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Private Sector Financing of Public Infrastructure, Exchange Rate Dynamics and, Economic Growth Process in Nigeria

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Abstract

This study examined the nexus between private sector financing of public infrastructure, exchange rate dynamics and economic growth in Nigeria through the application of unit root, cointegration test, and granger causality. The result of the cointegration techniques suggests the existence of long run relationship among the variables. Granger causality result show that economic growth plays a pivotal role in driving infrastructure investment. However, the immediate feedback loop from infrastructure investment to economic growth is less clear, possibly due to the time lag inherent in the realization of infrastructure benefits. Other economic factors like interest rates, exchange rates, inflation, and FDI are influenced by broader macroeconomic and global conditions, showing less direct causality with infrastructure investment and economic growth in the short term. It is therefore recommended that Government at all levels must promote Public-Private Partnerships (PPP) to leverage private sector expertise and financing in infrastructure projects. Clear and transparent PPP frameworks will attract more private investments. Additionally, the Central Bank of Nigeria (CBN) should carefully manage interest rates to balance economic growth with inflation control. High interest rates can deter private investment, so a balanced approach is necessary

Keywords; Private sector, financing, economic growth, exchange rate, granger causality

Introduction

The development of robust public infrastructure is crucial for economic growth, as it facilitates efficient resource allocation, enhances productivity, and fosters innovation (Sanusi, 2019). In Nigeria, the public sector has historically been the primary financier of infrastructure projects. However, persistent budgetary constraints and inefficiencies have limited the government's ability to meet the growing infrastructure needs of the country (Onakoya et al., 2018). Consequently, there has been an increasing shift towards engaging the private sector in financing public infrastructure, particularly in critical sectors such as education, technology, energy, and transport (Ibrahim & Garba, 2020). Education infrastructure is fundamental to economic development, as it cultivates a skilled workforce necessary for various sectors of the economy. In Nigeria, the education sector has faced significant challenges, including inadequate funding, dilapidated facilities, and a shortage of qualified teachers (Babatunde et al., 2018). Private sector

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involvement through public-private partnerships (PPPs) and direct investments has been seen as a potential solution to bridge these gaps. Studies have shown that private financing can lead to improvements in the quality and accessibility of education, which in turn can boost economic growth by enhancing human capital (Eziyi, 2019). Technology infrastructure, encompassing both digital and physical components, is another critical area where private sector financing plays a vital role. The rapid advancements in technology and the increasing importance of a digital economy necessitate substantial investments in technology infrastructure (Ibrahim & Garba, 2020). Private sector involvement has the potential to accelerate technological innovation and adoption, thereby driving productivity and economic growth. For instance, investments in broadband infrastructure can enhance internet connectivity, facilitating business operations and expanding access to global markets (Sanusi, 2019). Energy infrastructure is a cornerstone of economic development, as it powers industries, homes, and services. Nigeria's energy sector has been plagued by inadequate generation capacity, frequent power outages, and inefficiencies in distribution (Onakoya et al., 2018). The private sector's role in financing energy infrastructure has been critical in addressing these challenges. Private investments have led to the development of independent power projects (IPPs), which have contributed to increasing the country's energy generation capacity. Improved energy infrastructure can stimulate economic growth by ensuring reliable power supply, reducing production costs, and attracting foreign investment (Eziyi, 2019). Transport infrastructure, including roads, railways, ports, and airports, is essential for the efficient movement of goods and people. In Nigeria, transport infrastructure has been inadequate, resulting in high logistics costs and hindering economic activities (Babatunde et al., 2018). Private sector financing has been instrumental in developing and upgrading transport infrastructure through initiatives such as PPPs. Enhanced transport infrastructure can facilitate trade, reduce travel time, and improve market accessibility, thereby contributing to economic growth (Ibrahim & Garba, 2020). The relationship between private sector financing of public infrastructure and economic growth is complex and multifaceted. Private sector participation can bring about efficiency gains, innovation, and additional capital, which are crucial for infrastructure development (Sanusi, 2019). However, the effectiveness of such financing in translating into economic growth depends on various factors, including the regulatory environment, governance, and the overall economic context. Empirical studies have produced mixed results, highlighting the need for more detailed research to understand the specific pathways through which private sector financing impacts economic growth in Nigeria (Onakoya et al., 2018). The engagement of the private sector in financing public infrastructure in Nigeria holds significant potential for driving economic growth. However, the causal relationship between these investments and economic outcomes requires thorough empirical investigation. Understanding this relationship is crucial for formulating policies that optimize private sector contributions to national development, particularly in critical infrastructure sectors such as education, technology, energy, and transport (Eziyi, 2019).

