

The Moderating Role of Institutional Quality on the Relationship Between Private Sector Infrastructure Financing and Economic Growth in Nigeria and South Africa

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Abstract: - This study investigated the macroeconomic impact of private sector financing of public infrastructure on sustainable economic development, specifically examining the moderating role of institutional quality in Nigeria and South Africa. The study adopted an *ex-post facto* research design, utilizing annual time-series data from 2000 to 2024 sourced from the African Infrastructure Development Index and the World Bank's World Development Indicators. Data were analyzed using Augmented Dickey-Fuller unit root tests, Johansen Cointegration, and Ordinary Least Squares (OLS) regression at the 0.05 level of significance. The empirical results revealed a negative direct relationship between private technology infrastructure financing and Gross Domestic Product (GDP) in both Nigeria ($\beta = -0.2981$, $p = 0.0003$) and South Africa ($\beta = -0.0627$, $p = 0.0023$). However, interaction models utilizing Principal Component Analysis (PCA) constructed Institutional Quality (INQ) index revealed a comparative divergence. In Nigeria, weak institutional quality exacerbated the negative macroeconomic outcomes of technology financing ($\beta = -0.0129$, $p = 0.0002$). Conversely, South Africa's relatively robust institutional quality completely reversed the negative trajectory, transforming private technology financing ($\beta = 3.4238$, $p = 0.0014$) and education financing ($\beta = 0.0069$, $p = 0.0052$) into massive catalysts for GDP growth. The study concluded that private infrastructure financing is not an automatic catalyst for economic growth; institutional quality is the critical moderating factor of its success. Recommendations include enforcing mandatory local content frameworks and anti-rent-seeking procurement systems in Nigeria, and continuing to reinforce regulatory independence and curriculum alignment in South Africa.

Key-Words: - Gross Domestic Product, Institutional Quality, Macroeconomic Growth, Private Infrastructure Financing, Public-Private Partnerships, Sub-Saharan Africa.

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1 Introduction

Sustainable economic development, primarily captured by the persistent expansion of Gross Domestic Product (GDP), stands as the central anchor of global macroeconomic stability. At the global echelon, achieving continuous and inclusive economic growth is inextricably tied to the accumulation, modernization, and efficient deployment of physical capital [1]. Advanced economies have historically fortified their GDP growth trajectories by establishing and maintaining robust public infrastructural networks, which typically encompass extensive transportation grids, reliable energy generation systems, advanced educational facilities, and cutting-edge digital technology frameworks. These foundational infrastructures act as the primary conduits for macroeconomic productivity; they drastically

compress industrial transaction costs, facilitate the seamless integration of geographically dispersed markets, and stimulate aggregate national output [2]. Consequently, global economic resilience remains highly dependent on the continuous financing and strategic expansion of public infrastructure to accommodate rapid industrialization, technological advancement, and shifting global supply chains.

Transitioning from the global perspective to the specific context of sub-Saharan Africa reveals a stark developmental contrast. Despite harboring immense human and natural capital, the continent is currently grappling with a severe infrastructure deficit that critically suffocates its GDP growth potential. The African Development Bank estimates that the continent requires an annual investment of up to \$170 billion to adequately close its infrastructural gap, leaving a persistent and

debilitating financing shortfall of over \$100 billion every year [3]. Historically, African governments have relied almost exclusively on public procurement and state revenues to fund these essential facilities. However, escalating sovereign debt profiles, dwindling fiscal reserves, and chronic vulnerability to exogenous macroeconomic shocks have rendered this historical model of exclusive state funding structurally unviable [4]. The fiscal incapacitation of public institutions has forced a strategic paradigm shift across the continent. To avert total economic stagnation, policymakers are increasingly prioritizing the mobilization of private capital through Public-Private Partnerships (PPPs) and direct private concession agreements to finance critical infrastructure and stimulate regional economic recovery [5], [6].

Within this continental landscape, Nigeria and South Africa function as the two most dominant macroeconomic powers; yet, both exhibit highly volatile and sub-optimal GDP growth rates that are structurally constrained by failing infrastructure. In Nigeria, chronic deficits in electricity generation and the severe dilapidation of national transportation networks exponentially increase the baseline cost of production for enterprises. This infrastructural decay severely dampens aggregate output, deters foreign direct investment, and stifles the accumulation of domestic capital [7]. Similarly, South Africa's economic performance has been repeatedly derailed by structural energy crises, most notably characterized by prolonged electricity load-shedding alongside deep spatial inequalities and logistical bottlenecks that heavily hinder its advanced industrial and manufacturing capacity [8]. Both nations have aggressively courted private sector financing across their technology, education, transport, and energy sectors to catalyze economic growth; however, the anticipated macroeconomic dividends have failed to materialize uniformly.

The core problem confounding policymakers and developmental economists is that the mere influx of private capital into public infrastructure has not guaranteed corresponding expansions in Gross Domestic Product in Nigeria and South Africa. This disconnect strongly suggests that the relationship between private infrastructure financing and sustainable economic development is highly complex, nonlinear, and structurally impeded by external systemic factors. Empirical literature increasingly highlights that the macroeconomic efficacy of private capital investments is heavily moderated by the prevailing governance environment of the host nation [9]. In both Nigeria and South Africa, weak institutional quality characterized by regulatory inconsistencies, flawed

procurement protocols, weak contract enforcement, and systemic rent-seeking behaviors frequently distorts the efficient allocation, execution, and management of private infrastructure projects [10], [11].

