INFRASTRUCTURE DEVELOPMENT AND INDUSTRIAL OUTPUT IN NIGERIA: A Dynamic Model Approach

Taofik Mohammed Ibrahim
Department of Economics
Ahmadu Bello University, Zaria, Kaduna, Nigeria

ABSTRACT

This paper empirically examines the influence of infrastructure (proxied by telephone density, energy consumption and capital expenditure in transport and communication) on industrialization (measured by industrial output) in Nigeria from 1981 to 2015. It synthesizes the production function and growth approaches to estimate the industrial output elasticity of infrastructure development using the dynamic ordinary least squares (DOLS) estimation technique that accounts for present and past effects of infrastructural development on industrialization. The Toda-Yamamoto modified Wald (MWALD)-based causality test that arbitrage between the results with and without structural breaks was used to define the direction of causality between infrastructure and industrial output. The unit root tests that account for break and without break were employed to ascertain the stationarity of the data, while the residual-based cointegration test with a structural break was employed to determine the cointegrating relationship among the variables. Findings suggest that all proxy of infrastructure except telephone density impacted positively on industrial output when structural breaks were not accounted for. Telephone density and energy consumption impacted on industrial output in the presence of structural breaks, while capital expenditure in transport and communication did not impact on industrial output. This suggests that fluctuations in infrastructural development, to a large extent, affected the magnitude of the impact of infrastructure on industrialization in Nigeria. The study recommends that government needs to look for other stable sources of financing infrastructure because reliance on oil revenue has *brought about fluctuations in infrastructural development, which has affected the industrial drive of the nation.*

JEL classification: O1, H4, H54, L9

1. Introduction

The role of infrastructure in industrial development has been well documented in the literature (See, for example, Cellini and Torrisi, 2009; and Straub, 2012). The emphasis on infrastructure draws inspiration from the East Asian economic miracle during which large-scale infrastructure investments were made as a panacea for sustained industrialization. With an average annual infrastructure budget allocation of 30 per cent, accumulation of infrastructure stocks has outpaced investments in other regions. Consequently, between 1975 and 2005, East Asia's GDP increased tenfold; South Asia's GDP increased fivefold; and all other regions' economies grew by factors of between two and three (Straub, 2012). More recent debates on measures to spur industrialization and sustained growth, poverty reduction, and improved standard of living in low- and middle-income developing countries have been centred on the need to promote large-scale expenditure in infrastructure (African Development Bank, 2016).

The common argument for increased public spending on infrastructure is its strong growth-enhancing effect through higher productivity of production factors. This is particularly the case with developing countries, where the stock of infrastructure is relatively low. For instance, in sub-Saharan Africa, less than 20 per cent of roads are paved, and less than one in five Africans has access to electricity. The average waiting time for a fixed telephone connection is three and a half years (World Bank, 2015). Transport costs are the highest of any region. A 2010 study by the African Development Bank on infrastructural development in the region argued that the biggest financial institution in Africa is worth over $200 billion in total assets while it is estimated that the amount needed annually until 2020 to close Africa's infrastructural gap is $93 billion. Furthermore, a recent report by PricewaterhouseCoopers (PwC) revealed that Nigeria's infrastructural financing need is likely to grow from $23 billion in 2013 to an estimated $77 billion by 2025 (Aremu, 2016). This indicates that for any meaningful industrial development to take place in Nigeria, the huge infrastructure gap needs to be filled. This is with a view to creating an enabling environment for the private sector to strive efficiently.

Conspicuously, the share of infrastructure in Nigeria's gross domestic product (GDP) is small when compared with other sectors of the economy. This understates the importance of the sector in the economy with respect to sub-sectoral inter-sectoral linkages, especially with such directly productive sectors of the economy as industry (manufacturing, crude petroleum, and solid minerals). The infrastructure sector accounted for a share of 7.4 per cent of Nigeria's GDP in the 1981 fiscal year. The share declined to 6.69 per cent in 1985, reaching a peak of 8.92 per cent in 1988 before declining to 4.03 per cent in the 1990s. This decline in the share of infrastructure in the country's GDP persistently worsened all through the 2000s owing to the fluctuations in the global crude oil market.

Within the same period, the contribution of the industrial sector to GDP also fluctuated. For instance, it accounted for 0.4, 1.2, 1.5, 1.3, -0.02, 1.02 and -0.7 per cent in 2009, 2010, 2011, 2012, 2013, 2014 and 2015 respectively. This implies that an empirical assessment of the link between infrastructure spending and industrial development is needed to account for this fluctuation. Moreover, recent inquiries have highlighted the fact that public infrastructure exerts a direct influence on total factor productivity and the rate of return on private capital. This may in turn spur growth through other channels. For instance, Straub (2012) argued that effective public infrastructure such as reliable electricity supply and good road networks help in reducing the need for the private sector to spend on maintenance of its own stock of physical capital thereby raising the rate of capital formation and industrial development.

It is against this background that this study examines the industrial output elasticity of infrastructure development using the dynamic ordinary least squares (DOLS) estimation technique proposed by Stock and Watson (1993). This approach accounts for present and past effects of infrastructural development on industrialization and departs from previous literature (such as Olufemi et al., 2013; Michael, 2016; Oyeniran and Onikosi-Alliyu, 2016) that have focused on long-run and contemporaneous correlations. The modified Toda Yomamoto causality testing technique (with and without breaks) is also used to account for the significance of a shortage or increment in infrastructure due to fluctuation in government earnings.

The rest of the paper is organized as follows: the state of infrastructure and industrialization policies in Nigeria during the period under review are presented in section 2, followed by a review of empirical literature in section 3. The discussion of the theoretical framework and methodology is in section four, while the empirical results and major findings are presented in section 5. The concluding remark is presented in section 6.

2. Macroeconomic Policy Basis of Public Investment in Infrastructure towards Industrialization in Nigeria (1970-2015)

2.1 Developmental plans

Since independence in 1960, the Nigerian government has prepared and implemented four different national development plans. These plans are as follows: First National Development Plan, 1962-1968; Second National Plan, 1970-1974; Third National Development Plan, 1975-1980; and the Fourth National Development Plan, 1981-1985.

2.1.1 *First National Development Plan (1962-1968)*

The total capital expenditure profile of the first national plan amounted to £676.8 million over the six-year period. Of this sum, approximately 14 per cent was allocated to primary production and 13 per cent to trade and industry. Thus, the two sectors that were accorded top priority in the plan accounted for more than one quarter of the total capital expenditure over the period. Equally notable is the fact that more than 70 per cent of the total expenditure was devoted to those sectors which contributed directly to economic growth (primary production, trade and industry, electricity, transport system, communications, irrigation and industrial water supplies). Total planned fixed investment for the six year period of the plan was £1,183 million. About £90 million of this amount was to be invested in the private sector at an average of £65 million annually (Olaloku, 1987). The plan assumed that £793 million would be invested in projects in the public sector at an average annual investment of £132.2 million. The public sector investment was to be, in descending order: transport, electricity, primary production, trade and industry education (Olaloku, 1987).

In summary, the first year of the plan was essentially a period of preparation: detail costing, designing, planning of projects and similar preparatory works such as site acquisition. Public investment, which in the first year of the plan period amounted to £64.6 million, declined slightly to £63.4 million in 1963. Thereafter, it rose gradually to approximately £90.0 million in 1966. The expected annual average investment of £112.8 million was never achieved due to the Civil War.

2.1.2 *Second National Development Plan (1970-1974)*

The Second National Development Plan contained policy framework and programmes for the reconstruction of damaged areas as well as the construction and development of the rest of the country. The Plan set out clearly the national objectives and priorities of post-war Nigeria. It also outlined the general policy measures and programmes of action which flowed from the objectives as well as the agreed national scale of priorities. The estimated net nominal investment expenditure amounted to £780 million. The Plan projection was that in the first year, aggregate expenditure would be distributed among the economic, social and administrative sectors in the proportion 60.0 per cent, 25.9 per cent and 14.1 per cent respectively. In broad terms, strict adherence to these proportions was important to ensure that available resources were not channelled to the less productive sectors of the economy. This also helped the federal government to emphasize the need to maximize value added to the gross domestic product by establishing heavy industries in the intermediate and capital goods sectors. This marked the first stage of the import substitution industrialization (ISI) strategy which involved the replacement of imported non-durable consumer goods and their inputs with domestic production (Olaloku, 1987).

