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Physical Infrastructure and Economic Performance in Nigeria: A Ridge Regression Analysis

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Abstract: In Nigeria, how far the deplorable state of most infrastructural facilities and the state of disrepair affect the growth potentials of the nation is relatively unknown. In view of this, this study investigates the role of infrastructure on economic performance in Nigeria using annual time series data for the period 1990-2019. The study employed Principal Component Analysis to develop an infrastructure index based on six major infrastructure indicators (electricity, telecommunication, rail density, air transport, energy use, and internet penetration) and also utilized the ridge regression estimation technique due to the presence of high multicollinearity among our variables. The study found that infrastructure positively and significantly enhanced economic performance within the period. The study, therefore, recommends the need for the Nigerian government and its agencies to monitor infrastructure spending closely and firmly adhere to due process following the enabling fiscal policy.

Keywords: Infrastructure; Ridge Regression; Economic Performance

JEL Classification: H4; H54; O4

1. Introduction

Infrastructure, which includes community buildings such as hospitals and schools, transportation networks such as airports, seaports, rail and road, and utility services such as water, power, and waste services, is a fundamental determinant of

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nationhood, a means of attracting substantial private sector investment, and a measure of a country's success on the global stage Aworinde and Akintoye (2019). A well-developed infrastructure can help stimulate and expand an economy's commercial activity. For example, enough electricity supply, a good road network, and an effective communication system, among other things, can promote the ease of business operations and foster the production of goods and services, ultimately leading to more excellent economic performance. Hence, infrastructure is critical to any country, whether developed or developing. Consequently, a country's various infrastructures must be handled competently to serve not just as a source of pride for that country but also as an encouragement to other countries to achieve economic development. It is the backbone of any economy and a pillar of quality of life (Ekeocha, *et al.*, 2022). As a result, any nation seeking to be competitive and achieve long-term growth and development must prioritize infrastructure development.

There are two ways in which infrastructure development can boost economic performance: directly and indirectly. Infrastructure, primarily a pure public good, directly contributes to economic performance through the productivity effect. Infrastructure substitutes or complements other inputs in the production function. Consequently, an increase in infrastructure stock would boost the productivity of other components, thereby improving economic performance Almeida and Mendonca (2019). On the other hand, infrastructure positively affects aggregate output via a number of indirect transmission mechanisms, such as adjustment cost, private capital, and labour productivity (Straub, 2008; Owolabi-Merus, 2015). Various factors, such as the rate of urbanization, openness, government revenue, external reserves, population density, and type of government, have influenced public infrastructure investment (Javid, 2019).

Governments worldwide constantly look for innovative ways to boost their economies' ability to create products and services. In this view, for the past two decades, emphasis has turned to infrastructure development as a veritable tool for increasing the economy's productive potential. Infrastructure is highly vital in an economy's growth process. Indeed, development economists regard infrastructure as a prerequisite for industrialization and economic development Ogbaro and Omotoso (2017). Policymakers think adequate infrastructure investment is the cornerstone of social and economic progress. According to the World Bank (2008), developing global infrastructure is critical to decreasing poverty, enhancing growth, and achieving the Millennium Development Goals (MDGs).

However, re-inventing public infrastructure has remained a central issue in economic development, particularly in developing African countries whose economies are characterized by structural rigidities, weak support services, and institutional frameworks, declining productivity, a high level of corruption, and policy instability (Ekpung, 2014). Infrastructure investment is expected to result in significant

nationwide transformation by removing bottlenecks and breakdowns in the transportation and energy sectors, increasing GDP, generating employment, and facilitating and enhancing mobility. The poor infrastructure in Nigeria, similar to nearly all developing countries, has sparked an ongoing interest in determining if infrastructure funds have generated significant results over time. The dismal status of most infrastructure facilities, as well as the state of disrepair and lack of maintenance culture, as experienced by Nigerians, impact the country's overall growth potential (Owolabi-Merus, 2015). Because infrastructure offers social comfort to citizens, a lack of infrastructure reduces workers' conditions, diminishing their overall output (Ekpung, 2014).

