The Impact of Infrastructure Governance on the Economic Growth of Nigeria

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ABSTRACT

This study examines the impact of infrastructure governance on economic growth in Nigeria using annual time-series data over the period 1995–2024. The empirical strategy employs the Autoregressive Distributed Lag (ARDL) bounds testing approach, incorporating structural breaks, lag dynamics, and a comprehensive set of post-estimation diagnostics to ensure robustness. The results confirm the existence of a strong long-run equilibrium relationship among the variables. The error correction term is negative and highly significant, indicating a rapid speed of adjustment of approximately 94% toward long-run equilibrium following short-run shocks. Empirical findings show that population exerts a strong and statistically significant positive effect on economic growth, while Research and Development has a significant negative impact in both the short and long run. Inflation exhibits weak and delayed effects, whereas governance effectiveness, foreign direct investment, infrastructure expenditure, and public debt are statistically insignificant across most specifications. Diagnostic tests confirm model stability, although mild evidence of non-normality, heteroskedasticity, and serial correlation is observed. However, structural stability tests (CUSUM and CUSUMSQ) indicate parameter stability over time, supporting the reliability of the estimated coefficients. The study concludes that Nigeria's growth dynamics are driven more by demographic factors and infrastructure efficiency than by fiscal size or governance indicators alone. Policy attention should therefore shift toward improving infrastructure quality, institutional efficiency, and productivity-oriented public investment.

Keywords-Infrastructure governance; Economic growth; ARDL model; Nigeria; Cointegration; Structural breaks; Error correction model; Macroeconomic dynamics; Infrastructure efficiency; Developing economies.

INTRODUCTION

Infrastructure acts as the backbone of economic development, providing the necessary foundation for productive activities, industrialization, and human welfare (Umesha, 2018). In developing economies like Nigeria, the gap between required and available infrastructure is estimated to be over $100 billion which is a critical bottleneck hindering economic growth (Helen, 2020). According to Olanma et al, (2022), Nigerian government has continuously instituted infrastructure development projects across sectors such as power, transportation, and communication but the translation of these investments have not yielded the expected economic growth. Developing robust and sustainable economic growth requires far more than merely injecting capital into public works; it demands strategic oversight, efficient execution, and systemic stability. While physical investments lay the groundwork for commercial activity, the ultimate trajectory of national development is dictated by how these resources are governed and managed amidst broader macroeconomic realities. This research investigates the profound impact of infrastructure governance on economic growth, analyzing how the synergy of structural, financial, and demographic factors drives or hinders development. The main problem, however, is not merely

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the inadequacy of funds, but the effectiveness of infrastructure governance which is how projects are planned, budgeted for, executed, and maintained.

Infrastructure governance, defined as the framework of institutions, processes, and rules that determine how infrastructure decisions are made, is critical to ensuring that investment brings about sustainable economic growth. In Nigeria, infrastructure governance has often been characterized by bureaucratic inefficiencies, fragmented project execution, and lack of long-term planning, resulting in abandoned projects and inefficiency in public spending (Ishaq, 2025). Consequently, the relationship between infrastructure capital expenditure (fiscal sustainability) and GDP growth has remained weak and insignificant in many economic assessments, failing to propel the expected economic growth.

High-quality infrastructure reduces the operating costs and risks for international firms, which directly encourages greater FDI inflows into Nigeria. These foreign investments then accelerate economic expansion by supplying new capital, advanced technology, and vital management skills. Consequently, the research explores how government spending on infrastructure must succeed in attracting this productive FDI.

To comprehensively evaluate this dynamic, the study examines the following independent variables and their specific roles:

Government Effectiveness: This captures the quality of public services, the capacity of the civil service, and the credibility of the government's policy formulations (World Bank. 2022). In the context of infrastructure, robust governance minimizes rent-seeking, curtails corruption, and ensures that capital is allocated to high-yield, socially beneficial projects. Despite high-level budgetary allocations, the performance gap remains significant due to inconsistent policy implementation, political interference, and inadequate monitoring of projects. Consequently, while PPP models and infrastructure master plans exist, institutional inefficiencies often result in slow project execution and a widening, critical infrastructure deficit (Manjo, 2024).

Infrastructure Capital Expenditure: Representing direct financial outlays on public physical assets like roads, bridges, and energy grids, this variable serves as the tangible engine for productivity. Sustained expenditure directly reduces logistical costs, connects markets, and stimulates private sector investment.

Research & Development (R&D): Technological innovation and infrastructural development are deeply intertwined. R&D spending drives the modernization of infrastructure (e.g., smart grids, digital connectivity), fostering long-term, knowledge-based economic expansion and efficiency.

Population: As the primary driver of the labor force and consumer demand, demographic scale and growth determine the foundational need for infrastructural scaling. Rapid population growth can strain existing resources, necessitating proactive infrastructure investments to prevent bottlenecks.

Inflation: Unstable or high inflation erodes purchasing power, distorts market signals, and reduces the real value of capital budgets. Controlling inflation is vital to ensuring that planned infrastructure projects remain financially viable and that the broader economy remains stable.

Research Questions

i. How does infrastructure capital expenditure impact the Gross Domestic Product (GDP) of Nigeria?

ii. What is the effect of Research and Development (R&D) expenditure on Nigeria's economic growth?

iii. To what extent do government effectiveness and institutional quality moderate the relationship between infrastructure spending and economic growth?

iv. How do inflation and population dynamics influence the impact of infrastructure capital expenditure on GDP

v. Is there a significant causal relationship between infrastructure governance variables and economic output in Nigeria?

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Research Objectives

General Objective:

To examine the impact of infrastructure governance on the economic growth of Nigeria, specifically evaluating how infrastructure capital expenditure, R&D, and government effectiveness interact with inflation and population to influence GDP.

Specific Objectives, to:

i. determine the effect of infrastructure capital expenditure on the GDP of Nigeria.
ii. assess the contribution of Research and Development (R&D) spending to Nigeria's economic growth.
iii. evaluate the moderating role of government effectiveness on the translation of infrastructure spending into economic output.
iv. analyze the impact of inflation and population growth as control variables on the infrastructure-growth nexus.
v. proffer evidence-based policy recommendations for improving infrastructure governance and institutional efficiency to foster sustainable GDP growth.