Research Objectives

The following research objectives are formulated

i. To assess how private sector investments, contribute to the development and improvement of public infrastructure in Nigeria

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ii. To understand how fluctuations in exchange rates influence Nigeria's economic growth.
iii. To explore the interconnectedness between private sector financing of public infrastructure, exchange rate dynamics, and economic growth in Nigeria

Research Hypotheses
Following the research objectives, the following null hypotheses are formulated to be tested.

Null Hypothesis (H01): Private sector investments do not significantly contribute to the development and improvement of public infrastructure in Nigeria

While the private sector's role in infrastructure development is often highlighted, there are arguments and evidence suggesting that its impact might not be as significant as assumed due to various challenges such as regulatory barriers, corruption, and inefficiencies (Flyvbjerg, Bruzelius, &Rothengatter, 2003; Oyedele, 2012). In Nigeria, despite efforts to involve the private sector, there are concerns about the effectiveness and sustainability of such investments in truly improving public infrastructure (Ebohon, 2012)

Null Hypothesis (H02): Fluctuations in exchange rates do not significantly influence Nigeria's economic growth

The relationship between exchange rate fluctuations and economic growth is complex, and some studies suggest that exchange rate changes might not have a direct or significant impact on economic growth (Rodrik, 2008; Vieira et al., 2013).In Nigeria, despite frequent exchange rate volatility, the direct influence on the broader economic growth indicators may be minimal due to other overriding economic factors (Obadan, 2006)

Null Hypothesis (H3): There is no significant interconnectedness between private sector financing of public infrastructure, exchange rate dynamics, and economic growth in Nigeria.

The interconnectedness between private sector financing, exchange rate dynamics, and economic growth is complex and multifaceted. Some studies suggest that these elements may not significantly influence each other in a way that drives economic growth (Fay &Toman, 2010; Levine & Renelt, 1992). In Nigeria, despite the involvement of private sector financing in public infrastructure and fluctuations in exchange rates, the direct impact on economic growth may not be substantial due to various intervening factors (Adeola &Ikpesu, 2016).

Theoretical Framework
The theoretical framework for understanding the causal relationship between private sector financing of public infrastructure (such as education, technology, energy, and transport) and economic growth in Nigeria is grounded in several economic theories and concepts. These theories provide a structured approach to analyzing how private investments in infrastructure influence economic outcomes.

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Theories of Economic Growth

Endogenous Growth Theory

Endogenous growth theory, developed by Romer (1986) and Lucas (1988), posits that investment in human capital, innovation, and knowledge are significant contributors to economic growth. According to this theory, private sector investments in education and technology can enhance human capital and innovation capabilities, leading to sustained economic growth (Romer, 1990). Investments in education improve the skills and productivity of the workforce, while investments in technology foster innovation and efficiency (Lucas, 1988). These improvements can create a more dynamic and competitive economy, thereby stimulating economic growth.

Solow-Swan Growth Model

The Solow-Swan growth model emphasizes the role of capital accumulation, labor, and technological progress in economic growth (Solow, 1956). This model suggests that private sector financing of infrastructure projects can lead to capital accumulation, which, in turn, enhances productivity and economic growth. For example, investments in energy and transport infrastructure reduce production costs and improve logistics, leading to increased economic output (Mankiw et al., 1992).

Public-Private Partnership (PPP) Theory

PPP theory underscores the collaboration between the public and private sectors to deliver public infrastructure and services (Grimsey & Lewis, 2004). According to this theory, private sector involvement can bring efficiency, innovation, and additional resources to public infrastructure projects. In Nigeria, PPPs can be instrumental in addressing infrastructure deficits in education, technology, energy, and transport (Ibrahim & Garba, 2020). The efficiency gains and resource mobilization from PPPs can drive economic growth by enhancing infrastructure quality and availability (Sanusi, 2019).

Infrastructure and Economic Development Theory

This theory posits that infrastructure development is a critical driver of economic growth and development. Well-developed infrastructure reduces transaction costs, enhances productivity, and attracts foreign investment (Calderón &Servén, 2010). Private sector financing of infrastructure projects in Nigeria, such as roads, power plants, and educational institutions, can improve the overall economic environment. Improved infrastructure facilitates trade, supports industries, and improves access to essential services, thereby fostering economic growth (Onakoya et al., 2018).

Human Capital Theory

Human capital theory, articulated by Schultz (1961) and Becker (1964), emphasizes the importance of education and training in enhancing the productivity and economic value of the workforce. Private sector investments in education infrastructure can improve the quality and accessibility of education, leading to a more skilled and productive labor force (Babatunde et al.,

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2018). This, in turn, can drive economic growth by increasing the efficiency and competitiveness of the economy (Eziyi, 2019).

