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TRENDS AND DETERMINANTS OF PRIVATE SECTOR PARTICIPATION IN INFRASTRUCTURE DELIVERY IN NIGERIA'S PPI PROJECTS

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Abstract. This paper examines trends and factors that have influenced private-sector investment in infrastructure projects in Nigeria between 1990 and 2023. Despite growing interest in public–private partnerships (PPPs), private investment remains uneven across sectors such as transport, energy, information and communication technology (ICT), and municipal solid waste. Using project-level data from the World Bank's Private Participation in Infrastructure (PPI) database, the paper applies Ordinary Least Squares (OLS) and Quantile Regressions (QRs) to estimate the reasons behind the current investment level. The results suggest that ICT projects are not receiving significant investment, particularly on a small or medium scale, indicating sector-specific or constrained risks. Conversely, foreign sponsors are associated with higher investment values, though this only becomes apparent in large projects. Quantile regression further highlights the heterogeneous effects across the investment distribution. There are no consistent effects on multilateral support or on the type of project, such as Greenfield projects. These findings emphasise the necessity of targeted policy measures to encourage private investment in the ICT sector, which has historically experienced lower investment levels, and the requirement for more nuanced infrastructure planning approaches that consider project size diversity. The use of bootstrapped quantile regressions also helped to ensure robustness despite the small sample size of the projects. This research will be useful for policymakers, investors, and development financial institutions interested in investing in infrastructure in Nigeria.

Keywords: private sector investment, PPPs, ICT, foreign sponsors, multilateral support, infrastructure finance.

JEL Classification: E22, F55, O18, O33

1. Introduction

Infrastructure plays a critical role in economic development, particularly in developing countries. In Nigeria, however, the potential of infrastructure to support growth is limited by major deficits in key sectors such as transport, energy, water, and ICT (Akuesodo, Okonkwo, Okaro & Okoye, 2023). Despite the introduction of policy reforms and an increase in donor funding, public financing has proven to be inadequate on its own (Okolie & Edo, 2023). However, efforts have been made over the years to mobilise privately owned capital through public-private partnerships (PPPs) and other forms of private participation in infrastructure (PPI). While these mechanisms have shown promise in other parts of the world, the situation in Nigeria has been different (Nwangwu, 2021). Private Participation in Infrastructure (PPI) is defined as an arrangement in which the private sector is contracted to finance, build or operate publicly owned infrastructure assets (Wu, 2024).

The 2024 report from Nigeria's National Planning Commission indicates that the country has been experiencing a significant infrastructure financing gap, currently estimated at over 100 billion USD. Consequently, the country is unable to finance essential infrastructure projects using state funds alone (Alamu, Hassan, Asa & Odunayo, 2024). Consequently, this has been demonstrated to stifle economic productivity, increase the cost of doing business, and stymie attempts to realise national and continental development plans and visions, such as Vision 2050 and the African Union Agenda 2063 (African Development Bank, 2023). Consequently, projects frequently encounter delays, face insufficient funding, or are abandoned (Acquah, 2022; Buertey, Atsrim, Boateng, Brace, & Aaron, 2024).

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Furthermore, the delivery of services is jeopardised, and infrastructure remains in a state of disrepair (Mazele & Amoah, 2022).

The ramifications of this financing discrepancy are far-reaching. It is important to note that this problem is relevant to a variety of different stakeholders, including government implementing agencies, local communities reliant on infrastructure services, private investors seeking bankable projects, and development finance institutions (Bolomope, Baffour Awuah, Amidu & Filippova, 2021). While this phenomenon is predominantly observed in Nigeria, it is also part of a broader pattern in Sub-Saharan Africa, where private investments tend to concentrate on a select few sectors and countries (Adeosun, Orisadare, Fagbemi, & Adedokun, 2021; Mundonde & Makoni, 2023). It is imperative to acknowledge that the issue has deteriorated substantially since the early 2000s, coinciding with the decline in oil revenues and the escalation of fiscal constraints (Hernandez et al., 2022).

Despite these challenges, the coexistence of PPP policies and institutional reforms, including the establishment of the Infrastructure Concession Regulatory Commission (ICRC), has yet to yield consistent investment patterns across sectors. For instance, the fields of energy and ICT have been successful in attracting the attention of the private sector. However, other areas, such as water and municipal waste management, have not been able to mobilise sufficient capital (ICRC, 2022). According to recent literature, project attributes, including the sponsor's origin, the type of contract, and multilateral support, have the capacity to affect investment outcomes (Arazu & Lusty, 2023). Nevertheless, to date, these models have not been empirically evaluated in the Nigerian context, employing quantitative and project-level data.

In light of the aforementioned challenges, the objective of this study is to ascertain the factors that influence the magnitude of private sector investment in infrastructure projects in Nigeria. Despite the general consensus on the significance of evaluating the role of private capital, there is a paucity of empirical research at the individual project level aimed at identifying the factors influencing investment decisions (Chinzara, Dessus, & Dreyhaupt, 2023).

In consideration of the aforementioned context, the present study has two primary objectives. Firstly, the study aims to analyse trends in private sector participation (PSP) in Nigeria's infrastructure projects between 1990 and 2023. Secondly, the study aims to examine the project-level characteristics, such as project type, source of the sponsor, sector, and multilateral assistance, and their interaction with the magnitude of private investment.

In order to address these objectives, the study is informed by four research questions. The initial research question can be linked to the first question: What major trends have been observed in the involvement of the private sector in Nigerian infrastructure projects between 1990 and 2023? The second objective has the following research questions: What kinds of projects, such as Greenfield and Brownfield, interest private investors more in Nigeria? What impact does the origin of sponsors and multilateral support have on investment outcomes in infrastructure projects? What effect do sectoral patterns (such as energy, transport, ICT and water) have on determining the size of private investment? Is the impact of foreign sponsorship on the level of private investment influenced by the existence of multilateral support?

This study addresses these questions and makes a significant contribution to infrastructure finance literature in three ways. The main contributions of this study are consistent with its aims and research design. Firstly, it provides a quantitative analysis of the private sector's involvement in Nigerian infrastructure projects. This is achieved by drawing on project-level data from the World Bank's PPI database, thus achieving Objective 1. Secondly, Ordinary Least Squares (OLS) and Quantile Regression models are employed to evaluate the impact of project characteristics on the outcomes of investment projects of different sizes, thus directly addressing Objective 2. Thirdly, the study analyses empirical data on sector-specific and sponsor-related investment trends. This provides policy-relevant information that can be used to formulate specific interventions to attract the necessary funds to underfunded infrastructure sectors.

Within this empirical and policy framework, the research contributes to the existing body of literature on infrastructure finance by providing empirical evidence based on disaggregated Nigerian data. More precisely, the article aims to analyse trends and the factors influencing private investment in infrastructure construction in Nigeria using data from over 140 projects funded between 1990 and 2023. This can provide policymakers, investors and development institutions with valuable insights as they seek to transform the country's PPP and infrastructure financing. Lastly, the findings clarify which structural and institutional preconditions are more appealing to investors.

2. Literature Review

2.1 Theoretical Foundation

This paper is underpinned by three theoretical frameworks that offer a systematic explanation of why investors in the private sector are attracted to infrastructure projects: the theory of public goods, the theory of agency and the theory of institutional voids. Each theory offers a unique yet simultaneous

perspective on the factors influencing private investment in Nigerian infrastructure.

Firstly, the theory of public goods provides a rationale for why infrastructure should be perceived as a matter of governmental interest due to its non-excludability attribute, positive externalities, and high fixed costs (Khair, Hashim, & Anagnostopoulou, 2021). The aforementioned characteristics of the market have a deleterious effect on the provision of infrastructure services. This phenomenon is analogous to the Nigerian context, where the state has historically been compelled to engage with private entities in order to fulfil fundamental infrastructure requirements (Cahyadi, 2024). The present study is founded upon the principles of public goods theory, which posits that specific sectors, such as water and transportation, require policy support to attract private capital.

