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Transport Infrastructure and Economic Growth: Evidence from Africa Using Dynamic Panel Estimates

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Abstract: Empirical evidences on the importance of transport capital development in fastening productivity and economic development for panel sets, particularly for African countries and island state cases, have been very scarce in the literature. Such type of study is very important as public finance is limited and sustainable transport improvements usually have opportunity costs. Planners need guidance, based on solid empirical grounds, to aid in their decision to improve existing transportation and build new infrastructure. This study analyses the contribution of transport capital to growth for two different data sets namely for a sample of Sub Saharan African (SSA) countries and also for a developing states (SIDS) using both cross sectional and panel data analysis. In both sample cases, the analysis concluded that transport capital has been a contributor to the economic progress of these countries. Analysis further revealed that in the SSA case, the productivity of transport capital stock is superior as compared to that of overall capital. Such is not the case for the SIDS where transport capital is seen to have the average productivity level of overall capital stock.

1. Introduction

Though decision makers and economists salute the importance of transport capital development in fastening productivity and economic development, yet this has received inadequate interest in the literature. Moreover most available research tend to focus on the economic effect of aggregate public capital at national and regional level and they have been mostly based on developed countries' cases[2]. Research using cross section and panel data set for sample of countries has even more scarce. Overall, most of them tend to establish positive impacts of public and transport capital on growth. It should be again

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[2] See classical work from Aschauer (1989),Munell (1992) and Hulten and Schwab (1993) and also more recent research from Pereira and DeFructos (1999),Fernald (1999) and Pereira and Roca-Sagales (2003).

stressed that these studies focused mainly on developed country cases (see Aschauer (1989c), Nourzad and Vrieze (1995), Canning (1999), and Canning and Bennethan (2000) for instance). We have not come across any research focusing exclusively on cross sectional and panel data analysis for developing country cases, particularly in the African context. As such no published studies have been identified based on panel of island states (SIDS). Such type of study is very important as public finance is limited and sustainable transport improvements usually have opportunity costs in terms of alternative investment, especially in the above cases. It is a fact that countries in the above samples have been driven mostly by ad hoc considerations having no explicit focus on long term requirements in as far as transportation capital is concerned. This also explains the high volatility of investment expenditures patterns observed along years. Planners need guidance based on solid empirical grounds, to aid in their decision to improve existing transportation and build new infrastructure. Research in the above context also believed to yield interesting insights about the debate and to fill a gap in the body of literature.

This study thus examines the growth impacts of transport capital using both cross sectional and panel data estimation for i) a sample of 38 Sub-Saharan African countries over the years 1980-2000 and ii) a sample of 13 small island developing states[3]. The sample has been determined based on data availability. The study is similar to Canning (1999), but the novelty is that is focuses exclusively on developing countries and island states with an updated data set. We shall start (Section 2) by briefly reviewing the literature on the growth effects of public and transport capital in panel data sets. In Section 3 we specify the preferred model and elaborate on data sources. Section 4, 5 and 6 deals with specification test and analysis of results and Section 7 provides a summary of finding and policy implications.

2. Literature review

We provide a very brief overview of the theoretical considerations that might explain the linkages between transportation improvement and the economy. The two most cited explanations relating transport improvement to economic growth in the literature has been

[3] see Appendix for list of countries

that of reduced transportation costs and increased accessibility. These have often been referred to as the primary transportation benefits. The above not only impacts directly on productivity and growth but also work through other important avenues. They filter down to enhanced productivity and economic growth through the following channels namely, reorganization and rationalization of production, better productivity and higher level of private (inwards and foreign direct) investment, wider markets, increased specialization and economies of scale, and also effects on labour market supply , labour costs and labour productivity.