2.1.3 *Third National Development Plan (1975-1980)*

The nominal total of the capital expenditure programmes of all the governments of the federation during the Third National Development Plan period was ₦32.9 billion. The amount embodied an element of "double counting" to the tune of ₦727.6 million which represented the bulk of federal government transfers to state governments for meeting part of their capital expenditures in the fields of agriculture, water supply, urban road development, sewage, etc. The exclusion of this inter-governmental transfer from the nominal total expenditure of ₦32.9 billion reduced the size of the public sector investment programmes to about ₦32 billion. This sum was the total estimated cost of the programmes of all the governments of the federation during the Plan period. An important feature of the Third National Development Plan was the annual phasing of capital expenditures. About 16.8 per cent of gross capital expenditure was disbursed in the first year of the Plan, 20.7 per cent in the second, 21.8 per cent in the third, 20.7 per cent in the fourth and 20.0 per cent in the fifth year (Olaloku, 1987).

In summary, sectoral percentage distribution of the gross capital expenditure shows that the economic sector with 62.3 per cent of the total outlay had the largest allocation, followed by administration with 13.6 per cent; regional development with 12.6 per cent and the social sector with 11.5 per cent. This shows that the policy was designed to significantly increase the economy's productive capacity and improve the nation's social services to meet the policy objectives set out by government.

2.1.4 *Fourth National Development Plan (1981-1985)*

The Fourth Plan recognized the role of social services in bridging the gap between the urban and rural sectors, but continued to receive a small share of the aggregate government public investment. The total allocation under the federal allocation programme was ₦2.2 billion, which amounted to about 5.5 per cent of the projected total federal government capital investment during the plan period. A significant distinction between the fourth and third development plans in the educational sector was that federal investment in primary education was completely absent in the latter. For the health sector, a total of ₦1.2 billion was estimated as total capital estimation of the federal government of which the National Basic Health Scheme had a financial allocation of ₦100 million, while the establishment of new hospitals gulped about ₦150 million. Of the total investment of ₦82 billion spent in the Fourth Development Plan, the share of the public sector was ₦70.5 billion. This was distributed among the federal (₦40 billion), state and local (₦28 billion) governments, as well as the Federal Capital Development Authority (₦2.5 billion). The balance of ₦11.5 billion was reserved for the private sector (Olaloku, 1987). In summary, the Fourth Development Plan was a success in terms of regional development, but some public sector investment did not yield returns as expected (e.g., National Electric Power Authority and Nigeria Telecommunications Corporation).

Furthermore, public investments within this period were allocated to large capital and skill intensive projects, particularly heavy and intermediate industries like steel, oil refineries and fertilizer production. However, besides suffering from protracted and cost increasing construction periods and low capacity utilization, the Ajaokuta and Delta steel companies and the various steel mills have constituted a burden to the annual budgets due to recurrent losses and the supply of expensive industrial input into the downstream sectors (Owosekun, 1991).

2.2 The Structural Adjustment Programme (SAP)

In 1986, the government initiated the Structural Adjustment Programme as a short-term plan whose major objectives centred on rural development and poverty alleviation. The key elements of SAP were deregulation and reduction or full withdrawal of subsidies. In line with these objectives, government established the Directorate of Food, Roads and Rural Infrastructure (DFRRI), charged with the responsibility of providing basic infrastructure that would facilitate the development of agriculture by increasing agricultural output and creating an enabling environment for farm produce to get to the final consumers. In the 1986 fiscal year, it received a budgetary allocation of ₦300 million, in 1987 it received ₦400 million while ₦500 million was allocated to the agency in 1988 to develop rural infrastructure (Usman, 1991).

The share of total public investment in economic, social and community services and administration rose to 31.1, 17.8 and 9.2 per cent respectively in 1986 compared to 11.7, 13.4 and 5.6 per cent respectively in 1985. In 1987 the total public investment fell by 25.3 per cent to ₦6,372.5 million from ₦8,526.8 million in 1986. In 1988, this amount rose by 30.9 per cent to ₦8,340.1 million. This amount rose by 80.3 per cent to ₦15,034.1 million in 1990. This trend continued until 1991. Generally, public investment increased during the SAP era.

In 1989, Nigeria launched a new industrial policy. However, in terms of emphasis, the small- and medium-scale enterprise (SME) projects contained in the 1989 industrial policy stood out. The SAP-induced industrial policies included interest rate deregulation, debt conversion, the privatization and commercialization policy, and the new export policy incentive (Usman, 1991). Previous initiatives designed to assist small- and medium-scale industries in Nigeria include: mandatory minimum credit allocation by banks to small-scale enterprises (SMEs); introduction of other specialized schemes, including the World Bank SME I and SME II loan programmes, the Family Economic

Advancement Programme (FEAP) and the Agricultural Credit Guarantee Scheme Fund (ACGSF).

2.3 The Petroleum (Special) Trust Fund (PTF)

The PTF was established by Decree 25 of 1994 (and amended by Decree 1 of 1995). It was empowered to utilize the gains from the increase in the prices of petroleum products to complete all government-abandoned projects and rehabilitate decaying infrastructure nationwide. The PTF's influence was felt in seven sectors of the economy, namely roads, health, education, water supply, food supply, security and agriculture. In the area of water supply, a total of ₦120 million was used to drill boreholes in selected states including Katsina, Cross River, Akwa-Ibom, Kogi, Abia and Borno. Also, ₦11,953,000 million was allocated to construct roads between 1995 and 1997. A total of ₦9,588 billion was expended on education, specifically university education, technological/technical education and teacher education. For the health sector, a total of ₦1.354 billion was allocated to support some key priority programmes such as: The National Essential Drugs Programme, National AIDS Control Programme and Improvement of Physical Infrastructure and Equipment Maintenance Programme (Falola and Heaton, 2008).

2.4 National Economic Empowerment Development Strategy (NEEDS)

Nigeria's macroeconomic policy thrust outlined in the National Economic Empowerment and Development Strategy (NEEDS) document was aimed at creating a stable environment for accelerated pro-poor growth. In this regard, government's fiscal policy sought to enhance revenue collection, and strengthen public financial management through effective fiscal allocation, coordination and monitoring. NEEDS reforms towards improving transport sector infrastructure were aimed at completing 3,000 kilometres of roads and strengthening the Road Maintenance Agency, which monitored the repair and rehabilitation of some 500 roads in the country. Roads rehabilitation, maintenance and new roads were expected to increase from 3,000 in 2003 to 3,500 in 2004, 4,000 in 2006 and 4,500 in 2007 (National Planning Commission, 2004).

The NEEDS policy in the health sector targeted priority diseases such as malaria, tuberculosis, HIV/AIDS and reproductive health-related illness. It was designed to target reduction of the HIV/AIDS prevalence rate from 6.1 per cent in 2003 to 5.0 per cent in 2007. Access to safe water was targeted to increase from 64.1 per cent in 2003 to 70.0 per cent in 2007, while access to adequate sanitation was expected to increase from 53.0 per cent in 2003 to 65.0 per cent in 2007. With regard to power, the target was to generate 4,000 megawatts in 2004, 5,000 megawatts in 2005, 7,000 megawatts in 2006 and 10,000 megawatts in 2007. In the education sector, the major policy thrust of NEEDS was targeted at increasing the adult literacy rate from 57.0 per cent in 2003 to 65.0 per cent in 2007. However, most of these targets were not met. For instance, as at September 2009, the total power generated in Nigeria was less than 6,000 megawatts as against the targeted value of 10,000 in 2007. Adult literacy as at 2010 was less than 52 per cent while access to safe water and good sanitation did not improve (National Planning Commission, 2004).

2.5 Vision 20:2020

The capital expenditure layout under the vision 20:2020 economic plan was specifically targeted at infrastructural development that would enhance industrial growth in Nigeria. Notably, the emphasis was on capital expenditure in sectors like education, health, transport and communication. In line with this policy, the appropriated capital expenditure allocation to education stood at ₦74,923,247,201 in 2010, which was a huge increment from ₦40,005,096,429 in 2009. This figure increased steadily in nominal terms from 2010 to 2015. The health sector experienced mixed achievements; capital expenditure on key infrastructure stood at ₦32.2 billion in 2006 and increased to ₦96.9 billion and ₦97.2 billion in 2007 and 2008 respectively. This figure fell precipitously to ₦52.5 billion and ₦49.9 billion in 2009 and 2010 respectively. In terms of allocation to the transport and communication sectors, the target of the vision 20:2020 has not been achieved either.