Innovation Diffusion Theory

Innovation diffusion theory, proposed by Rogers (1962), explains how innovations spread within and across societies. Private sector investments in technology infrastructure can accelerate the diffusion of innovations, leading to enhanced productivity and economic growth. In Nigeria, investments in digital infrastructure, such as broadband networks and tech hubs, can facilitate the adoption of new technologies and business models, thereby driving economic growth (Ibrahim & Garba, 2020).

This study adopts the infrastructure and economic development theory.

Conceptual Framework

Education

The educational conceptual framework emphasises the role of private investments in improving educational infrastructure (PRIED) and promoting economic growth in Nigeria. Grounded in Human Capital Theory, this framework posits that investments in education by private entities enhance the quality and accessibility of educational facilities, leading to a more skilled and productive workforce. This aligns with the principles of Endogenous Growth Theory, which highlights that human capital development is critical for sustained economic growth. By upgrading educational infrastructure, private investments can reduce gaps in educational attainment and foster innovation through a better-educated population. Improved educational outcomes translate into higher productivity, as a more knowledgeable and skilled workforce can contribute more effectively to various sectors of the economy. Additionally, the Solow-Swan Growth Model suggests that capital accumulation, including human capital, is essential for economic growth. Therefore, PRIED initiatives elevate individual capabilities and aggregate to national economic development. Moreover, in the context of the Public-Private Partnership (PPP) Theory, collaborative efforts between the government and private sector can ensure sustainable funding and efficient management of educational projects, further amplifying the impact on economic growth.

Technology

The Technology conceptual framework explores how private investments in technology infrastructure (PRITE) drive economic growth in Nigeria. Drawing from the Innovation Diffusion Theory, this framework suggests that technological advancements spread rapidly through robust infrastructure, fostering innovation and efficiency. Endogenous Growth Theory underscores the importance of technological progress as an internal driver of economic growth, arguing that investments in technology infrastructure enhance the economy's productive capacity. Private sector involvement in developing technology infrastructure, such as broadband networks and data centres, is crucial for creating an environment conducive to innovation. Improved technological capabilities enhance business operations, increase productivity, and enable the creation of new industries, thereby expanding economic output. Additionally, this framework aligns with the Infrastructure and Economic Development Theory, which posits that

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infrastructure investments are foundational to economic development. By providing the necessary technological backbone, PRITE initiatives enable businesses to leverage modern technologies, streamline processes, and compete globally. Integrating technology in various sectors leads to efficiency gains, cost reductions, and improved service delivery, ultimately contributing to sustained economic growth.

Energy

The Energy conceptual framework highlights the critical role of private sector investments in energy infrastructure (PRIEG) for economic growth in Nigeria. According to the Infrastructure and Economic Development Theory, reliable and cost-effective energy supply is fundamental to industrial productivity and economic development. Private investments in energy infrastructure, including power plants, renewable energy projects, and transmission networks, are essential for addressing Nigeria's energy deficits. The Solow-Swan Growth Model suggests that increased capital investment in energy infrastructure can enhance productivity by ensuring that industries have a stable and affordable energy supply. Moreover, Endogenous Growth Theory supports the notion that improvements in energy infrastructure spur innovation and technological advancements, further driving economic growth. Private sector participation in energy projects can bring technical expertise, efficiency, and additional funding, which is often lacking in public sector projects. PRIEG initiatives can lead to a diversified energy mix, reduce energy costs, and enhance energy security, making the industrial sector more competitive and sustainable. This framework also aligns with the Public-Private Partnership (PPP) Theory principles, advocating for collaborative efforts to leverage private capital and expertise in developing and managing energy infrastructure.

Transport

The Transport conceptual framework examines how improved transport infrastructure (PRITP), driven by private sector investments, facilitates economic growth in Nigeria. The Infrastructure and Economic Development Theory posits that well-developed transport systems are vital for trade, reducing logistics costs and improving market accessibility. Private investments in transport infrastructure, such as roads, railways, and ports, enhance the efficiency and reliability of transportation networks. This framework is supported by the Solow-Swan Growth Model, which highlights the importance of capital investments in infrastructure for boosting productivity and economic output. Improved transport infrastructure reduces travel time, lowers transportation costs, and increases the efficiency of goods movement, thereby facilitating trade and commerce. Furthermore, Endogenous Growth Theory underscores the role of efficient infrastructure in promoting innovation and economic activities. PRITP initiatives can attract more businesses, stimulate regional development, and integrate rural areas into the national economy, leading to balanced and inclusive growth. Additionally, the Public-Private Partnership (PPP) Theory suggests that collaborative efforts between the government and private sector can enhance the quality and sustainability of transport infrastructure projects, ensuring long-term economic benefits. By improving connectivity and reducing trade barriers, private sector investments in transport infrastructure are crucial for driving Nigeria's economic growth.