Secondly, in the context of PPP arrangements, where the government assumes the principal role and the private investor functions as the agent, the dynamics of such interactions can be elucidated through the lens of agency theory. The theory posits that well-designed contracts have the capacity to balance competing interests, mitigate opportunism and successfully share risk among the two parties (Barbir, 2021). The current state of the theory in this study highlights the implications of origin variables, such as the sponsor's origin and whether the project is Greenfield or Brownfield, as well as the project structure based on various institutional and contractual arrangements that can influence investment outcomes (Demirel, Leendertse & Volker, 2022; Opara & Ozor, 2023).

Thirdly, the theory of institutional voids is employed to explain market-based investment restrictions in environments with weak institutions. This theory highlights the lack of legal system development, weak regulatory implementation, and fragmented financial markets as factors that deter private participation (Matus-Ruiz, Saka-Helmhout & Carillo, 2025). In Nigeria, policy disagreements represent institutional voids, an inability to be creditworthy and vulnerabilities in enforcement (Akang, 2023; Randa, 2025). These risks are generally mitigated by multilateral engagement, as evidenced by the provision of guarantees, co-financing, or technical standardisation (Bazbauers & Engel, 2021). This is identified as the expository variable in the study.

The three aforementioned theories, when considered collectively, form the conceptual foundation of the study. The theory of public goods posits the necessity of infrastructure to be supported by collective action and government assistance. Agency theory elucidates the manner in which characteristics of sponsors and contract agreements influence the flows of investments. Institutional voids theory rationalises the potential of multilateral institutions to fill in policy and market gaps. These theoretical assumptions inform the choice and interpretation of the variables used in the study's empirical model.

2.2 Empirical Literature

At a global level, private participation in infrastructure (PPI) has become a key policy instrument for filling public investment gaps, particularly in capital-intensive sectors such as energy, transport, and ICT. Dugal and Tiwari (2024) also state that the Build-Operate-Transfer (BOT) model is the most commonly used PPI model and performs exceptionally well in environments with well-defined legal structures, proper risk allocation and government support. The models usually rely on efficiency improvements and the mobilisation of off-budget finance in order to deliver public infrastructure.

Building on this, there are also empirical studies that emphasise the importance of project-level attributes in determining investment patterns. According to Yregal (2025), macroeconomic stability, contract enforcement and sector regulation are powerful indicators of whether a developing country will invest in private infrastructure. Casalini, Gatti and Vecchi (2025) also highlight that infrastructure systems involving natural monopolies or cash flow uncertainties are not appealing to private investors unless they are strongly guaranteed or even subsidised.

Moreover, recent attempts utilising disaggregate data have substantiated that foreign sponsorship and multilateral backing substantially impact the magnitude and sustenance of private investment. Fleta-Asin and Munoz (2021) posit that projects involving multilateral agencies are more likely to attract larger and more diverse private investments due to their high credibility. However, it should be noted that such advantages are contingent on the specific type of sector and institutions in the host country. It is noteworthy that they have played an even more pivotal role in sub-Saharan Africa, where they have stabilised what Mayfield, Punzo, Beasley, Clarke, Holt and Jobbins (2023) term the infrastructure trilemma of affordability, quality and sustainability.

In the African context, African risks are significantly limited due to regulatory fragmentation, the number of bankable projects being low, and the existence of a perceived risk (Zattler, 2024). In the context of Sub-Saharan Africa, the concentration of PPI is observed to be focused on a limited number of sectors, predominantly energy, and within a select group of countries, namely South Africa and Nigeria, as noted by Lee and Cardenas Gonzalez (2022). This phenomenon has been attributed, in part, to the inequitable capabilities of nations in the areas of de-risking projects and the deployment of PPP frameworks.

In Nigeria specifically, a great deal of literature has been written on descriptive evaluation or general policy analysis. For instance, ICRC's (2023) reports

note that despite the introduction of numerous PPP reforms in Nigeria, only a few projects have achieved financial closure. Mark (2024) asserts that political risk, the slow pace of project approval, and inadequate institutional frameworks are key factors discouraging the private sector from participating in Nigerian infrastructure projects.

Moreover, sector-specific studies demonstrate a difference in the mobilisation of private capital. As Nyamkure (2022) notes, sectors such as water and sanitation have not attracted significant investment because electricity, ports and ICT are considered more bankable and have clearer revenue models. Lisinge and van Dijk (2022) also emphasise the importance of project structuring (first-time versus repeat) and sponsor composition (foreign versus domestic), both of which have a critical impact on funding outcomes.

Despite the existence of these insights and the size of the PPI portfolio in Nigeria, no rigorous empirical work has been conducted that employs project-level information and collectively tests the impact of investment determinants, such as the type of project, the presence of a foreign sponsor or multilateral funding, on the level of investment. Much of the existing literature is based on aggregate or policy-level analysis, providing little detail on valuable differences in project scale, industry, and institutional arrangements.

In light of the aforementioned context, a comprehensive review of the extant literature pertaining to private investment in Nigeria discloses several limitations that necessitate further academic research. Firstly, although a number of studies have previously identified a set of potential determinants of private investment, there remains a significant lack of empirical research investigating these determinants in the context of Nigeria, particularly concerning project-level empirical data and a robust econometric approach. Secondly, the prevailing standard of aggregated national or sectoral information obscures crucial variations between projects, particularly with regard to deviations in the magnitude of the commitment, investor identity, and involvement of multilateral partners. Such methodological weaknesses impede the capacity to attain profound insight into the dynamics of investments. Thirdly, the extant literature has relatively ignored advanced econometric methods, including quantile regression, that have the potential to inform a deeper understanding of circumstances in which investment drivers have different project sizes. The absence of these modes of analysis hinders the differentiation between aspects that affect small-scale investments and large-scale mega-projects. The identification of these gaps would facilitate the development of theoretical perspectives and evidence-based policymaking in this area.

It is evident from the findings of this research that there is an urgent need for econometric analysis of private investment in infrastructure at the project level in Nigeria in order to address these gaps. Utilising a log-linear and quantile regression model to analyse a cleaned data sample of over 140 PPI projects, this research will contribute to the existing literature's void in terms of both empirical and methodological aspects, providing useful information to policymakers and investors.

2.3 Conceptual Framework

The conceptual framework employed in this paper is predicated on institutional economics, infrastructure finance and risk-sharing theory. The objective of this study is to ascertain the factors that influence the extent of privately funded investment in infrastructure projects in Nigeria. To this end, the study will consider both infrastructure-specific factors and sector-wide or sponsorship factors.

The amount of private investment in a project is central to the framework, and is measured in terms of the natural logarithm of the investment value. The outcome of this process is likely to be influenced by a number of factors.

The initial consideration is the nature of the project. Greenfield projects, defined as the construction of new infrastructure, are characterised by a heightened risk profile and a greater capital intensity. These risks have the potential to either deter or appeal to potential investors, thereby influencing the levels of investment.

Furthermore, the provenance of the project sponsorship is of consequence. The presence of foreign sponsors could result in increased investment due to their superior financial capabilities, experience, and international reputation. It may also be interpreted as an indication of the confidence felt by other investors in their participation.

In addition, multilateral financing from institutions such as the World Bank or the African Development Bank can enhance a project by mitigating perceived risk through co-financing, guarantees or technical assistance. This can potentially increase investment, particularly when the assistance is accompanied by foreign sponsorship.

Another critical factor to consider is the sector in which the project operates. Different sectors, such as energy, transportation and ICT, have different levels of market risk, regulatory clarity and cost recovery regimes. For example, ICT sector projects may receive less investment from the private sector due to the high rate of technological change, the difficulty of quantifying assets, and the inability to attribute revenue to specific projects.

The analysis also takes into account the general improvement in policy and economic conditions over the study period by incorporating a time trend.

