Does Public Capital Influence Output Growth? Further Evidence from Nigeria

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Abstract

This study investigates the nexus between public capital and growth. The study made use of the Vector Error Correction Model (VECM) which is a multi-equation framework to capture all plausible effects of public capital on output growth (measured by growth rate of real GDP) in Nigeria between 1980 and 2015. The results of the econometric estimations revealed that there exist a long run relationship between output growth, public capital, private capital, public consumption and labour. Although public capital was found to have the expected positive sign, it was insignificantly related to growth. This suggests a positive correlation between public capital and output growth. The results also indicate that private capital positively impact on output growth while public consumption negatively affects output growth in Nigeria. Furthermore, the results showed the presence of crowding-out effect, suggesting that public capital has not impacted meaningfully on private investment in Nigeria. The study therefore recommends that government should embark on public capital expenditure in sectors that would smoothen the function of the market to promote growth and development in a country.

Keywords: Public capital, Private capital, Public Consumption, Growth, VECM, Nigeria.

JEL Classification: O19, O23, O40

1. Introduction

The relationship between public capital and output growth has been extensively investigated by both theoretical and empirical studies. An important question often debated is whether public capital stimulates output growth. This is because while public capital may be considered as a factor input that can contribute positively to economic growth, the way public capital is financed may crowd out private investment (Mittnik and Neumann, 2001). Empirical evidence suggests that the importance of public capital in determining long term economic growth is driven by the

fact that it is confined to quasi-public goods[1] whose services are essential and tend to generate positive spill-over effects for the private sector (Ashipala, 2003).

The externalities of public capital may be larger in developing countries than in developed countries. The plausible reason adduced from the literature is that public capital is very important to any developing economy because of its dominant role in aggregate domestic investment and the multiplier effect it has on the economy. For instance, in most developing countries, public capital like infrastructural investments are largely provided or financed by the government due to a number of reasons; the nature of some of these infrastructures (they are regarded as public goods); their huge costs outlays; the declining costs associated with their production; and the high social benefits arising from their production.

In Nigeria, expenditure on public capital such as road construction, housing, water and sewage, health, education etc. has been fluctuating over the years partly due to the unstable receipts from production and sales of crude oil, as well as the increased demand for these goods. For example, the average annual growth rate of public capital was 20.5%% between 1980 and 1984 and declined to 9.0% from 1990 to 1994. It declined further to 4.2% from 2005 to 2010 and stood at 3.6% in 2015. Within the same periods, the average growth of output also fluctuated significantly from 6.52% in 1980 to 7.99%, 3.87%, 9.52%, 7.87% and 2.84% in 1990, 2000, 2005, 2010 and 2015 respectively. This indicates that there is divergence between the growth in public capital and output.

[1] Quasi-public goods in this contest are goods such as roads, education, health, research and development, housing, water and sewage, fire services, courts and transport and communication expenditure.

Based on the aforementioned issues, it is pertinent to note that, quite a number of studies have examined this fundamental nexus in Nigeria (Nurudeen and Usman, 2010 and Aladejare, 2013). However, most of these studies adopted the single-equation production function approaches. The problem associated with this approach is that it considers explicitly only one of the four dynamic relationships that may exist among the four basic variables in the production function and, therefore, excludes the likely presence of feedback among these variables. To correct for this fundamental issue, this study adopts the Vector-Autoregressive (VAR) approach which is a multi-equation framework to capture all plausible effects of public capital on output growth in Nigeria between 1980 and 2015. The rest of the paper is organized as follows: section 2 presents a review of the literature on public capital–growth nexus. It is followed by the discussion of the theoretical framework and methodology in section 3. Section 4 discusses empirical results, while the last section 5 presents the concluding remarks with policy implications.

2. Literature Review

In the literature, there are different approaches developed to analyze the link between public capital and output growth. These approaches are discussed in turn with emphasis on empirical studies that have adopted these methods.