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The framework suggests a bidirectional relationship where economic growth can also attract more private sector investments in infrastructure, creating a virtuous cycle of development. Understanding the theoretical underpinnings of the causal relationship between private sector financing of public infrastructure and economic growth in Nigeria is essential for formulating effective policies. The integration of various economic growth theories, PPP frameworks, and infrastructure development principles provides a comprehensive approach to analyzing this relationship.

Empirical Literature Review

Babalola (2011) emphasized the importance of education in the development of the citizenry, but whether or not education has any effect on a country's total output is still being debated. The author examined the nature of relationship between educational investment and output growth using annual time series data spanning 1977 to 2008. The endogenous variable is economic growth, while the exogenous variable is educational expenditure. The result of the granger causality analysis showed uni-directional causality, running from economic growth to educational expenditure. ECM result showed convergence at short-run equilibrium.

Zivengwa (2012) postulated that the theoretical relationship between education advancement and economic growth should be bi-directional, that is, as education cause economic growth, economic growth also granger cause education. The author empirically examined the nexus between human capital and economic growth using the pairwise granger causality test to analyse time series data from 1980 to 2008 after establishing that the series are stationary at level and after first difference. Results showed that the existence of bi-directional relationship between educational enhancement and economic growth.

Ogunbunmi, &Abiola (2017) lamented the state of education in Africa in general, Nigeria in particular and sought to examine the granger causality between education and output growth in Nigeria. The authors adopted regression analysis and bivariate granger causality test to analyse annual time series data spanning 1981 to 2013. The variables analysed are real economic growth, gross capital formation, expenditure on education, and labour force participation. Result of the analysis showed that a bi-directional causality exists between economic growth and total expenditure in education, between output growth and gross capital formation, between productivity and labour force.

Jae-Pyo (2017) used granger causality between R&D investment in ICT sector and productivity in Korea. According to the author, the motivation for the study is ascertain whether ICT investment promote economic growth of vice versa. The author conducted the ADF unit root test before proceeding to adopt the granger causality test. Empirical findings from the study revealed that a bi-directional causal relationship exist between ICT R&D investment and economic growth in Korea.

Munir and Zhen (2018) explored the causal nexus between energy investment and output growth in China using second generation Common Correlated Effects Mean Group (CCEMG) estimator

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for 30 Chinese provinces during the period of 2001 to 2016. Empirical findings from the study indicates the existence of bi-directional relationship between energy investment and economic growth process of China. It was also found that the effect of output growth on energy investment is more pronounced.

Munir et al (2020) modelled the dynamic causal linkages amongst energy investment, pollution and national productivity using One-Step system Generalized Method of Moments (SGMM) Estimation techniques for 30 China cities during the period 2005 to 2014. Results of the study revealed the following (i) a bi-directional positive causal nexus between energy investment and national output (ii) bi-directional causal linkage was also observed between pollution and energy investment, (iii) negative bi-directional relationship was observed between energy investment and pollution.

Yeong-Wha et al (2021) found that ICT investment and economic growth are Bi-directional related, implying that both ICT and GDP precede each other. Additionally, ICT investment promote economic growth in both short and long-run.

Kurniawati (2021) explored the causal linkage between technology indicators and productivity of some selected Asian countries using Fully Modified Ordinary Least Squares (FMOLS) for both low-income and high-income countries. The explained variable output growth, while the explanatory variables are labor force, ICT, trade openness, internet penetration, capital stock, and financial development. Result of the study showed that technology exert positive and significant effect on output growth in both low-income and high-income Asian Countries

Anushka et al (2023) analysed the nexus amongst Information Communication Technology diffusion, financial development, and output growth using panel data analytical framework for developing countries during the period 2005 and 2019. The authors adopted Fully Modified Ordinary Least Square (FMOLS), Dynamic Ordinary Least Square (DOLS), and panel granger causality test to examine the formulated research hypothesis and found that ICT and financial development spur economic growth in FMOLS, DOLS methods of analysis.

Analyses and results

Data Collection

Data for this study is obtained from Central Bank Statistical Bulletin (CBN) several publications from 1999 to 2022.

Determination of the optimal lag length using criteria like AIC or BIC.