This background prompted an assessment of the role of infrastructure on economic performance in Nigeria. Unlike previous studies, this study develops a composite index for Nigeria's economic and social infrastructure stocks (electricity, telecommunications, internet usage, air transport, rail density, and energy use) using Principal Component Analysis (PCA). Also, based on the ridge regression estimation technique proposed by Hoerl and Kennard (1970), the objective is to determine whether these infrastructure indicators improve economic performance.

2. Literature Review

2.1. Conceptual Clarification

Infrastructure refers to the basic facilities and systems that serve a country, city, or other areas and include the services and facilities required for the economy to operate effectively. These basic facilities include public and private physical improvements, including roads, trains, bridges, tunnels, water supply, sewage, electrical grids, and telecommunications. Generally, it refers to the physical components of interconnected systems that provide commodities and services required to enable, sustain, or improve societal living conditions. Infrastructure refers to the basic facilities and services that facilitate various economic activities and improve the country's economic performance Ayeni and Afolabi (2020). It is the sum of material, institutional, and personal facilities available to economic agents that contribute to the equalisation of remuneration for comparable inputs in the case of appropriate resource allocation, resulting in complete integration and maximum level of economic activity (Torrisi, 2009). Infrastructure improvement projects can be sponsored publicly, privately, or through public-private partnerships.

Hansen (1965) classified infrastructure into two types: economic and social. Economic infrastructure which includes aspects like irrigation, power and transportation refers to the fundamental facilities and services that directly benefit an economy's production and distribution processes. Social infrastructure, on the other hand, refers to those fundamental activities and services that indirectly benefit

numerous economic activities in addition to attaining particular social goals such as education, health care and communication. However, Aschauer (1989) distinguished between core and non-core infrastructures. He assigned a central role to public capital in a country's economic progress, notably as a component of the core infrastructure. Roads and highways, airports, public transportation, electric and gas networks, water distribution networks, and sewer networks are examples of core infrastructures, while non-core infrastructures are the residual components. Sturm and Jacobs (1995) made a similar distinction and categorized infrastructure as basic or complimentary. Main railways, roads, canals, harbours and docks, the electromagnetic telegraph, drainage, dikes, and land reclamation are examples of basic infrastructure. Light trains, tramways, petrol, electricity, water supply, and local telephone networks are examples of complementary infrastructure.

Biehl (1991) classified infrastructure into network and nucleus. Roads, railroads, waterways, communication networks, and energy and water provisioning systems are examples of network infrastructure, whereas schools, hospitals, and museums are examples of nucleus infrastructure, which are distinguished by a high degree of immobility, indivisibility, non-interchangeability, and multi-purpose features.

Previous research has revealed that the study of the relationship between infrastructure and economic performance is still limited in regards to the number of works and research methodologies used, as well as the diversity of conclusions. Furthermore, no research has yet used the ridge regression estimation technique to examine the effect of economic and social infrastructure on economic performance. This methodology for analyzing the relationship between these two variables in Nigeria is thus novel and noteworthy.

2.2. Infrastructure and Economic Performance

The two theoretical channels through which infrastructure could improve economic performance are direct and indirect. Aschauer (1989) proposed the first channel of the infrastructure growth nexus, arguing that public infrastructure investment supports growth through private capital and is not subject to user charges. As a result, a significant increase in capital stocks has a positive but diminishing impact on the marginal product of all components, including labour and capital. This, in turn, lowers production costs and raises the level of private output. In the empirical research for developing nations, the impact of infrastructure on economic performance through private capital development is widely documented (Otto & Voss, 1994; Nadiri & Mamuneas, 1996; Albala-Bertrand & Mamatzakis, 2004; Agenor, *et al.* 2005; Agenor & Moreno-Dodson 2006; Straub, 2008).