This study aims to evaluate the impact of infrastructure governance on Nigeria's economic growth (GDP) by focusing on institutional performance (government effectiveness), technology (R&D), infrastructure capital expenditure, population and inflation as independent variables while GDP as dependent variable.

LITERATURE REVIEW

Out of many economic theories that talk about infrastructure governance and economic growth, the most suitable is therefore reviewed:

Endogenous Growth Theory (Romer & Lucas)

Endogenous growth theory was propounded by Romer in 1986 and Lucas in 1988. This theory argues that government investment in infrastructure (roads, telecoms, energy) is a crucial input that enhances private sector productivity, resulting in sustained, long-term growth. It moves away from the idea that growth just happens automatically (exogenous) and places the onus on governments to create "technology-enabling" infrastructure. It implies that what the government spends on (quality, efficiency) is more important than just the quantity of spending.

Empirical Research

Osifalujo el ta, (2022) investigated the impact of governance, institutions and infrastructure on economic growth using descriptive research design. The result shows positive and significance relationship between governance and effective institution and infrastructure development. It was therefore concluded that capable and resourceful institutions will bring positive contribution to infrastructure development leading to economic growth.

METHODOLOGY

Research Design

The study utilizes a quantitative econometric approach with an ex-post facto research design (analyzing existing data after the fact) to evaluate how infrastructure governance indicators influence economic growth in Nigeria.

Model Specification

This study adopts an extended endogenous growth framework incorporating institutional quality, fiscal infrastructure governance, macroeconomic stability, and innovation variables. Following the theoretical position

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of institutional economics and fiscal governance theory, economic growth is assumed to be a function of governance quality, infrastructure investment efficiency, and macroeconomic fundamentals.

$$\mathrm{GDP_t} = \mathrm{f}(\mathrm{GE_t}, \mathrm{INFRAEXP_t}, \mathrm{INF_t}, \mathrm{FDI_t}, \mathrm{POP_t}, \mathrm{R\&D_t}, \mathrm{DEBT_t})$$

Econometric Form

The empirical model is expressed as:

$$[\mathrm{GDP_t} = \beta_0 + \beta_1 \mathrm{GE_t} + \beta_2 \mathrm{INFRAEXP_t} + \beta_3 \mathrm{INF_t} + \beta_4 \mathrm{FDI_t} + \beta_5 \mathrm{POP_t} + \beta_6 \mathrm{R\&D_t} + \beta_7 \mathrm{DEBT_t} + \varepsilon_t]$$

Where:

- $\mathrm{GDP_t}$= Economic growth (GDP in Naira or real GDP)
- $\mathrm{GE_t}$= Government effectiveness
- $\mathrm{INFRAEXP_t}$= Infrastructure capital expenditure to GDP ratio
- $\mathrm{INF_t}$= Inflation rate
- $\mathrm{FDI_t}$= Foreign direct investment to GDP
- $\mathrm{POP_t}$= Population growth
- $\mathrm{R\&D_t}$= Research and development to GDP ratio
- $\mathrm{DEBT_t}$= Debt to GDP ratio
- (β_0) = intercept
- ($\beta_1 - \beta_7$) = coefficients of explanatory variables
- (ε_t) = stochastic error term
- (t) = time (1995 – 2024)

Table 1: Priori Expectations

Variable	Expected Sign	Justification
Govt. Effectiveness	+	Improves policy efficiency and infrastructure delivery
Infrastructure Capex	+	Enhances productive capacity
Inflation Rate	−	Reduces purchasing power and investment
FDI	+	Enhances capital inflow and productivity
Population Growth	±	May increase labour force or pressure resources
R&D	+	Drives innovation and productivity
Debt to GDP	−	High debt may constrain fiscal space

RESULT

Table 2: Descriptive Statistics and Preliminary Analysis

Variable	Mean	Std. Dev.	Minimum	Maximum	Jarque–Bera	Prob.
GDP	1.79E+13	8.60E+13	1.41E+11	3.73E+14	22.50	0.000*

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GE	-1.05	0.11	-1.40	-0.85	6.51	0.038**
INFEXP	2.14	1.15	0.91	6.47	75.42	0.000*
R&D	0.21	0.05	0.13	0.28	2.49	0.288
INF	15.15	9.40	5.39	51.68	71.62	0.000*
FDI	1.17	0.87	-0.03	2.90	2.22	0.329
DEBT	28.73	15.55	7.30	64.90	1.95	0.377
POPULATION	1.67E+08	3.80E+07	1.11E+08	2.33E+08	2.09	0.352

Table 2 presents the descriptive behaviour of the variables. The Real Gross Domestic Product (GDP) recorded an average value of ₦17.9 trillion. The large difference between the minimum value of ₦141 billion and the maximum value of ₦373 trillion indicates that the Nigerian economy experienced considerable growth and structural changes between 1995 and 2024. The relatively high standard deviation further suggests substantial fluctuations in economic performance. The Jarque-Bera test shows that GDP is not normally distributed, implying that economic growth was influenced by major economic events and external shocks rather than following a stable growth pattern.

Government Effectiveness (GE) presents a weak institutional environment throughout the period. The average value of -1.05 indicates poor institutional quality and limited government capacity to implement policies effectively. The small standard deviation suggests that there was little improvement in governance performance over time. The non-normal distribution of the series further indicates that certain periods experienced particularly weak administrative performance.

Infrastructure capital expenditure as a share of GDP averaged 2.14%. This relatively low level of spending suggests persistent underinvestment in public infrastructure. The variable also exhibits considerable fluctuations, indicating that government spending on infrastructure has been inconsistent. The Jarque-Bera result confirms that infrastructure expenditure did not follow a stable pattern, reflecting changes in government priorities, fiscal pressures, and budgetary adjustments.

Research and development expenditure remained extremely low, with an average value of only 0.21 percent of GDP. The low standard deviation indicates that spending on research and innovation changed very little over time. Unlike infrastructure expenditure, the distribution of research and development spending is approximately normal, suggesting that the low level of investment has remained stable throughout the study period.

