TE_t^{\delta}P_t^{\theta}$ ..... (2)

Taking the natural logarithm on both sides to linearize the model, we get:

$\ln(Y_t)=\ln(A_t)+\alpha\ln(K_t)+\beta\ln(L_t)+\gamma\ln(TR_t)+\delta\ln(TE_t)+\theta\ln(P_t)$ ..... (3)

For econometric estimation, we assume $\ln(A_t)$ embody the intercept and possibly a time trend or other exogenous factors (like policy changes or technological advancements). Including an error term ε_t the model to be estimated now becomes

$\ln(Y_t)=\beta0+\beta1\ln(K_t)+\beta2\ln(L_t)+\beta3\ln(TR_t)+\beta4\ln(TE_t)+\beta5\ln(P_t)+\varepsilon t$ .....(4)

Equation (4) is represented in ARDL form thus

$\Delta GDP_t = C_0 + \delta_1 GDP_{t-1} + \delta_2 GFCF_{t-1} + \delta_3 LF_{t-1} + \delta_4 TR_{t-1} + \delta_5 TE_{t-1} + \delta_6 P_{t-1} + \sum^{k}_{i=0} \lambda_1 \Delta GDP_{t-1} + \sum^{k}_{i=0} \lambda_2 \Delta GFCF_{t-1} + \sum^{k}_{i=0} \lambda_3 \Delta LF_{t-1} + \sum^{k}_{i=0} \lambda_4 \Delta TR_{t-1} + \sum^{k}_{i=0} \lambda_5 \Delta TE_{t-1} + \sum^{k}_{i=0} \lambda_6 P_{t-1} + \mu$

…… (5)

Where δ1 to δ6 are the long-run coefficients; while λ1 to λ6 are the short-run coefficients to be estimated, c is the intercept while μ is the error term.

PRESENTATION OF RESULTS AND DISCUSSION OF FINDINGS

Descriptive statistics

Table 4.1 descriptive statistics

	GDP	TR	TE	P	LF	GFCF
Mean	38124.89	725.3751	3788.230	4.687939	45729846	37.53317
Median	26935.32	189.9700	370.1100	4.613981	43010211	34.11000
Maximum	73382.77	6456.270	21456.83	5.355567	70911721	91.22000
Minimum	16211.49	6.310000	23.20000	3.929883	32844703	14.90000
Std. Dev.	20553.99	1286.952	5714.004	0.340500	12348023	20.50170

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Skewness	0.575236	2.884406	1.490229	0.179504	0.523708	1.117645
Kurtosis	1.703335	11.87011	4.224477	2.297819	1.938690	3.747579
Jarque-Bera	5.133417	191.2616	17.73672	1.062489	3.798407	9.490475
Probability	0.076788	0.000000	0.000141	0.587873	0.149688	0.008693
Sum	1563121.	29740.38	155317.4	192.2055	1.87E+09	1538.860
Sum Sq. Dev.	1.69E+10	66249813	1.31E+09	4.637610	6.10E+15	16812.79
Observations	41	41	41	41	41	41

Source: Authors computation

From table 4.1, the average GDP during the study period was ₦38,124.89 billion, with a substantial range between a minimum of ₦16,211.49 billion and a maximum of ₦73,382.77 billion. This wide range reflects the significant growth Nigeria experienced over time, though the variability (as shown by the standard deviation of ₦20,553.99 billion) suggests periods of both economic expansion and contraction. The skewness of GDP data (0.575) indicates a slight bias towards lower GDP values but with occasional years of strong economic performance pushing the mean upward.

Telecommunications infrastructure (TE), with a mean of ₦3,788.23 billion, stands out as a key driver of economic growth. The large gap between the maximum value of ₦21,456.83 billion and the minimum value of ₦23.20 billion indicates a rapid and transformational expansion of the telecommunications sector. The positive skewness (1.49) and high kurtosis (4.22) suggest that while investment in telecommunications was concentrated in a few specific periods, the sector has grown exponentially. This aligns with the broader economic trend of increasing reliance on telecommunications to facilitate digital transactions, communication, and innovation, making it one of the most pivotal sectors for Nigeria's long-term growth.

In contrast, transport infrastructure (TR) demonstrates a mean investment of ₦725.38 billion, but its extreme variability (ranging from ₦6.31 billion to ₦6,456.27 billion) reveals inconsistency in government or private sector focus on transport. The highly positive skew (2.88) and extreme kurtosis (11.87) imply that large investments in transport were rare and concentrated in a few significant projects. This inconsistent investment pattern may explain why transport infrastructure failed to show a strong, statistically significant relationship with GDP in the long term. Given the essential role transport plays in enhancing economic connectivity and productivity, the uneven investment in this sector may have hampered its potential to contribute to sustained economic growth.