Based on the vision 20:2020 policy layout, the commitment of the federal government to enhance the contribution of the industrial sector to national economic development has been demonstrated in various policy pronouncements and actions. The Nigeria Industrial Revolution Plan (NIRP) was approved, with its formal launch scheduled for early 2014. The NIRP aimed to expand the country's industrial capacity by pursuing systematic development in agro-allied industries, metals and solid minerals processing, oil and gas industries, light manufacturing, and construction and services (National Planning Commission, 2010).

In line with the power sector's road map, the transfer of some of its operations to private enterprises to boost efficiency in the sector was implemented. To address challenges in the privatization process, especially labour-related issues, the federal government released ₦72.7 billion to the Federal Ministry of Power. Of this amount, 62.0 per cent was used to offset the outstanding payments due to the Power Holding Company of Nigeria (PHCN) workers, while the balance was utilized by the power generation and distribution companies to support their operations. The acquisition of the unbundled companies from PHCN was completed with the new owners formally taking over the companies. A Canadian firm, Manitoba Hydro International, was also formally given the schedule of delegated authority that transferred managerial control over the Transmission Company of Nigeria (TCN) to it (Central Bank of Nigeria, 2015).

The National Enterprise Development Programme (NEDEP) was launched in 2014. The aims of the programme are to generate five (5) million direct jobs by focusing on skills acquisition, entrepreneurship training, business development services and access to finance. The programme targets small businesses and is being coordinated by the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) (Central Bank of Nigeria, 2015). Similarly, the National Automotive Industry Development Plan (NAIDP) was launched in the same year. The plan, among other things, aims to make the environment conducive for automotive companies by providing incentives to local manufacturers. The auto policy is expected to result in substantial savings from reduction of the US$6.5 billion spent annually on the importation of vehicles and car spare parts. On the back of this policy, two Indian vehicle manufacturing companies, TATA Motors and TVS Motor Company indicated interest in establishing assembly plants in Nigeria. The drive to patronize made-in-Nigeria products received a boost in 2013. The maiden exhibition of "Made-in-Aba" products was held in Abuja during that year (Central Bank of Nigeria, 2014).

3. Review of Existing Literature

The literature on the impact of infrastructure on the industrial sector is scanty. However there is an abundance of theoretical and empirical works on the contribution of infrastructure to economic growth and development. Thus, since total factor productivity and the production process are emphasized in most of the studies on infrastructure-growth nexus, the issue of industrialization development can be deduced as the measure of growth and development in a country. Therefore, this section will review works on the impact of infrastructure on aggregate and sectoral output growth and development.

In the framework adopted by a vast majority of studies on infrastructure-growth nexus, public capital (measured by public investment in infrastructure) is considered an input in a production function. The endogenous growth version of the approach is well documented in the work of Barro (1990) and further extended by Futagami, Morita and Shibata (1993) by including both public and private capital stock accumulation as input in the production process to show the effect of public investment in infrastructure on growth.

The seminal work of Aschauer (1989) is the first study to measure the impact of infrastructure on growth and development using the production function approach. In his findings, Aschauer asserts that the stock of public infrastructure capital is a significant and major determinant of aggregate output and total factor productivity in the US economy. However, his estimated marginal product of infrastructure capital, which was over 100 per cent per year, seems implausible and very high. The size of the estimated coefficient of the marginal product of infrastructure was a source of controversy and arguments among scholars. Notably, Munnell (1992) opined that the implied impact of public (infrastructure) investment on private sector output emerging from aggregate time series studies is too large to be credible. This is because the model Aschauer adopted depends solely on whether both effects can be identified independently.

Further to the submission of Munnell (1992), Duggal, Saltzman and Klein (1999) criticized the production-function approach on the basis that treating infrastructure capital as a factor input in a production-function, like private capital and labour, violates the standard marginal productivity theory as it assumes a market-determined per unit cost of infrastructure, known by individual firms, which can be included in the total cost. It implies that treating infrastructure as a factor input in the production-function presumes that the marginal cost (MC) of an increase in infrastructure is well known by firms. Aaron (1990) also faulted this approach for its inability to separate the direct from the indirect effects of infrastructure on economic growth.

Although the production function approach has been criticized, most of the studies that adopted the analytical approach for country-specific studies made use of the ordinary least squares (OLS) estimation technique to capture the signs of each of the explanatory variables and to measure output elasticity with public and private capital in the production process (See Aschauer, 1989; Akpan, 2005; Arslanalp et al., 2010; Dash, Sahoo and Nataraj, 2010; Enimola, 2011; Akanbi, Abalaba and Afolabi, 2013; Olufemi et al., 2013; Owolabi-Merus, 2015; Michael, 2016; and Oyeniran and Onikosi-Alliyu, 2016). On the other hand, a cross section of studies made use of the panel data estimation technique to avoid spurious regression. Studies in this regard include Devarajan, Swaroop and Zou, 1996; Adenikinju, (1998); Shioji, (2001); Agenor, 2010; and Bueffie et al. (2012). Canning and Bennathan (2002) tried to solve the problem of non-stationarity associated with the use of time series data by estimating a production-function in a cointegrated panel framework. Demetriades and Mamuneas (2000) and Esfahani and Ramires (2003) handled the causality issue by introducing a "time-lag" between variables of public infrastructure and productivity. The issue of causality was handled differently by Calderon and Serven (2008) by introducing an instrumental variable to estimate a Cobb-Douglas production function (in first difference) as lagged values of explanatory variables.

The findings of these studies show that public investment in infrastructure measured either using physical indicators of infrastructure stock or public infrastructure spending flows have positive impact on growth and development. Specifically, the study by Dash, Sahoo and Nataraj (2010) for the Chinese economy used the two-stage least squares (TSLS) and dynamic ordinary least squares (DOLS) techniques on data spanning between 1970 and 2006. The study found that both physical and social infrastructure have a significant positive impact on China's economic growth. In the same vein, Enimola (2011) employed the vector error correction estimate (VECM) to investigate empirically the influence of infrastructure investment on economic growth in Nigeria from 1980 to 2006. The findings of the study reveal a positive steadily declining long-run impact of infrastructure on economic growth. The studies by Akpan (2005); Olufemi et al. (2013); Michael (2016); and Owolabi-Merus (2015) for Nigeria also found a positive effect of infrastructure on economic growth and development.

Studies like Akanbi, Abalaba and Afolabi (2013), on the impact of sectoral infrastructure on economic growth, used the generalized Cobb-Douglas production function and extended the neoclassical growth model to include transport infrastructure stock to show the impact of transport infrastructure on economic growth in Nigeria for the period 1981 to 2011. The ordinary least squares regression (OLS) results revealed that transport output and investment made on transport infrastructure in Nigeria make significant positive contribution to growth. Another study by Oyeniran and Onikosi-Alliyu (2016) on the effect of investment in telecommunication infrastructure on economic growth in Nigeria between 1980 and 2012, used the autoregressive distributed lag (ARDL) bounds testing approach proposed by Pesaran et al. (2001) to estimate the long-run and short-run effects of investment in telecommunication infrastructure on economic growth. The findings of the study show that foreign direct investment in information and communication technology affects economic growth in Nigeria more than government investment.

Based on the shortcomings of the production function approach, some studies have adopted the use of the cost function approach to estimate the impact of infrastructure on economic growth and development. The cost-function approach assumes that infrastructure investment is provided externally by government as a free input in the production process. Most studies specify a cost function for the private sector, with firms being assumed to aim at producing a given level of output at minimum private cost. Because the input prices are exogenously determined, the instruments of the firm are the quantities of the private inputs. Alternatively, firms are assumed to maximize their profits given output and input prices.

When firms optimize, they take into account the environment in which they operate. One of these environmental variables is the state of technical knowledge (A). Another is the amount of public infrastructure capital available (G). The public capital stock enters the cost or profit function as an unpaid fixed input. Although the stock of infrastructure is considered externally given in the cost-function approach, each individual firm will still decide the amount to be used.

This implies that a firm's use of infrastructure is part of its optimization problem, which, in turn, leads to the need of a demand function for infrastructure that must satisfy the conditions of the standard marginal productivity theory (Duggal, Saltzman and Klein. 1999). To make this approach comparable with the production-function approach, authors such as Demetriades and Mamuneas (2000) used Hotelling's Lemma to obtain supply functions, which can be used to calculate output elasticities of public capital.