In addition to the direct effect of infrastructure on economic performance via private input productivity and the rate of return on private capital, infrastructure has a

positive effect on aggregate output through a variety of indirect transmission mechanisms such as adjustment cost, labour productivity, and the durability of private capital.

Improved infrastructure stock will lower the cost of private capital and unit labour cost by reducing the logistic cost of private investment and allowing for more flexible private investment in devices such as energy generators for more productive investments in machines (Straub, 2008). Furthermore, upgrades in communication technology and the road network cut travel time and aid in better planning work time, which increases labour efficiency and productivity Ayeni and Afolabi (2020).

Reviewing the empirical evidence on the effect of infrastructure on economic performance in developed economies, Hulten and Schwab (1991) found that public infrastructure has no significant impact on economic performance in USA. To support this claim, Holtz-Eakin (1993) revised empirical performance estimates based on the Solow growth model and found that a significant rise in the investment rate did not result in a persistent increase in the rate of economic development; however, there was temporary faster growth and an extended temporary growth phase before output per effective worker stabilised at a new, higher level.

Canning and Fay (1993) in their study discovered that transportation infrastructure positively and significantly contributed to economic performance in developing economies. This findings is consistent with the studies of Tatom (1993); Demurger (2001); Tella *et al*., (2007); Ogbaro and Omotoso, (2017).

However, the findings by Fedderke and Bogetic (2006) on South Africa; Nedozi, *et al.*, (2014); Owolabi-Merus (2015); Adelowokan *et.al.*, (2019) on Nigeria found that infrastructure investment has a positive effect on economic growth. Thus undermining it undermines the growth and development of the economy. As a result, it should receive adequate and qualitative attention. Similarly, Dissou and Didic (2011) discovered in a different study for Benin that public infrastructure investment can boost private investment and sustain capital accumulation. Thus, the crowding-out effects of public infrastructure are sensitive to the mode of funding chosen by the government. The plausible impact of public spending on private investment can be explained by infrastructure finance mechanisms such as public-private partnerships and subcontracting, which crowd in private investment. The studies of Javid (2019), Almeida and Mendonca (2019) and Ekeocha, Ogbuabor and Orji (2022) came to a similar conclusion. While studies like Adesoye (2014); Aworinde and Akinloye (2019) found that infrastructural investment has a negative influence on economic growth.

3. Methodology

3.1. Theoretical Framework

The theoretical framework employed in this study is the endogenous growth model of Barro (1990) which introduced public investment in infrastructure as the core endogenous factor that drives growth. This theory was used in the works of Canning and Pedroni (2004), Agenor (2010), Almeida and Mendoca (2019) and Ekeocha *et al*. (2022). The uniqueness of public-policy endogenous growth theory is the relaxation of the restricted measure of infrastructure in determining both output level and steady-state growth rate. He underlined that increased infrastructure spending on roads, highways, and telephones will stimulate private industry and hence enhance economic performance.

Barro (1990) model adds public spending to the Romer, (1896) AK model.

$$Y = BK^{1-\propto}G^{\propto} \quad (3.1.)$$

Where K is the level of capital and G is government spending on investment

3.2. Model Specification

The basic model of this study is based on Hoerl and Kennard's (1970) ridge regression model, which is guided by the theoretical framework stated in (3.1). Ridge regression is a specialized technique that uses the ridge trace as an alternative to the least squares estimator to analyze multiple regression data that is multicollinear in nature. This seeks to reduce the standard error by including some bias in the regression estimates.

The functional form of the model is restated as:

$$RGDP = f(INFR) \quad (3.2.)$$

Where $RGDP$= Real Gross Domestic Product; $INFR$ = infrastructure index.