Power infrastructure (P) presents a more stable picture, with a mean of 4.688 and relatively low variability (standard deviation of 0.34). The minimal skewness (0.18) and near-normal distribution suggest that investment in power infrastructure has been relatively consistent over time. However, the modest average investment level implies that power infrastructure may not have kept pace with the needs of a growing economy, especially when compared to the rapid expansion in telecommunications. This underinvestment in power likely contributes to the ongoing energy constraints that Nigeria faces, limiting the potential productivity gains that could be achieved through reliable electricity supply.

The labor force (LF) shows a mean of 45.73 million workers, reflecting Nigeria's large and growing population. The labor force has expanded steadily over the period, with a standard deviation of 12.35 million, indicating significant demographic shifts. The low skewness (0.52) and relatively normal distribution suggest that labor growth has been consistent. Finally, gross fixed capital formation (GFCF), with a mean of ₦37.53 billion, shows considerable variability (standard deviation of ₦20.50 billion). The positive skewness (1.12) and high kurtosis (3.75) indicate periods of high capital investment, but these periods were likely concentrated and insufficiently sustained. This volatility in capital formation suggests inefficiencies in investment strategies, which may include poor allocation of resources or underutilization of

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capital assets.

Toda-Yamamoto causality Test

Table 4.2 VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: LGDP			
Excluded	**Chi-sq**	**df**	**Prob.**
LLF	7.710158	2	0.0212
GFCF	2.020518	2	0.3641
LTE	6.019380	2	0.0493
LTR	2.014240	2	0.3653
LP	8.034102	2	0.0180
All	42.33064	10	0.0000
Dependent variable: LLF			
LGDP	2.714153	2	0.2574
Dependent variable: GFCF			
LGDP	6.872246	2	0.0322
Dependent variable: LTE			
LGDP	6.352858	2	0.0417
Dependent variable: LTR			
LGDP	4.492334	2	0.1058
Dependent variable: LP			
LGDP	0.730626	2	0.6940

Source: Authors computation

The result of the Block Exogeneity Wald Tests also known as Toda-Yamamoto causality test shows a unidirectional causality from labor force and power infrastructure to GDP. In which case, the Nigerian economy grows as the size of the labor force and electricity generation increases. On the other hand GDP caused changes in GFCF and not vice versa. Given the role of capital in an economy, this result deviates from a priori expectation and the [35] growth theory. The causality result also shows bidirectional causality between telecommunication infrastructure and GDP meaning that as the telecommunication infrastructure in Nigeria continue to expand the Nigerian economy grows which in turn leads to more telecommunication infrastructure. Finally no causal relationship was found to exist between Transport infrastructure and GDP which was not expected given the role transportation play in an economy. This could have been as a result of the poor transport system in Nigeria, given the bad roads, deficient rail infrastructure, poor maintenance of existing roads and the total neglect of waterways as a means of transportation in Nigeria.

ARDL estimation results

Table 4.3 Short run and long run result

Cointegrating Form				
Dependent variable GDP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LGDP(-1))	0.223711	0.125703	1.779671	0.0941

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D(LLF)	0.922719	0.929983	0.992188	0.3359
D(LLF(-1))	-4.47428	0.837408	-5.34301	0.0001
D(GFCF)	-0.00409	0.001534	-2.66853	0.0168
D(LTR)	0.064427	0.056024	1.150001	0.267
D(LTE)	0.028524	0.029648	0.962088	0.3503
D(P)	0.093494	0.033785	2.767296	0.0137
D(P(-1))	-0.05614	0.040235	-1.39519	0.182
CointEq(-1)	-0.66633	0.123963	-5.37529	0.0001
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LLF	0.218647	0.441646	0.495072	0.6273
GFCF	-0.00883	0.002162	-4.08523	0.0009
LTR	-0.02461	0.043821	-0.56161	0.5822
LTE	0.165617	0.024532	6.750996	0
P	0.093359	0.056413	1.654928	0.1174
C	5.640721	7.602038	0.742001	0.4688
Adjusted R-squared	0.999288			
Durbin-Watson stat	2.727839			

Source: Authors computation

Table 4.4 ARDL Bounds Test

Test Statistic	**Value**	**k**
F-statistic	**14.06492**	**5**
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.26	3.35
5%	2.62	3.79
2.50%	2.96	4.18
1%	3.41	4.68

Source: Authors computation

The ARDL results indicate that gross fixed capital formation and the labor force exert a negative impact on GDP in the short term. While the effect of capital remains unchanged in the long run, the labor force's influence shifts to a positive, albeit insignificant, contribution. This finding negates the [35] growth model, which posits that capital and labor are fundamental drivers of economic growth. The observed deviation may stem from Nigeria's inadequate infrastructure, which hampers the productivity of both labor and capital, as noted by [45]. This suggests that without addressing infrastructural deficiencies, the expected benefits of capital and labor on economic growth may continually be stifled.