Sturm, Jacobs and Grote (1998) noted that many authors estimating cost or profit functions adjust the stock of public capital by an index (such as the capacity utilization rate) to reflect its use by the private sector. Two reasons have been advanced for adjusting the stock of public capital. First, it is a collective input that a firm must share with the rest of the economy. However, since most types of public infrastructure are subject to congestion, the amount of it that one firm may employ will be less than the total amount supplied in the economy. Moreover, the extent to which a capacity utilization index measures congestion is dubious. Second, firms might have some control over the use of the existing infrastructure stock. For example, a firm may have no influence on the highways provided by the government, but can vary its use of existing highways by choosing routes. Therefore, there are significant swings in the intensity with which public capital is used. As pointed out by Sturm, Jacobs and Grote (1998), an important advantage of the cost-function approach is that it is less restrictive than the production-function approach.

The use of a flexible functional form hardly enforces any restrictions on the production structure. For example, apriori restrictions placed on the substitutability of production factors, as in the production-function approach, do not apply. Apart from the focus on the direct effects in the production-function approach, public capital might also have indirect effects. Firms might adjust their demand for private inputs if public capital is a substitute or a complement to other production factors. It seems very plausible that, for instance, a large stock of infrastructure raises the quantity of private capital used, and therefore, indirectly raises production.

By using a flexible functional form, the influence of public infrastructure through private inputs can be determined. A flexible function not only consists of many parameters that need to be estimated, but also of many second-order terms which are cross products of the inputs. These second-order variables can create multicollinearity problems. Therefore, the data set not only has to be relatively large, it must also contain enough variability so that multicollinearity can be dealt with. In other words, the most appealing feature of the cost-function approach also induces the greatest problem; the flexibility of the functional form requires considerable information to be included in the data. Most cost-function studies therefore use panel data, which combine a time dimension with either a regional or a sectoral range.

Ayogu (2000) used the generalized least squares (GLS) technique to jointly consider the contemporaneous correlation across equations when estimating the output elasticities parameters for each respective regional cost function in the six geo-political zones of Nigeria. The results of the study reveal a strong association between infrastructure and growth.

Using a pooled regression analysis, Moreno, López-Bazo and Artís (2003) estimated a cost function model for 12 manufacturing sectors in Spanish regions between 1980 and 1991. Their results indicate that infrastructure development such as roads impacted meaningfully on the manufacturing firms sampled in the study. Ezcurra and Gil (2005) also used a pooled regression to analyse Spanish regional production costs in the agricultural, industrial, and services sectors from 1964 to 1991 and found similar results.

Cohen and Morrison (2004) estimated a cost-function model using maximum likelihood techniques. They analysed data for 48 US states on prices and quantities of aggregate manufacturing output and inputs (specifically: capital, production and non-production labour, as well as materials) and on public highway infrastructure; their analysis spanned 1982 to 1996. They assumed that manufacturing firms minimize short-run costs by choosing a combination of inputs for a given level of input prices, demand (output), and capacity (capital) as well as for given (external) technological and environmental conditions. The model also distinguished between intra- and interstate effects of public infrastructure and accounted for interaction between the two. More specifically, for a given state, the model included not only the public infrastructure of that state but also the infrastructure in neighbouring states. In sum, the results of the cost-function studies were broadly in line with those of studies using the production-function approach: public capital reduces cost, but there is much heterogeneity across regions and/or industries.

Another method adopted in the literature to determine the impact of infrastructure on economic growth and development is the growth model approach. Growth models have been classified in the literature into two broad categories: those built on the basis of the neoclassical view (Solow, 1956; Swan, 1956), and those known as endogenous growth models (Romer 1986, 1990; Lucas, 1988; Grossman and Helpman, 1991; Aghion and Howitt, 1992; among others). In the neoclassical framework, government policy, particularly fiscal, plays no role in determining the long-run economic growth rate, given that this is determined by exogenous population growth and technological progress rates. On the other hand, for the endogenous growth framework, the engine of growth is human capital, knowledge and/or technology. Accumulation of any of these three variables takes place according to a conscious decision by private agents in the economy. This allows fiscal policy to impact on the long-run growth rate through either some taxes or types of public expenditure affecting decisions by private firms about investing in human capital, knowledge or research and development. In this regard, it is important to mention that public goods play a crucial role as they can bring about changes in the long-run growth rate.

Using Arrow's (1962) model, Romer (1986) constructed the "learning by doing" model, by assuming that knowledge creation is a product of investment. This model indicates the significance of learning through experience. Further, it implies that capital by itself produces knowledge. Therefore, by increasing capital, the firm will increase knowledge through learning how to produce more efficiently, which suggests that learning by doing works via firms' investment. Romer (1986) further assumes that there is a spillover effect, suggesting that knowledge is a public good that any firm can access at no cost. Therefore, once a piece of knowledge is discovered, it is disseminated throughout the whole economy. The fact that the model exhibits externality effects allows for the possibility that government policies can have an effect on economic growth, as shown below.

$$Y_i = F(K_i, A_{i,} L_i) \tag{1}$$

where: A_i represents the index of knowledge available to a firm or the baseline technology.

The assumption that learning by doing works through firms' investment implies that changes in A_i represent overall learning in the economy, which is proportional to K, aggregate capital accumulation. Given that knowledge is assumed to be a public good due to its non-excludability and non-rivalry characteristics, this implies that once discovered it becomes common knowledge. Combining the assumption of learning by doing and knowledge spillover implies replacing A_i with K, which gives:

$$Y_i = F(K_i, K, L_i) \tag{2}$$

Equation (2) indicates diminishing marginal returns to capital at the firms' level, but constant returns to capital at the aggregate level resulting from the spillover effect. This also involves assuming a competitive market where each firm is a price taker and very small, such that its investment does not have a major effect on aggregate investment, and thus takes K as given. Since each firm takes price and K as given when maximizing profit, each firm considers its private marginal product, ignores its investments' (k_I) contribution to aggregate investment, K, and as a result, ignores its contribution to aggregate knowledge. Thus, in equilibrium, all firms follow the same decision rule (Romer, 1986).

To determine the optimal growth rate, the decentralized economy results are compared with those from the social planner. Unlike the individual firms that took K, the aggregate capital, as given, the planner recognizes the contribution of each firm's investment to aggregate capital stock and to the production of all firms in the economy; therefore, the planner internalizes the spillover effect. This indicates that the social planner sets the growth rate of consumption taking into consideration the average product of capital, whereas individual firms consider their private marginal product of capital. Consideration of the private marginal product instead of the average product of capital indicates that the growth rate is too low in the decentralized economy (Romer, 1986).

By internalizing the spillover effect, the social planner offsets the diminishing returns to capital faced by individual firms, thereby enjoying constant returns at the social level. The decentralization growth rate is low because firms base their decision on the private marginal product of capital, which is less than the social marginal product. This is where government policy may have an effect on economic growth, because it presents an opportunity for government policy to increase the decentralized growth rate to the central planner growth rate, which indicates clearly how government policy may affect economic growth (Cellini and Torrisi, 2009).

Various extensions of the basic endogenous growth models with fiscal policy have been derived by allowing publicly-provided goods to be productive in stock and/or flow form (Cashin, 1995; Turnovsky, 1997; Tsoukis and Miller, 2003; and Agenor, 2010). Another way is by allowing different forms of expenditure to be productive (Glomm and Ravikumar 1997; Zagler and Durnecker, 2003; Ghosh and Roy, 2004; Aregbeyen, 2006; and Gomez, 2007).

Scholars who adopted the growth model approach have used pooled regression for cross-country studies, while those working on country-based studies have used ordinary least squares (OLS). Easterly and Rebelo's (1993) article represents an important piece of work using public infrastructure in an empirical growth model. The authors ran pooled regressions (using individual country decade averages for the 1960s, 1970s and 1980s) of per capita GDP growth on a set of conditional variables and on public investment in different sectors (added one at time): agriculture, education, health, housing and urban infrastructure, transport and communication, industry and mining. Milbourne, Otto and Voss (2003) used OLS to measure the effect of public investment on economic growth at steady state. Cellini and Torrisi (2009), Nurudeen and Usman (2010), and Aladejare (2013) also used OLS to determine the effects of various types of public investment on economic growth in Italy and Nigeria.