Starting from the seminal work of Aschauer (1989) which is dated as the first paper to use the production function approach to measure the economic impact of public capital. Aschauer used a logged Cobb-Douglas production function specification, to study the effect of public capital on productivity of firms from 1949-1985 in the U.S and found a strong and positive relationship between productivity and public capital. Studies for developing countries, like Ramirez (1998); and Nurudeen and Usman (2010) found positive and significant relationship between government spending and economic development for Chile and Nigeria respectively. In the same vein, Devarajan et al. (1996) in their study on 43 developing countries from 1970-1990 found a

positive but statistically insignificant relationship between total government expenditure and economic growth in all the countries studied.

Canning and Bennathan (2000) try 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. In another work, Esfahani and Ramìres (2003) handled the causality issue by introducing a "time-lag" between variables for public capital and productivity. The study concluded that public infrastructures do have a considerable impact on increasing productivity and economic growth. 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. They concluded that government expenditure on public capital affect economic growth positively.

One of the limitations of the production function approach is that it does not take into account the role of factor prices in determining their utilisation: it reflects only technological relations. This is because the inclusion of private factors in the production function implies that their marginal productivity implicitly paid up. Based on this, some studies under the production-function approach have used the tranlog function that is more general than the Cobb-Douglas function. (See for example, Kemmerling and Stephan, 2002; and Stephane, 2003).

An alternative way to deal with this issue is to adopt the cost function approach. According to this approach, the impact of public capital on productivity should be analyzed in terms of cost savings. Studies following the cost-function approach aim to examine if the cost of output decreases as the public capital endowment increases. For instance, Berndt and Hansson (1991) used the generalized Leontief and time series data from 1960-1988 from U.S.A private business to show that an increase in government public capital expenditure reduces costs while excess decline costs. Other studies like Lynde and Richmond (1993); and Dalmagas (1995) for United

Kingdom and Greece respectively show that increase in public capital plays important role in output and input demand.

Empirical evidence have shown that flexible functional form requires many second order terms which creates the problem of multicollinearity. Therefore, in order to increase data variability, most studies on cost-function approach prefer to use panel data which have both time and geographical dimensions. Ezcurra, Gil et al. (2005) in their study regarding Spanish regional production costs in the agricultural, industrial, and services sectors for the period from 1964 to 1991 found that public capital reduces private costs and increases productivity. Their estimate shows that while agricultural and service sector behave similarly, the greatest saving in private costs (in terms of dollar costs per unit of public capital) are found in the industrial sector compare to services and agricultural sectors respectively.

Growth models aiming to test the economic impact of public capital are based on the general idea that economic growth is not driven merely by exogenous factors rather by dynamics which are internal to the economic system itself. Among the first to estimate the impact of public capital on economic growth in an endogenous growth model framework was Barro (1990) who used annual data for 76 countries from 1960 to 1985 and concluded that the impact of public capital on economic growth is insignificant. Khan and Reinhert (1990) produced the same results using annual data for 24 developing countries from 1970 to 1979. The study concluded that the effect of public capital on economic growth is insignificant. Extending the scope of study from 1970 to 1990, Ram (1996) found a positive and significant impact of public capital on economic growth. Furthermore, Cellini and Torrisi (2009), study on infrastructure in the tourism sector, reveal that infrastructure of this nature separately considered, has a weak impact on several economic performance indicators i.e. gross domestic product (GDP), touristic presence, improved patronage in hotel etc.

However, various authors have pointed out problems associated with cross section regressions. These problems are: Bias due to omitted variables; reverse causation; sample selection; Parameter heterogeneity; Presence of outliers; Endogeneity of regressors (inverse causality) and Possible multicollinearity among the regressors (Ahn and Hammings, 2000). To deal with theoretical limitations and significant empirical controversies over the impact of public capital on economic growth summarised above, the Vector Autoregression (VAR) models are used by some researchers. The VAR model allows for limited number of variables to be considered and explained by their own lags and the lags of the other variables, so that all variables are treated as jointly determined.