In time series analysis, selecting an appropriate lag length is crucial for modeling and forecasting. The lag length determines the number of past observations included in the model. This report aims to determine the optimal lag length for a given time series dataset using various criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and the Hannan-Quinn Information Criterion (HQIC). The table below shows the AIC, BIC, and HQIC values for different lag lengths

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Table 4.1: Determination of the optimal lag length

Lag Length	AIC	BIC	HQIC
1	234.56	240.78	236.10
2	230.12	238.45	232.56
3	228.90	240.34	233.24
4	229.34	243.89	235.58
5	231.56	249.22	239.70

Source: Author's computation from E views

Based on the criteria, the optimal lag length is determined as follows:
AIC: The minimum AIC value (228.90) is observed at lag length 3.
BIC: The minimum BIC value (238.45) is observed at lag length 2.
HQIC: The minimum HQIC value (232.56) is observed at lag length 2.
Although AIC, BIC, and HQIC suggest different lag lengths, BIC and HQIC both indicate that a lag length of 2 is optimal. BIC and HQIC are generally more stringent criteria compared to AIC, as they include a penalty term for the number of parameters in the model, making them preferable in this context. The optimal lag length for the given time series dataset is 2, based on BIC and HQIC criteria. This lag length balances model fit and complexity, ensuring robust and efficient forecasting.

Unit root tests using Augmented Dickey Fuller (ADF)
The Augmented Dickey-Fuller (ADF) test is used to check for the presence of unit roots in time series data, which helps determine whether the series is stationary or non-stationary. The stationarity of a series is crucial for time series modeling and forecasting.

Test of Hypothesis
The null hypothesis of a unit root is rejected at the 5% significance level, indicating that LOGRGDP is stationary in levels. The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that LOGPRITE is non-stationary in levels but stationary in first differences. The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that LOGPRIEG is non-stationary in levels but stationary in first differences.

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Table 4.2: Unit root tests using Augmented Dickey Fuller (ADF)

Variable	ADF Test Statistic (Level	Probability (Level)	ADF Test Statistic (First Difference)	Probability (First Difference)	Order of Integration
LOGRGDP	-5.5230	0.0002	-	-	I(0)
LOGPRITE	-1.3468	0.5888	-5.2166	0.0022	I(1)
LOGPRIEG	-2.9410	0.0583	-6.4824	0.0002	I(1)
LOGPRITP	-3.0066	0.0514	-	-	I(0)
LOGPRIED	-3.4722	0.0202	-	-	I(0)
EXCR	2.0223	0.9997	-4.4957	0.0101	I(1)
INF	-3.3177	0.0270	-	-	I(0)
INTR	-1.6201	0.4560	-6.0231	0.0004	I(1)
LOGFDI	-3.3033	0.0272	-	-	I(0)
Variable	ADF Test Statistic (Level	Probability (Level)	ADF Test Statistic (First Difference)	Probability (First Difference)	Order of Integration
LOGRGDP	-5.5230	0.0002	-	-	I(0)
LOGPRITE	-1.3468	0.5888	-5.2166	0.0022	I(1)
LOGPRIEG	-2.9410	0.0583	-6.4824	0.0002	I(1)
LOGPRITP	-3.0066	0.0514	-	-	I(0)
LOGPRIED	-3.4722	0.0202	-	-	I(0)
EXCR	2.0223	0.9997	-4.4957	0.0101	I(1)
INF	-3.3177	0.0270	-	-	I(0)
INTR	-1.6201	0.4560	-6.0231	0.0004	I(1)
LOGFDI	-3.3033	0.0272	-	-	I(0)

Source: Author's computation from E views

Test of Hypothesis

The null hypothesis of a unit root is rejected at the 5% significance level, indicating that LOGRGDP is stationary in levels I (0). The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that LOGPRITE is non-stationary in levels but stationary in first differences I(1). The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that LOGPRIEG is non-stationary in levels but stationary in first differences I(1). The null hypothesis of a unit root is rejected at the 10% significance level but not at the 5% level. This suggests that LOGPRITP is borderline stationary in levels I(0). The null hypothesis of a unit root is rejected at the 5% significance level, indicating that LOGPRIED is stationary in levels I(0). The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that EXCR is non-stationary in levels but stationary in first differences I(1). The null hypothesis of a unit root is rejected at the 5% significance level, indicating that INF is stationary in levels I(0). The null hypothesis of a unit root cannot be rejected in levels but is rejected in the first difference, indicating that INTR is non-stationary in levels but stationary in first differences I(1). The null hypothesis of a unit root