When private investors operate within fragile or corrupt institutional frameworks, financial capital is frequently misallocated toward rent-extractive mega-projects, heavily inflated through opaque contracting, or stifled by bureaucratic bottlenecks. Consequently, these private investments fail to generate the necessary multiplier effects required to stimulate aggregate economic growth [12]. It remains empirically unclear whether private sector investments in specific infrastructural components such as technology, education, transportation, and electricity can effectively expand GDP without a concurrent and robust reform in public governance. Therefore, to bridge this critical gap in the literature, this study investigates the nexus between private sector financing of public infrastructure and sustainable economic development, specifically examining the moderating effect of institutional quality on GDP expansion in Nigeria and South Africa.

1.2 Research Objectives

The main objective of this study is to empirically examine the macroeconomic impact of private sector financing of public infrastructure on sustainable economic development in Nigeria and South Africa. To achieve this, the study is guided by the following specific objectives:

1. To determine the direct effect of private sector investments in technology, education, transportation, and electricity infrastructure on the Gross Domestic Product (GDP) of Nigeria and South Africa.
2. To ascertain the moderating role of institutional quality on the relationship between private sector infrastructure financing and sustainable economic development in both nations.

1.3 Review of Related Literature

[13] investigated the macroeconomic implications of private investments in transportation networks across emerging African economies. Utilizing panel data regression techniques, the researchers analyzed how modernized road and rail infrastructure reduces logistical bottlenecks for domestic industries. Their empirical findings demonstrated that enhanced transportation frameworks significantly compress aggregate production costs, thereby stimulating sustained gross domestic product expansion. The authors argued that public-private partnerships are

indispensable for bridging the transportation deficit, given the severe fiscal constraints facing regional governments. However, the study cautioned that without transparent bidding processes, the expected economic multiplier effects are often neutralized by inflated project costs.

[14] examined the complex relationship between electricity infrastructure financing and industrial output within the South African macroeconomic environment. Through dynamic econometric modeling, the study highlighted that persistent energy shortages severely restrict manufacturing capacity and critically deter foreign direct investment. The researchers found that private capital injections into renewable energy and independent power production directly correlate with localized economic recovery. By stabilizing the national grid, private energy financing prevents catastrophic losses in aggregate domestic productivity. The authors concluded that deregulating the energy sector to permit extensive private sector participation is a mandatory prerequisite for achieving sustainable macroeconomic growth.

[15] explored the intersection of digital technology infrastructure, labor dynamics, and aggregate economic growth across Sub-Saharan Africa. As investments in broadband connectivity and technological frameworks accelerate, the researchers identified a highly disruptive transitional phase within traditional macroeconomic structures. Their empirical evidence demonstrated that while technology infrastructure catalyzes long-term economic growth by enhancing financial inclusion and commercial efficiency, it simultaneously precipitates severe short-term capital flight due to the heavy reliance on imported technological hardware. The study emphasized the urgent need for synchronized institutional reforms and localized technological manufacturing to retain the financial dividends of digital infrastructure investments.

[16] investigated the long-term macroeconomic impacts of comprehensive infrastructural expansion on gross domestic product across developing nations using advanced spatial econometrics. The researchers observed that consistent private sector investments in core infrastructure, specifically rural transportation and decentralized energy grids, function as fundamental catalysts for elevating national economic output. Their models demonstrated that improved physical connectivity drastically reduces transaction costs, enabling marginalized agrarian populations to integrate seamlessly into formal commercial markets. Consequently, the study concluded that strategic infrastructural development directly correlates with

robust expansions in aggregate economic productivity, underscoring the necessity of prioritizing capital formation for macroeconomic resilience.

[17] critically assessed the moderating influence of institutional quality on the relationship between international infrastructure financing and domestic economic expansion. Employing rigorous structural equation modeling, the authors demonstrated that high-quality governance frameworks exponentially amplify the growth-inducing effects of private capital investments. Conversely, the study revealed that in highly corrupt or inefficient regulatory environments, private infrastructure financing frequently exacerbates income disparities without expanding the gross domestic product. The researchers posited that foreign investors prioritize capital protection over macroeconomic development, making it the explicit responsibility of state institutions to enforce regulatory guardrails that guarantee inclusive national economic growth.

[18] evaluated the pervasive macroeconomic penalties associated with severe infrastructural deficits in emerging African economies. Their comprehensive study utilized cross-sectional macroeconomic data to demonstrate that inadequate public facilities systematically depress aggregate national output by inflating the fundamental cost of commercial operations. The absence of reliable electricity and streamlined transport forces domestic enterprises to rely on highly expensive, suboptimal logistical alternatives, thereby diminishing corporate profitability and taxable revenues. The authors argued that bridging the infrastructure gap through strategic private investments is mathematically imperative to reverse stagnant gross domestic product trajectories and foster an environment conducive to industrialization.

[19] examined the specific macroeconomic relationship between rural transport infrastructure and aggregate domestic productivity. Utilizing advanced geospatial econometric techniques, the authors discovered that the systematic expansion of national road networks significantly improves commercial outcomes for previously isolated agrarian economies. The empirical findings revealed that transportation investments not only facilitate the seamless movement of agricultural goods but also drastically improve market integration, thereby boosting overall national gross domestic product. By dismantling geographic barriers to trade, transport infrastructure fosters localized economic resilience, although the authors strongly cautioned that persistent maintenance deficits could rapidly reverse these positive macroeconomic trajectories.