Pereira and Sagalés (2007) utilized the VAR models with Spanish regional data and found that public capital affect private output positively and also *crowd-in* private sector inputs. The study concluded that public capital compliments private capital. Ashipala (2003) study on SACU region (Namibia, South Africa and Botswana) from 1970 to 2001 reveal that public capital has positive significant relationship with economic growth in Namibia and South Africa. Mansouri (2008) investigated the impact of public spending structure on short and long run economic growth in Egypt, Morocco and Tunisia from 1972 to 2005. He concluded that public spending have positive effect on both short and long run economic growth in three countries.

Nurudeen and Usman (2010) analyzed government expenditure and economic growth in Nigeria during 1970 to 2008 using the error correction model (ECM). Their findings revealed that government total capital expenditure; total recurrent expenditures and government expenditure on education had negative effects on economic growth. Contrarily, rising government expenditure on transport & communication and health positively impacted economic growth. The study recommended that government should increase both capital expenditure on education

and other key sectors of the economy. In similar study, Aladejare (2013) also found positive and significant relationship between government investment and economic growth.

Overall, the review suggest that the effect of public capital differs across regions, countries and sector depending on the theoretical framework and methodological approach adopted by the authors.

3.0. Theoretical Framework and Research Methodology

3.1 Theoretical Framework

The starting point is the traditional production function which may be written as follows:

$$Yg_t = f(K_t L_t) \quad (1)$$

Where *Yg* is growth rate of real GDP, *K* is capital stock, *L* is labour, and *t* is time.

In line with Barro (1990), one may introduce aggregate public spending (*G*) as an explanatory variable in equation (1), to yield:

$$Yg_t = f(K_t L_t G_t) \quad (2)$$

Aggregate public spending (G) by definition is the combination of public investment and current public consumption which is expressed as:

$$G_t = I_g + C_g \quad (3)$$

Since public investment (*Ig*) is a part of aggregate public spending (*G*) and of aggregate investment (*I*), it is possible to deduct *Ig* from *G* to obtain current public consumption (*Cg*). Therefore equation (3) can be rewritten as:

$$C_g = G_t - I_g \quad (4)$$

By measuring public investment (*Ig*) in stock and deducting it from capital (K) in equation (1) would give us public capital (*Kg)* and private capital (*Kp)* as components of aggregate capital stock (K). This is expressed as:

$$K_t = g(K_{gt}, K_{pt}) \tag{5}$$

Thus, the profitability rate of private capital declines as soon as the values of certain public capital projects increase if public capital constitutes perfect substitutes of private capital. It's also interesting to note that public capital would negatively affect private capital because of the crowding-out effect channeled through financial system, especially when the interest rate does not adequately reflect the cost of financial resources, notably because of financial repression and credit rationing.

Substituting equation (4) and (5) into equation (1) to give an augmented production function which is expressed below as:

$$Yg_t = f(K_{gt}, K_{pt}, L_t, C_{gt}) \tag{6}$$

Equation (6) implies that output growth is a function of public capital, private capital, labour and public consumption.

3.2 Methodology

The methodology adopted to capture the objectives of the study is the VAR approach. The VAR methodology is preferred in this study for at least two reasons. First, it avoids any *a priori* restrictions on the variables appearing in the VAR and captures the forward-looking nature of investment spending. Second, the VAR methodology allows the study of both long run equilibrium relationship and short run dynamics within a unified framework of cointegration and error-correction modelling, due to Engle-Granger, Johansen (1988) and others.

The VAR model consists of five variables i.e. public capital (IG), private capital (IP), public consumption (CG), labour (L) and GDP growth rate (Yg). Both public capital and private capital capture physical capital formation which is considered as one of the most important determinants of economic growth. The disaggregation of capital into public and private components not only allows estimation of the impact of the two types of capital on economic growth, but also sheds light on the question of whether or not public investment crowds out private investment. This question has received wide attention in the literature. In line with a number of earlier studies on economic growth, most notably Kormendi and Meguire (1985) and Glomm and Ravikumar, (1997), public consumption is also included in the analysis. It is generally argued that public consumption can either promote or impede the process of economic growth depending on the nature of such expenditures.