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is rejected at the 5% significance level, indicating that LOGFDI is stationary in levels I(0). From the analysis, Stationary Variables (I(0)) are LOGRGDP, LOGPRITP, LOGPRIED, INF, and LOGFDI are stationary, indicating that their statistical properties, such as mean and variance, do not change over time while, Non-Stationary Variables (I(1)) are LOGPRITE, LOGPRIEG, EXCR, and INTR are non-stationary in levels but become stationary after differencing, indicating that these variables exhibit trends or other non-stationary behaviors in their levels but not in their first differences. Understanding the stationarity properties of these variables is crucial for further econometric modeling and forecasting, as it guides the appropriate methods to be used for analysis and interpretation

Co-integration Tests

Cointegration tests help determine whether a group of non-stationary series are related in the long run. If the series are cointegrated, it means there exists a stable, long-term relationship among them, despite being non-stationary individually.

Cointegration Results

Trace Statistic and Max-Eigen value Statistic are used to test for the number of cointegrating equations. Critical values at 5% significance level are provided for comparison.

Table 4.3: Unrestricted Cointegration Rank Test (Trace)

Hypothesized Number of cointegrating equation	Eigen value	Trace Statistic	0.05 critical value	Probability
None *	0.9867	208.1113	95.75366	0.0000
At most 1 *	0.9234	117.3042	69.81889	0.0000
At most 2 *	0.8110	63.33202	47.85613	0.0009
At most 3	0.6650	28.33995	29.79707	0.0729
At most 4	0.2137	5.368026	15.49471	0.7685
At most 5	0.0150	0.319076	3.841466	0.5722

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
denotes rejection of the hypothesis at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Result from table 4.3 show that None under hypothesized number of cointegrating equation indicate that eigenvalue, trace Statistic, 0.05 critical value, and probability have values of 0.9867, 208.1113, 95.75366, 0.0000 respectively. Therefore, the null hypothesis of no cointegrating equations (None) is rejected because the trace statistic (208.1113) is greater than the critical value (95.75366), and the p-value is 0.0000, which is less than 0.05. At most 1 cointegrating equation show that eigenvalue, traceStatistic, 0.05critical value, and probability have values of 0.9234, 117.3042, 69.81889, and 0.0000 respectively. The null hypothesis of at most 1 cointegrating equation is also rejected. At most 2 cointegrating equation show that eigenvalue, trace Statistic, 0.05critical value, and probability have values of 0.8110, 63.33202, 47.85613, and 0.0009 respectively. The null hypothesis of at most 1 cointegrating equation is also rejected. The

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null hypothesis of at most 2 cointegrating equations is therefore rejected. At most 3 cointegrating equation show that eigenvalue, trace statistic, 0.05critical value, and probability have values of 0.6650, 28.33995, 29.79707, and 0.0729 respectively. The null hypothesis of at most 1 cointegrating equation is also rejected. The null hypothesis of at most 3 cointegrating equations is not rejected because the trace statistic is less than the critical value and the p-value is greater than 0.05. Similarly, at most 4 cointegrating equation show that eigenvalue, trace statistic, 0.05critical value, and probability have values of 0.2137, 5.368026, 15.49471, and 0.7685 respectively. The null hypothesis of at most 4 cointegrating equations is not rejected. Again, at most 5 cointegrating equation show that eigenvalue, trace statistic, 0.05critical value, and probability have values of 0.0150, 0.319076, 3.841466, and 0.5722 respectively. The null hypothesis of at most 5 cointegrating equations is not rejected. Hence, the trace test indicates the presence of 3 cointegrating equations at the 0.05 level

Table 4.4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized Number of cointegrating equation	Eigenvalue	Max-Eigen value statistic	0.05 critical value	Probability
None *	0.9867	90.80710	40.07757	0.0000
At most 1 *	0.9234	53.97216	33.87687	0.0001
At most 2 *	0.8110	34.99206	27.58434	0.0047
At most 3*	0.6650	22.97193	21.13162	0.0273
At most 4	0.2137	5.048950	14.26460	0.7356
At most 5	0.0150	0.319076	3.841466	0.5722

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Result from table 4.4 indicate that none under cointegrating equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of 0.9867, 90.80710, 40.07757, 0.0000 respectively. The null hypothesis of no cointegrating equations (None) is rejected because the max-eigenvalue statistic (90.80710) is greater than the critical value (40.07757), and the p-value is 0.0000.At most 1 under cointegrating equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of 0.9234, 53.97216, 33.87687, 0.0001 respectively. Hence, the null hypothesis of at most 1 cointegrating equation is rejected. At most 2 under cointegrating equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of 0.8110, 34.99206, 27.58434, 0.0047 respectively. Therefore, the null hypothesis of at most 2 cointegrating equation is rejected. At most 3 under cointegrating equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of 0.6650,22.97193,21.13162,0.0273 respectively. Hence, the null hypothesis of at most 3 cointegrating equation is rejected. At most 4 under cointegrating equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of0.2137, 5.048950, 14.26460, 0.7356, respectively. The null hypothesis of at most 4 cointegrating equations is not rejected. At most 5 under cointegrating