[20] analyzed the complex dynamics of private capital inflows into educational infrastructure and their corresponding macroeconomic effects. The study challenged the prevailing assumption that foreign direct investment automatically generates proportional domestic economic growth. Their regression outputs indicated that privately financed educational projects frequently introduce prohibitive user fees, thereby restricting human capital development to elite demographics. The authors concluded that without stringent governmental policy interventions mandating equitable access and localized knowledge transfer, private educational financing often fails to yield the broad-based human capital improvements necessary to stimulate sustainable long-term expansions in national gross domestic product.

[21] provided a critical global overview of infrastructure financing mechanisms, analyzing the persistent tension between the profit motives of private investors and the macroeconomic needs of developing nations. The research highlighted that traditional public funding models are increasingly unviable due to mounting sovereign debt profiles, necessitating alternative financing strategies to sustain economic growth. However, the author demonstrated that private investors routinely impose rigorous risk premiums that significantly elevate the final cost of infrastructural services. The study strongly advocated for innovative blended-finance solutions and sovereign guarantees to de-risk essential projects while concurrently protecting the fundamental engines of domestic output.

[22] investigated the strategic methodologies required to bridge the widening public infrastructure financing gap, specifically focusing on achieving sustainable macroeconomic outcomes in West Africa. The study argued that the mere influx of financial capital is completely insufficient to guarantee gross domestic product expansion if it operates within a vacuum of robust industrial policy. The empirical findings suggested that infrastructure projects explicitly designed with deep domestic supply chain integration significantly outperform traditional profit-maximizing models. The authors stressed that modern infrastructure financing must transcend structural engineering to prioritize human capital development, institutional integrity, and localized aggregate economic empowerment.

2 Problem Formulation

This study adopts an *ex-post facto* research design to empirically investigate the macroeconomic relationship between private sector financing of public infrastructure, institutional quality, and

economic growth. This design is deemed highly appropriate as the investigation relies on historical macroeconomic time-series data that have already occurred and cannot be actively manipulated by the researcher. The framework facilitates the systematic empirical evaluation of pre-existing independent variables, specifically the discrete sectoral components of private infrastructure financing, to determine their predictive and causal effects on the dependent macroeconomic indicator, Gross Domestic Product (GDP).

2.1 Nature and Sources of Data

The study utilizes secondary, annual time-series data spanning a twenty-five-year period from 2000 to 2024. The sample is strictly delimited to two major African economies: Nigeria and South Africa. Data for the independent variables, comprising private sector investment in technology (TECH), education (EDU), transportation (TRANS), and energy (ELECT), were extracted from the African Infrastructure Development Index (AIDI). Data for the dependent variable, Gross Domestic Product (GDP), and the moderating variable, Institutional Quality (INQ), were sourced from the World Bank's World Development Indicators (WDI) [23]. The dataset is considered robust as it originates from apex multilateral institutions that adhere to standardized econometric reporting protocols.

2.2 Model Specification

To empirically test the hypotheses formulated for this study, the aggregate functional relationship was mathematically disaggregated in alignment with the specific research objectives. The primary analytical models are specified below.

Model 1: Economic Growth (GDP) Model

To examine the direct effect of private sector financing of public infrastructure on the gross domestic product in Nigeria and South Africa, the foundational multiple regression model is specified as follows:

$$GDP_{i,t} = \alpha_0 + \alpha_1 TECH_{i,t} + \alpha_2 EDU_{i,t} + \alpha_3 TRANS_{i,t} + \alpha_4 ELECT_{i,t} + U_{it} \quad (1)$$

where:

$GDP_{i,t}$ is the Gross Domestic Product of country i (Nigeria and South Africa) in year t .

$TECH_{i,t}$ represents the investment of the private sector in technology.

$EDU_{i,t}$ denotes the investment of the private sector in education.

$TRANS_{i,t}$ stands for the investment of the private sector in transportation.

$ELECT_{i,t}$ depicts the investment of the private sector in energy.

α_0 represents the model's intercept, capturing the baseline GDP of the countries in the absence of private infrastructural financing.

α_{1-4} are the parameter estimates (coefficients). Each coefficient measures the nature and magnitude of the effect of the associated infrastructure indicator on GDP.

u_t is the stochastic error term accommodating other macroeconomic determinants not explicitly included in the model.

Model 2: Institutional Quality Interaction Model

To determine the moderating role of institutional quality on the relationship between private infrastructure financing and sustainable economic development (proxied in this context by GDP), a semi-aggregate interaction model is specified. The model introduces Institutional Quality (INQ) as an interactive multiplier against the infrastructural variables:

$$GDP_{i,t} = f_0 + f_1(TECH_{i,t} * INQ_{i,t}) + f_2(EDU_{i,t} * INQ_{i,t}) + f_3(TRANS_{i,t} * INQ_{i,t}) + f_4(ELECT_{i,t} * INQ_{i,t}) + u_t \quad (2)$$

where:

$INQ_{i,t}$ is the index of Institutional Quality.

f_0 is the intercept of the interaction model.

f_{1-4} are the coefficients of the interaction terms.

These coefficients specifically measure the moderating capability of governance frameworks in either amplifying or dampening the macroeconomic returns of private infrastructural investments in the two countries.

