Public Spending on Infrastructures and Productive Efficiency in Sub-Saharan Africa: An Analysis from the Stochastic Production Frontier on Panel Data

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Abstract

This article highlights differences on how public infrastructure spending impacts on the productive efficiency of 27 sub-Saharan Africa countries grouped into three economic zones, namely CEMAC, ECOWAS and COMESA. It mobilizes the approach of panel data stochastic production frontier to calculate efficiency scores achieved between 1990 and 2012, determines the specific effects of different economic zones and business cycles on productive efficiency, and tries to explain the origin of the disparities. Although the results show that the impact of public infrastructure spending on productive efficiency is positive in sub-Saharan Africa as a whole, it appears that, while this impact is not significant in the CEMAC zone, it is strongly significant in ECOWAS and COMESA. The implications are that, in such a context, the management of such expenses must meet a strategic medium-term deposit which operates productivity and creates incentives for business frameworks. The paper is therefore in line with endogenous growth theories which attribute virtues of improved total factor productivity and competitiveness of economies to public spending.

1. Introduction

Although the fiscal policy debates in recent years focused on the definition of a desirable level of public deficit in the short and medium term, public expenditure continues to be the main instrument used by countries to boost the performance of their productive apparatus in sub-Saharan Africa (SSA).

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However, disparities between sub-regions and countries in this part of the world appear so important that it is crucial to investigate the origin of observed differences. Can we attribute them to differences in technology, factor endowments, and productive efficiency or to all of them? Such a decomposition seems all the more urgent as the debt crisis in Europe has increased public distrust vis-à-vis public spending, making public decision makers in developing countries to question the relevance of deficits. This decomposition will help, at least, to decide between slowing down spending or accelerating growth.

In sub-Saharan Africa where there is need for emergence and the sustainability of different economic groupings making it necessary to create conditions for the effective use of productive structures, the characterization of the impact of public infrastructure spending on efficiency according to size, economic groups and phases of the economic cycle is of particular interest. However, works on such expenditures were more interested in their impact on growth or overall output as if the technical efficiency of production systems was assured. In addition, these studies used more computable general equilibrium models or classical econometrics which were not necessarily adapted to the analysis of productive efficiency. The analysis of the impact of spending on efficiency remained superficial, if not marginal, with isolated treatments in some areas (Dumont J C, Mesple Somps - S, (2000), Sarr F, Ndiaye (2010)). The approach of stochastic production frontiers that fills most of the shortcomings of several other known approaches probably helps to deepen some aspects of the issue raised. Through it, the effect of public infrastructure investment policies on the actual conditions of economic activity, and thus total factor productivity can be evaluated on sub-Saharan Africa (SSA) while emphasizing the specificities of the different sub-regions.

The objective of this article is therefore to highlight the differences in the impact of public spending on infrastructure on productive efficiency in SSA using the following three economic zones: the Common Market of East and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS) and the Monetary Community of Central Africa (CEMAC).

To achieve this objective, the panel data stochastic production frontiers approach is used not only to compute efficiency scores, but also to determine the specific effects of different economic zones and business cycles.

The rest of the paper is organized into five sections: section 2 examines the dynamics of public spending on infrastructure and real gross domestic product in sub-Saharan Africa, section 3 gives a brief literature review and the theoretical framework, section 4 proposes a methodology for assessing the impact of these expenditures while considering the effects of economic zones and business cycles, section 5 presents and discusses the results and section 6 concludes the paper.

2. I-The Dynamics of Public Expenditure on Infrastructure and Real Gross Domestic Product in sub-Saharan Africa

During the last decade, the issue of public spending has occupied the central scene in political and economic debates. One of the areas of analysis has been the relationship between public expenditures and total production in an economy and their justification as tools of stabilization or recovery. However, one can question their effectiveness in terms of economic policy objectives, and sectors to which they are often dedicated. Until the mid-90s, welfare economic policies in Africa gave a central role to public spending. This was due to the absence of financial markets capable of supporting the construction of an efficient productive sector. Public spending therefore, has often been used to fill the gap between private savings and investment. Their main aim was the building of basic infrastructures necessary for the creation of productive industrial sectors which determine the international competitiveness of economies.

Three main economic zones in sub-Saharan Africa are used to observe the evolution of public spending on infrastructure and the growth of real GDP. The selection criteria are size and coherence of economic and monetary unions. It is true that Eastern and Southern Africa have other separate and distinct organizations identifiable to each of these geographic areas, such as the South African Development Community (SADC), the Community of East Africa (EAC-5) or the South African Custom Union (SACU). However, since there is an organization bringing together all the countries in these two sub-regions and that presents sufficiently advanced evidence of economic integration, it seems more appropriate to consider it instead.