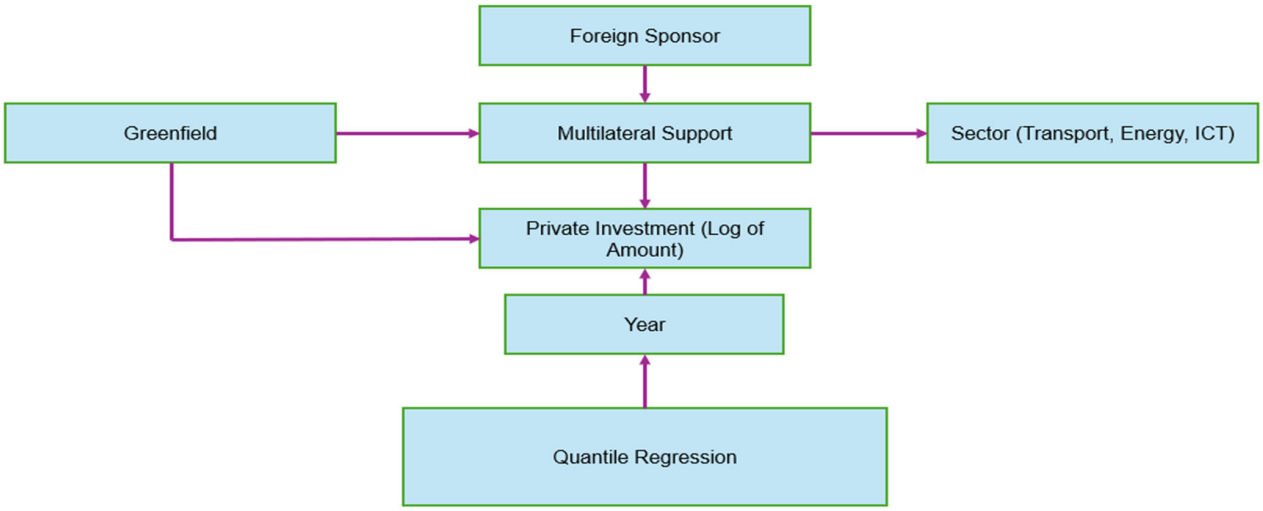

Figure 1. Conceptual framework of the study

Ultimately, the interaction between these factors and investments may differ from project to project. Some considerations may be necessary for small projects, while others are of extraordinary importance for large projects. To capture this variation, the study uses quantile regression to examine outcomes at low, medium and high levels of investment rather than taking an average.

This notion is illustrated in Figure 1 above, which demonstrates how the structural design of a project, the source of its sponsor, the presence of multilateral assistance, the type of sector, and time are likely to affect investment by quantiles.

3.0 Research Methods

3.1 Research Design

The present study employs a quantitative and cross-sectional design, drawing upon project-level data on infrastructure investments in Nigeria between 1990 and 2023. The dataset is cross-sectional, comprising individual observations for each project. However, given that each project is captured in the year in which the project's financial close is recorded, the dataset may be stated more accurately as a cross-sectional dataset with a time control. Including a Year variable does not establish a panel structure, since projects are not repeated across different years. However, it does enable the model to account for changes in investment levels over time that may be associated with other macroeconomic or policy conditions.

The analysis is informed by a positivist research philosophy, as the research aims to discover observable and measurable relationships between investment amounts and project features.

A combination of descriptive statistics and econometric modelling was adopted to investigate investment trends and the factors that determine investment. Multiple regression techniques were employed to deliver reliable results concerning both the average and distributional impacts. This is crucial in the context of infrastructure data, given that project sizes and financing scales can vary considerably.

3.2 Data Source and Variable Construction

This study's data set relies on the Private Participation in Infrastructure (PPI) database, which was provided by the World Bank and summarises comprehensive information on infrastructure projects that achieved financial close in Nigeria between 1990 and 2023. Of the 140 projects, 60 (42 per cent) passed the cleaning process, with those lacking substantial data on key variables and missing investment data being eliminated. The relatively large turnover of 80 out of 140 projects, representing 58 per cent, was primarily caused by incomplete reporting of the required financial information in the World Bank PPI database. Specifically, several projects lacked quality data on the total amount of private investment, the sponsor's origin, and the industry. Projects lacking this information were excluded because these variables were key components of the econometric specification; inclusion would have introduced bias into the regression or distorted the outcomes (Wooldridge, 2020). The omission of these projects ensured the internal consistency and comparability of the variables. While this loss could be considered an example of selection bias, the remaining sample of 60 projects is representative of the full range of sectors and time periods covered by the database. Therefore, both sectoral and temporal heterogeneity were maintained. The chosen period (1990–2023) is based on records from the World Bank's Private Participation in Infrastructure (PPI) database for Nigeria. This database

lists all infrastructure projects that reached financial close during this period. Data first became available in 1990, which is the earliest year for which there is a constant and internationally comparable series. The latest reporting year is 2023.

Dependent Variable:

Investment. Total private investment in USD per project, log-transformed to rectify skewness and facilitate the interpretation of coefficients in percentage terms.

Independent Variables:

– Greenfield. Binary variable (1 = Greenfield project, 0 = Brownfield or Alternative).
– Foreign Sponsor: Binary variable (1 = lead sponsor is foreign, 0 = domestic).
– Multilateral. Binary variable (1 = project involved a multilateral institution, 0 = otherwise).
– Sector. Categorical variable capturing sector classification (Energy, Transport, ICT, Water); base category is Energy.
– Year. The fiscal year of Project financial closure (to control for time effects).

Interaction Term:

– Foreign Sponsor × Multilateral. Captures whether the effect of a foreign sponsor depends on multilateral support.

These independent variables have been selected in accordance with the theoretical frameworks outlined above. According to the Agency Theory, the variable "Foreign Sponsor" highlights the link between the design of a contract and the sponsor's background, which can reduce opportunism and align incentives towards PPP arrangements. The Multilateral Support variable is based on the theory of institutional voids, whereby multilateral intervention can address the shortcomings of weak local institutions by providing guarantees, credibility and regulation. The interaction between foreign sponsors and multilateral support is also based on the institutional voids theory, as it measures the effectiveness of foreign participation when complemented by multilateral institutions. The sectoral dummies relate to public goods theory, as certain types of infrastructure (e.g., ICT or municipal solid waste) are likely to receive less investment in the absence of policy support compared to more established sectors such as energy. Lastly, incorporating Greenfield and Year controls is a pragmatic consideration of the project's form and timing. However, it is also consistent with the theoretical assumption that institutional maturity and contract structure influence private investment decisions.

Energy has been selected as a base category because it is the largest and most developed sector in the Nigerian PPI portfolio. This makes it a stable basis for comparing other sectors. Energy also represents a significant proportion of infrastructure investment initiatives, making it a logical reference point for evaluating the performance of other sectors. All variables were manually cross-checked and cleaned to ensure the model's internal consistency and validity.

3.3 Model Estimation Strategy

Two main econometric models are employed to test the study's hypotheses:

3.3.1 Log-Linear Regression Model (OLS)

The model is used to estimate the average percentage change in investment that can be achieved for each factor. It can be used to analyse skewed investment data and makes it easy to interpret coefficients in terms of elasticity.

Model specification:

$$Log(INV_i) = \beta_0 + \beta_1 Greenfield_i + \beta_2 Foreign_i +$$
$$+\beta_3 Multilatral_i + \beta_4 (Foreign \times Multilateral)_i +$$
$$+\beta_5 Sector_{Transport,i} + \beta_6 Sector_{ICT,i} +$$
$$+\beta_7 Sector_{Water,i} + \beta_8 Year_i + \epsilon_i$$

Where:

– $Log\ (INV_i)$ is the natural logarithm of private investment in USD for the project *i*;
– $\dot{o}_i$ is the error term;
– Gteenfieldi, $Foreign_i$, $Multilateral_i$ are binary indicators for project characteristics;
– *Foreign x Multilateral* is an interaction term;
– $Year_i$ is the project's financial closure year.

In order to decrease skewness, the dependent variable, total private investment per project, is log-transformed and then interpreted as a percentage. This transformation can be attributed to the highly dispersed and positively skewed distribution of investment values, with the lowest recorded investment value being 2 million USD and the highest 2.9 billion USD. Log transformation is useful for normalising the distribution and stabilising the variance, thereby improving the performance and interpretation of the model. The independent variables, such as project type, sector and sponsor origin, are either binary or categorical and are not log-transformed, as this would not make sense. The Year variable is listed as a numeric control with a temporal effect and is not transformed either, which makes it easy to interpret.