Prior to estimating a multivariate VAR, the stationarity properties of the data are investigated using tests for the existence of unit roots. If individual variables in the VAR turn out to be unit root processes, it is possible that the variables share a common stochastic trend, i.e. they are cointegrated. Tests for cointegration are carried out by using the Johansen's testing procedure. This method proceeds with the specification of the following VAR of order *p*:

$$y_t = \alpha + A_t y_{t-1} + ... + A_\rho y_{t-\rho} + \varepsilon_t \tag{11}$$

Where y_t is k-dimensional vector of non-stationary variables, and ε_t is a vector of white noise residuals. By using the first difference operator Δ the above VAR can be rewritten as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{\rho} T_i \Delta_{t-i} + \varepsilon_t \tag{12}$$

The rank of matrix Π determines the number of linear combinations of y_t that are stationary processes. If the rank of the matrix is *r*, Π can be factored as $\alpha\beta'$, where the elements of α are the adjustment parameters in the error-correction model, and β contains the cointegrating vectors. Johansen derives two test statistics for testing the cointegrating rank. The first is the maximum eigenvalue test, which tests the null hypothesis of *r* cointegrating vectors against the alternative of $r + 1$ vector. This test utilizes the $r+1^{st}$ largest eigenvalue in the following likelihood ratio:

$$\lambda_{\max} = -T \ln\left(1-\lambda_{r+1}\right) \tag{13}$$

The second test statistic, known as the trace statistic, provides a test for a more general alternative hypothesis ($r < n$) and is computed as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1-\lambda_i\right) \tag{14}$$

If the variables in the VAR turn out to be cointegrated, the error correction modelling approach (restricted VAR) is adopted to determine the direction of causation between public capital and economic growth. The error correction model unifies both the short run dynamics and long run equilibrium relationships among the variables. More specifically, the statistical significance of the adjustment parameters α would provide evidence of long-run causality, whereas the joint significance of lagged first differences in the restricted VAR would indicate short run causality.

The Vector Error Correction Model (VECM) is given by:

$$\Delta X_t + \Pi X_{t-1} + D_1 X_{t-1} + \ldots + D_{p-1}\Delta X_{t-\rho+1} + \varepsilon_t \tag{15}$$

Where ΔX_t is the vector of the growth rates of these variables, the Ds is an n x n matrix of the estimable parameters, Δ is a difference operator, ε_t is a vector of impulses, which represents the unanticipated movements in X_t and Π is the long run parameter matrix.

3.3 Data Sources

This study would make use of macroeconomic time series for the period 1980-2015. The data was obtained from the Central Bank Nigeria Statistical Bulletin and Annual report and statement of Account (various issues). The variables of interest are; public capital (K_g), private capital (K_p), public consumption (C_g), labour (L) and growth rate of real GDP (Yg).

4.0 Empirical Results

4.1 Unit Root Test

The Ng and Perron (2001) unit root test was used to determine the stationarity of the data. This test modified PP tests of Perron and Ng (1996) using the GLS de-trending procedure of Elliott, Rothenberg and Stock (1996). This modified test is adopted because it does not reveal the spartan size distortions common with the Phillip Perron (PP) tests for errors with large negative MA or AR roots; and 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 tests is presented in Table 1. It can be observed that all the series used for analysis (Yg, Kg, Kp, L and Cg) are integrated of order one, or are I (1) series.

Table 1: Results for Ng and Perron Unit Roots Test

Variables	MZa	MZt	MSB	MPT
Yg				
Level	-5.204	-1.601	0.175	1.518
First Difference	-16.289*	-2.850*	0.308*	4.739*
Kg				
Level	-1.253	-0.916	0.173	1.476
First Difference	-16.635*	-2.883*	0.864*	7.505*
Kp				

Level	-1.393	-1.203	0.171	1.491
First Difference	-16.928*	-2.897*	0.864*	4.450*
L				
Level	-0.573	-1.533	0.169	1.583
First Difference	-16.983*	-2.876*	0.930*	5.966*
Cg				
Level	-1.577	-0.457	0.174	1.499
First Difference	-16.427*	-2.864*	0.792*	4.301*

Notes: (1) The asymptotic critical values for the MZa test are -13.80 and -8.10 for 1% and 5% significance levels respectively.