That is why the Common Market of East and Southern Africa (COMESA) has been retained. The Economic Community of West African States (ECOWAS) and the Economic and Monetary Community of Central Africa (CEMAC) are two other free trade areas that complete the selection.

Table 1 shows the evolution of the percentage of public expenditure and public infrastructure spending on GDP of the CEMAC, ECOWAS and COMESA economic zones. From a theoretical perspective, these expenditures contribute to the upward shift of production frontiers in economies in which they are granted. Such a move implies an improvement of technological performance of production activities. Such improvement does not depend on the productive and organizational efficiency of private companies but instead helps in stimulating them.

Table1: Evolution of the Proportion of Public Spending and Public Infrastructure Spending on GDP of Different Economic Zones in SSA

Economic groupings	Public spending	1990 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CEMAC	DPUB	23,7	23,7	23,7	27,0	25,0	21,9	28,6	22,7	20,8	27,0	27,6
	INFRA	21,7	21,7	21,7	18,9	18,4	17,0	18,8	20,4	20,6	27,8	24,8
ECOWAS	DPUB	19,9	19,9	19,9	20,2	21,4	21,8	22,8	23,4	22,8	23,6	23,7
	INFRA	16,2	16,2	16,2	17,0	16,2	17,7	17,1	18,4	18,7	19,3	20,5
COMESA	DPUB	28,7	28,7	28,7	26,6	26,7	26,7	26,6	27,3	28,6	33,3	33,1
	INFRA	17,2	17,2	17,2	17,0	18,3	18,1	19,6	21,1	23,1	20,4	21,5

Source: Data obtained from the World Bank database2011.

From table 1, we observe a constant growth pattern in public spending on infrastructure, and fluctuations in the evolution in total public expenditure. Since the late 90s, they were at 83 %, 81 % and 59 % for CEMAC, ECOWAS and COMESA regions respectively; in 2012 they increased to 89%, 86% and 64% in each region. Besides these regional differences, there are also disparities within regions, which though specific to individual economies, still merit to be considered within medium-term strategic plans. In fact, these expenditures concern communication infrastructure, energy production and also the building of hospitals, schools and training centers; expenditures that are known as investments for the future, are also unevenly distributed among countries and sub- regions of sub-Saharan Africa. It is agreed that these infrastructures though physical, contribute to the formation of human capital which is a source of productivity.

The relevance of such statistics is certainly increased when compared to the growth rates of national outputs in countries of these sub-regional economic zones. Indeed, public spending on infrastructure is specially justified in the context where they cause an upward shift of the production possibilities frontier by creating an environment that favors the optimal utilization of resources in the economy. They then generate externalities and spillover effects that benefit all productive and industrial activities. And, their direct impact on productivity or technical efficiency can be calculated and used as an analytical tool in economic policy in general and production policy in particular. In the framework of economic zones, the convergence of these effects plays a central role in the coordination of fiscal policies. Observing the average growth rates of the various zones of interest in Table 2, we tried to identify the sources of differences.

### Table 2: Average Growth Rate of GDP in the Various Economic Zones

Economic groupings	1990 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CEMAC	5,8	5,8	5,8	5,5	12,5	5,1	2,5	6,0	4,3	2,6	3,9
ECOWAS	3,2	3,2	3,2	3,8	2,8	4,5	3,2	3,3	3,9	3,0	4,1
COMESA	3,1	3,1	3,1	3,9	5,9	6,6	7,0	7,2	5,3	2,0	3,3
ASS	4,1	4,1	4,1	5,1	7,2	6,2	6,4	6,8	5,4	2,8	4,9

Source: data from the World Bank database 2011

In fact, it appears that the growth rate within the COMESA hovers around 5.1%, while those in ECOWAS and CEMAC hover around 3.7% and 4.7% respectively. Thus, although infrastructure spending rose steadily in the sub-regions of sub-Saharan Africa, their impacts on productive efficiency should be specified and differences in these impacts highlighted. Figures 1,2 and 3 below already show that the relationship between the growth of public spending on infrastructure and real GDP growth are not only affected by economic zones, but also depends on the phase of the business cycle. For the CEMAC zone in particular, Figure 1 shows that real GDP growth kept pace with public spending on infrastructure until 2003, between 2004 and 2007, they do not seem to maintain any relationship while in 2008 and 2009 they both undergo variations.