3.3.2 Quantile Regression Model

In order to capture distributional heterogeneity, particularly among small and large infrastructure projects, quantile regression is applied to the 25th, 50th (median) and 75th percentiles. This reveals whether investment determinants are homogeneous or heterogeneous across project size categories.

Quantile regression model:

$$Q_\tau\left(INV_i\right) = \beta_0^{(\tau)} + \beta_1^{(\tau)} Greenfield_i + \\ + \beta_2^{(\tau)} Foreign_i + \beta_3^{(\tau)} Multilateral_i + \\ + \beta_4^{(\tau)} Sector_{j,i} + \beta_5^{(\tau)} Year_i + \epsilon_i^{(\tau)}$$

Where:

– $\tau = 0.25, 0.5, 0.75$

– $Q_\tau\left(INV_i\right)$ denote the conditional quantile of investment at the percentile τ.

This model recognises that not all determinants may be relevant to mega-projects at the upper end of the investment spectrum.

3.4 Model Diagnostics and Robustness Checks

A series of diagnostic tests and robustness procedures were employed to ensure the reliability and validity of the estimated models. Firstly, multicollinearity was assessed using the Variance Inflation Factor (VIF). The VIF values of all the explanatory variables were found to be below the threshold of 5, indicating that there were no severe issues of multicollinearity.

Secondly, the Breusch-Pagan/Cook-Weisberg test was used to check for heteroskedasticity in the residuals of the OLS model. Where heteroskedasticity was detected, robust standard errors were calculated to adjust for the assumption of constant variance and improve the validity of the inference.

Thirdly, the Shapiro–Wilk test was used to check whether the residuals were normally distributed. Although normality is not a prerequisite for consistent parameter estimates in OLS, it is crucial for hypothesis testing, particularly at smaller levels.

Additionally, the potential impact of outliers and high-leverage points was examined using the Cook's distance feature and leverage statistics. This ensured that no single observation had an excessive influence on the estimated coefficients.

Finally, bootstrapped standard errors were produced to maximise the robustness of the quantile regression estimates, particularly given the small sample size. This method produces wider confidence intervals and enables testing of the distributions of the explanatory variables. As there were relatively few projects (n = 60), low statistical power was anticipated. To mitigate this issue, the analysis was conducted using quantile regression with robust and bootstrapped standard errors. This increases the reliability of the inferences across the distribution of investment levels.

4.0 Results and Discussion

4.1 Descriptive Statistics

The descriptive statistics show that the level of private infrastructure investment is highly scattered across the 60 observed projects. The mean investment value is 243.43 million USD, while the median is much lower at 56.97 million USD. This significant discrepancy suggests that some large-scale investment projects are distorting the average.

Table 1
Summary statistics of investment (in million USD)

Statistic	Value
Observations	60
Mean	243.43
Std. deviation	537.81
Minimum	2
25th Percentile	20.85
Median (50th)	56.97
75th Percentile	169.17
Maximum	2900
Skewness	3.69
Kurtosis	17.03
Note: The distribution of investment amounts is positively skewed, with a few large-value observations driving up the mean. The significant difference between the mean and median suggests high dispersion and the presence of outliers.	

The relatively high standard deviation (537.81 million USD) supports the idea that project investments differ significantly in size. This is also evident from its value range of 2 million USD (low limit) to 2.9 billion USD (high limit), indicating a highly unequal distribution of project funding.

Furthermore, a skewness measure of 3.69 indicates a right-skewed distribution, meaning most investments are concentrated at the lower end of the scale with several large projects far beyond the average. A kurtosis value of 17.03 confirms the presence of heavy tails or outliers in the data.

The application of quantile regression is appropriate in this context, as it possesses a superior capacity to estimate values across the population distribution when compared with a classical regression model based on the mean. This is due to the fact that the latter is susceptible to the influence of outliers (Koenker & Bassett, 1978).

The division of the dataset according to sector reveals that the transport industry is the most common sphere, with much investment in transport infrastructure, as the projects represented 51.67 per cent. This finding suggests that the policy focus is either on transportation or on privately owned logistics-related infrastructure. This may be linked to the economic importance of roads, ports and other similar infrastructure in trade and the movement of people within cities.

The energy sector is the second most significant, accounting for 23.33% of the total. The necessity for energy infrastructure is particularly pronounced in developing economies such as Nigeria, where it is essential to meet the energy demands of both industry

Table 2
Sectoral distribution of infrastructure projects

Sector	Frequency	Percent	Cumulative
Energy	14	23.33	23.33
ICT (information and communication)	11	18.33	41.67
Municipal solid waste	4	6.67	48.33
Transport	31	51.67	100
Total	60	100	
Note: Transport sector projects account for over half of the sampled projects, suggesting a possible policy emphasis or private sector interest in logistics infrastructure.			

and households. Information and communication technology (ICT) projects, including those under the ICT sector, represent 18.33%, exhibiting moderate interest in digital infrastructure, which potentially aligns with the country's digital transformation agenda.

Finally, the smallest size of projects includes municipal solid waste, accounting for 6.67 per cent of the sample. This underrepresentation may be indicative of a lack of interest on the part of the private sector in waste management, or of the challenges associated with the organisation of bankable projects within this sector.

This finding suggests that, despite the preponderance of privately sponsored investments in the energy and transport sectors, other critical infrastructure areas have received comparatively less attention. This may be an issue concerning the proportionate development of infrastructure, indicating a need for policy inducement to diversify participation within the private sector.

4.2 OLS Regression Results

The OLS regression model analysis outcomes reveal that the ICT sector is the only explanatory variable that is significant at the 5% level ($p = 0.021$). The corresponding coefficient for ICT sector projects shows a negative coefficient of -1.534, indicating that, other things being equal, projects in the ICT sector attract significantly lower levels of private investment relative to the base group, such as the energy and waste sectors. The dependent variable is log-transformed, which means that this coefficient can be expressed as a percentage. In particular, ICT projects receive approximately 78% lower levels of private investment than projects belonging to the base category (Energy), all other factors being equal. This is calculated as $(e^{-1.534} - 1) \times 100 \approx -78\%)$. This phenomenon is economically significant, signifying that ICT projects, on average, receive less than a quarter of the investment allocated to analogous energy projects. The negative correlation could be indicative of structural risks, such as excessively high perceived risk, reduced investment horizons, or regulatory risks in the digital infrastructure investment area.

Although the OLS model only identifies the coefficient of the ICT sector as statistically significant at the 5 per cent level, the directions and magnitudes of the other variables (e.g., foreign sponsorship: 0.736) are consistent with theoretical expectations. This implies that some effects may not reach statistical significance due to constraints in the sample size. Therefore, rather than emphasising significance, the focus is on larger-than-average effect sizes and consistency across subsections of the investment distribution (Alruwaili, 2025).

None of the other variables, including greenfield status, foreign sponsorship, multilateral involvement and their interaction, were found to have a statistically significant effect on log-investment. While the foreign

Table 3
OLS estimation of log-investment

Variable	Coefficient	Robust std. error	t-stat	p-value
Greenfield (1 = yes)	-0.218	0.720	-0.30	0.763
Foreign sponsor (1 = yes)	0.736	0.509	1.44	0.155
Multilateral support (1 = yes)	0.612	1.164	0.53	0.601
Foreign sponsor × multilateral support	0.518	1.417	0.37	0.716
Transport sector	-0.320	0.729	-0.44	0.663
ICT sector	-1.534 **	0.644	-2.38	0.021
Year	-0.007	0.032	-0.21	0.831
Constant	18.195	65.335	0.280	0.782
Note: Only the coefficient for the ICT Sector is statistically significant at the 5% level. It indicates that ICT sector projects attract significantly lower levels of investment, holding all other variables constant. * p<0.1, ** p<0.05, *** p<0.01				

sponsor variable indicates a positive impact on investment when a foreign counterpart is involved, with a positive coefficient of 0.736, it is not statistically significant (p = 0.155), possibly due to sample size issues or sector heterogeneity.

The year variable measure, which represents the time trend, is also insignificant. This finding suggests that there was no clear direction of upward or downward movement in investment over time during the sample period.