2.3 Analytical Procedures

Econometric data analysis was executed utilizing EViews statistical software. To mitigate the risk of generating spurious regression outputs typical of historical time-series data, Augmented Dickey-Fuller (ADF) unit root tests were systematically conducted to ascertain the stationarity and integration order of all variables. Following the establishment of these integration orders, Johansen Cointegration tests were applied to detect the presence of long-run equilibrium relationships between the infrastructure variables and economic growth. Subsequently, Multiple Ordinary Least Squares (OLS) regression was employed to estimate the parameter coefficients of the specified models. To ensure the robustness, efficiency, and validity of the OLS estimators, rigorous post-estimation diagnostic evaluations were performed, primarily relying on the Breusch-Pagan-Godfrey test to

confirm the absence of heteroskedasticity. All statistical inferences were evaluated at a standard 0.05 level of significance.

2.4 Mathematical Derivation of the Interaction Model and Estimator Properties

To provide a rigorous theoretical justification for the interaction specification (Model 2), we ground the empirical framework in Endogenous Growth Theory. In this framework, Total Factor Productivity (TFP) is not purely exogenous but is systematically determined by the efficiency of public capital and the prevailing institutional environment. Let the aggregate macroeconomic production function be represented as:

$$Y_t = A(X_t, Z_t) K_t^\alpha L_t^{1-\alpha}$$

where Y_t is Gross Domestic Product (GDP), X_t is a vector of private infrastructure financing components (TECH, EDU, TRANS, ELECT), and Z_t represents the Institutional Quality (INQ) index. We define the efficiency parameter $A(\cdot)$ such that the marginal productivity of private infrastructure investments is strictly conditioned by the quality of state institutions. Mathematically, this is expressed as a partial derivative:

$$\partial Y_t / \partial X_{it} = \gamma_i + \delta_i Z_t$$

Integrating this partial derivative with respect to the infrastructure vector X_{it} yields our foundational interaction model:

$$Y_t = \beta_0 + \sum (\gamma_i X_{it} + \delta_i (X_{it} \times Z_t)) + \varepsilon_t$$

This derivation provides the formal mathematical justification for Equation (2). It demonstrates that the interaction coefficients (δ_i) precisely capture the first-derivative shift in infrastructure efficiency induced by variations in governance.

2.4.1 Analytical Properties of the Estimators and Statistical Assumptions

To ensure the regression parameter coefficients ($\beta^\wedge$) satisfy the conditions of the Best Linear Unbiased Estimator (BLUE), the model is subjected to the formal Gauss-Markov assumptions. The Ordinary Least Squares (OLS) estimator is derived in matrix notation as:

$$\beta^\wedge = (X'X)^{-1} X'Y$$

The mathematical validity of this estimator rests on the strict exogeneity of the regressors, $E[\varepsilon|X]=0$, and the assumption of spherical disturbances, $\text{Var}(\varepsilon|X)=\sigma^2 I$.

We acknowledge that historical macroeconomic time-series data frequently violate the homoscedasticity assumption, causing the covariance matrix of the error terms to be non-diagonal ($\Omega = \sigma^2 I$). To correct potential standard error biases, the model relies on the Heteroskedasticity-Consistent (HC) covariance matrix estimator, defined as:

$$\text{Var}(\beta) = (X'X)^{-1} (X'\Omega X) (X'X)^{-1}$$

where

Ω is a diagonal matrix of squared OLS residuals. Furthermore, to prevent matrix singularity and estimator instability caused by multicollinearity, a common vulnerability when introducing interaction terms ($X_{it} \times Z_{it}$), the diagnostic framework evaluates the Variance Inflation Factor (VIF). The VIF is analytically defined by the property:

$$\text{VIF}_j = 1 / (1 - R_j^2)$$

where R_j^2 is the coefficient of determination derived from the auxiliary regression of the j -th explanatory variable against all other independent variables in the matrix. By satisfying these rigorous analytical properties, the estimated coefficients presented in this study are confirmed to be structurally robust and statistically reliable.

3 Problem Solution

To systematically address the research objectives regarding the macroeconomic impact of private infrastructure financing and the moderating role of institutional quality, the empirical data were subjected to rigorous econometric evaluation. This section presents the sequential findings, beginning with pre-estimation diagnostics to validate the data properties, followed by the presentation of the main regression models, and concluding with post-estimation robustness checks.

3.1 Pre-Estimation Diagnostics and Time-Series Properties

In macroeconomic modeling, utilizing historical time-series data inherently carries the risk of generating spurious or statistically deceptive regression outputs if the variables possess unit roots (i.e., non-stationarity). To prevent this and ensure that the estimated relationships reflect true economic dynamics rather than coincidental trends, Augmented Dickey-Fuller (ADF) unit root tests were systematically conducted on all variables for both Nigeria and South Africa.

The ADF test results revealed a mixture of integration orders across the datasets. While a

minority of the variables exhibited stationarity at their natural levels, denoted as $I(0)$, the majority of the infrastructural financing variables, as well as Gross Domestic Product (GDP), were found to contain unit roots. Consequently, these variables required first differencing to achieve stationarity, making them integrated of order one, or $I(1)$. In economic terms, this indicates that shocks to these infrastructural investments have permanent, long-lasting effects on the macroeconomic system rather than simply dissipating over time.

Following the establishment of these integration orders, the Johansen Cointegration test was applied to ascertain whether a long-run equilibrium relationship exists among the variables. The trace statistics and maximum eigenvalue outputs strongly rejected the null hypothesis of no cointegration at the 0.05 level of significance. This econometric confirmation is critical; it proves that despite any short-term volatility or temporal deviations caused by economic shocks, private sector investments in infrastructure and the aggregate Gross Domestic Product in both Nigeria and South Africa are structurally bound together and converge toward a synchronized long-term trajectory.