Specifying the equation in a log-log form, the model is presented as:

$$lnRGDP = \beta_0 + \beta_1 lnINFR + \beta_2 lnGCF + \mu_t \quad (3.3)$$

Where, β_0 is the constant, the value of the dependent variable when explanatory variables are zero, $\beta_1 and \beta_2$ = parameter estimate and μ_t= error term. In this model, we use Real GDP to measure economic performance, GCF as a measure of Gross Capital Formation and a composite index of six (6) major infrastructures was developed using the Principal Component Analysis (see Zheng & Rakovski, 2021; Khan *et al*, 2020; Zeng *et al.*, 2013) to account for both economic and social infrastructure (electricity, telecommunication, internet penetration, air transport, rail density and energy use). The Principal Component Analysis (PCA) is a multivariate

decision-making technique. This method creates a composite index by objectively defining a real-valued function over relevant variables. This study adopted an ex-post facto research design and annual time series data from the World Bank in World Development Indicators spanning 30 years (1990-2019).

3.3. Model Estimation Technique

Given the link between the variables in the model, Equation 3.3 is anticipated to be multicollinear. This violates the OLS (ordinary least squares) unbiasedness criterion. If the model terms are correlative and the columns of the design matrix X have an approximate linear relationship, the matrix $(X^T X)^{-1}$ will be close to singular. As a result, the least-squares estimate is very sesitive to random errors in the observed response Y resulting in a high variance. When two or more variables are highly linearly related, the problem of multicollinearity can be solved by abandoning the traditional least-squares method and instead using biased estimate techniques by introducing a penalty parameter k whose value should be greater than zero but less than one in order to reduce the standard error while also improving the predictive power of the model Wen and Shao (2019). The ridge trace technique proposed by Hoerl and Kennard (1970) is utilized to determine such optimum (k). The ridge trace plots the ridge regression parameters against various values of the ridge parameter k in a systematic way. As the estimates are plotted against different ridge parameter values, their values fluctuate and tend to become stable around a specific value of k. The optimum ridge parameter is chosen as the k around which the estimations become stable.

4. Results

4.1. Correlation Matrix

The assessment of the correlation between variables is widely accepted as a method for determining whether a group of variables has significant colinearity or not. The correlation coefficient denotes the strength of the seeming linear relationship between the variables tested. The parameter estimates become unstable in the presence of substantial multicollinearity. The correlation matrix is shown below:

Table 4.1. Correlation Matrix

Correlation	RGDP	INFR	GCF
RGDP	1		
INFR	0.859	1	
GCF	-0.888	0.853	1

Source: Author's Computation.

Table 4.1 illustrates that there is a strong correlation between real GDP, infrastructure, and gross capital formation. The correlation coefficients of this pair of variables are greater than 0.80, implying the presence of multicollinearity. As previously stated, this gives rise to the use of the ridge regression approach, which is one of the appropriate estimation techniques for addressing the problem of multicollinearity in a multiple regression model (Wen & Shoa (2019); Yoantika & Susiswo (2021).

5. Regression Result

Table 4.2. The Effect of Infrastructure on Economic Performance in Nigeria

Dependent Variable: Economic Performance (LNReal GDP)						
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Ridge Variance Inflation Factor	OLS Variance Inflation Factor
LNINFR	0.0682895	0.0178754	3.820306	0.001 *	2.0682	2.07
LNGCF	-1.007255	0.0448569	-22.454850	0.000 *	2.0682	2.07
C	13.80519	0.1445444	95.508300	0.000 *		
K – Value						0.001
Adjusted R^2						0.975
F-statistic						555.017
Probability F-statistic						0.000 *

*Note: *P < 0.01; **P < 0.05*
Source: Author's Computation.