A quantile regression was incorporated to achieve a more profound comprehension of the varying effects of the predictors across varying levels of investment, thereby capturing the heterogeneous effects that are not captured by mean-based estimation.

The theoretical perspectives delineated above also provide an interpretation for these conclusions. The underperformance of ICT projects, particularly in comparison to other sectors, lends credence to the Public Goods Theory. This theory posits that industries characterised by high externalities and non-exclusiveness experience underprovision in the absence of specific public policy interventions. The ineffectiveness of multilateral intervention is indicative of the Institutional Voids Theory, which posits that the absence of regulatory capacity, coupled with inadequate enforcement, signifies the inefficacy of multilateral intervention in mitigating market inefficiencies. The positive, albeit statistically insignificant, influence of foreign sponsorship is analogous to that of Agency Theory, wherein the design of contracts and the expertise of sponsors serve to mitigate risk and opportunism. Nevertheless, the findings of this study suggest that such gains are more substantial in the context of large-scale projects.

In summary, the OLS model reveals a sector-specific investment gap, particularly with regard to ICT projects, and suggests that investment levels may be influenced more conclusively by sectoral dimensions than by the financing source alone.

4.3 Quantile Regression Results

The findings of the quantile regression offer further insight into the uneven impact of the explanatory variables on various levels within the investment distribution.

It is noteworthy that at both the 25th percentile and the median, the sector_ict variable exhibits a statistically significant negative effect, with coefficients of -1.9226 and -1.9468, respectively. At the 25th percentile, this effect is found to be significant, with a p-value of 0.078, and at the median, it is also found to be significant, with a p-value of 0.030. In corroboration of the preceding OLS findings, the present results indicate that projects in the ICT sector consistently experience diminished private investment, particularly at the lower quantile and middle strata of the investment quantile distribution. This tendency suggests that investors are fundamentally reluctant to commit large amounts of financial capital to ICT projects. This may be due to the intangible nature of the industry, the rapid pace of technological change, or the low level of collateral value (Demmou & Franco, 2021).

Interestingly, the effects of the foreign sponsorship approach turn out to be marginally significant at the 75th percentile (p = 0.078), with a coefficient of 1.5314. This suggests that the involvement of foreigners in project sponsorship can be correlated with increased investment, but only at the upper end of the investment distribution. This suggests that foreign sponsors are more likely to be involved in capital-intensive infrastructure projects that involve complex financing and risk-sharing arrangements.

The other explanatory variables, including greenfield status, multilateral support, and their interaction, have no significant effect across the quantiles. The year variable is not significant, indicating that there is no time trend in the data.

Overall, the quantile regressions reveal the asymmetric effects of project characteristics on the

Table 4
Quantile regression estimates at 25th, 50th, and 75th percentiles (dependent variable: log(investment), bootstrapped SEs with 1,000 reps)

Variable	Q25 Coef.	Q25 p	Q50 Coef.	Q50 p	Q75 Coef.	Q75 p
greenfield	0.5918	0.665	-0.6564	0.469	0.5352	0.608
foreign	0.1896	0.791	0.7651	0.274	1.5314	0.078*
multilateral_dummy	-0.1021	0.947	-0.4562	0.763	1.355	0.395
Foreign sponsor x multilateral support	2.1379	0.304	2.0205	0.292	-1.1311	0.571
sector_transport	-0.1449	0.921	-0.6931	0.46	0.4801	0.648
sector_ict	-1.9226*	0.078	-1.9468**	0.03	-1.3467	0.225
year	-0.0726	0.233	-0.0284	0.557	0.0069	0.912
_cons	148.75	0.224	61.59	0.526	-9.7033	0.938
Note: Sector_ict remains significant across the 25th and 50th percentiles, reinforcing its negative association with investment at the lower and middle segments. Foreign Sponsor shows marginal significance at the 75th percentile. * p<0.1, ** p<0.05, *** p<0.01						

Table 5

Bootstrapped standard errors for quantile regression models ((dependent variable: log(investment); bootstrap replications = 1000)

Variable	Q25 SE	Q50 SE	Q75 SE
greenfield	1.3583	0.9002	1.0368
foreign	0.713	0.6924	0.8524
multilateral_dummy	1.5198	1.504	1.5812
Foreign sponsor x multilateral support	2.0587	1.8987	1.9816
sector_transport	1.451	0.9306	1.0443
sector_ict	1.0708	0.8728	1.0961
year	0.0602	0.048	0.0617
_cons	121.0067	96.4346	123.9609
Sector_ict remains significant across the 25th and 50th percentiles, reinforcing its negative association with investment at the lower and middle segments. Foreign involvement shows marginal significance at the 75th percentile. * p<0.10, ** p<0.05, *** p<0.01			

distribution of investment. They complement the OLS results by capturing effects that are not easily observable in averages, thereby enhancing the robustness and depth of the estimation process.

As demonstrated in Table 5, the bootstrapped standard errors of the quantile regression estimates of the 25th, 50th, and 75th percentiles of the relationship are reported. The present robustness test has been developed in order to address the concerns regarding a small sample size, non-normality of errors, and heteroskedasticity. It is well-documented that such issues can lead to bias in conventional standard errors and inference.

The bootstrapped standard errors of sector_ict are further compounded in that they are all within reasonable levels across all quantiles (Q25 = 1.0708; Q50 = 0.8728; Q75 = 1.0961). This further justifies the reliability of the statistically significant negative impact of sector_ict at the lower and middle ends of the investment distribution. This finding serves to reinforce the conclusion that projects within the ICT sector consistently receive disproportionately lower levels of investment, even when the potential for distributional distortions is taken into account.

Conversely, the bootstrapped standard errors within the foreign sponsorship and foreign support x multilateral exhibit demonstrate increased variability across the quantiles. For instance, at Q25, the standard error of foreign_multilat is 2.0587, in comparison to 1.8987 at Q50 and 1.9816 at Q75. This discrepancy can be attributed to the uncertainty surrounding interaction effects, which may justify the failure to achieve statistical significance for these terms in all quantiles.

Furthermore, the elevated standard errors of the constant term (_cons _) and other control variables, including greenfield status and year, suggest considerable variability in the average levels of investment and time effects. However, the model's validity is confirmed by the observation that it remains stable across all quantiles.

It is evident that the bootstrapped standard errors are conducive to the enhancement of the reliability of the level of significance provided in Table 4, particularly in the case of sector_ict and, to a lesser extent, foreign sponsors. This finding aligns with the findings of earlier empirical research, which supports the use of bootstrapping in quantile regression to circumvent the potential pitfalls of biased inference in small tournaments or skewed statistics (Galvao, Parker, & Xiao, 2024).

The findings of quantile regression have been shown to facilitate the identification of trends that were inaccessible to the OLS model, due to the latter's reduced statistical power. It is noteworthy that the impact of the ICT sector is consistently high at the 25th and 50th percentiles. However, at the 75th percentile, foreign sponsorship becomes a significant factor. The findings suggest that the characteristics of the project exert a divergent influence on the investment volume, contingent on the magnitude of the investment. This observation lends substantiation to the study's explanatory capacity, notwithstanding its modest sample size.

The quantile regressions also relate to the theoretical background of this paper. The considerable adverse effect of ICT on the lower and middle quantiles serves to expand the scope of Public Goods Theory, which emphasises that such sectors require greater government intervention to ensure that projects are appealing to private capital. The impact of foreign sponsorship at the upper quantile can be elucidated through the lens of Agency Theory, which posits that foreign agents are most effective in mobilising mass investments with shared risks and robust contractual agreements. Conversely, the absence of stable effects of multilateral support can be interpreted as evidence of the continued presence of institutional voids. This is due to the fact that weak enforcement and policy instability lower the signalling value of multilateral participation. Collectively, the findings characterise the trends in investment and indicate the applicability

of the theoretical assumptions in the Nigerian context.

Overall, the research makes a valuable contribution to theory by demonstrating that Public Goods Theory justifies endemic underinvestment in ICT, that Agency Theory clarifies the conditional benefits of foreign sponsorship and that Institutional Voids Theory explains the weak effect of multilateral support. By explicitly linking the sector and sponsor to these frameworks, the article makes a positive contribution to the body of knowledge regarding their role in weak institutional settings, such as Nigeria.