Empirical evidences at international level using cross sectional and panel data sets are also reviewed as these studies not only help us in the econometric specification and interpretation but also allows us to make important comparison. Aschauer (1989c), studied the economic contribution of public investment, of which transport capital forms part for the G7 countries using panel data for the period 1966-1985. He specified a Cobb-Douglas function and came out with an output elasticity of 0.34 to 0.73 which clearly shows the importance of public investment in productivity and growth. In a subsequent study, Aschauer (1995) also used a total productivity growth function with fixed country and time effects to study the similar effect for 12 OECD countries over the period 1960-1988. He reported a contribution between 33 – 55% of the non-military public capital stock to output growth.

Nourzad and Vrieze (1995) also studied a panel data for 7 OECD countries over the period 1963-88 on the effect public investment on output. Using similar econometric specification as Aschauer(1989c) but controlling for energy input price and taking into account random effects, they found a relatively low but significant output elasticity of 0.05 with respect to public investment. In a recent study Canning (1999) estimated an aggregate production function for a panel set of 77 countries. He used annual cross country data for the period 1960-1990 and his production function (a Cobb-Douglas function) incorporated labour, physical capital, human capital and infrastructure variables (number of telephones, electricity generally capacity and kilometres of transportation routes). His approach included panel data co-integration methods, which took account of non-stationary nature of data and are also robust to reverse causation. Canning found that the elasticity of output with respect to physical capital is around 0.37. However he observed no significant impact of elasticity generating capacity, or transportation structure on growth. But since these types of infrastructure capital have already been included in his physical capital stock, the implication was that that they had the normal growth effect of capital as a whole, thus justifying their importance.

In an another study, Canning and Bennathan (2000) built on the above data set(they extended the sample to 89 countries) and methodology to analyse the hypothesis. The other important difference as compared to Canning's (1999) study was that they also estimated a translog specification which allows for flexibility in the elasticity of substitution between factors and also flexibility in the pattern of rates of returns across countries. The authors reported, in the Cobb Douglas case, positive rates of return for the case of paved roads (0.048-0.083). When adding both together they retain their positive coefficient and were statistically significant. Results from the trans-log function shown that both kinds of infrastructure were necessary but not sufficient by themselves to trigger large changes in output. The study also revealed that infrastructure is more productive with higher levels of physical and human capital.

However we should also note that other studies at international level have proved the insignificance and mixed results of public investment on productivity and output growth. For instance, Ford and Poret (1991), using data on non-military public capital stock, and also including privately provided infrastructure services as well, for 11 OECD countries over the period 1960-1988 found that his broad definition of infrastructure (including structures in electricity, gas and water and structures in transport and communication) had significant effect on productivity and output for 5 of the 12 countries, namely, US, Germany, Canada, Belgium and Sweden. He used a total factor productivity growth and Autoregressive of order 1 and 2 models for his estimations.

Other researches reported that the importance of infrastructure on economic development has been overemphasised. For instance Neuser (1993), using public capital data from Ford and Poret (1991) for the G7 countries over the period 1970- 87, applied Total factor productivity growth and co-integration techniques to the sample. They reported insignificant and unstable results. Taylor-Lewis (1993), using the same data set for the same countries under observation, but regressing a Cobb-Douglas function found that the contribution of public physical infrastructure to output were insignificant.

It is observed that existing literature has been exclusively concentrated on panel sets of developed countries cases. Moreover most of these studies dealt with the estimation of the output effect from public capital in general. The novelty of the study is that it attempts to analyse the contribution of one component of public capital, transport capital[4], for two different independent samples[5] namely for a sample of developing countries from the Sub-Saharan Africa (SSA) and also for a samples of small island states (SIDS) respectively.

3. Econometric Model and Data

We adopt similar econometric framework as in the standard literature by specifying an extended Cobb-Douglas production function as follows to model our hypothesis

$$Q_{it} = A_{it}\, L_{it}^{\beta 1}\, K_{it}^{\beta 2} G_{it}^{\beta 3} U_{it} \quad (1)$$

where Q is total output, *A* is total factor productivity, K is total physical capital of the country, G is transportation capital, L is labor and U is an error term. We use i to index countries and t to index time. Equation 1 can be put in linear form by taking the natural logarithmic on both sides. The respective coefficients would then represent the output elasticity with respect to each dependent variable.