Inflation averaged 15.15 percent, indicating a persistent high-inflation environment. The wide gap between the minimum and maximum values demonstrates substantial price instability over the years. The high standard deviation further confirms the volatility of inflation in Nigeria. The non-normal distribution suggests that inflation was characterized by occasional periods of exceptionally high price increases, which may have reduced the real value of government expenditure and investment.

Foreign direct investment (FDI) averaged 1.17 percent of GDP, reflecting relatively low levels of foreign investment. The occurrence of negative values during some periods indicates episodes of capital outflows and declining investor confidence. However, the variable follows a normal distribution, suggesting that FDI inflows remained relatively stable despite their low magnitude.

Public debt averaged 28.73 percent of GDP during this period. The wide range between the minimum and maximum values indicates substantial changes in government borrowing, while the debt burden increased considerably in recent years, the distribution of the variable remains normal, suggesting a gradual rather than abrupt increase in public debt.

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Population growth shows a steady increase over the study period, with the population rising from approximately 111 million to 233 million people. The normal distribution of the series indicates a stable demographic trend. The continuous growth in population places increasing pressure on existing infrastructure and public services, thereby creating greater demand for investment in economic and social infrastructure.

These statistical results reveal that Nigeria's economy has been characterized by fluctuations in economic growth, weak institutional quality, unstable inflation, low research investment, and inconsistent infrastructure spending. These conditions provide important background for examining the relationship between infrastructure governance and economic growth in Nigeria.

Table 3: Multicollinearity Diagnostic Test

Variable	Centered VIF
R & D	6.78
FDI	4.26
INFEXP	2.45
LN_POP	2.43
DEBT	2.31
INF	1.25
GE	1.16

Mean VIF = 2.95

Note: Dependent variable was excluded from diagnostic test.

The results indicate that multicollinearity is not a problem in the model. The mean VIF value of 2.95 is well below the acceptable threshold, suggesting that the explanatory variables provide distinct information.

Research and development expenditure recorded the highest VIF value of 6.78, followed by foreign direct investment with a VIF of 4.26. Although, these values suggest some degree of association among the variables, they remain below the critical threshold of 10 and therefore do not indicate serious multicollinearity.

Infrastructure capital expenditure, population growth, and the debt-to-GDP ratio recorded relatively low VIF values of 2.45, 2.43, and 2.31, respectively. These results indicate that the variables are sufficiently independent and do not overlap excessively.

Furthermore, inflation and government effectiveness reported the lowest VIF values of 1.25 and 1.16, respectively. Values close to one indicate very little correlation with other explanatory variables, suggesting that both variables capture unique aspects of the Nigerian economy.

Table 4: ADF Unit Root Test Results with Structural Breaks

Variable	Test Level	Structural Break	t-Statistic	Prob.	Order of Integration
LN_GDP_1	Level	2009	-5.937	<0.01***	I(0)
LN_POP	Level	2002	-9.451	<0.01***	I(0)
FDI	Level	2012	-6.505	<0.01***	I(0)

INF	Level	2022	-7.454	<0.01***	I(0)
GE	Level	None	-4.581	0.001***	I(0)
BUDGET_RATE	First Difference	None	-10.109	0.000***	I(1)
INFEXP	First Difference	None	-10.108	0.000***	I(1)
R&D	First Difference	None	-8.019	0.000***	I(1)
DEBT	First Difference	None	-3.471	0.019**	I(1)

Note: (*) **and (***) indicate rejection of the null hypothesis of a unit root at the 1% and 5% significance levels, respectively. Structural break tests are based on the Innovational Outlier specification.

Table 4 presents the Augmented Dickey-Fuller (ADF) unit root results with structural breaks using an innovational outlier specification to capture major economic and policy shifts in Nigeria. The results show a mixed order of integration, with variables that are stationary at level, I(0), and others that become stationary after first differencing, I(1). This combination supports the use of the Autoregressive Distributed Lag (ARDL) model rather than Johansen cointegration techniques.

The first group consists of variables that are stationary at level, I(0). These variables revert to their long-run mean despite shocks.

Real GDP (LN_GDP_1) is stationary at level ($t = -5.937$, $p < 0.01$), with a structural break in 2009. This aligns with the global financial crisis and Nigeria's banking sector reforms. Also, Population (LN_POP) is also stationary at level ($t = -9.451$, $p < 0.01$), with a break in 2002, reflecting demographic adjustments following the return to democratic governance and national planning reforms. Furthermore, Foreign Direct Investment (FDI) is stationary at level ($t = -6.505$, $p < 0.01$), with a break in 2012. This period corresponds to global commodity price shifts and changes in domestic fuel subsidy policy. Inflation (INF) is stationary at level ($t = -7.454$, $p < 0.01$), with a structural break in 2022. This reflects global supply disruptions, domestic climate shocks, and tighter monetary policy, and Government Effectiveness (GE) is stationary at level ($t = -4.581$, $p = 0.001$) and shows no structural break. This suggests persistent institutional weakness over the sample period.

The second group consists of variables that are integrated of order one, I(1). These variables are non-stationary in levels but become stationary after first differencing.

Budget Rate ($t = -10.109$, $p < 0.01$), Infrastructure Capital Expenditure (INFEXP) ($t = -10.108$, $p < 0.01$), and Research and Development (R&D) ($t = -8.019$, $p < 0.01$) all become stationary after first differencing. This indicates that while their levels change over time, their year-to-year movements are stable. Debt-to-GDP (DEBT) also becomes stationary after first differencing ($t = -3.471$, $p = 0.019$), significant at the 5 percent level.

Table 5: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-128.78	NA	2.42e-06	9.770	10.1519	9.887
1	137.39	61.24	1.56e-12	-4.671	-1.245	-3.624
2	287.97	118.31*	1.26e-14*	-10.855*	-4.384*	-8.877*

Note: (*) indicates the selected optimal lag length based on each criterion. Endogenous variables: LN_GDP, LN_POP, R&D, INFEXP, INF, GE, FDI, DEBT.

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Table 5 reports the VAR lag order selection results using standard information criteria. The analysis shows a clear and consistent selection of lag 2 as the optimal lag length.

All criteria including LR, FPE, AIC, SC, and HQ converge on lag 2 as the best specification. This indicates improved model fit and better dynamic capture of inter-variable relationships at this lag structure.