4.4 Robustness and Diagnostic Tests

Diagnostic tests establish the accuracy and reliability of the inferred models. The results of the variance inflation factor (VIF) test show that multicollinearity is not a concern, as all the findings are well below the critical value of 5 (Kalnins & Praitis Hill, 2025). The Breusch-Pagan/Cook-Weisberg test does not reject the homoskedasticity hypothesis, suggesting that the OLS residuals are homoscedastic.

The Shapiro-Wilk test indicates that the residuals are normally distributed ($p = 0.1450$), although this is not a requirement for unbiased estimation in OLS. This enhances sound inference in hypothesis testing, particularly in cases with small sample sizes.

The Cook distance statistic reveals a few moderate-influence points (maximum = 0.25), surpassing the conventional threshold of 4/n (equivalent to 0.067 with $n = 60$). However, none of these points appear to have an excessive level of influence, and the key findings remain unchanged when robustness is applied.

Lastly, quantile regression analysis uses bootstrapped standard errors, making the results particularly reliable. This is particularly important for small samples and models where non-normal errors or heteroskedasticity are suspected (Orenti, Zolin, Marubini, Antonelli, Ambrogi & Cesana, 2024).

These diagnostics all confirm the validity of the model specifications and the reliability of the estimates in the previous sections.

The Q-Q plot shows the standardised residuals alongside the theoretical points at the quantiles of a normal distribution. The fact that a significant proportion of the residuals are located near the reference line implies that the normality assumption is satisfied. It is important to note that minor deviations in the far upper tail are not an uncommon occurrence in economic data, particularly when it contains price investment outliers. This finding aligns with the results of the Shapiro-Wilk test ($W = 0.970$, $p = 0.145$), which did not reject the null hypothesis of normality. The application of OLS estimation is justified by the evidence presented in the study, which indicates that the distribution of residuals approximates a normal distribution, particularly at the centre of the distribution (Burton, 2021).

5. Conclusion and Policy Recommendation for Future

5.1 Conclusions

The objective of this study was to investigate the determinants of private investment in infrastructure projects in Nigeria, with a focus on the dynamics of the sector and the characteristics of sponsors. To elaborate further, the objective was twofold: firstly, to examine the trends in participation by the private sector (PSP) in the infrastructure projects in Nigeria over 1990-2023, and to determine the most relevant determinants, such as project type, sponsor origin, and multilateral participation, that drive the levels of private investment. In order to achieve these objectives, the analysis was informed by four research questions that guided the study to attain these objectives. The primary focus of the first question pertained to the predominant patterns of the private sector's role in Nigerian infrastructure construction between 1990 and 2023. The sub-questions used to achieve the second objective included the following determinants of financing levels: which project types are likely to attract private investors (Greenfield as opposed to Brownfield); sponsor origin and multilateral support as determinants of investment outcomes; the influence of differences in sectors (such as energy, transport,

Table 6
Diagnostic tests summary

Test	Statistic/Result	Conclusion
VIF for Multicollinearity	Mean VIF = 2.42	No multicollinearity detected
Breusch-Pagan/Cook-Weisberg Test	$\chi^2 = 0.80$ ($p = 0.3706$)	Homoskedasticity assumption satisfied
Shapiro-Wilk Normality Test (residuals)	$W = 0.970$ ($p = 0.1450$)	Residuals approximately normal
Cook's Distance (Max Observed)	Max = 0.25 (4/60 = 0.067)	Some moderate influence; not extreme
Bootstrapped SEs in Quantile Model	Reps = 1000	Improved inference for small sample sizes
Note: The OLS residuals passed the normality and heteroskedasticity checks, and no individual data point exerted undue influence. The bootstrapped quantile model supports the robustness of the findings.		

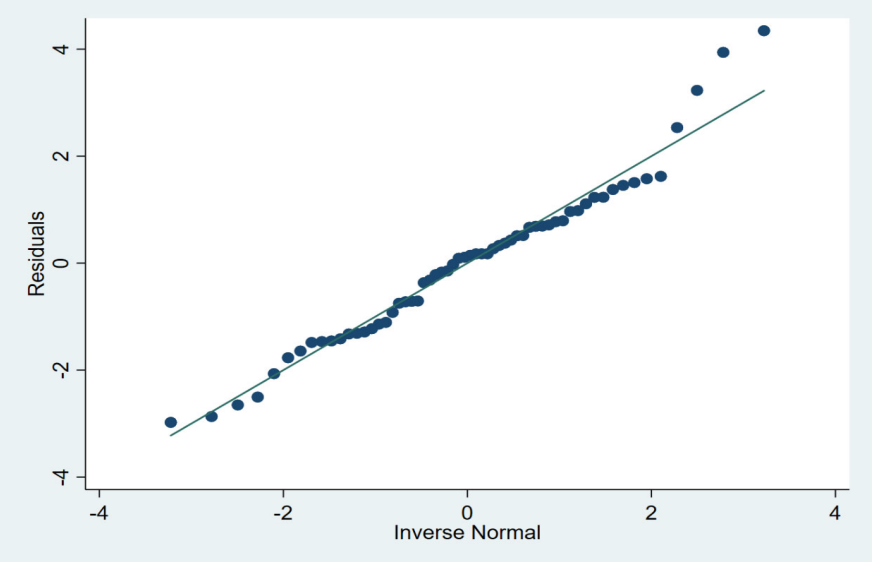

Figure 2. Normal Q-Q Plot of Residuals

ICT and water) on investment size; and the effect of multilateral support on changes in investment levels caused by foreign entity sponsorship.

To address these questions, Ordinary Least Squares (OLS) and Quantile Regression (QR) methods were applied to a dataset comprising 60 infrastructure projects. The OLS model revealed that investment in ICT sector projects is significantly lower than in other projects, even when other explanatory factors are considered. The same was found to be true in the quantile regressions, particularly at the 25th and 50th percentiles. This indicates that the adverse impact of affiliation with the ICT sector is more pronounced in low- and mid-tier investment facilities. This may also indicate sector limitations associated with regulatory ambiguity, unclear revenue streams and the increasing perceived risk of ICT infrastructure, particularly in a developing context.

The outcomes also indicated that foreign sponsorship has a slightly positive impact on investment, as indicated by the 75th percentile. This suggests that international sponsors are more likely to invest in larger-scale projects. However, multilateral actions and Greenfield-type institutions failed to demonstrate a consistent, statistically significant effect on investment in any of the models. The findings showed that differences between sectors are a determining factor in investment flows. Although the transport sector was the most prevalent, it did not have a statistically significant impact on the scale of investment. This suggests that prevalence in an industry does not necessarily lead to increased funding.

Although only the ICT sector exhibits a statistically significant pattern, the direction and magnitude of the remaining coefficients, such as foreign sponsorship, align with the hypotheses. Since the sample size is small, these trends may have practical significance in cases where statistical significance cannot be demonstrated. This lends weight to the use of quantile regression in the study, which highlights various effects throughout the investment distribution.

Diagnostic checks were performed on all models, including those for multicollinearity (Variance Inflation Factor), heteroskedasticity (Breusch-Pagan/Cook-Weisberg test) and residual normality (Shapiro–Wilk test). Further influential data point testing, measured by Cook's distance, confirmed that there were no outliers. The quantile regression models estimated using bootstrapped standard errors also supported the robustness of the results, particularly with regard to mitigating slight sample bias and non-normality in the residual distribution.

Overall, the analysis reveals the heterogeneous characteristics of investment factors across sectors and levels of investment. The ICT industry's ongoing poor performance in attracting investment underscores the necessity of targeted policy interventions to mitigate digital infrastructure risks and promote transparent regulatory regimes. Furthermore, as foreign sponsors play a more influential role only at higher levels of investment, it may be necessary to develop differentiated approaches to large-scale projects when considering foreign capital. These findings have practical implications for policymakers, investors and development finance institutions seeking to maximise the private sector's role in infrastructure development.