This dynamics is also explained by the unfavorable experiences of these economies: first, the recession of the 90s whose effects persisted till 2002, then the austerity program implemented by these economies due to their admission to the Heavily Indebted Poor Countries Initiative (HIPC), that some attained the completion point in 2006, and finally the effects of the international financial crisis of 2007-2008. On the contrary, Figures 2 and 3 show more synchronized movement between changes in the growth rate of real GDP and public spending on infrastructure, but with high amplitudes for the latter in the ECOWAS, and a stronger correlation between the two variables in COMESA.

Figure1: Evolution of Real GDP and the Share of Infrastructure in GDP in the CEMAC zone
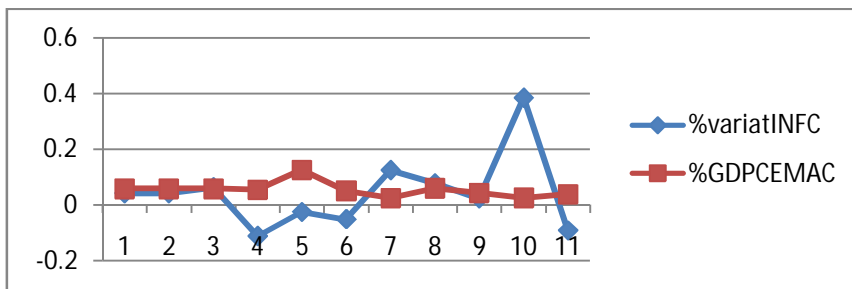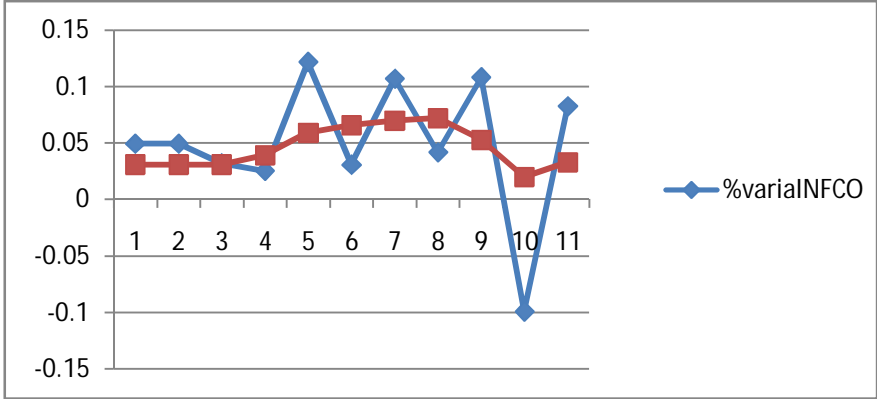

Sources: author, using data from the Regional Economic Outlook: Sub-Saharan Africa (2009, 2011)

Figure 2: Evolution of Real GDP and the Share of Infrastructure in GDP in the ECOWAS zone
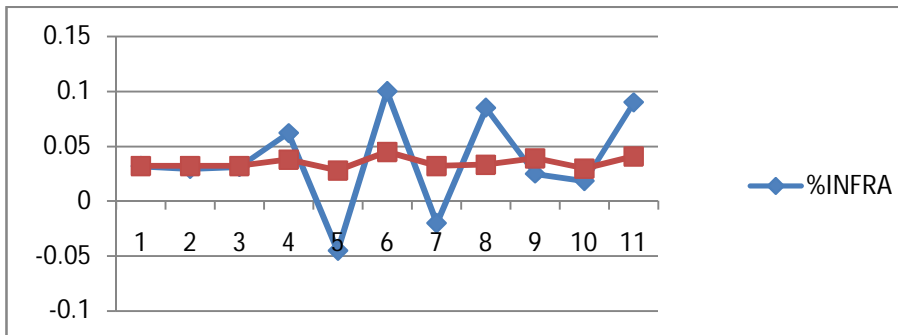
Sources: author, using data from the Regional Economic Outlook: Sub-Saharan Africa (2009, 2011)

Figure3: Evolution of Real GDP and the Share of GDP in Infrastructure in COMESA

Sources: author, using data from the Regional Economic Outlook: Sub-Saharan Africa (2009, 2011)

In sum, three concerns emerge from the analysis of the trends of these two variables in these three zones of sub-Saharan Africa which has important consequences for public expenditure on infrastructure policies: the impact of the latter on productive efficiency, the specific effects of economic zones and the effects of the business environment.