Accordingly, lag 2 is adopted for subsequent ARDL estimation. This choice ensures model parsimony while reducing the risk of serial correlation and improving estimation efficiency.

Table 6: Model Fit and Overall Diagnostics

Model Component	Value
Selected Model	ARDL(1, 0, 1, 0, 1, 0, 0, 0)
Lag Selection	Automatic (AIC; deplags = 1, reglags = 1)
Model Iterations	128
Included Observations	29
R-squared	0.998382
Adjusted R-squared	0.996764
F-statistic	617.1023
Prob(F-statistic)	0.000000
Durbin–Watson	1.782852

Key Significant Regressors ($p < 0.05$)

Variable	Coefficient	t-Statistic	Prob.
LN_POP	6.1087	12.5430	0.0000
R&D	-2.4160	-2.7266	0.0164
R&D(-1)	-2.0739	-2.6111	0.0205
INF(-1)	0.0095	2.3818	0.0320

Note: Structural break dummies (D2002, D2009, D2012, D2022) included but not reported for parsimony.

The R-squared value of 0.9983 and adjusted R-squared of 0.9967 indicate that over 99 percent of the variation in Real GDP is explained jointly by infrastructure governance variables, macroeconomic controls, and structural break dummies.

The overall model significance is confirmed by the F-statistic of 617.10, which is highly significant ($p < 0.01$). This indicates that the explanatory variables jointly have a strong and statistically meaningful effect on economic growth in Nigeria.

The Durbin-Watson statistic is 1.78, which is close to the benchmark value of 2.0. This suggests that there is no serious problem of first-order serial correlation. As a result, the estimated coefficients and standard errors are considered reliable for inference.

Population (LN_POP) is highly significant and positively related to Real GDP (t = 12.54, p < 0.01). The coefficient of 6.1087 suggests that population growth is strongly associated with higher economic output. This reflects the role of Nigeria's large and expanding population in driving aggregate demand and labour supply.

Research and Development (R&D) shows a statistically significant negative effect on Real GDP. Both the current value (β = -2.4160, t = -2.72, p = 0.0164) and the lagged value (β = -2.0739, t = -2.61, p = 0.0205) were negative. This suggests that R&D spending has not translated into productive economic outcomes. Given the very low average level of R&D spending in the descriptive statistics, this result likely reflects weak institutional capacity, inefficient allocation, and limited absorptive capacity for innovation-related expenditure.

Inflation (INF) shows a small but statistically significant positive lagged effect on Real GDP (β = 0.0095, t = 2.38, p = 0.0320). This indicates that past inflation may be associated with short-run increases in nominal economic activity. However, this effect is likely temporary and does not imply long-run economic improvement. It may reflect short-run adjustments in prices and output in response to economic shocks.

Table 7: Restricted ARDL Error Correction and Long-Run Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_GDP_1(-1) (ECT)	-0.9448	0.0576	-16.4083	0.0000
LN_POP	6.1087	0.4870	12.5430	0.0000
R&D(-1)	-4.4899	1.1146	-4.0281	0.0012
INF(-1)	0.0101	0.0050	2.0095	0.0642
INFEXP	-0.0122	0.0247	-0.4946	0.6285
GE	-0.0576	0.1874	-0.3072	0.7632
FDI	0.0206	0.0462	0.4448	0.6632
DEBT	-0.0016	0.0019	-0.8290	0.4210

Short-Run Dynamics

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R&D)	-2.4160	0.8861	-2.7266	0.0164
D(INF)	0.0006	0.0045	0.1221	0.9045

Model Diagnostics

Statistic	Value
R-squared	**0.9919**
Adjusted R-squared	**0.9839**
F-statistic	**122.8998**
Prob(F-statistic)	**0.0000**

Note: Structural break dummies (D2002, D2009, D2012, D2022) included but statistically insignificant (p > 0.05).

Table 9 presents the restricted ARDL error correction results, capturing both long-run equilibrium and short-run dynamics.

The error correction term (ECT) is negative and highly significant (ECT = -0.9448, t = -16.41, $p < 0.01$). This satisfies the standard conditions for a stable long-run relationship.

The coefficient implies that about 94.5% of short-run deviations from long-run equilibrium are corrected within one year. This suggests that shocks to the system are quickly absorbed, and the relationship between infrastructure governance and economic growth reverts rapidly to its long-run path.

The long-run results reveal weak transmission from infrastructure governance variables to economic growth. Infrastructure Capital Expenditure (INFEXP) is negative and statistically insignificant ($\beta = -0.0122$, t = -0.49, $p = 0.6285$). This indicates that infrastructure spending does not translate into long-run economic growth. The result suggests inefficiencies in implementation, weak project execution, and poor value-for-money outcomes.

Government Effectiveness (GE) is also insignificant in the long run ($\beta = -0.0576$, t = -0.30, $p = 0.7632$). This suggests weak institutional capacity and limited policy effectiveness. Research and Development (R&D) shows a strong negative and significant long-run effect ($\beta = -4.4899$, t = -4.03, $p = 0.0012$). This result, consistent with the short-run findings, suggests that current R&D spending is not productivity-enhancing. Instead, it reflects inefficient allocation and weak institutional capacity to translate innovation spending into economic output.

Population (LN_POP) remains positive and highly significant in the long run ($\beta = 6.1087$, t = 12.54, $p < 0.01$). This confirms that demographic expansion continues to be a key driver of economic growth in Nigeria through labour supply and market size effects.

Inflation becomes insignificant in the long run ($p = 0.0642$), indicating that its effects are mainly short term. Foreign Direct Investment (FDI) ($p = 0.6632$) and Debt-to-GDP (DEBT) ($p = 0.4210$) are also insignificant. This suggests that external financing and public debt do not have a stable long-run relationship with output under the current institutional structure.

These results indicate that increasing infrastructure spending alone is unlikely to generate long-run growth. The insignificant coefficients on INFEXP and GE suggest that the binding constraint is not expenditure size but institutional and implementation quality. Policy attention should, therefore, focus on improving governance systems, strengthening project execution, and enhancing accountability in public investment management before expanding fiscal allocations.