5.2 Policy Recommendations for Future

The findings of this study provide valuable information for policymakers regarding future infrastructure investment in emerging economies. One of the most

consistent results was the negative and statistically significant correlation between ICT sector projects and the magnitude of private investment, which was observed even in the lower and median quantiles. This suggests that investors find ICT infrastructure relatively unattractive, probably due to high perceived risk, a lack of clarity in regulation and/or long gestation times. In response, policymakers should prioritise ICT infrastructure by establishing specific de-risking mechanisms. This could involve issuing government-secured assurances, simplifying the licensing process and enhancing regulatory frameworks governing digital infrastructure and data. In order to encourage investment in ICT, such reforms in Nigeria must address specific regulatory uncertainties. These include the overlap of the Nigerian Communications Commission's (NCC) mandates with those of other ministries regarding broadband implementation, inconsistent spectrum licensing regulations and an absence of a unified framework for data security and digital protection. Better policies on right-of-way charges for fibre optic expansion and open access to spectrum allocation would reduce direct costs and mitigate risk for private investors. Streamlining approvals at federal and state levels, particularly for urban fibre rollout, would also make projects more bankable. Such initiatives would foster investor confidence and facilitate the coordination of infrastructure development with broader ambitions in the digital economy.

Furthermore, the finding that foreign sponsorship is positively associated with increased investment, particularly in the higher quantiles, highlights the importance of attracting and sustaining foreign finance for infrastructure megaprojects. The government must therefore increasingly pursue investment-friendly environments by promoting macroeconomic stability, providing fiscal incentives and ensuring that foreign investors can easily acquire land and permits. In practice, this involves streamlining the land acquisition processes set out in the Land Use Act 1978, which has already lengthened the approval process and introduced uncertainty into project timelines. Nigeria could become a more attractive destination for foreign investment by setting up one-stop investment clearance centres and reducing overlaps between state and federal agencies' bureaucracies. Not only would foreign participation introduce capital, it would also provide technical expertise and access to international financial markets, both of which are crucial to the successful operation of capital-intensive projects such as those in the energy, transport and digital infrastructure sectors.

Information on the sectoral allocation of investments also suggests that infrastructure policy measures based on sectors are necessary. Due to the extreme variation in investment size and concentration within the transport industry, a one-size-fits-all approach may not ensure fair investment across all sectors. Therefore, governments need to use differentiated frameworks based on risk and return characteristics. For example, these may include areas such as municipal solid waste, where it can be more difficult to attract private capital unless funding is provided to bridge the viability gap or a government guarantee is offered. In Nigeria, for instance, municipal solid waste PPPs often stagnate due to uncertainties in tariff setting and the division of accountability between local governments and federal environmental authorities. Implementing a clear cost-recovery system, perhaps coupled with performance-based subsidies, could increase investor confidence in this industry.

Finally, the differences in determinants identified in this paper across the investment distribution, as illustrated by the quantile regression findings, highlight the usefulness of shifting away from mean-based models, such as OLS. When incorporated into infrastructure planning, quantile-based analysis enables policymakers to determine not only whether a factor affects investment, but also the specific level at which it does so and its impact on particular types of projects. This has practical implications, as policies promoting investment in smaller or riskier projects may require a different approach to those promoting large-scale ventures. To address the wide range of constraints and opportunities, a more sophisticated, distribution-sensitive approach to investment analysis and policymaking is suggested.

5.3 Limitations and Future Research Directions

Although the study reveals new insights into the factors influencing private investment in infrastructure projects in emerging economies, several limitations are evident. Firstly, the sample size is still relatively limited at 60 examples, as presented by the available data. This reduces the extent to which the conclusions can be generalised and may hinder the identification of subtle statistical relationships. Quantile regression models using bootstrapped standard errors were utilised to address the limitations of the small sample size; however, sampling bias may still occur. Secondly, the analysis was limited to observable project-level features, such as the type of sponsorship, sector classification and year. Key country-based macroeconomic or institutional factors that could profoundly impact investment decision-makers, such as regulatory quality, political risk, or creditworthiness, were not taken into account. Excluding these macro-level variables creates the risk of omitted variable bias. Assuming that such factors are correlated not only with the nature of the project, but also with the results of the investment, the effects of the project-level variables may be partially confounded. For example,

significantly better GDP growth could lead to increased investment in ICT projects, meaning the negative ICT coefficient observed here could be exaggerated if growth had not been taken into account. In a similar manner, the quality of regulation may have a bearing on both the probability of multilateral involvement and the amount of private investment, which in turn may confound the connotation of the multilateral support variable. Despite the fact that the objective of this research was to pay close and detailed attention to the visible drivers at the project level, it is necessary to acknowledge this constraint, as the findings must be interpreted as being contingent on macroeconomic and institutional conditions. Such country-level measures could be directly incorporated into future studies to help differentiate the relative contributions of project-specific versus economy-wide factors in determining private infrastructure investment.

Furthermore, the implementation of dynamic modelling and panel estimation was precluded by the data structure, thereby rendering the control of potential temporal effects or unobserved heterogeneity among projects or countries unfeasible. Additionally, the delineation of specific sectors can obscure the heterogeneity present within these categories, particularly in the ICT and energy sectors, where various sub-sectors (e.g., mobile broadband and fibre optics, or solar and gas) may possess differential appeal in terms of attracting private capital. It was also hypothesised that quantiles are linear or monotonic, a supposition that is congruent with the objectives of the present study. Nevertheless, it is possible that more encompassing modelling strategies will be pertinent in future research.

It is recommended that future studies extend the data set beyond Nigeria to encompass a greater number of countries and a more extensive historical period. This expansion will facilitate the utilisation of more sophisticated econometric models, such as fixed-effects or random-effects methods. Furthermore, the integration of qualitative information, such as expert interviews or investor surveys, into the findings may prove beneficial. This integration should be accompanied by a clear identification of the factors that may drive or suppress the quantitative trends identified. Future research may benefit from a mixed-methods approach, which has been demonstrated to enhance the depth of analysis and increase policy-relevance. Researchers can also investigate the relationship between public finance mechanisms (such as blended finance or public guarantees) and measures of the impact of private investment, with a focus on underfunded sectors, including waste management and ICT. It is recommended that future research explore the context-explicit dynamics of infrastructure finance in emerging economies. This exploration should be particularly focused on regulatory innovation, institutional quality, and risks throughout the project lifecycle.

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References:

Acquah, E. L. (2022). *An assessment of abandonment of GETFUND building projects in Ghana: A case of Ghanaian tertiary institutions*. University of Johannesburg (South Africa).

Adeosun, O. A., Orisadare, M. A., Fagbemi, F. & Adedokun, S. A. (2021). Public investment and private sector performance in Nigeria. *International Journal of Emerging Markets*, *16*(8), pp. 1697–1720.

African Development Bank (AfDB). (2023). *Nigeria Country Strategy Paper 2025–2030*. Abidjan: African Development Bank Group. Available at: https://www.afdb.org/en/news-and-events/press-releases/nigeria-african-development-bank-approves-strategy-boost-economic-growth-83309

Akang, A. U. (2023). Regulatory compliance and access to finance: implications for business growth in developing economies. *Sciental Journal of Education Humanities and Social Sciences*, *1*(2), pp. 8–23.

Akuesodo, U. E., Okonkwo, I. V., Okaro, C. S., & Okoye, N. J. (2023). Infrastructure deficit and human development index: Nigeria's experience, *African Banking and Finance Review Journal*, 6(6), pp. 273–291. Available: http://www.abfrjournal.com/index.php/abfr/article/view/111

Alamu, O. I., Hassan, A. O., Asa, K. J. & Odunayo, H. A. (2024). Addressing Infrastructure Deficits through Public-Private Partnership Funding of Public Projects in Nigeria: A Review. *TWIST*, *19*(3), pp. 130–138.

Arturs, K., & Praitis Hill, K. (2025). The VIF score. What is it good for? Absolutely nothing. *Organizational research methods*, *28*(1), pp. 58–75.

Alruwaili, R. (2025). Do we focus on process over outcome? Review of published studies in two prominent Saudi journals. *Cogent Education*, *12*(1), p. 2443286.