$$q_{it} = a_{it} + \beta_1 l_{it} + \beta_2 k_{it} + \beta_3 g_{it} + u_{it} \quad (2)$$

The small letters denotes that our variables are in natural logarithmic terms. Our dependent variable, the output level of the country, has been measured by Purchasing Power Parity Real Gross Domestic Product (chain index). The physical output *k* has been proxied by the investment to GDP ratio and we use labour force to capture the effect of Labour (l). The first two variables have been made available from the Penn World Tables 6.1 and labour force figures were available from the International Financial Services (IFS) and the

[4] This component usually forms one of the major parts of government's capital expenditure but is also observed to be a very volatile item.
[5] Canning and Bennathan (2000), although had 89 countries in his sample, however did not focused on the African context exclusively.

International Labour Organisation (ILO). The next step was to find a suitable proxy for transportation capital and the only reliable one available for the purpose of our study is the length of paved road in kilometers as data constraint restricts to segregate the transport capital figures from the country's total investment (k). This has been used in a number of study (see Canning, 1999 and Canning and Bennethan, 2000 among others). The data on road kilometers was extracted from Canning database (A database of World Infrastructure stocks, 1950-95) and extended [6] to have a complete series up till 2000.

Availability of a complete set of data permits us to close on a cross section sample 38 Sub-Saharan countries and 13 SIDS and a time period of 20 years (1980-2000) for the SSA countries and 15 years (1985-2000) for the SIDS.

4. Cross – Section and Pooled OLS Analysis and Results

In this section we perform independent cross sectional analysis of the two data sets. Table 1 reports result for OLS regressions on a cross section of countries averaged over the period 1980-2000 (Sub-Saharan) and 1990-2000 (SIDS) respectively. The limitations of using a single-equation OLS cross sectional regression model and pooled OLS are known (see Kennedy 2003). To overcome these short comings, panel data techniques are advised.

Analysing the case of the SIDS first, from Table 1 (Column 4) it can be observed that the output elasticity of transport (proxied by length of paved roads) is positive but insignificant, implying that transport might indeed be unimportant in the economic growth of a country. As argued before care should be taken in interpreting this result as the transport infrastructure capital appears twice, once on its own in the road figures and also in the overall investment figure. We follow Canning (1999) interpretation by arguing since the transportation infrastructure appears twice the correct interpretation is that it has the average productivity level of overall investment, that is 0.134. We have also run a pooled time series and the result, reported in column 5, seems to consolidate those from the cross section.

[6]We used various sources including World Development Report (WDR), individual countries CSO publications and The International Road Federation (IRF) statistics.

Table 1:Cross-Country estimates: Sub Saharan and SIDS countries

Variable	*SSA cross section*	*SSA Pooled OLS*	*SIDS cross Section*	*SIDS Pooled OLS*
Constant	*2.50*	*2.78*	*3.21*	*4.66*
	*(5.41)****	*(18.45)****	*(8.15)****	*(25.42)****
l	*0.42*	*0.31*	*0.14*	*0.21*
	*(2.23)***	*(5.92)****	*(2.59)***	*(5.69)****
k	*0.23*	*0.42*	*0.13*	*0.26*
	*(3.12)****	*(9.23)****	*(3.54)****	*(2.82)***
g	*0.103*	*0.301*	*0.08*	*0.05*
	*(2.43)***	*(8.02)****	*(1.23)*	*(0.92)*
R^2	*0.4171*	*0.2776*	*0.3036*	*0.2951*
Number of observations	*819*	*819*	*208*	*208*

Note: * indicates 10% level of significance, ** 5% level of significance, *** 1% level of significance. The small letters denotes variables in natural logarithmic and t values are in parentheses.

In the case of the cross section of the sample of Sub Saharan countries (column 2), the output elasticity of transport infrastructure is reported to be positive and statistically significant. This might suggest that investment in transport capital is more productive than investment on average (output elasticity of 0.226) and that there may be large externalities to transport capital. The results are here as well confirmed to a large extent the pooled time series estimation (refer to column 3).