In summary, two major issues have been identified from the literature reviewed as the main reasons why results obtained by most studies vary in terms of the sign and size of coefficients measuring the impact of infrastructure on aggregate or sectoral growth. These issues are measurement and identification. The former has to do with how different studies measured infrastructure as a concept. Essentially, infrastructure is a multi-dimensional concept, comprising services that range from transport to clean water. However, many studies adopt a single indicator, i.e. telephone density, as proxy for infrastructure, thereby omitting other measures of infrastructure. This is likely to lead to invalid inferences due to omitted variable biases. Furthermore, a more severe measurement of infrastructure is through spending flows. That is public investment or its accumulation via perpetual inventory into public capital, which is adopted by most studies in the literature. Public investment and public capital are likely to be poor proxies for infrastructure accumulation if the private sector plays a significant role in infrastructure provision and development in a country. This is increasingly common in many countries. Besides, even if all infrastructure in a country were owned by the public sector, the link between observed public capital expenditure and the accumulation of infrastructure assets or the development of infrastructure services may be weak because of the inefficiencies in public procurement and outright corruption in most developing countries (Pritchett, 2000).

Buhr (2003) opined that infrastructure can also be measured in terms of its contribution and requirement in the society. He divided societal requirement into two: physical and social. The physical requirements are infrastructure in areas like water, energy (electricity and gas) and health care. Social requirements are security, information (telecommunication), education, mobility (roads) and environmental protection. Thus, the adoption of any of these measures of infrastructure would determine the sign and size of the impact of infrastructure on economic growth and development.

The second issue (identification) relates to the approach to be adopted when modelling the impact of infrastructure on aggregate or sectoral output. Three approaches have been identified in the literature, viz. production function, cost function and growth model. Adoption of any of these methods would go a long way in unravelling the two-way causality link between infrastructure and growth, which is one of the most problematic issues to contend with. This is because richer or faster-growing countries may systematically devote more resources to infrastructure, and empirical assessments of the impact of infrastructure that fail to take this into account are likely to be subject to an upward simultaneity bias. Nevertheless, most studies adopt the production function approach because it allows for the flexibility of quantifying the effect of infrastructure on growth using estimation techniques that can account for the effect of infrastructural investment on output.

3. Theoretical Framework and Methodology

3.1 Theoretical framework

The theoretical framework for this study is based on the synthesis of the production function and growth approaches. This method is in line with Barro (1990) as extended by Futagami et al. (1993). Public investment infrastructure capital is an input into the aggregate production function, thus, there is an optimal level of infrastructure which maximizes the growth rate. If infrastructure level is too low, growth in the industrial sector will fall, whereas if it is high, growth in the industrial sector rises. Aggregate output produced using infrastructure capital at time t is expressed as:

$$Y_t = f(K_t, L_t, \theta_t, \phi) \tag{3}$$

where: at time t, Y is the total output of the industrial sector, K is capital stock, L is labour, θ is a vector of infrastructure variables and ϕ is a control variable (real interest rate).

For simplicity, we assume that capital fully depreciates at each period and savings rate (s) is constant. Thus testing the possibility of constant return to scale, equation (3) in Cobb-Douglas production form and including (A) as a measure of total productivity yields:

$$Y_t = A_t, K_t^a, L_t^b, \theta_t^c, \phi_t^d \tag{4}$$

Taking natural logarithms yields the equation:

$$\ln Y_t = \ln A_t + a\ln K_t + b\ln L_t + c\ln\theta_t + d\ln\phi_t \tag{5}$$

Taking first differences of equation (5) and including the stochastic term yields:

$$\Delta\ln Y_t = \alpha + a\Delta\ln K_t + b\Delta\ln L_t + c\Delta\ln\theta_t + d\Delta\ln\phi_t + \varepsilon_t \tag{6}$$

The elasticity of industrial output with respect to infrastructure c is the main variable of interest in this study. The other production elasticities: a, b and d are of interest mainly in order to assess the shape of the production function.

Based on the discussion on the measurement of infrastructure, three different measures of infrastructure are adopted in this study to account for both the physical and social requirements of infrastructure. Therefore, telephone density, energy consumption and total capital expenditure on the transport and communication sectors are adopted as the three proxy for infrastructure. These three measures are adopted because of their relevance in the production process, which can lead to an increase in industrial output in the country. For instance, telephone density defines the level of telecommunication penetration in the economy. Easy access to telephone makes communication among production agents easier. Energy consumption, on the other hand, is key to the development of industries in the nation. Access to energy would reduce the cost of production. In addition, increase in capital expenditure in the transport and communication sectors ensures the construction of good road networks that would link the input of production to the producers, making the production process easier, efficient and cost-effective.

In order to avoid multicollinearity and to compare the impact of these measures of infrastructure, each infrastructure proxy is expressed as a function of industrial output growth. Thus, equation (6) is the generic model, while three specific equations are adopted and estimated using the dynamic approach that accounts for present and past effects of infrastructure on industrial output.

3.2 Estimation technique

In carrying out the linear combination of the variables in the model, an alternative approach, which certainly has more advantage over both the single equation and the Johansen maximum likelihood procedure, is adopted for this study. This approach, which was proposed by Stock and Watson (1993), improves on others by correcting for regressors' endogeneity and serial correlation, which is the major criticism of the single equation method and the Johansen maximum likelihood procedure by including leads and lags of first differences of the regressors and also using the GLS procedure to correct for plausible serial correlation among the errors. In addition, the Stock-Watson method has asymptotic optimality properties like the Johansen procedure. This is expressed below as:

$$\ln Y_t = P_t X' + \sum_{i=-m}^{i=m} a_i \Delta \ln K_{t-i} + \sum_{i=-n}^{i=n} b_i \Delta \ln L_{t-i} + \sum_{i=-o}^{i=o} c_i \Delta \ln ted_{t-i} + \sum_{i=-p}^{i=p} d_i \Delta \ln ri_{t-i} + e_1 \tag{7}$$

$$\ln Y_t = R_t M' + \sum_{i=-m}^{i=m} \alpha_i \Delta \ln K_{t-i} + \sum_{i=-n}^{i=n} \beta_i \Delta \ln L_{t-i} + \sum_{i=-o}^{i=o} \delta_i \Delta \ln epc_{t-i} + \sum_{i=-p}^{i=p} \pi_i \Delta ri_{t-i} + e_2 \tag{8}$$

$$\ln Y_t = Q_t D' + \sum_{i=-m}^{i=m} \varphi_i \Delta \ln K_{t-i} + \sum_{i=-n}^{i=n} \gamma_i \Delta \ln L_{t-i} + \sum_{i=-o}^{i=o} \lambda_i \Delta \ln tex_{t-i} +$$

$$\sum_{i=-p}^{i=p} \tau_i \Delta ri_{t-i} + e_1 \quad (9)$$

where $X = [a, b, c, d]$, $P = [1, K, L, ted, ri]$; $M = [\alpha, \beta, \delta, \pi]$; $R = [1, K, L, epc, ri]$; $D = [\varphi, \gamma, \lambda, \tau]$; $Q = [1, K, L, tex, ri]$; *ted* = telephone density; *epc* = energy consumption; *tex* = total capital expenditure in transport and communication; and m, n, o and p are the lengths of leads and lags of the regressors.

3.3 Causality test

In order to show the causal link between infrastructure and industrial output, the Toda and Yamamoto (1995) (T-Y henceforth) causality test, which is based on an augmented VAR modelling that introduced a modified Wald test statistic (MWALD) is adopted for this study. This approach to causality does not require pretesting for cointegration properties of the series. Furthermore, The T-Y test is chosen ahead of the conventional Granger causality due to its power property in dealing with series of different levels of integration, and also to avoid specification bias and spurious regression.