Arazu, O. W. & Lusty, M. K. (2023). Public Private Partnership and Economic Growth in Nigeria, (1971–2020)', *Journal of Xi'an Shiyou University, Natural Science Edition*, 19(2), pp. 667–686. Available at: https://www.xisdxjxsu.asia/V19I02-58.pdf

Barbir, D. (2021). February. Corporate governance and agency theory. In *RSEP CONFERENCES* (p. 47).

Bazbauers, A. R. & Engel, S. (2021). *The global architecture of multilateral development banks: A system of debt or development?*. Routledge.

Bolomope, M. T., Baffour Awuah, K. G., Amidu, A. R. & Filippova, O. (2021). The challenges of accessing local finance for PPP infrastructure project delivery in Nigeria. *Journal of Financial Management of property and Construction*, *26*(1), pp. 63–86.

Buertey, J. T. I., Atsrim, F. K., Boateng, K., Brace, R. & Aaron, L. (2024). An Evaluation of the Causes, Impact and Perceptions about Abandoned Public Funded Projects in Ghana. *Current Approaches in Engineering Research and Technology*, *6*, pp. 94–126.

Burton, A. L. (2021). OLS (Linear) regression. *The Encyclopedia of Research Methods in Criminology and Criminal Justice*, 2, pp. 509–514.

Cahyadi, R. (2024). Taxes and Infrastructure Development: A Review from Various Countries. *Advances in Taxation Research*, *2*(3), pp. 132–142.

Casalini, F., Gatti, S. & Vecchi, V. (2025). Financing Infrastructure with Public–Private Partnerships. In *The Palgrave Handbook of Development Finance* (pp. 263-283). Palgrave Macmillan, Cham

Chinzara, Z., Dessus, S. & Dreyhaupt, S. (2023). *Infrastructure in Africa: How Institutional Reforms Can Attract More Private Investment*. Washington, DC: World Bank Group. Available at: https://documents1.worldbank.org/curated/en/099625202203325213/pdf/Infrastructure-in-Africa-How-Institutional-Reforms-Can-Attract-More-Private-Investment.pdf

Demirel, H. C., Leendertse, W. & Volker, L. (2022). Mechanisms for protecting returns on private investments in public infrastructure projects. *International Journal of Project Management*, *40*(3), pp. 155–166.

Demmou, L. & Franco, G. (2021). Mind the financing gap: Enhancing the contribution of intangible assets to productivity. *OECD Economic Department, Working Papers*, (1681), pp.0_1–62.

Dugal, M. & Tiwari, S. R. (2024). Impact of Risk, Subsidy, and Bid-Criteria on the Private Investment in Public–Private Partnerships in Infrastructure Projects. *Journal of Risk and Financial Management*, *17*(5): 184.

Fleta-Asín, J. & Muñoz, F. (2021). Renewable energy public–private partnerships in developing countries: Determinants of private investment. *Sustainable Development*, *29*(4), pp. 653–670.

Galvao, A. F., Parker, T. & Xiao, Z. (2024). Bootstrap inference for panel data quantile regression. *Journal of Business & Economic Statistics*, *42*(2), pp. 628–639.

Hernandez, M., Timmis, E., Saldarriaga, M., Matta, S., Mukhtar, N., Joseph-Raji, G., Ogebe, J. & Kojima, M. (2022). Nigeria public finance review: Fiscal adjustment for better and sustainable results. *World Bank*.

Infrastructure Concession Regulatory Commission (ICRC). (2022). *Annual Report 2022*. Abuja: ICRC. Available at: https://www.icrc.gov.ng/portfolio-item/2022-annual-report-2/

Infrastructure Concession Regulatory Commission (ICRC). (2023). *Second Quarter 2023 Bulletin*. Abuja: ICRC. Available at: https://www.icrc.gov.ng/wp-content/uploads/2023/08/ICRC-Bulletin-Q2-2023.pdf

Khair, M.H.M., Hashim, H.N.M. & Anagnostopoulou, M. (2021). Public Good Theory: A Theoretical Justification for Permissive License To Use and Re-Use Orphan Works. *UUM Journal of Legal Studies*, *12*(1), pp. 179–197.

Koenker, R., and Bassett, G. (1978). Regression quantiles. *Econometrica*, 46(1), 33–50.

Lee, N. & Cardenas Gonzalez, M. (2022). *Stuck Near Ten Billion: Public-Private Infrastructure Finance in Sub-Saharan Africa*, Centre for Global Development Policy Paper 251, February 2022. Available at: https://www.cgdev.org/sites/default/files/stuck-near-ten-billion-public-private-infrastructure-finance-sub-saharan-africa.pdf

Lisinge, R.T. & van Dijk, M.P. (2022). Regional transport infrastructure programmes in Africa: what factors influence their performance?. *Canadian Journal of African Studies/Revue canadienne des études africaines*, *56*(1), pp. 99–121.

Mark, O. (2024). Public-Private Partnerships (PPPs) In Infrastructure Development in Nigeria: Evaluating Success and Challenges. *University of Africa Journal of Governance and Politics, p.* 68.

Matus-Ruiz, M., Saka-Helmhout, A. & Carillo, J. (2025). How institutional voids are experienced and enacted through social innovation initiatives by multinationals in emerging markets. *International Business Review*, *34*(2), 102382.

Mayfield, M., Punzo, G., Beasley, R., Clarke, G., Holt, N. & Jobbins, S. (2023). Challenges of complexity and resilience in complex engineering systems.

Mazele, O. & Amoah, C. (2022). The causes of poor infrastructure management and maintenance in South African municipalities. *Property Management*, *40*(2), pp. 192–206.

Mundonde, J., & Makoni, P. L. (2023). Public-private partnerships and water and sanitation infrastructure development in Zimbabwe: what determines financing?. *Environ Syst Res 12, 14*. https://doi.org/10.1186/s40068-023-00295-7

National Planning Commission. (2024). *Innovative Options for Financing Infrastructure Development*. Abuja: National Planning Commission. Available at: https://nationalplanning.gov.ng/wp-content/uploads/2024/10/INNOVATIVE-OPTIONS-FOR-FINANCING-INFRASTRUCTURE-DEVELOPMENT.pdf

Nwangwu, G. (2021). Public-Private Partnerships in Nigeria: The Journey so far. *Journal of Commercial and Property Law*, *8*(3), pp. 97–115.

Nyamkure, B. (2022). *Infrastructure, Institutional Quality and Infrastructure Financing Gaps: The Case of Selected African Countries* (Doctoral dissertation, University of the Witwatersrand, Johannesburg (South Africa)).

Okolie, U. C. and Edo, Z. O. (2023). Issues and failure of infrastructure project implementation in Nigeria. *Social Sciences, Humanities and Education Journal (SHE Journal)*, *4*(3), pp. 580–596.

Opara, M. & Ozor, C. K. (2023). Public-Private Partnerships in West Africa: A Policy Comparison of Nigeria and Ghana. *International Journal of Business and Management, 18*(2), pp .158–158.

Orenti, A., Zolin, A., Marubini, E., Antonelli, P., Ambrogi, F. & Cesana, B. M. (2024). Robust Regression as a Sensible Alternative to the Weighted Ordinary Least Squares Regression in case of Heteroskedasticity. A Tutorial. *Epidemiology, Biostatistics, and Public Health*, *19*(1).

Randa, I. O. (2025). Public-Private Partnership Strategies for Infrastructure Financing in Developing Countries. In *Public Private Partnership Dynamics for Economic Development* (pp. 27–52). IGI Global Scientific Publishing.

Wooldridge, J. M. (2020). *Introductory Econometrics: A Modern Approach*, 7th Ed

Wu, W. (2024). Infrastructure Investment and Finance in the Global South: Private Participation and Its Determinants. *Public Finance and Management*, *23*(3), pp. 99–112.

Yregal, B. (2025). The determinants of private investment in Ethiopia (Doctoral dissertation, Addis Ababa University).

Zattler, J. (2024). *Private sector mobilisation: Turning a pipe dream into reality* (No. 14/2024). IDOS Discussion Paper.

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