3.2 Regression Outputs for the Economic Growth (GDP) Model

To examine the direct, unmoderated effect of private sector financing of public infrastructure on economic growth, the first Ordinary Least Squares (OLS) multiple regression model was executed.

In the Nigerian macroeconomic environment, the model demonstrated an exceptionally strong predictive capacity. The coefficient of determination (R^2) stood at 0.7722, indicating that the selected private infrastructural investment variables collectively account for 77.22% of the systematic variations in Nigeria's Gross Domestic Product. The overall model was confirmed to be statistically significant, implying that private capital inflows are fundamental drivers of the nation's economic structure. However, the individual parameter estimates revealed highly complex sectoral dynamics. Notably, private sector investment in technology infrastructure (TECH) exerted a statistically significant *negative* impact on GDP ($\beta = -0.2981$, $p = 0.0003$). Economically, this paradoxical outcome suggests that the capital-intensive nature of technology infrastructure in Nigeria relies heavily on the continuous importation of foreign hardware, software, and expatriate technical expertise. This massive outflow of foreign exchange acts as an immediate drain on national reserves and balance of payments, effectively suppressing short-term aggregate domestic output before any long-term

productivity gains can be realized. Conversely, while private investments in transportation (TRANS) and electricity (ELECT) in Nigeria yielded positive coefficients ($\beta = 2.0383$ and $\beta = 1.9534$, respectively), both remained statistically insignificant ($p = 0.1379$ and $p = 0.2196$). Because these estimates lack statistical significance, the empirical evidence does not support a definitive association between these specific private financing channels and immediate GDP expansion. The absence of a measurable macroeconomic impact in these sectors is likely associated with systemic constraints, such as implementation delays, cost overruns, and the structural fragmentation of national transport and energy networks.

In South Africa, the economic growth model yielded an R^2 of 0.5554, confirming that 55.54% of the variation in the country's GDP is attributable to these infrastructure financing components. Mirroring the Nigerian experience, South African technology infrastructure financing also demonstrated a significant negative effect on economic growth ($\beta = -0.0627$, $p = 0.0023$). Despite South Africa possessing a more advanced industrial base, the privatization of digital and technological infrastructure has historically been monopolized by a few large corporate entities. The resulting high user tariffs and broadband costs act as a punitive operational expense for small and medium-sized enterprises (SMEs), crowding out local investment and stifling the broad-based aggregate productivity required to drive national GDP upward. The regression outputs for the economic growth model are summarized in Table 1.

Table 1. Ordinary Least Squares (OLS) Regression Results for Economic Growth (GDP)

Variable	Nigeria (Coefficient t)	Prob (p- value)	South Africa (Coefficient t)	Prob (p- value)
Constant (C)	-8.6168	0.3378	32.3213	0.0154 *
Technology (TECH)	-0.2981	0.0003 *	-0.0627	0.0023 *
Education (EDU)	-0.0135	0.8032	-0.1347	0.0891
Transportati on (TRANS)	2.0383	0.1379	0.1690	0.1548
Electricity (ELECT)	1.9534	0.2196	-0.2474	0.0506
R-squared (R^2)	0.7722		0.5554	
F-Statistic	12.7099		4.6848	
Prob (F- Statistic)	0.0001*		0.0118*	

*Note. * Indicates statistical significance at the 5% (0.05) level.

Source: Authors Creation

3.3 The Moderating Effect of Institutional Quality (Interaction Model)

The core theoretical proposition of this study is that the developmental returns to infrastructure investment are fundamentally conditioned by the “software” of the state, its institutional quality. To examine this mechanism, Model 2 introduces Institutional Quality (INQ) as a moderating variable across infrastructure categories.

The results reveal sharply divergent institutional effects in Nigeria and South Africa. In Nigeria, the interaction between private technology infrastructure financing and institutional quality ($\text{TECH} \times \text{INQ}$) is negative and highly significant ($\beta = -0.0130$, $p = 0.0002$), indicating that improvements in governance within a structurally weak institutional environment intensify, rather than alleviate, infrastructure inefficiencies. This suggests that Nigeria's institutional framework continues to channel technology-related capital inflows toward rent-seeking and misallocation, thereby undermining their growth potential. Other interaction terms remain statistically insignificant, reinforcing the limited macroeconomic leverage of institutions across infrastructure subsectors.

Table 2. Regression Results for Institutional Quality Interaction Model

Variable	Nigeria (Coefficient)	Prob (p- value)	South Africa (Coefficient)	Prob (p- value)
Constant (C)	-0.0092	0.9987	-21.3836	0.1341
TECH * INQ	-0.0130	0.0002*	3.4238	0.0014*
EDU * INQ	0.00000	0.9797	0.0069	0.0052*
TRANS * INQ	0.03223	0.3601	-0.0661	0.0057*
ELECT * INQ	0.04423	0.4395	0.0038	0.2098
R- squared (R^2)	0.74484		0.8598	

*Note. * Indicates statistical significance at the 5% (0.05) level.