The T-Y approach involves three steps. The first is finding the maximum order of integration (d-max) of the series that are to be incorporated in the model using the conventional ADF unit root test. The second involves specifying a well-behaved kth optimal lag order vector autoregressive model in levels (not in the difference series). This is usually determined based on selection criterion such as the Akaike information criterion (AIC), Bayesian information criterion (BIC), or Schwarz info criterion (SIC) or a combination of these criteria, which will make the VAR model well-behaved in terms of AR unit root graph, VAR residual serial correlation LM-stat, and VAR residual normality tests. The third is carrying out the modified Wald (MWALD) test by intentionally over-fitting the underlying model with additional d-max order of integration. This process would be done twice. The first is for the variables at levels while the second would account for structural breaks in the series in order to reflect the fluctuation in infrastructural spending due to variation in government earnings. Therefore, considering the following VAR (p) model:

$$y_t = \alpha + \beta_1 y_{t-1} + \ldots + \beta_\rho y_{t-\rho} + \varepsilon_t \quad (10)$$

where y_t, α and ε_t (0Ω) are *n*-dimensional vectors and β_k is an n x n matrix of parameters for lag *k*. To implement the T-Y approach, an augmented VAR (p + d) model is utilized. This is expressed as:

$$y_t = \hat{\alpha} + \hat{\beta}_1 y_{t-1} + \ldots + \hat{\beta}_\rho y_{t-\rho} + \hat{\beta}_{\rho+d} y_{t-\rho-d} + \hat{\varepsilon}_t \quad (11)$$

where circumflex above the variable in equation (11) denotes estimated parameter from ordinary least squares (OLS). The *p* order of the process is assumed to be known, while *d* is the maximal order of integration of the variables in the model. The null hypothesis presented below is not rejected if the jth element of y_t does not Granger-cause the ith element of y_{t-1}.

H_o: the row i, column j element in β_k equals zero for k = 1,. . . . ., *p*. (12)

3.4 Sources of data

The annual time series data used in this study relate to the period 1981 to 2015 and were obtained from the *Central Bank of Nigeria Statistical Bulletin* (2015) and *World Development Indicator* (World Bank, 2015). The variables of interest are: industrial real output (*Y*), total employed labour (*L*), gross fixed capital formation (*K*), telephone density (*ted*), energy consumption (*epc*) and total capital expenditure in transport and communication sector (*tex*).

4. Empirical Results

4.1 Unit root test

To determine the nature of stationarity of the series, this study adopts the Ng and Perron (2001) and Zivot and Andrew (1992) unit root tests. The latter is adapted to endogenously determine the structural break within the series. This is important because according to Zivot and Andrew (1992), the presence of a structural break in a series may lead to a biased and inconsistent result. The Ng and Perron (2001) test modified Phillip Perron (PP) tests of Perron and Ng (1996) using the GLS de-trending procedure of Elliott, Rothenberg, and Stock (1996). This is adopted because it does not reveal the Spartan size distortions common with the Phillip Perron (PP) tests for errors with large negative moving average (MA) or autoregressive (AR) roots; it also possesses substantially higher power than the PP tests when the autoregressive term is close to unity (Ng and

Perron, 2001). The three M-tests (MZa, MZt, and MSB) and modified Elliot, Rothenberg and Stock's (1996) point optimal test (MPT) were considered in ascertaining the presence of unit root in the data used for analysis. The null hypothesis is that there is the presence of unit root.

The results of the Ng and Perron unit root and Zivot and Andrews (1992) tests are presented in tables 1 and 2. It can be observed that all the series used for analysis (*Y*, *K*, *L*, *ted*, *epc*, *tex* and *ri*) are integrated of order one or are I (1) series. From table 2, three break points were selected for telephone density as a proxy for infrastructure in the three different tests conducted (test which included intercept only, trend only, and both intercept and trend). These were for the years 2000, 2001 and 1995. For energy consumption as a proxy for infrastructure, the years 2001, 1994 and 1994 were selected for the three different tests. The years 1991, 1994 and 2007 were selected as the breakpoints for capital expenditure in transport and communication. Based on this information, dummy variables were included in the model to account for breaks in the series. The dummy took binary number 1 for years where there is a break and 0 if otherwise.

Table 1. Results for Ng and Perron Unit Roots Test

Variables	MZa	MZt	MSB	MPT
Y				
Level	-6.938	-1.851	0.172	3.146
First Difference	-23.128*	-3.629*	0.267*	6.732*
K				
Level	-11.334	-1.465	0.126	1.230
First Difference	-14.631*	-3.672*	0.277*	6.418*
L				
Level	-5.292	-1.465	0.132	1.630
First Difference	-16.182*	-3.802*	0.277*	5.883*
Ted				
Level	-4.408	-1.402	0.127	3.146
First Difference	-15.938*	-3.851*	0.318*	9.957*
Epc				
Level	-5.259	-1.548	0.095	2.041
First Difference	-16.099*	-2.833**	0.944*	5.687*
Tex				
Level	-6.438	-2.281	0.108	3.150
First Difference	-15.599*	-3.736*	0.269*	5.841*

Variables	MZa	MZt	MSB	MPT
Ri				
Level	-5.279	-1.625	0.113	1.781
First Difference	-21.527*	-3.575*	0.308*	4.640*

Notes: (1) The asymptotic critical values for the MZa test are -14.20 and -9.20 for 1% and 5% significance levels respectively.

(2) The asymptotic critical values for the MZt test are -3.42 and -2.62 for 1% and 5% significance levels respectively.

(3) The asymptotic critical values for the MSB test are 0.14 and 0.16 for 1% and 5% significance levels respectively.

(4) The asymptotic critical values for the MPT test are 4.03 and 5.48 for 1% and 5% significance levels respectively.

(5) *, ** depicts the rejection of the null hypothesis at 1% and 5% significant level.

Table 2. Zivot-Andrews Unit Root Test Results

	Z-A (1992)					
Variables	Intercept only		Trend only		Both intercept and trend	
	t-stat.	Breakpoint	t-stat	Breakpoint	t-stat.	Breakpoint
Y	-5.091*	1993	-4.823*	1999	-3.832*	1989
K	-2.954**	1990	-4.443*	2000	-2.658**	1999
L	-8.857*	1997	-9.454*	1997	-2.516**	2002
TED	-4.443*	2000	-5.114*	2001	-4.392*	1995
EPC	-6.828*	2001	-6.614*	1994	-6.989	1994
TEX	-5.346*	1991	-7.127*	1994	-4.893*	2007
RI	-6.385*	1993	-4.818*	2006	-6.182	1994

Notes: * and ** imply significance at 1% and 5% respectively based on percentage points of the asymptotic distribution critical values as provided by Zivot and Andrew (1992) in table 2 page 30.

Source: Authors' computation.

4.2 Cointegration test

To ascertain a long-run relationship among the variables in the presence of a structural break, the Gregory-Hansen (G-H) co-integration technique was adopted. The G-H co-integration method is a non-linear co-integration procedure that accounts for structural break and allows co-integrating vectors to change at an unknown time period to capture shifts in time series trends caused by policy changes. In adopting this method, the optimal lag length of the model needs to be established using various information criteria. Thus the optimal lag length of

1 is selected based on Schwarz information criterion (SIC). The results presented in table 3 reveal a long-run relationship between industrial output, infrastructure and the control variables in Nigeria in the presence of structural break. Specifically, the augmented ADF, Z_t, and Z_α test statistics exceed the critical value at the 5 per cent level and 1994 is the observed breakpoint, which coincides with a decrease in oil price caused by the Gulf War. This fall in oil price resulted in supply shock that affected the earnings of the Nigerian government.

Table 3. Gregory and Hansen Structural Breaks Cointegration Test

	Equation 7	Equation 8	Equation 9
		ADF Procedure	
t-stat	-5.217*	-5.954*	-6.102*
Lag	1	1	1
Break point	1994	1994	1994
		Phillips Procedure	
Za-stat	-32.341*	-35.882*	-36.560*
Za-break	1994	1994	1994
Zt-stat	-5.209*	-5.814*	-6.009*
Zt-break	1994	1994	1994

Note: * denotes significance at 5% based on percentage points of the asymptotic distribution critical values as provided by Gregory and Hansen (1996)

4.3 Stock-Watson dynamic OLS estimates

The industrial output-infrastructure equations presented in table 4 were estimated including fixed 1 lead and 1 lag. The results have two parts. One part indicates the impact of infrastructure on industrial output without accounting for structural breaks in the model. The other shows the effect of infrastructure on industrial output in the presence of structural breaks in the series. For the results without structural breaks, the long-run elasticity of infrastructure (proxied by telephone density) is 0.146 and insignificant. This implies that telephone density does not impact on industrial output in the long run. However, this assertion changed when structural break was accounted for in the series. The elasticity of telephone density improved to 0.325 and was statistically significant at 1 per cent significance level. The coefficient of the dummy variable was statistically significant suggesting that accounting for the fluctuation in telephone density in Nigeria is key in determining the long-run impact of telephone density, as a measure of infrastructure, on industrial output.