5. Panel Analysis

5.1. Sub-Saharan African (SSA) countries' Case

We now turn to panel estimates of the Sub-Saharan country case. Column 2 of Table 2 below provides estimates the fixed effects coefficients of the extended Cobb-Douglas production function equation specified previously. Though statistically insignificant, following the previous interpretation, it is shown that transportation capital has the average productivity level of overall investment and might be a significant determinant. The rest of the explanatory variables are also significant and have the expected signs. Although the result concerning the importance of transport capital as a determinant appears sensible, one might wonder whether the estimated model is unduly restrictive.

Table 2: Panel data estimates: SSA countries (38 countries over 1980-2000)

Variable	***Fixed-effects***	***Random-effects***	***P(h)***
Constant	*2.444*	*2.546*	*2.747*
	*(20.86)****	*(20.70)****	*(48.39)****
l	*0.0842*	*0.058*	*0.472*
	*(3.203)***	*(2.274)***	*(5.96)****
k	*0.114*	*0.112*	*0.158*
	*(3.35)****	*(3.34)****	*(9.88)****
g	*0.0229*	*0.0194*	*0.121*
	(1.27)	*(1.12)*	*(4.19)****
R^2	*0.672*	*0.667*	
Number of observations	*819*	*819*	*819*

Note: * indicates 10% level of significance, ** indicates 5% level of significance, *** indicates 1% level of significance.

An alternative to the fixed effect model is the random effects model where there is a common constant and the error term has a component that represent the extent to which the intercept of the i_{th} country differs from the overall intercept, that is countries differences are stochastic. The assumption can be tested by means of the Hausman test, which can be seen as a test for the random effect model versus the fixed effect model. In fact the Hausman test tests the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. The p-value (prob>chi2= 0.05) value turned out to be insignificant at 1%. The Hausman test thus favors the random effects model[7] and the estimates are shown in column 3 of table 8.2. Since the null hypothesis of homoscedasticity was rejected at 1%, the White correction was adopted to obtain heteroscedasticity consistent estimation[8] and this is shown in the last

[7] For a detailed treatment of the fixed and random effects model see among other Green (1997).

[8] The Bhargava, Franzini and Narendranathan (BFN) (1982) test yielded a d_p statistic of 0.16 which confirmed no serial correlation.

column with p(h) values. Note that since we employ a panel data set, the issue of non-stationarity of the variables is less serious (Garcia Mila, McGuire and Porter (1996)).

The small letters denotes variables in natural logarithmic and t values are in parentheses Referring to the heteroskedastic consistent coefficients of column 4, we can observe that the coefficient of transport infrastructure is statistically significant. This tends to support the results obtained in cross section regression and consolidate the view that investment in transport capital is more productive than investment on average (that is more than 0.158). The results tend to confirm those of Canning (1999) and Canning and Bennethan (2000). The other control variables had the required signs were significant as well.

5.2. The Small Island Developing States (SIDS) case

Table 3 below presents both the estimates of the fixed and that of the random effect model of the SIDS panel data. The first column of table 3 shows the fixed effects estimates of the model. The output elasticity of transport infrastructure is seen to be insignificant. The p-value (Prob>chi2 = 0.38) of the Hausman test is insignificant at 1% thus implying the random effects model.

Table 3: Panel data estimates: SIDS case 13 countries (1985-2000)

Variable	***Fixed-effects***	***Random-effects***	***P(h)***
Constant	*3.216*	*3.565*	*4.059*
	*(8.15)****	*(10.20)****	*(36.61)****
l	*0.370*	*0.357*	*0.101*
	*(8.96)****	*(8.86)****	*(5.45)****
k	*0.443*	*0.330*	*0.125*
	*(3.74)****	*(3.27)****	*(2.26)***
g	*0.030*	*0.0302*	*0.0582*
	(0.49)	*(0.50)*	*(1.08)*
R^2	*0.3064*	*0.3036*	
Number of observations	*208*	*208*	*208*

Note: * indicates 10% level of significance, ** indicates 5% level of significance, *** indicates 1% level of significance and t values are in parentheses.