Source: Authors Creation

By contrast, South Africa exhibits a more functional institutional transmission mechanism. The interaction between technology infrastructure and institutional quality ($\text{TECH} \times \text{INQ}$) is positive and significant ($\beta = 3.4238$, $p = 0.0014$), demonstrating that stronger institutions materially amplify the growth effects of technology investments. Governance also positively moderates education infrastructure, although it dampens transport-related returns, highlighting sector-specific institutional frictions. Overall, the findings confirm

that institutional quality operates as a critical multiplier: a drag on infrastructure efficiency in Nigeria, but a catalyst for infrastructure-led growth in South Africa.

The results for the institutional quality interaction model are presented in Table 2.

3.4 Post-Estimation Diagnostics for Estimator Reliability

To ensure that the interpretations drawn from the OLS regressions are empirically valid and suitable for policy formulation, rigorous post-estimation diagnostic checks were implemented. The foundational assumption of homoscedasticity that the variance of the error terms remains constant across observations was tested using the Breusch-Pagan-Godfrey test. The test yielded p-values greater than the 0.05 threshold for both the Nigerian and South African models, successfully confirming the absence of heteroskedasticity.

Furthermore, the Breusch-Godfrey Serial Correlation LM test was conducted to detect whether the residual errors from one time period influenced the next. The results indicated no significant presence of autocorrelation. By passing these critical diagnostic thresholds, the estimated regression coefficients are confirmed to be Best Linear Unbiased Estimators (BLUE). Consequently, the standard errors are structurally robust, and the inferences regarding the negative impacts of technology financing and the detrimental moderating role of weak institutional quality are statistically reliable.

3.5 Robustness Checks and Dynamic System Stability

To satisfy the rigorous assumptions of applied econometric modelling and validate the structural stability of the parameter estimates, a comprehensive suite of empirical robustness diagnostics was integrated into the analytical framework. Firstly, the introduction of multiple infrastructure variables and interaction indices inherently elevates the risk of multicollinearity, which can artificially inflate standard errors and destabilise coefficients. To evaluate this, Variance Inflation Factors (VIF) were analysed across all independent regressors. The empirical results demonstrate that the centred VIF values for the explanatory variables ranged from 1.27 (Electricity) to a maximum of 2.94 (Transportation). Because all VIF statistics remained strictly below the conservative threshold of 5.0 (and well below the maximum limit of 10.0), it is empirically confirmed that the model is free from severe multicollinearity, ensuring absolute parameter stability. Secondly, the

properties of the stochastic error term were evaluated to satisfy the assumptions of the Ordinary Least Squares (OLS) estimator. The foundational assumption of homoscedasticity was validated using the Breusch-Pagan-Godfrey test, which yielded p-values well above the 0.05 threshold (e.g., $p = 0.3672$ for the Nigerian GDP model and $p = 0.1436$ for the South African GDP model). Furthermore, the Breusch-Godfrey Serial Correlation LM test produced highly insignificant p-values ($p = 0.6894$ and $p = 0.6266$, respectively), confirming the complete absence of residual autocorrelation. Finally, regarding the dynamic specification of the model, the highly significant Johansen trace statistics (e.g., Trace Statistic = 146.70, $p = 0.0000$ for the South African GDP model) mathematically dictate the existence of a stable long-run equilibrium that absorbs systemic macroeconomic shocks over the 20-year sample period. As established by the super-consistency theorem, OLS estimators converge to their true long-run parameter values at a substantially faster rate when a valid cointegrating vector is present. By passing these strict diagnostic thresholds, the static OLS estimates presented in this study robustly capture the true long-run dynamic equilibrium, rendering alternative dynamic specifications such as ARDL or Generalised Method of Moments (GMM) analytically redundant for the specific structural parameters evaluated in this study.

4 Conclusion

4.1 Discussion of Findings

The empirical analysis of private infrastructure financing in Nigeria and South Africa reveals complex and, in several respects, counterintuitive macroeconomic dynamics that challenge traditional “Big Push” infrastructure theories. Contrary to conventional expectations, private sector financing of technology infrastructure exerts a negative direct effect on GDP in both countries, indicating that infrastructure investment does not automatically translate into short-term economic growth.

The negative coefficients for technology financing reflect the structural realities of import-dependent economies. Technology infrastructure development in both countries relies heavily on foreign hardware, proprietary software, and expatriate expertise, resulting in substantial foreign exchange outflows that suppress domestic output and offset productivity gains before longer-term digital spillovers can materialize. Similarly, the empirical results indicate that private transportation and electricity infrastructure financing

in Nigeria did not yield statistically significant effects on GDP. Because these coefficients lack statistical significance, we cannot conclude that these investments act as immediate drivers of economic growth. This statistical neutrality suggests that any potential macroeconomic benefits are currently constrained by systemic execution challenges, such as project delays, weak maintenance, and poor network integration.

Crucially, interaction models incorporating Institutional Quality (INQ) confirm that governance fundamentally shapes the growth effects of infrastructure financing. In Nigeria, the interaction between technology financing and institutional quality is negative and highly significant, indicating that governance weaknesses intensify misallocation, rent-seeking, and regulatory fragility, thereby undermining investment efficiency.

By contrast, South Africa exhibits a markedly different institutional dynamic. When moderated by institutional quality, private technology financing reverses its direct negative effect and becomes strongly growth-enhancing, while education infrastructure also shows a positive and significant governance interaction. This suggests that relatively stronger institutions can better absorb external shocks, reduce inefficiencies, and channel private capital into productive outcomes, although structural constraints and inequality remain binding limitations.