The validation of the ridge regression estimation technique could be verified with credible indexes of adjusted R^2, *t* test and *F* tests. The result indicates that the regression equation is significant (0.000) with inference drawn from 5% significance level and the fitting degree of adjusted R^2 of 0.975 is excellent see Table 4.2. Also, the probability values of t-statistics for the explanatory variables INFR and GCF of 0.001 and 0.000 respectively indicates that the variables are statistically significant at 5% significance level. This result is consistent with the theoretical expectation of a positive association, implying that increased infrastructure development in Nigeria will greatly boost economic performance. The importance of infrastructure to economic performance is substantial in terms of magnitude. Indeed, for every 1 percent increase in infrastructure, economic performance improves by roughly 0.07 percent. Furthermore, there is a negative and statistically significant relationship between gross fixed capital formation and economic performance. A 1 percent increase in gross fixed capital formation decreases Nigeria's economic performance by 1.007 percent.

Furthermore, the ridge trace plot in Figure 4.1 shows that the chosen ridge parameter is 0.001, for it is at this value that the parameter estimates seem to become stabilized. Also, all of the variance inflation factors meet the requirements; VIF $\leq$ 10, as the standard thumb rule Gujarati (2009). The VIFs of the estimated coefficients (2.068) which is lower than 10 indicates that the multicollinearity problem has been resolved.

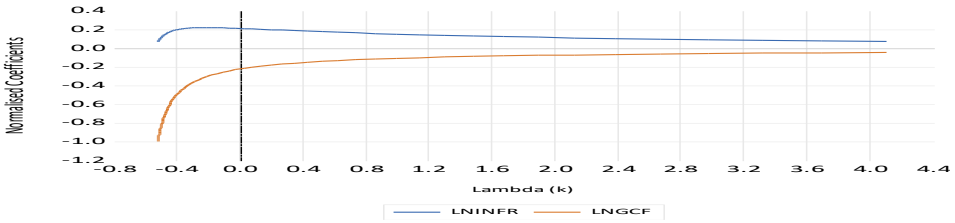

Figure 4.1. Ridge Trace Plot for the Effect of Infrastructure on Economic Performance in Nigeria

5.1. Discussion of Findings

The findings demonstrated that infrastructure is positively and significantly related to economic performance. The availability of infrastructure influences the marginal productivity of private capital at the aggregate level and reduced the manufacturing expenses at the microeconomic level. Infrastructure impacts on profitability, output, income and employment, particularly for small and medium-sized businesses. It also has an impact on international trade costs and service quality (trade logistics), which impacts competitiveness in export/import markets. Finally, it has an effect on domestic transaction costs and access to market information, allowing the economy to benefit from market liberalization policies that increase efficiency. Nigeria is characterized as one of the countries with high infrastructural deficits, ranking 24th out of 54 African countries (African Infrastructure Development Index, AIDI, 2021), the result of a positive relationship demonstrates that infrastructure development offers massive opportunities for improving the Nation's economic performance. This positive result is consistent with the findings from the studies of Ekeocha *et al.*, (2022) on Africa; Khan *et al.* (2020) on South Asia; Adelowokan *et al*,. (2019) on Nigeria study but contradicts the findings of Shi, *et al.*, (2017) on China study; Roy *et al.*, (2014) on India. This could be due to an overinvestment in infrastructure, which could result in diminishing returns. Returns may be negative if governmental infrastructure investment crowds out private sector activity. This crowding out effect can arise as a result of preferential loans for government-supported infrastructure projects, resulting in inefficient resource utilization when projects are not subject to market discipline. Infrastructure development can potentially increase input costs and cause disruptions.

6. Summary and Conclusion

This study investigated the effect of infrastructure on economic performance in Nigeria for the period 1990-2019. This study was founded on the Barro (1990) endogenous growth model and measured infrastructure with an infrastructure index computed through a principal component analysis of six major infrastructure indicators to account for both economic and social infrastructure. Last, we measure economic performance with real GDP growth using *ex post facto* research design that employs ridge regression model.

This study concludes that infrastructure development is critical for improving economic performance. Since this study acclaims the importance of infrastructure in achieving economic performance, the Nigerian government should implement more projects within the country focused at enhancing and increasing access to all types of infrastructure. To do this, the study recommends that infrastructure funding be used efficiently and effectively for the benefit of citizens.

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