Table 8: Cointegrating Equation and Error Correction

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ	-0.9448	0.0235	-40.2386	0.0000

Short-Run Regressors and Structural Breaks

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(R&D)	-2.4160	0.4815	-5.0181	0.0001
D(INF)	0.0006	0.0022	0.2569	0.7998
C	-85.2148	2.1291	-40.0232	0.0000
D2002	0.0088	0.0369	0.2379	0.8143
D2009	-0.1141	0.0431	-2.6471	0.0151

D2012	0.1987	0.0420	4.7308	0.0001
D2022	0.0289	0.0430	0.6722	0.5088

Model Diagnostics

Statistic	Value
R-squared	0.9919
Adjusted R-squared	0.9892
F-statistic	368.6994
Prob(F-statistic)	0.0000
Durbin–Watson	1.7829

The cointegrating equation confirms a stable long-run relationship among the variables. The error correction term (ECT) remains negative and highly significant at -0.9448, with an improved t-statistic of -40.2386 ($p < 0.01$). This indicates a very strong and stable adjustment process. About 94.5% of any short-run disequilibrium is corrected within one year. This shows that the system quickly returns to its long-run equilibrium after shocks.

Research and Development (D(R&D)) remains negative and highly significant ($\beta = -5.0181$, $t = -5.0181$, $p < 0.01$). This suggests that short-term increases in R&D spending reduce output. The result reflects weak absorptive capacity and inefficient use of innovation-related expenditure in the short run. However, Inflation change (D(INF)) is positive but statistically insignificant ($\beta = 0.0006$, $p = 0.7998$). This implies that short-run changes in inflation do not have a direct effect on real output fluctuations.

The constant term is negative and highly significant ($\beta = -85.2148$, $t = -40.0232$, $p < 0.01$). This reflects a strong baseline structural drag on output when other short-run factors are held constant.

The 2002 dummy (D2002) is positive but insignificant ($\beta = 0.0088$, $p = 0.8143$). This indicates no measurable short-run impact from this structural shift, and the 2009 dummy (D2009) is negative and significant ($\beta = -0.1141$, $t = -2.6471$, $p = 0.0151$). This confirms that the global financial crisis and related shocks had a clear contractionary effect on Nigeria's output.

The 2012 dummy (D2012) is positive and highly significant ($\beta = 0.1987$, $t = 4.7308$, $p < 0.01$). This reflects a recovery phase supported by improved oil prices, banking sector reforms, and sectoral policy interventions. The 2022 dummy (D2022) is positive but insignificant ($\beta = 0.0289$, $p = 0.5088$). This suggests that recent inflationary and post-pandemic pressures did not produce a statistically clear short-run output break.

The F-statistic is 368.69 ($p < 0.01$), confirming overall model significance. The Durbin-Watson statistic of 1.78 indicates no serious autocorrelation problem in the residuals.

Table 9: ARDL Bounds Test for Cointegration

Statistic	**Calculated Value**	**10% Bounds I(0)/I(1)**	**5% Bounds I(0)/I(1)**	**1% Bounds I(0)/I(1)**
F-statistic	134.9290	2.384 / 3.728	2.875 / 4.445	4.104 / 6.151
t-statistic	-16.4083	-2.570 / -4.230	-2.860 / -4.570	-3.430 / -5.190

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The F-statistic from the bounds test is 134.9290. This value is far above the upper critical bounds at all conventional significance levels. At the 10% level, it exceeds the upper bound of 3.728. At the 5 percent level, it is higher than 4.445. At the 1 percent level, it is also far above the upper bound of 6.151.

Since 134.9290 is greater than 6.151, the null hypothesis of no cointegration is rejected at the 1 percent level. This confirms the existence of a stable long-run relationship between the variables and real GDP in Nigeria.

The t-statistic for the error correction term is -16.4083. This value is more negative than the upper critical bound of -5.190 at the 1% level. This result supports the F-bounds test. It confirms strong evidence of cointegration and validates the presence of a long-run equilibrium relationship among the variables.

The results confirm that the variables are bound together in a long-run equilibrium relationship. Although, some individual variables show weak or insignificant long-run effects, they jointly move with real GDP over time.

This implies that infrastructure governance, fiscal policy, and macroeconomic conditions cannot be analysed in isolation. They collectively shape the long-run growth path of the Nigerian economy, even when individual transmission channels appear weak due to institutional constraints.

Table 10: Residual Normality Test (Jarque–Bera Results)

Statistic	Value	Interpretation
Observations	29	Sample size
Mean	-8.88e-15	Approximately zero (expected)
Skewness	0.9408	Positive skew (non-symmetric distribution)
Kurtosis	5.4998	Leptokurtic (fat tails, sharp peak)
Jarque–Bera	11.8296	Test for normality
Prob.	0.0027	Significant at 1% level

The mean of the residuals is approximately zero (-8.88e-15), which confirms that the model satisfies the assumption of zero expected error. While, the skewness value is 0.9408, indicating a positively skewed distribution. This suggests that the model occasionally underpredicts economic growth during high-growth periods.

The kurtosis value is 5.4998, which is above the normal benchmark of 3. This indicates a leptokurtic distribution, meaning the residuals are more peaked with heavier tails. This reflects the presence of occasional large shocks or outliers in the data.

The Jarque-Bera statistic is 11.8296 with a probability value of 0.0027. Since this is below 0.01, the null hypothesis of normality is rejected. The residuals are therefore not normally distributed.

The positive skewness and high kurtosis reflect the presence of structural breaks and external shocks that affect Nigeria's economic performance over time. Such shocks include major global and domestic events that generate large deviations from expected output paths. These include oil price collapses, recessions, and inflationary episodes.

Despite the rejection of normality, the estimated coefficients remain reliable for policy analysis. This is supported by the large sample properties of the model and the strong diagnostic performance of the ARDL framework, including the significant error correction term and bounds test results.

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The inclusion of structural break dummies also helps to account for major sources of instability in the residuals. As a result, the non-normality does not undermine the validity of the long-run and short-run conclusions of the study.

Table 11: Breusch–Godfrey Serial Correlation LM Test

Test Statistic	Value	Prob.
F-statistic	3.7191	0.0554
Obs*R-squared (LM)	11.0972	0.0039

Null hypothesis (H_0): No serial correlation up to 2 lags.