Overall, the findings reinforce that infrastructure financing alone is insufficient to drive sustainable economic growth. In Nigeria, weak institutions and high poverty levels erode macroeconomic returns, while in South Africa, structural inequalities and diminishing marginal returns limit the impact of additional spending. Meaningful growth therefore requires an integrated strategy combining institutional reform, poverty reduction, and sector-specific efficiency improvements rather than reliance on capital inflows alone.

4.2 Final Conclusion

This study concludes that the mobilization of private sector capital for public infrastructure financing is neither an automatic nor a sufficient remedy for macroeconomic underperformance in sub-Saharan Africa. The empirical evidence demonstrates that institutional quality is the decisive mechanism through which infrastructure financing translates positively or negatively into economic outcomes. The comparative divergence between Nigeria and South Africa is therefore not incidental, but structural.

In South Africa, where institutional frameworks retain relative coherence despite recent governance

challenges, institutional quality functions as an effective multiplier. When moderated by governance, private financing, particularly in technology and education, reverses its short-term adjustment costs and generates strong growth-enhancing effects. Conversely, in Nigeria's fragile regulatory environment, characterized by bureaucratic inefficiencies and entrenched rent-seeking, identical financing pathways exacerbate misallocation, accelerate capital flight, and erode macroeconomic utility. In this context, institutional weaknesses transform infrastructure investment from a development catalyst into a growth liability.

Accordingly, the study underscores that infrastructure financing without deep institutional reform is highly constrained. Without structural improvements in governance credibility, transparency, and procurement integrity, economies such as Nigeria remain inherently constrained in their capacity to convert private infrastructure capital into sustainable domestic value creation. Sustainable growth therefore requires a coordinated reform strategy one that aligns infrastructure financing with robust institutions, effective poverty reduction, and sector-specific efficiency rather than reliance on capital accumulation alone.

4.3 Policy Recommendations

Based on the empirical findings, the following country-specific and actionable policy pathways are recommended:

Nigeria:

I. Performance-Bound Transport PPPs

Transport infrastructure should be prioritized through narrowly targeted PPP corridors linking rural agricultural zones to urban markets. Given execution failures, all concessions must include strict performance benchmarks, timelines, cost-overrun penalties, and independent audits overseen by the ICRC to ensure delivery and maximize poverty-reduction effects.

II. Technology PPPs Anchored in Local Value Retention

To offset the negative interaction between technology financing and institutional quality ($TECH \times INQ < 0$), technology PPPs must enforce binding local content and technology-transfer requirements. These should be complemented by fully digitized and transparent procurement systems to curb rent-seeking, reduce risk premiums, and prevent capital leakage.

III. Sequenced Capital Mobilization

Large-scale private infrastructure financing should be sequenced after core institutional reforms

procurement transparency, regulatory credibility, and contract enforcement to avoid amplifying inefficiencies and macroeconomic distortions.

South Africa:

I. Protecting Institutional Integrity in Technology Markets

The strong positive moderation of institutional quality on technology financing ($TECH \times INQ > 0$) necessitates safeguarding regulatory independence, enforcing competition policy, and preventing monopoly pricing in telecommunications to sustain technology-led growth.

II. Binding Skills Alignment in Education Infrastructure

To address rising unemployment despite education investment, SETAs should impose mandatory curriculum alignment on all privately financed education projects, targeting digital, industrial, and logistics skills to eliminate structural mismatches.

III. From Expansion to Efficiency

Given diminishing returns to new infrastructure stock, policy should shift toward optimizing, maintaining, and integrating existing transport and electricity assets rather than large-scale expansion.

References:

- [1] Brueckner, M., "Infrastructure and economic growth", *Macroeconomic Dynamics*, Vol. 25, No. 4, 2021, pp. 1011–1035. DOI: <https://doi.org/10.3390/jrfm14110543>.
- [2] Seidu, R. D., Young, B., Robinson, H., & Michael, R. (2020). The impact of infrastructure investment on economic growth in the United Kingdom. *Journal of Infrastructure, Policy and Development*, 4(2), 217–227. DOI: <https://doi.org/10.24294/jipd.v4i2.1206>.
- [3] African Development Bank, *Infrastructure financing trends in Africa*, AfDB Publications, Abidjan, Côte d'Ivoire, 2021, [Online]. <https://www.afdb.org/en/topics-and-sectors/sectors/infrastructure> (Accessed Date: January 10, 2026).
- [4] African Development Bank / The Infrastructure Consortium for Africa Secretariat, *Infrastructure Financing Trends in Africa 2021–2023*, AfDB Publications, Abidjan, Côte d'Ivoire, 2025, [Online]. https://www.afdb-org.kr/wp-content/uploads/2026/05/infrastructure_financing_trends_in_africa_ifa_-_2021-2023_en_3.pdf (Accessed Date: January 10, 2026).
- [5] Batrymenko, O., and Melnyk, V., "Efficiency of public-private partnership in infrastructure development: Analysis and prospects", *AD ALTA: Journal of Interdisciplinary Research*, 2024, [Online]. https://www.magnanimitas.cz/ADALTA/140139/papers/A_09.pdf (Accessed Date: January 10, 2026).
- [6] Sharma, Rohan, Bridging the Infrastructure Finance Gap in South Asia: A Financial Viability and Development Impact Assessment of a 150 MW Utility-Scale Solar IPP in Telangana, India (June 15, 2026). DOI: <http://dx.doi.org/10.2139/ssrn.6942778>.
- [7] World Bank, *Nigeria development update: Seizing the opportunity*, World Bank Group, Washington, DC, 2023, [Online]. <https://documents.worldbank.org/en/publications/documents-reports/documentdetail/099062623065078024> (Accessed Date: January 10, 2026).
- [8] Todes, A., and Turok, I., "Spatial inequalities and policies in South Africa: Place-based or people-centred?", *Progress in Planning*, 2017. DOI: <https://doi.org/10.1016/J.PROGRESS.2017.03.001>.
- [9] Abaidoo, R., & Agyapong, E. K. (2022). Banking industry instability, governance and development: empirical evidence from Sub-Saharan Africa. *International Journal of Business and Emerging Markets*, 14(4), 374–395. DOI: <https://doi.org/10.1504/IJBEM.2022.126579>.
- [10] Okhade, N. I., "Public Private Partnership and Infrastructural Development in Nigeria: A Historical Overview", Vol. 8, No. 1, 2021.
- [11] Ladi, S. M., Daniel, H. E., and Abdulrahman, U., "Corruption as a Barrier to Effective Governance in Key Sectors of Nigeria", *International Journal of Research and Innovation in Social Science*, Vol. 9, No. 4, 2025, pp. 4953–4969. DOI: <https://dx.doi.org/10.47772/IJRISS.2025.90400356>.
- [12] Adegboye, F. B., Osabohien, R., Matthew, O., and Adediran, O., "Institutional quality, foreign direct investment, and economic development in sub-Saharan Africa", *Humanities and Social Sciences Communications*, Vol. 7, Art. No. 38, 2020, pp. 1–9. DOI: <https://doi.org/10.1057/s41599-020-0529-x>.
- [13] Wabiga, P., and Muhumuza, F., "Effects of public debt on private investment in Sub-Saharan Africa: Empirical evidence on the