The long-run elasticity of energy consumption as a proxy for infrastructure (0.029 and 0.196) had the expected apriori sign for both equations (with or without structural breaks). The two coefficients were statistically significant and suggest that for instance, a 10 per cent increase in energy consumption would bring about a 0.3 per cent and 1.9 per cent increase in industrial output in Nigeria.

Though relatively small, the long-run elasticity of capital expenditure in transport and communication (0.086) as a proxy for infrastructure was positive and statistically significant in the model without breaks. However, when breaks were accounted for, the coefficient remained positive but insignificant. This indicates that if the fluctuation in capital expenditure in transport and communication is accounted for, its impact on industrial output would not be significant enough to bring about any change in the long run. The control variable, real interest rate, had the expected negative sign for all the equations estimated, suggesting that changes in interest rate is a major determinant of growth in industrial output. Total labour force showed a strong positive and significant impact on industrial output for models with and without breaks, while gross fixed capital formation as a proxy for capital showed positive impact on industrial output in equations (8) and (9).

Table 4. Stock-Watson Dynamic OLS Result: Fixed leads and lags specification (lead=1, lag=1)

Regressors	Dependent Variable: Y (real industrial output)			
	Without break		With break	
	Coefficient	t-statistic	Coefficient	t-statistic
Equation 7				
Intercept	-11.983	-7.248***	-14.173	-10.358***
Capital	0.143	1.212	-0.165	-0.839
Labour	0.294	3.819***	0.692	5.646***
Telephone density	0.146	1.584	0.325	3.276***
Real interest rate	-0.239	-3.021***	-0.672	-5.039***
Dummy			0.516	2.306**
R^2	0.702		0.782	

Regressors	Dependent Variable: Y (real industrial output)			
	Without break		With break	
	Coefficient	t-statistic	Coefficient	t-statistic
Adj R^2	0.691		0.762	
Durbin Watson	1.891		2.132	
Equation 8				
Intercept	7.972	1.649	13.834	2.925**
Capital	0.425	3.433***	0.333	2.744**
Labour	0.184	4.334***	0.568	5.168***
Energy consumption	0.029	3.588***	0.196	4.667***
Real interest rate	-0.657	-5.214***	-0.659	-5.460***
Dummy			0.688	2.061*
R^2	0.732		0.812	
Adj R^2	0.712		0.791	
Durbin Watson	2.019		2.104	
Equation 9				
Intercept	-9.892	-6.025***	-9.892	-3.777***
Capital	0.388	2.416**	0.371	2.770**
Labour	0.723	2.251**	0.898	2.338**
Capital expenditure in trans/comm	0.086	2.387**	0.092	0.942
Real interest rate	-0.879	-2.325**	-0.722	-1.356
Dummy			0.061	2.091*
R^2	0.796		0.715	
Adj R^2	0.765		0.709	
Durbin Watson	2.027		1.845	

Note: *, ** and *** depict significance at the 10%, 5% and 1% levels respectively

Source: Authors' computation

4.4 Causality test results

The results of the Toda-Yamamoto Granger non-causality test with and without breaks are presented in tables 5 and 6. The results in table 5 (causality without break) indicate that there exists a unidirectional causality running from the three proxies of infrastructure to real industrial output, thus confirming the cointegrating relationship in table 4 and also showing the importance of infrastructure in the growth and development of industrialization in Nigeria. The results for the model accounting for breaks also reveal the same results except for capital expenditure in transport and communication as a proxy for infrastructure, which indicates a bidirectional causality between industrial output and infrastructure. This implies that as capital expenditure in transport and communication changes, growth in industrial output also increases in the same direction and magnitude.

Table 5. Toda-Yamamoto Causality (Without breaks) Test Result

Null hypothesis	df	MWALD	Prob	Decision
Y does not Granger-cause *ted*	2	3.528	0.1713	Do not reject
ted does not Granger-cause *Y*	2	9.571	0.0084	Reject
Y does not Granger-cause *epc*	2	1.815	0.4035	Do not reject
epc does not Granger-cause *Y*	2	7.960	0.0187	Reject
Y does not Granger-cause *tex*	2	3.928	0.1403	Do not reject
tex does not Granger-cause *Y*	2	9.729	0.0077	Reject

Source: Authors' computation.

Table 6. Toda-Yamamoto Causality (With breaks) Test Result

Null hypothesis	df	MWALD	Prob	Decision
Y does not Granger-cause *ted*	2	1.296	0.5230	Do not Reject
ted does not Granger-cause *Y*	2	7.282	0.0262	Reject
Y does not Granger-cause *epc*	2	1.806	0.4054	Do not reject
epc does not Granger-cause *Y*	2	8.828	0.0121	Reject
Y does not Granger-cause *tex*	2	6.190	0.0453	Reject
tex does not Granger-cause *Y*	2	7.772	0.0205	Reject

Source: Authors' computation.

5. Conclusion

This study has investigated the relationship between industrialization (measured by industrial output) and infrastructure (proxied by telephone density; energy consumption and capital expenditure in transport and communication) in Nigeria during the period 1981 to 2015. It employed two different unit root tests to determine the stationarity of the data: the Ng and Perron (2001) unit root test and the Zivot and Andrews (1992) unit root test which account for structural break in the series. It also carried out a causality test that compared the results with and without a structural break using the Toda-Yomamoto causality test. The dynamic

OLS estimation technique proposed by Stock and Watson (1993) was used to estimate the industrial output elasticity of infrastructure development in Nigeria taking account of the structural break. The results obtained reveal that all proxy of infrastructure except telephone density impacted positively on industrial output when structural break is not accounted for. Further, telephone density and energy consumption impacted positively on industrial output in the presence of structural breaks, while capital expenditure in transport and communication did not. This implies that fluctuations in infrastructural development to a larger extent affected the magnitude of the impact of infrastructure on industrialization in Nigeria. The causality test results further reveal a unidirectional causal relationship between infrastructure and industrial output, indicating that infrastructure is vitally important to the industrialization aspiration of the nation. Another relevant policy implication of these findings is the need for government to look for other stable sources of financing infrastructures in Nigeria because reliance on mostly oil revenue has brought about the fluctuation in infrastructural development which has an effect on the industrial drive of the nation.

References

Aaron, H. J. (1990). Why is infrastructure important? Discussion in A. H. Munnel, Ed. Is there a shortfall in public capital investment? *Federal Reserve Bank Conference Series*, 34, 51B63. Boston.

Adenikinju, A.F. 1998. Government investment and manufacturing performance in Nigeria. In: *Rekindling Investment for Economic Development in Nigeria.* Proceedings, Nigerian Economic Society Annual Conference Proceedings. pp. 303-319.

African Development Bank. (2016). *Annual Report.* Abidjan, Côte d'Ivoire: ADB.

Agenor, P.-R. (2010). A theory of infrastructure-led development. *Journal of Economic Dynamics and Control* 34: 932-950.

Aghion, P. and Howitt, P. (1992). A model of growth through creative destruction. *Econometrica* 60: 323-351.

Akanbi, B., Abalaba B. and Afolabi D. (2013). Transport infrastructure improvement and economic growth in Nigeria. *International Journal of Humanities and Social Science Invention* 2(1): 26-31.

Akpan, N. I. (2005). Government expenditure and economic growth in Nigeria: A disaggregated approach. CBN *Economic and Financial Review* 43(1).

Aladejare, S.A. (2013). Government spending and economic growth: Evidence from Nigeria. *MPRA Paper*, No. 43916.

Aregbeyen, O. (2006). Public expenditure and economic growth in Africa. *Indian Journal of Economics* 87(344): 55-76.

Aremu, K. (2016). Leveraging Nigeria's pension assets to bridge infrastructural gap. *Zenith Economic Quarterly* 12(4): 35-42.

Arrow, K.J. (1962). The economic implications of learning by doing. *Review of Economic Studies* 29: 155-173.

Aschauer, D.A. (1989). Does public capital crowd out private capital? *Journal of Monetary Economics* 24(2): 171-188.

Arslanalp, S., Bornhorst, F., Gupta, S. and Elsa, S. (2010). Public capital and economic growth. *IMF Working Paper,* 10/175. Washington, DC: IMF.

Ayogu, M. (2000). Before Prebendalism: a positive analysis of core infrastructure investment in a developing fiscal federalism. *African Development Review* 11(2): 169B98.

Barro, R.J. (1990). Government spending in a simple endogenous growth model. *Journal of Political Economy* 98: 103B125.