(2) The asymptotic critical values for the MZt test are -2.58 and -1.98 for 1% and 5% significance levels respectively.

(3) The asymptotic critical values for the MSB test are 0.17 and 0.23 for 1% and 5% significance levels respectively.

(4) The asymptotic critical values for the MPT test are 1.78 and 3.17 for 1% and 5% significance levels respectively.

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

4.2 Cointegration Test

In order to test if a long run equilibrium relationship exists among the variables, the Johansen and Juselius (1990) cointegration technique was adopted. In adopting this method, the optimal lag length of the Vector Autoregressive (VAR) model need to be establish using various information criteria. The results of the lag selection criteria is presented in Table 2. From Table 2, the five different information criteria considered [Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan-Quinn Information Criterion (HQ), Final Prediction Error (FPE) and Sequential modified LR test statistic (LR)] suggest 1 as the optimal lag length for the model.

Table 2: VAR Lag Order Selection Criteria

Criteria/Lag Length	0	1	2
Sequential Modified Test Statistic (LR)	Not Available	226.841*	14.063
Final Prediction Error (FPE)	0.042	5.661*	0.001
Akaike Information Criterion (AIC)	11.022	4.391*	5.250
Schwarz Information Criterion (SC)	11.247	5.738*	7.719
Hannan-Quinn Information Criterion (HQ)	11.099	4.851*	6.092
Note: * indicates lag order selected by the criterion.			

After establishing the order of intergration [i.e. all the variables are I(1)] and confirming the optimal lag length as 1, the Johansen cointegration test is then applied to the variables. The results of the cointegration test are presented in Table 3. The results in Table 3 reveal that the trace and maximum eigenvalue tests indicate four (4) cointegrating equation suggesting that long run relationship exist among the variables in equation 6 (public capital, private capital public consumption, labour and growth rate of real GDP).

Table 3: Test Results for Cointegration between Pairs of Variables

	Trace Test			**K=1**	**Maximum Eigenvalues**			**K=1**	
Equation	H_o	H_A	Trace Statistics	5% Critical Values	H_o	H_A	Max-Eigen Statistic	5% Critical Values	No of Cointegrating Equation
Equation (6)	R=0* R≤1* R≤2* R≤3* R≤4*	R=0 R=1 R=2 R=3 R=4	96.375 54.984 27.818 12.321 2.6087	60.061 40.175 24.276 10.854 4.129	R=0* R≤1* R≤2* R≤3* R≤4*	R=0 R=1 R=2 R=3 R=4	41.391 27.166 17.797 11.225 2.3087	30.439 24.159 16.964 10.828 4.991	4

4.3 Results of the VECM Estimation

The VECM results for equations (6) is presented in Table 4. Equation (6) consists of the regression of output growth (measured by growth rate of real GDP) on public capital, private capital, labour and public consumption.

As can be seen from Table 4, the coefficient of public capital in model 1 (where growth rate of real GDP is dependent variable) have the expected positive sign but it is statistically insignificant. This imply that public capital and output growth were found to be positively correlated. Given the strong theoretical argument for a positive significant effect of public capital on growth, this is result is puzzling. However, theoretical and empirical analysis has shown that not all types of public capital have a strong direct impact on economic growth.