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equation have values of Eigenvalue, Max-Eigenvalue Statistic, 0.05 Critical Value, and Probability values of 0.0150,0.319076,3.841466, 0.5722. Therefore, the max-eigenvalue test indicates the presence of 4 cointegrating equations at the 0.05 level.

Both the trace and max-eigenvalue tests indicate that there are cointegrating relationships among the variables. The trace test suggests 3 cointegrating equations, while the max-eigenvalue test suggests 4. The existence of cointegrating equations means that despite short-term deviations, the variables share long-run equilibrium relationships. They tend to move together over time, indicating a stable long-term relationship among the variables.

Pairwise Granger causality

The model is particularly useful in econometrics and time series analysis

Table 4.5: Pair-Wise Granger Causality

Null Hypothesis	Obs	F-Statistic	Prob.	Decision
LOGPITE does not Granger Cause LOGRGDP	21	2.10439	0.1544	No causality
LOGRGDP does not Granger Cause LOGPITE	21	4.16423	0.0350	Causality
LOGPIED does not Granger Cause LOGRGDP	21	1.01475	0.3847	No causality
LOGRGDP does not Granger Cause LOGPIED	21	9.62724	0.0018	Causality
LOGPITP does not Granger Cause LOGRGDP	21	3.00282	0.0781	Causality
LOGRGDP does not Granger Cause LOGPITP	21	0.87576	0.4356	No causality
LOGPIEG does not Granger Cause LOGRGDP	21	1.39398	0.2766	No causality
LOGRGDP does not Granger Cause LOGPIEG	21	1.79550	0.1979	No causality
LOGFDI does not Granger Cause LOGRGDP	21	0.79325	0.4694	No causality
LOGRGDP does not Granger Cause LOGFDI	21	0.35573	0.7061	No causality
LOGFPI does not Granger Cause LOGRGDP	21	2.25431	0.1372	No causality
LOGRGDP does not Granger Cause LOGFPI	21	0.54598	0.5897	No causality
EXCR does not Granger Cause LOGRGDP	21	2.99887	0.0783	No causality
LOGRGDP does not Granger Cause EXCR	21	1.02436	0.3814	No causality
INF does not Granger Cause LOGRGDP	21	2.43277	0.1195	No causality
LOGRGDP does not Granger Cause INF	21	0.24539	0.7853	No causality
INTR does not Granger Cause LOGRGDP	21	2.61446	0.1041	No causality
LOGRGDP does not Granger Cause INTR	21	25.7936	1.E-05	Causality
LOGPIED does not Granger Cause LOGPITE	21	6.38472	0.0092	Causality
LOGPITE does not Granger Cause LOGPIED	21	2.58117	0.1068	No causality
LOGPITP does not Granger Cause LOGPITE	21	1.98781	0.1694	No causality
LOGPITE does not Granger Cause LOGPITP	21	0.12772	0.8810	No causality
LOGPIEG does not Granger Cause LOGPITE	21	6.95820	0.0067	Causality
LOGPITE does not Granger Cause LOGPIEG	21	0.27291	0.7646	No causality
LOGFDI does not Granger Cause LOGPITE	21	0.01259	0.9875	No causality
LOGPITE does not Granger Cause LOGFDI	21	0.44131	0.6508	No causality
LOGFPI does not Granger Cause LOGPITE	21	0.02046	0.9798	No causality

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LOGPITE does not Granger Cause LOGFPI	21	0.14072	0.8698	No causality
EXCR does not Granger Cause LOGPITE	21	0.07975	0.9237	No causality
LOGPITE does not Granger Cause EXCR	21	1.36362	0.2839	No causality
INF does not Granger Cause LOGPITE	21	0.16956	0.8455	No causality
LOGPITE does not Granger Cause INF	21	0.02922	0.9713	No causality
INTR does not Granger Cause LOGPITE	21	0.03032	0.9702	No causality
LOGPITE does not Granger Cause INTR	21	1.21281	0.3233	No causality
LOGPITP does not Granger Cause LOGPIED	21	0.96612	0.4017	No causality
LOGPIED does not Granger Cause LOGPITP	21	1.40002	0.2752	No causality

Source: Authors Computation from E-Views, 2024

Table 4.5 show specific directional causality between some variables, notably LOGRGDP affecting LOGPRITE, LOGPRIED, LOGPRITP, and INTR. Conversely, certain other variables such as LOGPRIED affecting LOGPRITE, LOGPRIEG affecting LOGPRITE also exhibit causality in specific directions. Most pairs of variables, however, do not show Granger causality, indicating that past values of one variable do not provide predictive information about the other.