3. Literature Review and Theoretical Framework

3.1 Review of Related Literature

Theoretically, if we rapidly preview the virtues of Keynesian public spending, the question of its effectiveness or its contribution to productive efficiency falls within the theory of endogenous growth. As such, a few decades ago, many significant studies extended the issue of public spending to any reflection on the medium-term impact of public finances (Barro, 1989, Acemoglu et al. (2001). These studies highlight the potential beneficial effects of public finance on productivity and profitability of private capital which are key factors of growth.

Decomposing public investment expenditure into pure public spending, like those on infrastructure and non-pure public expenditure devoted to other productive activities, these studies reached the following formal conclusions: while pure public expenditure potentially affects total factor productivity and hence production efficiency positively, non-pure public expenditure, in certain circumstances, can instead crowd out private investment. As such, any reflections on public expenditure policies in situation of crisis must first identify the impact of the type of public investment on efficiency before proposing judicious adjustments.

Empirically, the consensus on the beneficial contributions of public infrastructure spending on total factor productivity does not stand unequivocally with different robustness tests undertaken. Evidences suggesting that such an impact is positive (Gramlich (1994), Sturm and De Haan (1995), Aschaeur (1989) and Munnell 1990)), are quickly offset by the results of other studies (Holtz-Eakin (1994), Evans and Karras (1994), and Baltagui Pinnoi (1995) and Garcia-Mila and al. (1996)) yet that relativize highlighting factors such as natural endowments economies, the quality of institutions and the phases of the business cycle. These factors undeniably affect the impact of infrastructures spending on efficiency or the overall output of the economy (Islam 1995 Tempel, 1999, Hall and Jones 1999. Acemoglu et al 2001).

3.2 Theoretical Framework for Analyzing the Impact of Public Expenditure on Productive Efficiency

Following Aschaeur (1988) and the studies of Barro (1989), Ardagna (2001),Van der Ploeg (2004) in their works on the effects of public spending on welfare, we assume that government services are not taxed, that is, the different components of public capital are considered to be supplied by firms, and is expected to have positive externalities on the productivity of factors of production (Romer, 1986, Lucas, 1988,Barro, 1990).Then we consider, as suggested by Ardagna (2001) and Van der Ploeg (2004) that public investment in infrastructure is capable to stimulate private investment. More precisely, we consider that, as long as the social return on public capital exceeds private returns (Agell and al., 1997, Aschaeur 1989), it is a productive investment increasing factors productivity and hence potential growth of the economy (Barro 1990; Agell and al.,1997). As such, following the approach of Hulten and Schab (1993) and refined by Mastromarco and Woitek (2006), we model capital assuming that it has a spillover effect that increases the productivity of all factors of production through increased efficiency.

Thus, as traditionally, aggregated production Y_t is determined by the levels of private capital input K_t, labor L_t and public capital G_t, and productivity A_t, which represents Hicks's neutral technical progress. We can therefore formally write:

$$Y_t = F(A_t, L_t, K_t, G_t) \qquad (1)$$

Technical progress (A_t) and public capital (G_t) are external to companies and can therefore be considered as factors capable of provoking a shift of the production frontier. The production function is written as:

$$Y_t = A_t L_t^{\beta_1} K_t^{\beta_2} G_t^{\beta_3} \qquad (2)$$

Equation (2) can be rewritten as:

$$Y_t = A_t G_t^{\beta_3} f(L_t, K_t) \qquad (3)$$

From equation (3), we deduce the formula of total factor productivity (TPF) as follows:

$$TPF = A_t G_t^{\beta_3} \qquad (4)$$

Equation (4) shows that the level of total factor productivity is determined by non incorporated technical progress A_t and the contribution of public capital. This expression is in conformity with the spirit of the models of Barro (1990), Barro and Sala-i-Martin (1992), Van der Ploeg (2004) that justify the use of public investment. These aspects form the basis of the empirical specifications below.

4. Methodology

In order to put to evidence the three aspects of the impact of public expenditure on infrastructure on productive efficiency in sub-Saharan Africa, the empirical framework inspired by Mastromarco and Woitek (2006) and the data used and their sources are presented in this section.

4.1. Empirical Analysis of the Impact of Public Spending on Efficiency

The panel of 27 countries for the analysis is made up of 6 countries for CEMAC, 7 for ECOWAS and 14 for COMESA. Using a Cobb-Douglas technological specification, the production function of the panel of 27 countries is written as:

$$Y_{it} = \Theta_{it} L_{it}^{\beta_1} K_{it}^{\beta_2} \qquad (5)$$

With i =1, ..., 27 and t ranges from 1990 to 2010.