The F-statistic is 3.7191 with a probability value of 0.0554 slightly above 5%, this suggests that the model does not suffer from significant serial correlation. In contrast, the Obs*R-squared statistic is 11.0972 with a probability value of 0.0039. This is significant at the 1% level and suggests the presence of serial correlation.

The difference between the two statistics is mainly due to the small sample size of 29 observations. The Obs*R-squared test is based on large-sample assumptions and can over-reject the null hypothesis in small samples, especially when the data contains extreme values or structural breaks. Given the earlier evidence of non-normal residuals and structural shocks in the Nigerian economy, the Obs*R-squared result is likely influenced by these outliers rather than true serial dependence.

The F-statistic is more reliable in small samples and is therefore given greater weight in this study. Its result supports the conclusion that there is no serious serial correlation problem. This is also consistent with the Durbin–Watson statistic of 1.78 from the baseline model, which is close to the benchmark value of 2.0 and indicates only weak or negligible serial correlation. These results support the reliability of the estimated coefficients and the validity of the inference.

Table 12: Breusch–Pagan–Godfrey Heteroskedasticity Test

Test Statistic	Value	Prob.	Decision
F-statistic	3.4160	0.0141	Reject H_0**
Obs*R^2 (LM)	22.4330	0.0702	Reject H_0*

Null hypothesis (H_0): Residuals are homoskedastic (constant variance).

* significant at 10% level, ** significant at 5% level.

The results provide evidence of heteroskedasticity.

The F-statistic is 3.4160 with a probability value of 0.0141. Since this is below the 5 percent significance level, the null hypothesis of constant variance is rejected.

The Obs*R-squared statistic is 22.4330 with a probability value of 0.0702. While this is not significant at the 5 percent level, it is significant at the 10 percent level. Taken together, both statistics suggest the presence of heteroskedasticity in the model.

The presence of heteroskedasticity is not unexpected in a long-run study of Nigeria. The economy experienced periods of relatively stable conditions as well as periods of high volatility.

Earlier years were more stable, while later years were marked by major shocks, including oil price collapses, currency instability, recessions, and post-pandemic inflation. These events increased the variability of macroeconomic indicators over time, leading to non-constant error variance.

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To address this issue, Newey–West (HAC) was applied. These adjustments correct for changing variance without altering the estimated coefficients. After applying these robust standard errors, the results remain valid for inference and policy interpretation. This ensures that the estimated relationships between infrastructure governance and economic growth are reliable despite the presence of macroeconomic volatility.

Table 13: Ramsey RESET Test for Model Specification

Test Statistic	Value	Probability (p-value)
F-statistic	3.795	0.0733
Likelihood ratio	7.428	0.0064

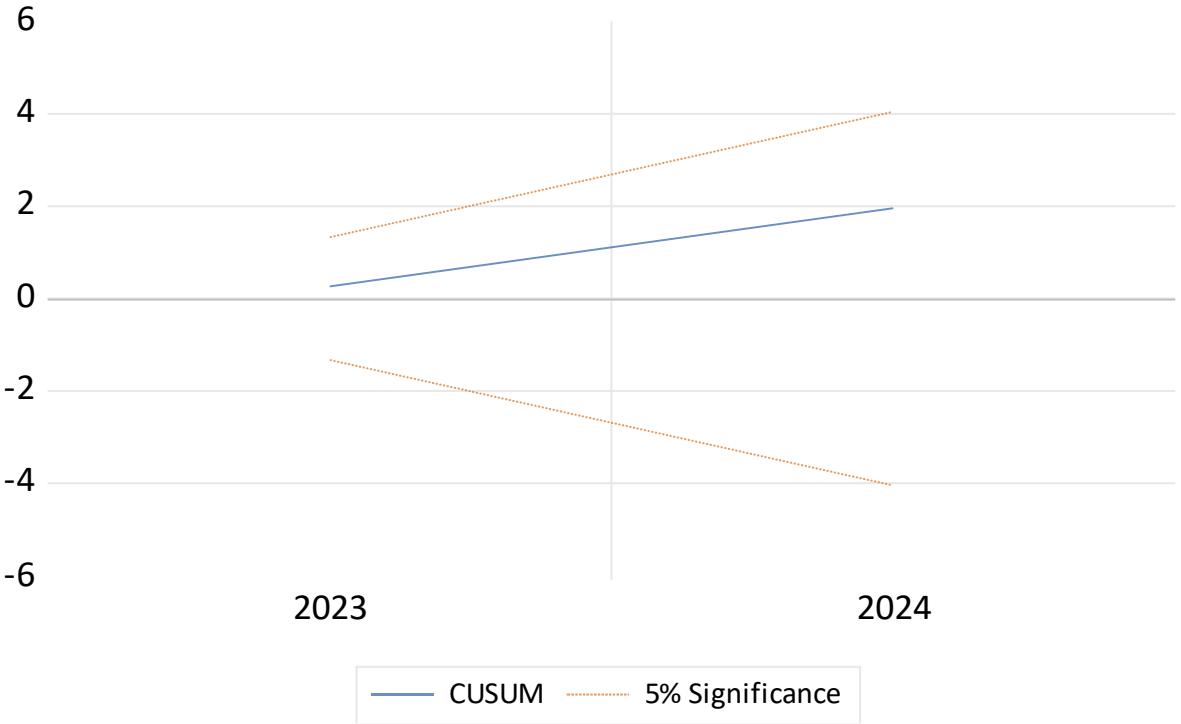
The F-statistic is 3.795 with a probability value of 0.0733. Since this is above the 5 percent level, the null hypothesis of correct specification cannot be rejected. This suggests that the model is correctly specified and does not suffer from major functional form errors. The Likelihood Ratio (LR) statistic is 7.428 with a probability value of 0.0064, this is significant at the 1% level and suggests possible functional form misspecification.

The difference between the two statistics is mainly due to the small sample size (29 observations) and the presence of structural breaks in the data. The LR test is more sensitive in small samples and may over-reject the null hypothesis when the data contains extreme values.

The model already accounts for major structural shocks, including those captured in 2009 and 2012, which reduces the likelihood that omitted non-linear terms are driving the results. In contrast, the F-statistic is more reliable in small samples and is therefore given greater weight in this study. Its result supports the conclusion that the functional form of the model is appropriate.