The null hypothesis of homoskedasticity was also rejected at 1% in this case. The last column presents the P(h), the heteroskedastic consistent variables. The coefficient of interest to us, that is the transport infrastructure one, is again observed to be insignificant thus suggesting that transport capital may have the average productivity level of overall investment for the SIDS panel case, that is 0.125.

6. Dynamic Panel Data Regression

However there might still be the possibility of endogeneity of the explanatory variables and the loss of dynamic information even in panel data framework. In fact it can be argued that national income of previous years may in fact affect the level of investment in next year's transportation capital projects. Moreover there might well exist some time lagged effect of transportation and other private inputs effect on aggregate output as well. The incorporation of dynamics into our model necessitates equation above to be rewritten as an AR (1) model in the following.

$$q_{it} - q_{it-1} = \alpha_t + \nu q_{it-1} + \beta x_{it} + \mu_{it}$$

where the LHS is the log difference in tourist arrivals over a period; q_{it} = the log of GDP; x_{it}= the vector of explanatory variables, that is x = [l, k, g] and α_t = the period specific intercept terms to capture changes common to all countries; μ_{it} = the time variant idiosyncratic error term. Equivalently, above equation can be written as

$$q_{it} = \alpha_t + (\nu + 1) q_{it-1} + \beta x_{it} + \mu_{it}$$

Since q_{t-1} might be endogeneous to the error terms through $u_{it-1,}$ a problem of endogeneity exists and it will therefore be inappropriate to estimate the above by OLS. To overcome this problem of endogeneity, an instrumental variable need to be used. Two approaches, namely Instrumental Variable (IV, Anderson and Hsiao (1982)) and two Generalised Methods of Moments estimators (GMM (Arellano and Bond's (1991)), first and second step respectively, can be used in this regard. We used the latter technique, as the IV approach leads to consistent but not necessary efficient estimates of the parameters (see Baltagi, 1995).

Moreover, the first step GMM estimator will be used since it has been shown to result in more reliable inferences. The asymptotic standards errors from the two step GMM estimator have been found to have a downward bias (Blundell and Bond, 1998). The results from estimating equation (9) using the Arellano-Bond (1991) first step GMM estimator are contained in Table 4.

Table 4: Dynamic Panel Data Estimation (First Step GMM estimator)

Variable	*SSA case*	*SIDS case*
Constant	*4.34*	*5.9*
	*(4.82)**	*(5.13)***
q(Lagged)	*0.14*	*0.12*
	(1.28)	*(1.74)**
l	*0.452*	*0.31*
	*(2.21)***	*(1.74)**
l(lagged)	*0.34*	*0.045*
	(1.24)	*(0.94)*
k	*0.43*	*0.25*
	*(3.45)****	*(2.34)***
k (lagged)	*0.11*	*0.085*
	*(1.83)**	*(1.27)*
g	*0.22*	*0.015*
	*(3.14)****	*(0.34)*
g(lagged)	*0.043*	*0.004*
	*(1.64)**	*(0.6)*
Diagnosis tests		
Sargan Test of Overidentifying restrictions	*prob>chi2=0.17*	*prob>chi2= 0.008*
Arellano-Bond test of 1st order autocorrelation	*prob>chi2= 0.21*	*prob>chi2= 0.13*
Arellano-Bond test of 2nd order autocorrelation	*prob>chi2= 0.65*	*prob>chi2= 0.64*

Note: * indicates significance at 10% level, ** at 5% level and *** at 1% level. The small letters denotes variables in natural logarithmic and the heteroskedastic-robust z-values are in parentheses.

The results confirm more or less the preceding ones. Transport capital stock in fact is judged to have been more productive than the overall level of investment for the SSA case and have the same productivity of the overall investment for the case of SIDS. Interestingly the analysis reveals that for the case of SSA, all types of capital investment seem to have some lagged event on the level of output indicating that it may take some time for investment to have its full effect. Such is not observed for the case of SIDS and this may be explained by the fact there are adjustment in such economies given the small size of their markets and the economy as a whole.