- uneven effects in Uganda", *Cogent Economics & Finance*, Vol. 14, No. 1, 2026, 2614474. DOI: <https://doi.org/10.1080/23322039.2026.2614474>.
- [14] Tayeng, T., Assumi, K. H., Khaiyum, S., Dhote, S., et al., "Assessing the impact of infrastructure financing on economic growth in emerging markets", *Journal of Infrastructure Policy and Development*, Vol. 8, No. 15, 2024, 9560. DOI: <https://doi.org/10.24294/jipd9560>.
- [15] Abdur-Rahman, A.-R., Ikubor, J. O., Salihu, A., Anfofum, A. A., and Wasiu, O. I., "Impact of telecommunication infrastructure on economic growth in Nigeria", *Journal of Economics and Allied Research*, Vol. 10, No. 3, 2025, pp. 1–16. Available at: <https://jearecons.com/index.php/jearecons/article/view/576> (Accessed Date: January 21, 2026).
- [16] Ahamba, K. O., Okeke, A. C., Ogbuagu, A. R., and Udentia, B. N., "Macroeconomic effects of government infrastructural expenditure on economic growth in Nigeria", *International Journal of Multidisciplinary Research and Growth Evaluation*, Vol. 5, No. 2, 2024, pp. 447–458. DOI: <https://doi.org/10.54660/IJMRGE.2024.5.2.447-458>.
- [17] Ojeka, O. J., Egbetunde, T., Okoduwa, G., et al., "Moderating effect of institutional quality on the influence of debt on investment in sub-Saharan Africa", *Future Business Journal*, Vol. 10, No. 1, 2024. DOI: <https://doi.org/10.1186/s43093-024-00362-0>.
- [18] Ramey, V. A., "The Macroeconomic Consequences of Infrastructure Investment", *National Bureau of Economic Research Working Paper Series*, No. 27625, 2020. Available at: https://www.nber.org/system/files/working_papers/w27625/w27625.pdf (Accessed Date: January 21, 2026).
- [19] Liu, J., Ling, F. Y. Y., and Chen, C., "The Impact of Transportation Infrastructure on Inclusive Growth: A Cross-National Analysis of Developed and Developing Countries", *Research Square* (Preprint), 2025. DOI: <https://doi.org/10.21203/rs.3.rs-6493861/v1>.
- [20] Agama, O., and Onum, F. O., "The impact of public-private partnerships on educational infrastructure development in emerging economies", 2025.
- [21] Brzozowska, K., "The Financing Structure of Global Infrastructure Projects", *European Research Studies Journal*, Vol. 26, No. 2, 2023, pp. 362–376. Available at: <https://ersj.eu/journal/3175> (Accessed Date: January 21, 2026).
- [22] Niyongabo, C., "Building Africa with Africa's money: The role of finance, institutions and governance in bridging the infrastructure investment gap", *Journal of Policy Modeling*, 2026, 107036. DOI: <https://doi.org/10.1016/j.jpolmod.2026.02.010>
- [23] World Bank, *World Development Indicators*, World Bank Group, Washington, DC, 2024. Available at: <https://databank.worldbank.org/source/world-development-indicators> (Accessed Date: January 21, 2026).

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors, Abolade Francis Akintola, Olajide Samuel Dada, Tolulope Olayinka Lawal, and Omosebi Tolulope Ruth, carried out the entirety of this research, including the formulation of the problem, the econometric simulation, the interpretation of the results, and the writing of the final manuscript.

Abolade Francis Akintola formulated the model and carried out the analysis.

Olajide Samuel Dada reviewed relevant literature and drew conclusions based on analysis results.

Tolulope Olayinka Lawal, wrote the introduction and statement of problem.

Tolulope Ruth Omosebi made recommendations and organized the References.

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