Both transport and telecommunications infrastructure exhibited positive but statistically insignificant coefficients in the short run, indicating that immediate improvements in these areas did not significantly impact GDP. In the long run, enhancements in transport infrastructure again failed to produce a notable effect on Nigeria's economic growth which deviates from findings of [17] and [19]. The long run coefficient

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of information and telecommunications infrastructure however stands out with a positive value of 0.1656 and a highly significant p-value of 0.0000 in line with findings of [46] [47]. In real terms the result indicates an expansion of the Nigerian economy by about 0.17 percent as a result of a 1 percent increase in telecommunication infrastructure. This underscores the critical role that telecommunications play in driving long-term economic growth in Nigeria. Increased investments in the telecoms sub-sector can facilitate better connectivity, enhance productivity, and support innovation, ultimately contributing to a more dynamic economy.

In the short run current period, power infrastructure demonstrated a positive and significant effect on GDP, with a coefficient of 0.0935, suggesting that a 1 percent improvements in power supply triggered economic growth by 0.935 percent in the short term. This result is similar to findings of [2]. The long-run coefficient is also positive at 0.0934 but lacks statistical significance indicating that while power infrastructure contributes positively to GDP growth over time, its impact is not robust enough to be deemed statistically reliable. This scenario implies that while enhancing power infrastructure is beneficial for stimulating short-term economic growth in Nigeria, its long-term effects may be tempered by other factors, such as the need for complementary investments in efficiency, technology, and management practices.

The bound test result in Table 4.4 shows that long run relationships exist between the study variable while the error correction term of -0.6663 (p = 0.0001) which is significant and negative, indicates that the system corrects itself towards long-run equilibrium at a relatively fast rate. The Adjusted R-squared of 0.999288 indicates that 99 percent of the deviation in GDP is as a result of the explanatory variables.

Discussion of Findings

Telecommunications infrastructure emerged as a pivotal driver of long-term economic growth in the ARDL results, with a statistically significant positive coefficient underscoring its central role in fostering sustained economic growth. This finding is further corroborated by the bidirectional causality between telecommunications infrastructure and GDP in the Toda-Yamamoto test, which indicates a feedback loop where growth in telecommunications stimulates economic activity, and vice versa. The descriptive statistics lend additional support, with a mean value for telecommunications infrastructure at ₦ 3,788.23 billion, and substantial variation between the minimum (₦ 23.20 billion) and maximum (₦ 21,456.83 billion) investments. This variability, alongside a skewed distribution (1.49), reflects the rapid and concentrated growth in Nigeria's telecommunications sector, particularly during key periods of technological advancement and liberalization. The expansion of telecommunications infrastructure does not only facilitate connectivity, but it also reduces transaction costs, and supports innovation, all of which are critical for the growth of the Nigerian economy.

Power infrastructure has a significant short-term effect on GDP in Nigeria, as shown by the ARDL model, which highlights immediate benefits from improvements in electricity generation. However, in the long run, while the effect remains positive, it lacks statistical significance, indicating that Nigeria's power sector struggles to support sustained economic growth. This is corroborated by the Toda-Yamamoto causality test and descriptive statistics indicating insufficient investment in power infrastructure to meet rising demands. Notably, Nigeria's electricity output hovers around 5,000 megawatts—less than 3% of the recommended global sustainable development standard [8]. This inadequacy poses a critical challenge, as unreliable power supply remains a significant barrier to small and medium enterprises (SMEs), industrial growth, and overall productivity [11]. Moreover, epileptic power supply in Nigeria leads to increased operational costs for businesses that rely on alternative energy sources like generators. This reliance not only diminishes profit margins but also hampers competitiveness in both local and international markets. The resulting economic strain stifles job creation especially among the youthful population.