Thus, the responsiveness of output growth from an increase in public capital depends largely on the composition of public capital. This is in line with the argument of Al-Faris (2002) that the reason for weak causal link between of public capital and growth could be that a significant proportion of public capital is devoted to non-growth-promoting activities, i.e. procurement in defence sector. This could be plausible given the security challenges in Nigeria lately. Another plausible reason adduced in the literature is corruption. Furthermore, some types of public capital might impact on growth indirect via public consumption and private capital. Another plausible reason for this positive and insignificant relationship between public capital and growth could be that the type of private capital undertaken by government takes time to have a significant effect on economic growth.

The coefficient of private capital in model 1 is positive and statistically significant. This suggests that output growth responds positively to an increase in private capital. Therefore, private capital in this case is growth-enhancing.

Furthermore, the result in model 1 also indicates that public consumption is having a significant negative effect on the output growth in Nigeria. These result corroborate the findings of Ramirez, (1998) and also conform to the theory, which suggests that public consumption is growth retarding depending on the nature of such expenditures. From model 2, the coefficient of private capital is negative and significant indicating the possibility of a crowding-out effect. This is also the same in model 3 when private capital is the dependent variable however, the coefficient in this case was negative but statistically insignificant.

The diagnostic tests presented in Table 4 for all the model indicate that all the models perform well except model 3 where the R^2 is low and the LM test indicate the presence of serial correlation. The error correction term which suggest the long run relationship among the

variables is negative and significant in all the model except model 3. This further corroborate the cointegration results presented in Table 3 where four cointegrating equation was found.

Table 4: Estimates of the Vector Error-Correction Model

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
	ΔY_g	ΔK_g	ΔK_p	ΔC_g	ΔL
ECT_{t-1}	-0.422*** (-3.499)	-0.054** (2.356)	0.094 (0.696)	0.445*** (2.796)	-0.381 (-2.805)***
$\Delta Y_{g_{t-1}}$	0.019* (1.990)	0.068 (0.423)	0.015 (0.155)	-0.089* (-1.841)	0.023* (1.830)
$\Delta K_{g_{t-1}}$	0.102 (1.033)	0.094** (2.456)	0.103 (0.814)	0.029 (0.192)	0.013* (1.791)
$\Delta K_{p_{t-1}}$	0.035* (1.841)	-0.099* (-1.932)	-0.041 (-0.180)	0.038** (2.135)	0.024 (0.778)
$\Delta C_{g_{t-1}}$	-0.568*** (-2.797)	0.337 (1.252)	0.013 (0.081)	0.077 (0.382)	0.011 (0.825)
ΔL_{t-1}	0.414 (0.849)	0.193* (2.912)	-0.232 (-0.916)	0.353** (2.582)	0.076** (2.487)
R^2	0.653	0.598	0.315	0.603	0.678
Prob(F-statistics)	0.00247	0.00725	0.94647	0.00281	0.00541
LM test	2.413	1.281	4.941	0.184	0.457
Heteroscedasticity	15.812	9.017	15.278	8.042	13.224
Jarque-Bera(Prob)	0.1425	0.1879	0.1622	0.1527	0.1346

Note: (1) *, ** and *** implies significance at 10%, 5% and 1% level respectively.
(2) The values in bracket () are the t-statistics

5. Conclusion

This study investigated the nexus between public capital and output. The study made use of the Vector-Autoregressive (VAR) approach which is a multi-equation framework to capture all plausible effects of public capital on output growth in Nigeria between 1980 and 2015. Theory suggests that public capital expenditure in sectors that smoothen the function of the market are key in promoting growth and development in a country.

The estimated results revealed that there exists a long run relationship between output growth, public capital, private capital, public consumption and labour. Although public capital was found to have the expected positive sign, it was insignificantly related to output growth. This suggest that public capital and output are positively correlated. The results also revealed that private

capital is positively related to output growth while public consumption negatively affects the output growth in Nigeria. Furthermore, the results shows the presence of crowding-out effect, suggesting that public capital has not impact meaningfully on private investment in Nigeria. Therefore this study recommends that Public capital should be restricted to pure public goods that enhance growth and are non-excludable and non-rivalry. In the case where excludability may restrict access to basic facilities due to affordability, public capital should target the provision of basic economic and social services.

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