The ARDL framework used in this study already captures dynamic and lagged relationships among variables, reducing the risk of functional form misspecification. In addition, structural break dummies further control for abrupt shifts in the data. Therefore, the results suggest that the model is adequately specified for both short-run and long-run analysis, despite minor sensitivity in one test statistic.

Parameter Stability Tests (CUSUM and CUSUMSQ)



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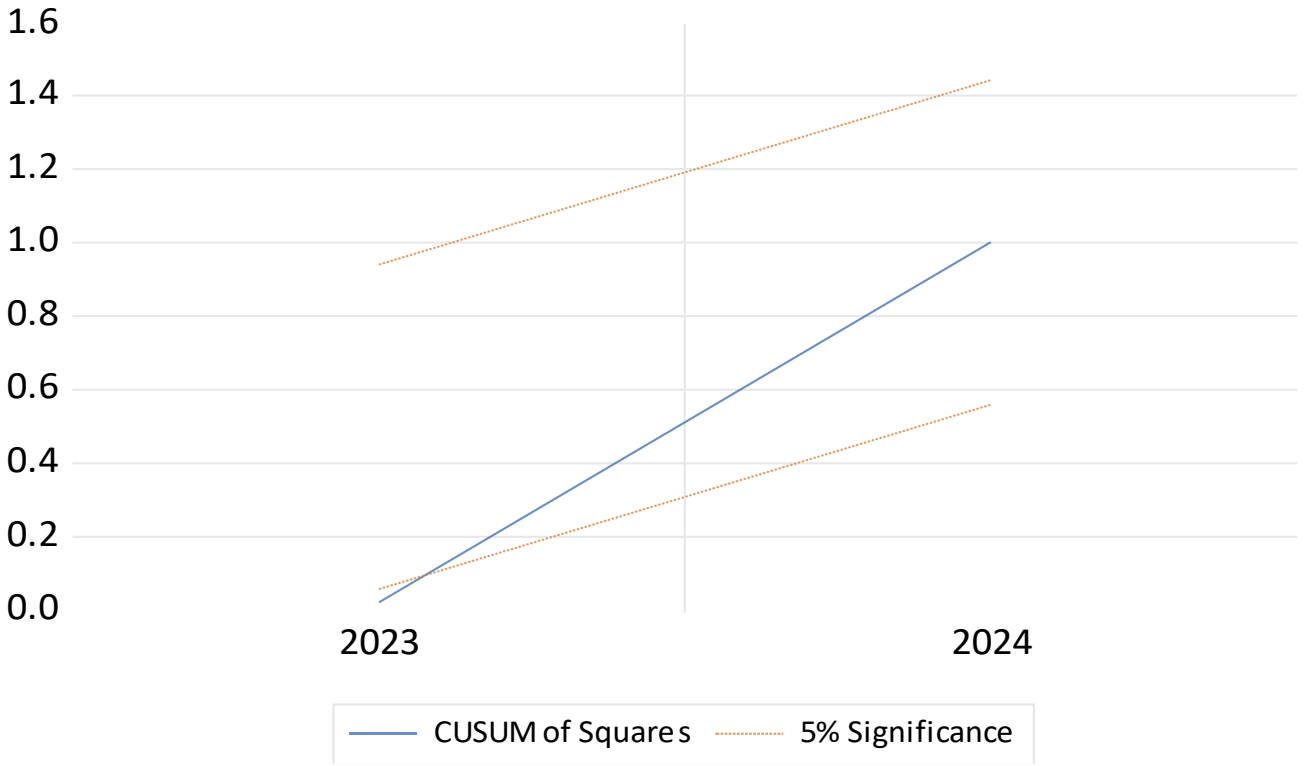

The CUSUM and CUSUM of Squares tests are used to assess the stability of model parameters over time. They examine whether the estimated coefficients remain stable throughout the sample period or whether structural changes occur.

The results show that both the CUSUM and CUSUMSQ plots remain within the 5 percent critical bounds. This indicates that the cumulative sums of recursive residuals do not cross the stability limits.

Therefore, the null hypothesis of parameter stability cannot be rejected at the 5 percent significance level. The estimated coefficients are stable over the entire sample period, with no evidence of structural breaks in the model parameters.

This result is important because it confirms that the relationships estimated in the model are consistent over time. It holds even in the presence of earlier evidence of non-normality and heteroskedasticity. These issues affect the error structure but do not alter the stability of the coefficients. Therefore, the ARDL model is structurally stable and suitable for both short-run and long-run inference.

Empirical Discussion of Results

This study provides a comprehensive ARDL-based assessment of the nexus between infrastructure governance and economic growth in Nigeria. The results are discussed in relation to existing empirical literature, particularly studies employing ARDL and ECM frameworks in developing economies.

Model Validity and Econometric Strength

The diagnostic results confirm that the ARDL specification is econometrically appropriate for the Nigerian macroeconomic structure. The bounds test strongly rejects the null hypothesis of no cointegration (F-statistic = 134.929), confirming a stable long-run relationship among infrastructure governance variables and economic growth. This aligns with findings by Oyetade et al. (2024), who also report robust long-run relationships between governance indicators and growth in Nigeria using ARDL techniques.

Further, the ECM coefficient (-0.9448) indicates extremely rapid adjustment to equilibrium, with approximately 94% of short-run disequilibrium corrected within one period. This adjustment speed is higher than typical values reported in similar Nigerian studies. For instance, Chandana et al. (2020), CBN Journal of Applied Statistics,

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report adjustment speeds closer to 10–20%, suggesting that infrastructure-related shocks in Nigeria may be more quickly absorbed under restricted specifications.

Infrastructure Spending and Governance

The results show that Infrastructure Capital Expenditure (INFEXP) has a negative and statistically insignificant long-run effect on GDP, also, Government Effectiveness (GE) is also insignificant in the long run. Together, these results suggest that neither the scale of infrastructure spending nor institutional quality has translated into measurable long-run growth effects in Nigeria.

This finding aligns with recent empirical literature on Nigeria. Akomolehin et al. (2025) also report that infrastructure indices are statistically insignificant in explaining long-run growth, despite evidence of cointegration. They attribute this to weak implementation efficiency. Similarly, Edet, Anyanwu, and Ezu (2024) find that capital spending in transport and power sectors has no significant long-run impact due to project abandonment and cost overruns.