Bueffie, E., A. Berg, C. Pattillo, R. Portillo, and Zanna, L.F. (2012). Public investment, growth, and debt sustainability: putting together the pieces. *IMF Working Paper* No. 12/144.

Buhr, W. (2003). What is infrastructure? Department of Economics, School of Economic Disciplines, University of Siegen. *Siegen Discussion Paper* No. 107- 03.

Calderon, C. and Serven, L. (2008). Infrastructure and economic development in sub-Saharan Africa. *Policy Research Working Paper Series*, 4712. The World Bank.

Canning, D. and Bennathan, E. (2000). The social rate of return on infrastructure investments. *Policy Research Working Paper Series,* 2390. The World Bank.

Cashin, P. (1995). Government spending, taxes and economic growth. *IMF Staff Papers* 42: 237-269.

Cellini, R. and Torrisi, G. (2009). The regional public spending for tourism in Italy: an empirical analysis, *MPRA Paper,* No.16131.

Central Bank of Nigeria. (2014). *Annual Report and Statement of Account.*

Central Bank of Nigeria. (2015). *Annual Report and Statement of Account*.

Central Bank of Nigeria. (2015). *Statistical Bulletin*.

Cohen, J. P. and Morrison, P. C. J. (2004). Public infrastructure investment, interstate spatial spillovers, and manufacturing costs. *Review of Economics and Statistics* 86: 551-560.

Dash, P., Sahoo, R.K and Nataraj, G., (2010). Infrastructure development and economic growth in China. *IDE Discussion Paper* No. 261.

Demetriades, P.O. and Mamuneas, T.P. (2000). Intertemporal output and employment effects of public infrastructure capital: evidence from 12 OECD economies. *Economic Journal* 110: 687-712.

Devarajan, S., Swaroop, V. and Zou, H. (1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics* 37: 313-344.

Duggal, V.G., Saltzman, C. and Klein, L.R. (1999). Infrastructure and productivity: a nonlinear approach. *Journal of Econometrics* 92: 47B74.

Easterly, W. and Rebelo, S. (1993). Fiscal policy and economic growth an empirical investigation. *Journal of Monetary Economics* 32: 417-458.

Elliott, G. Rothenberg, T.J. and Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica* 64: 813-836.

Enimola, S.S. (2011). Infrastructure and economic growth: the Nigeria experience, 1980B 2006. *Journal of Infrastructure Development* 2(2): 121B133.

Esfahani, H. and Ramìres, M.T. (2003). Institutions, infrastructure and economic growth. *Journal of Development Economics* 70: 443-477.

Ezcurra, R. and Gil, C. (2005). Public capital, regional productivity and spatial spill-overs. *The Annals of Regional Science* 39: 471-494.

Falola, T. and Heaton M. (2008). *A History of Nigeria*. Cambridge: Cambridge University Press.

Futagami, K., Morita, Y. and Shibata, A. (1993). Dynamic analysis of an endogenous growth model with public capital. *Scandinavian Journal of Economics* 95(4): 607-25.

Ghosh, S. and Roy, U. (2004). Fiscal policy, long-run growth, and welfare in a stock-flow model of public goods. *Canadian Journal of Economics* 37(3): 742-756.

Glomm, G. and Ravikumar, B. (1997). Productive government expenditures and long-run growth. *Journal of Economic Dynamics and Control* 21: 183-204.

Gomez, M. A. (2007). Fiscal policy, congestion and endogenous growth. *Journal of Public Economic Theory* 43(2): 130-145.

Gregory, A.W. and Hansen, B.E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics* 70: 99-126.

Grossman, G.M. and Helpman, E. (1991). *Innovation and Growth in the Global Economy*. Cambridge MA: MIT Press.

Johansen, S. and Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration B with applications to the demand for money. *Oxford Bulletin of Economics and Statistics* 52: 169-210.

Lucas, R.E. (1988). On the mechanisms of economic development. *Journal of Monetary Economics* 22: 3-42.

Michael, M.O.E. (2016). The dynamics of infrastructure and economic growth in Nigeria. *Journal of Global Economics* 4(1): 1-9.

Milbourne, R., Otto, G. and Voss, G. (2003). Public investment and economic growth. *Applied Economics,* 35: 527-540.

Moreno, R., López-Bazo, E. and Artís, M. (2003). On the effectiveness of private and public capital. *Applied Economics* 35: 727-740.

Munnell, A. (1992). Policy watch: infrastructure investment and economic growth. *Journal of Economic Perspectives* 6: 189-198.

National Planning Commission.(2004). *National Economic Empowerment and Development Strategy (NEEDS)* 1. Abuja: National Planning Commission.

National Planning Commission (2010). *First National Implementation Plan (1st NIP) for Nigerian Vision 20:2020*. Abuja: National Planning Commission.

Ng, S. and Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica* 69: 1519-1554.

Nurudeen, A. and Usman, A. (2010). Government expenditure and economic growth in Nigeria, 1970- 2008: a disaggregated analysis. *Business and Economics Journal* BEJ-4.

Olaloku, F.A. (1987). *Structure of the Nigerian Economy*. Lagos: Macmillian.

Olufemi, E.A., Olatunbosun, A.J., Olasode, O.S., and Adeniran, I.G. (2013). Infrastructural development and its effect on economic growth: the Nigerian perspective. *European Scientific Journal* 9(31): 431-452.

Owolabi-Merus, O. (2015). Infrastructure development and economic growth nexus in Nigeria. *International Journal of Academic Research in Business and Social Sciences* 5(1): 376-382.

Owosekun, A.A. (1991). Macroeconomic issues and case studies of public enterprises. In: *Public Enterprise in Nigeria*. *Nigerian Economic Society Annual Conference Proceedings*. pp.1-15.

Oyeniran, W.I. and Onikosi-Alliyu, S. (2016). Information and telecommunication infrastructure and economic growth: an experience from Nigeria. *Serbian Journal of Management* 11(2): 275-289.

Perron, P. and Ng. S. (1996). Useful modifications to some unit root tests with dependent errors and their local asymptotic properties. *Review of Economic Studies* 63: 435-463.

Pesaran, M.H., Shin, Y. and Smith R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics* 16, 289-326.

Pritchett, L. (2000). The tyranny of concepts: CUDIE (Cumulated, Depreciated, Investment Effort) is not capital. *Journal of Economic Growth* 5: 361-384.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy* 94: 1002-1037.

Romer, P.M. (1990). Endogenous technological change. *Journal of Political Economy* 98: 71-102.

Shioji, E. (2001). Public capital and economic growth: a convergence approach. *Journal of Economic Growth* 6: 205-227.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics* 70: 65-94.

Stock, J. and Watson, M.W. (1993). A simple estimator of cointegrating vectors in higher order integrated system. *Econometrica* 61(4): 783-820.

Straub, S. (2012). Infrastructure and development: a critical appraisal of the macro level literature. *Policy Research Working Paper,* 4590. The World Bank East Asia and Pacific Sustainable Development Department.

Sturm, J., Jacobs, J. and Grote, P. (1998). Output effects of infrastructure investment in the Netherlands, 1853-1913. *Journal of Macroeconomics* 21: 355-380.

Swan, T.W. (1956). Economic growth and capital accumulation. *Economic Record*, 32(3): 334-361.

Toda, H.Y. and Yamamoto, T. (1995). Statistical inferences in vector autoregressions with possibly integrated processes. *Journal of Econometrics* 66: 225-50.

Tsoukis, C. and Miller, N. (2003). Public services and endogenous growth. *Journal of Policy Modelling* 25(3): 297-307.

Turnovsky, S. (1997). Public and private capital in an endogenously growing open economy. In: Jensen, B.S. and Wong, K. Eds. *Dynamics, Economic Growth and International Trade*. Ann Arbor: The University of Michigan Press.

Usman, S. 1991. Financial and management problems of Nigerian public enterprises. In: *Public Enterprise in Nigeria*. *Nigerian Economic Society Annual Conference Proceedings.* pp.23-36.

World Bank. (2015). *World Development Indicator.* Washington, DC. The World Bank.

Zagler, M. and Durnecker, G. (2003). Fiscal policy and economic growth. *Journal of Economic Surveys* 17: 397-418.

Zivot, E., Andrews, D.W.K. (1992). Further evidence on the great crash, the oil price shock and the unit root hypothesis. *Journal of Business and Economic Statistics* 10: 251-270.