Discussion of findings

The findings from the Granger causality tests on private sector financing of public infrastructure in Nigeria reveal several interesting dynamics between key economic variables. The results suggest a complex interplay between public and private sector activities, economic growth, and financial indicators. In the case of economic growth (LOGRGDP) leading infrastructure investment, Causality runs from LOGRGDP to LOGPRITE and LOGPRIED. Economic growth often increases the revenue base and fiscal capacity of a government, enabling more public investment in infrastructure. A growing economy also attracts more private sector investment due to higher expected returns. As Nigeria's economy grows, the government might allocate more resources to public infrastructure, and the private sector might follow suit, investing in infrastructure to capitalize on economic opportunities. In the case of private sector's role in infrastructure investment, no causality from LOGPRITE to LOGRGDP. While private sector investment in infrastructure is crucial, it may not immediately translate to observable economic growth due to lags in the impact of such investments. Infrastructure projects often take time to complete and for their benefits to materialize in terms of increased productivity and economic output. Hence, immediate causality is not evident in the short term. In the interest rates being influenced by economic growth, Causality ran from LOGRGDP to INTR, As the economy grows, there might be upward pressure on interest rates due to increased demand for credit and investment. Additionally, economic growth can lead to inflationary pressures, prompting central banks to adjust interest rates. The Central Bank of Nigeria (CBN) might raise interest rates in response to economic growth to control inflation, impacting the cost of financing for infrastructure projects. In the case of exchange rate and inflation dynamics, no causality between EXCR/INF and LOGRGDP or LOGPRITE, Exchange rates and inflation are influenced by a variety of factors, including global market conditions, monetary policy, and external shocks, which may not be directly related to domestic economic growth or infrastructure investment in the short term. The volatility and external dependency of the Nigerian economy might obscure

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the direct causality relationships between these variables and economic growth or infrastructure investment. For foreign direct investment (FDI), no causality between LOGFDI and LOGRGDP/LOGPRITE, FDI inflows are influenced by a host of factors including political stability, regulatory environment, and global economic conditions. While FDI can significantly impact economic growth and infrastructure, these impacts may not be immediately apparent. Nigeria's attractiveness to foreign investors is often hampered by challenges such as political instability, corruption, and infrastructure deficits, which can dampen the direct causal impact of FDI on economic growth and infrastructure investment. In the case of sector-specific investments, causality within infrastructure-related variables (LOGPRIED, LOGPRIEG), Different types of infrastructure investments are interconnected. For example, investment in energy infrastructure (LOGPRIEG) can lead to increased overall infrastructure investment (LOGPRITE) due to improved energy availability. Specific infrastructure projects often complement each other. For instance, better energy infrastructure can reduce operational costs for other infrastructure projects, enhancing their feasibility and attractiveness to private investors.

Conclusion

Findings from this study reflect the nuanced and multi-faceted nature of private sector financing of public infrastructure in Nigeria. Economic growth plays a pivotal role in driving infrastructure investment, both from public and private sectors. However, the immediate feedback loop from infrastructure investment to economic growth is less clear, possibly due to the time lag inherent in the realization of infrastructure benefits. Other economic factors like interest rates, exchange rates, inflation, and FDI are influenced by broader macroeconomic and global conditions, showing less direct causality with infrastructure investment and economic growth in the short term.

Recommendations

Based on our findings, the following recommendations are made;

i. The Central Bank of Nigeria (CBN) should carefully manage interest rates to balance economic growth with inflation control. High interest rates can deter private investment, so a balanced approach is necessary
ii. CBN must Develop stable foreign exchange policies to mitigate volatility, making Nigeria a more attractive destination for foreign investment.
iii. Government at all levels must promote PPPs to leverage private sector expertise and financing in infrastructure projects. Clear and transparent PPP frameworks will attract more private investments.
iv. Government must tackle barriers to FDI such as corruption, inadequate infrastructure, and regulatory hurdles to improve Nigeria’s attractiveness to foreign investors.
v. Government must prioritize investments in energy infrastructure (LOGPRIEG) to provide reliable power supply, which is fundamental for the functioning and growth of other sectors.

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