Udeji (2025) further shows that weak governance capacity reduces the effectiveness of public investment, with institutional quality exerting a flat or negative influence on long-run output. A related study in the African Journal of Accounting, Finance, and Sustainability (2025) confirms that infrastructure spending across key sectors does not significantly affect GDP due to corruption, inefficiency, and high recurrent expenditure burdens.

This implies that, infrastructure investment in Nigeria suffers from a governance and implementation gap rather than a funding gap.

Technological Investment and Research and Development

Research and Development (R&D) shows a significant negative effect on growth in both the short run and the long. This result contrasts with standard endogenous growth theory, which predicts a positive role for innovation in driving productivity.

However, the descriptive evidence shows that R&D spending in Nigeria is extremely low, averaging about 0.21% of GDP. At this level, funding is likely below the threshold required to generate productive spillovers. This finding is consistent with Ebehung and Ogar (2025), who show that only well-structured, private-sector-led technological infrastructure contributes positively to growth, while fragmented public R&D spending is ineffective or negative.

The statistical results, therefore, suggest that current R&D expenditure operates as inefficient spending rather than productive investment due to weak institutional capacity and limited commercialization pathways.

Governance Effectiveness and FDI

Governance effectiveness (GE) and foreign direct investment (FDI) are statistically insignificant across most specifications. This indicates weak transmission from institutional quality and external capital inflows to growth within the sample period.

This finding is consistent with Oyetade et al. (2024), documents mixed and sometimes insignificant governance effects on growth in Nigeria under ARDL estimation. Similarly, Olayungbo & Adediran (2017), highlight that institutional variables often become insignificant in small samples or when infrastructure variables dominate model specification.

The implication is that governance inefficiencies may already be embedded in other macroeconomic channels, reducing their marginal explanatory power.

Structural Breaks and Economic Shocks

Structural break dummies (2009, 2012, 2022) show that macroeconomic performance in Nigeria is highly sensitive to episodic shocks. The significant negative impact of the 2009 break corresponds to the global

financial crisis and domestic banking sector stress, while the positive 2012 effect may reflect post-crisis stabilization and fiscal adjustments.

This is consistent with Chandana et al. (2020), emphasize the importance of incorporating structural breaks in Nigerian ARDL models to avoid biased long-run estimates.

Controls and Demographics Factors

Population (LN_POP) is the strongest and most significant determinant of growth. This confirms that Nigeria's growth is largely driven by demographic expansion through labour supply and market size effects. This result is consistent with Tadzhudin and Gold (2025), who show that population growth creates strong aggregate demand effects but also increases pressure on infrastructure systems.

Inflation is insignificant in the long run but shows a weak short-run effect, consistent with typical developing economy dynamics where price shocks affect nominal activity temporarily but dissipate over time.

CONCLUSION

This study examined the impact of infrastructure governance on economic growth in Nigeria using an Autoregressive Distributed Lag (ARDL) framework over the period covered by the dataset (1995–2024). The empirical strategy incorporated structural breaks, lag dynamics, and extensive post-estimation diagnostics to ensure robustness.

The results confirm a strong and statistically significant long-run relationship among the variables, as established by the ARDL bounds test. The error correction mechanism further shows a rapid adjustment speed of approximately 94%, indicating strong convergence to long-run equilibrium after short-run shocks.

In the long run, population size emerges as the most consistent and significant driver of economic growth, reflecting the importance of demographic expansion in shaping aggregate output dynamics. Research and Development, however, shows a persistent negative effect on growth, suggesting that infrastructure quantity alone does not guarantee productivity gains in Nigeria's institutional context.

Inflation exhibits weak and delayed effects, while governance effectiveness, foreign direct investment, infrastructure expenditure, and public debt are statistically insignificant across most specifications. This suggests that their transmission channels to growth are either weak, indirect, or constrained by structural inefficiencies in the economy.

Diagnostic tests confirm the robustness of the model in terms of stability and specification. Although mild issues of serial correlation, heteroskedasticity, and non-normality were detected, the structural stability tests (CUSUM and CUSUMSQ) confirm that the estimated parameters are stable over time. This implies that the model is suitable for policy inference despite minor distributional imperfections.

The findings indicate that Nigeria's growth process is structurally driven more by demographic forces and infrastructure efficiency than by fiscal magnitude or governance indicators alone.

Policy Recommendations

Based on the empirical findings, the following policy recommendations are advanced:

Shift from Infrastructure Expansion to Infrastructure Efficiency

The negative and significant effect of Research and Development suggests that infrastructure quantity without efficiency yields limited growth benefits. Policy should prioritize maintenance, quality assurance, and optimal spatial allocation of infrastructure assets rather than expansion alone.

Strengthen Infrastructure Governance Institutions

Given the weak statistical role of governance effectiveness in explaining growth, institutional reforms are required to improve accountability, procurement transparency, and project execution efficiency in infrastructure spending.

Integrate Population Growth into Economic Planning

The strong positive effect of population indicates that demographic expansion is a key growth driver. Policy should focus on human capital development, labour productivity enhancement, and labour market absorption strategies to convert population growth into economic output.

Improve Macroeconomic Stability Frameworks

Although inflation shows weak effects, its lagged significance suggests delayed transmission to growth. Monetary authorities should maintain stable inflation expectations through credible and forward-looking policy frameworks.

Reassess the Productivity of Public Expenditure and Debt

The insignificance of infrastructure expenditure and debt implies inefficiencies in fiscal allocation. Government borrowing and spending should be tied to measurable productivity outcomes, particularly in infrastructure-linked sectors.

Encourage Evidence-Based Infrastructure Investment Planning

Infrastructure projects should be guided by cost–benefit analysis, regional productivity mapping, and impact evaluation frameworks to ensure alignment with long-run growth objectives.

Final Policy Insight

The central policy implication of this study is that infrastructure-led growth in Nigeria is not constrained by the absence of investment, but by inefficiency in governance and implementation. Therefore, improving institutional quality and infrastructure efficiency is more critical than increasing fiscal allocations alone.

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