7. Summary results and Policy implications

Empirical evidences on the link between transport capital and economic growth for African countries and island state cases have been very scarce in the literature. We investigated, in the first instance, whether transport capital has contributed to the national income of a sample of African countries over the period 1980-2000. Cross section, pooled OLS and panel data analysis were performed and results from them highlight the importance of transport capital as an element of these countries development. Furthermore it has been observed that this type of capital might have been more productive than the overall investment. In the second instance similar analysis performed on a sample of SIDS (1985-2000) tends to show that transport capital has the average productivity level of overall investment. GMM estimates confirmed the above and further indicate that their might be some lagged effect for investment to fully reach its potential on output, particularly for the case of SSA.

The policy implications are obvious. *Ad hoc* government spending cuts and neglecting infrastructure needs[9] might have a deleterious effect on private sector investment and economic growth. It is a fact that, especially in developing country and small island state cases public finance is particularly limited and sustainable transport improvement usually comes at the expense of other investment projects which could be forgone as for instance, education or defense or social projects among others. Officials and planners have often

[9]Empirical Studies (Aschauer (1989) and Munnell (1991)) proved that it is precisely the reduction in infrastructure investment that could explain the drop in productivity and growth of many countries over in the 1970's and early 1980's.

been unable to make decisions regarding the use of limited public funds in transport and public infrastructure investment in the absence on solid empirical grounds. In addition national plans, meant to address many of the inadequacy of transport capital are often not adhered to during implantation. As a result transport development in most of the countries in the above samples has been driven mostly by *ad hoc* considerations having no explicit focus on long term requirements. This can explain the high volatility and the erratic pattern of investment expenditures in these types of investment along years.

The results from the study might thus guide in better and more efficient government budget allocation instead of *ad-hoc* spending in transport capital. It is recommended above all that government refrains itself in undergoing drastic cuts in public capital expenditure, even in difficult times. This is even more important in the case of transport capital projects. It is believed that the government would be better off in taking advantage of World Bank's and other international institutions infrastructural and developmental loans instead of capital expenditure cuts from the budget.

Moreover government should develop an integrated, efficient and affordable transport system which is sustainable from social, economic and environmental points of view. They need to take immediate action to formulate and adopt a long term vision and spell out the transport policies involving all stake holders. The long term plan should also incorporate the development of a land management regime to avoid misuse of land. This will regulate the physical framework in which transport infrastructure, particularly future road development and improvement.

Given government's budget constraint and in the light of our empirical analysis, the case of private financing and joint public/private financing arrangements should be less ambiguous so long there is addition to the country's stock of transport capital, no matter who is financing it. Recently in many countries (India and Latin America cases) private financing and concessions financing have been considered to set up and fund public infrastructure investment, particularly transport investment. Governments should ensure that the private sector have sufficient incentive to invest in transport capital and in its services as well. To this end, the government needs to develop an efficient institutional framework and further improvements are also required in a number of areas to create a conductive environment: These include improving the legislative and regulatory environment, including the formulation of a Public Private Partnership (PPP) law, removing unnecessary bureaucratic procedures and practices.

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Appendix

List of Sub-Saharan African countries

Algeria, Angola, Benin, Botswana, Burundi, Burkina Faso, Cameroon , Congo, Chad, Central Africa, Cote D'Ivoire, Gabon, Gambia, Ghana, Guina Bisseau, Egype, Ethopia, Kenya, Lesotho, Madagascar , Mozambique, Mauritania, Mauritius, Malawi, Mali, Morroco, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Togo, Tunisia, Uganda, Zambia, Zimbabwe

Small Island Developing States (SIDS)

Barbados, Cap Verde, Dominican , Fiji, G Bissau, Haiti, Jamaica, Mauritius, Papua New Guinea ,St Vincent, Seychelles, Salomon Is, Trinidad and Tobacco