Transport infrastructure has not demonstrated a statistically significant relationship with GDP in the ARDL

model both in the short and long term. This finding is also supported by the Toda-Yamamoto causality test, which revealed no causal link between transport infrastructure and GDP, contradicting theoretical expectations. Descriptive statistics indicate considerable variability in transport infrastructure investment, highlighting inconsistent funding patterns. The data show significant spikes in investment during certain periods but lack a sustained growth trajectory. A critical factor for these outcomes is Nigeria's low per capita investment in road infrastructure, recorded at just $26.87 in 2020. This figure starkly contrasts with higher investments in countries like Angola ($44.16), Morocco ($33.34), and Malaysia ($108.43) [48]. Consequently, of Nigeria's approximately 195,000 kilometers of road network, only around 60,000 kilometers are paved, and a large portion of these paved roads are in poor condition due to neglect and inadequate maintenance [49]. This creates significant barriers to the efficient movement of agricultural goods from rural to urban areas, leading to increased transport costs, longer transit times, and reduced access to broader markets, which in turn raises the price of goods, hampers agricultural productivity, and discourages investment in farming. During rainy seasons, many rural areas become practically cut off, exacerbating issues of supply and demand. This bottleneck not only isolates rural communities economically but also impacts the national economy by limiting the agricultural sector's potential for growth and contribution to food security and economic diversification. Furthermore, the results also highlight the underutilization of other alternative means of transport in Nigeria like air, rail and water. For instance, air transport which is the most active of the three underutilized form of transport in Nigeria only 13,006,481 passengers passed through Nigerian airports in 2021 up from 9,069,295 in 2020 [50].

The labor force exhibited mixed effects on GDP in the ARDL model. In the short run, the impact of labor force growth was negative, reflecting potential strains on resources or issues such as underemployment and skill mismatches. However, in the long run, the coefficient turned positive, though statistically insignificant, suggesting that labor force expansion has the potential to contribute to growth over time, but only if structural issues in the labor market are addressed. The descriptive statistics also supports this result with a mean of 45.73 million and a standard deviation of 12.35 million. This relatively high standard deviation reflects the changing dynamics of the labor market over the study period. Despite this growth, the labor force's long-term contribution to GDP remains muted in the ARDL model, which points to deeper issues in the quality and productivity of labor in Nigeria. Given that Labor productivity is heavily dependent on infrastructure. Poor transportation and limited access to electricity or the internet can also hinder workers' ability to perform tasks efficiently, thereby reducing their contribution to economic growth.

Similarly, gross fixed capital formation (GFCF) has a negative effect on GDP in both the short and long run. This unexpected outcome is further accentuated by the Toda-Yamamoto test, which shows that GDP caused changes in GFCF rather than the reverse. In the context of Nigeria, this counterintuitive finding can be attributed to several systemic issues, including inefficient allocation of capital, pervasive corruption, and inadequate investment in productive sectors. These challenges have hindered the effectiveness of capital formation in stimulating economic growth. Moreover, the inconsistent nature of capital investments—often characterized by sporadic spikes rather than sustained growth as seen in the descriptive statistics—suggests that without significant reforms to improve infrastructure and governance, the potential benefits of capital accumulation will remain unrealized.

CONCLUSION AND RECOMMENDATIONS

This study adopted a two pronged analytical approach to explore the interplay between infrastructure and economic growth in Nigeria. The ARDL results, supported by the Toda-Yamamoto causality test and descriptive statistics, paint a nuanced picture of Nigeria's economic growth dynamics. Telecommunications infrastructure stands out as a key driver of long-term growth, with consistent investment and strong bidirectional causality with GDP. In contrast, power infrastructure shows short-term benefits but lacks long-term significance which stems from the poor power supply in Nigeria. The Nigerian transport infrastructure

remains poorly developed and ineffective in stimulating growth given that large investments in transport were rare and concentrated. The labor force, despite its potential, is hampered by poor infrastructure and structural inefficiencies, and capital formation exhibits negative effects due to poor allocation and investment inefficiencies. Together, these findings underscore the need for the federal government of Nigeria to expand its public-private partnerships (PPPs) especially in the power and transport sectors to mobilize additional resources for infrastructure development. These partnerships can bring in private sector expertise, improve project efficiency, and reduce the financial burden on the government. Secondly, given telecommunication's significant positive impact on economic growth, the government of Nigerian should continue to sustain and strengthen telecoms policies to expand network coverage, improve internet access, and foster innovation to further stimulate economic activities and reduce transaction costs. Again, to address the inadequacies in power supply, comprehensive reforms in the electricity sector are essential. This includes ensuring transparency in policy implementation, and most importantly encouraging private sector participation to mobilize necessary funding for upgrades and maintenance. Finally, the lack of a significant relationship between transport infrastructure and GDP suggests a need for strategic policy realignment to the development of alternative transport routes such as rail and waterways to enhance trade and mobility.

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