Empirically, θ can be decomposed into a factor representing technology A, a measure of efficiency τ_{it} (whose values are comprised between 0 and 1), and an error term ω_{it}. When τ_{it} is equal to 1, the economy i is fully efficient, total output is located on the efficiency frontier. We can therefore write:

$$\Theta_t = A\tau_{it} w_{it} \qquad (6)$$

Using logs, equation (5) can be written as follows:

$$y_{it} = \alpha + \beta_1 l_{it} + \beta_2 k_{it} - u_{it} + v_{it} \qquad (7)$$

With i =1, ..., 27, t = 1990,..., 2010, $u_{it} = -\ln(\tau_{it})$ is a non-negative random variable and $v_{it} = \ln(w_{it})$ the error term. The specification of expected inefficiency is given by:

$$E(u_{it}) = z_{it}\delta \qquad (8)$$

Where u_{it} are assumed to be independently and identically distributed and non-negative, z_{it} is a (*1xk*) vector of variables influencing efficiency, and δ is a (*kx1*) vector of coefficients.

The estimation of the parameters of the production function and those of the expected efficiency equation is carried out by the method of one stage maximum likelihood, following the procedure first proposed by Kumbahakar, Ghosh and McGuckin (1991), Reifschneber and Stevenson (1991), and modified by Battese and Coelli (1995). The choice of this estimation method is justified by the aim to take into account the asymmetries in the distribution of the inefficiency term. Also, though it is established that the only distribution that can generate the maximum likelihood estimators with all required properties is the gamma distribution (Greene, 1990), the truncated distribution function used by Battese and Coelli (1995) is preferred to it, because from a Bayesian perspective, it puts to evidence at the same time, the statistical noise and the inefficiency term (Van den Broeck, Koop, and Steel, Osiewalski, 1994).

Consequently, three specifications are used to measure the impact of public spending on infrastructure on efficiency in sub-Saharan Africa, and the specific effects of economic zones and business cycles on efficiency. They are respectively named base model, economic zone specific effects model and business cycle effects model. In the base model, technical efficiency is considered to be a function of public spending on infrastructure, which can be formulated as follows:

$$E(u_{it}) = \delta_0 + \delta_1 G_{it} \qquad\qquad (9)$$

Where $E(u_{it})$ is the expected inefficiency of country i in year t, G_{it} public spending in country i in year t and the coefficient δ_1 shows the inefficiency effect of public spending, and δ_0 the inefficiency constant. If δ_1 is significant and negative, this implies that infrastructure spending contributes to improving the overall efficiency of the production system.

The second specification, economic zone specific effects model, highlights differences of inefficiency in different economic zones of SSA. Three dummy variables representing economic zones over time; C_{it}, U_{it}, and S_{it} are introduced to capture these differences in the three economic zones of CEMAC, ECOWAS and COMESA respectively. Therefore, the inefficiency equation can be written as follows:

$$E(u_{it}) = \delta_0 + \delta_1 C_{it} + \delta_2 U_{it} + \delta_3 S_{it} + \delta_4 G_{it} \qquad\qquad (10)$$

With: $C_{it} = \begin{cases} 1 \text{ if } i \in \text{ CEMAC} \\ 0 \text{ else} \end{cases}$ $U_{it} = \begin{cases} 1 \text{ if } i \in \text{ ECOWAS} \\ 0 \text{ else} \end{cases}$; $S_{it} = \begin{cases} 1 \text{ if } i \in \text{ COMESA} \\ 0 \text{ else} \end{cases}$

The interpretation of the coefficients in this specification is similar to that proposed in the first model. This means that the coefficients δ_1, δ_2 and δ_3 measure the effect of the different economic zones on the productive efficiency of their respective economies. The effect of infrastructure spending is captured by δ_4.

The last specification, model of business cycle effects, captures potential asymmetry in how productive structures react to the different phases of the business cycle in the different economic zones. The dummy variable D_{it} is introduced to capture these reactions both in the ascending phase, where it takes the value 1, and in the descending phase, where it takes the value 0. The inefficiency equation is thus specified as follows:

$$E(u_{it}) = \delta_0 + \delta_1 D_{it} + \delta_2 D_{it} G_{it} + \delta_3 G_{it} \qquad\qquad (11)$$

With : $D_{it} = \begin{cases} 1 \text{ if } y_{it} - y_{it-1} > 0 \\ 0 \text{ else} \end{cases}$

In this model, δ_1 measures the effect of the different phases of the business cycle on efficiency; δ_2 measures the impact of public infrastructure expenditure during a given phase of the business cycle on efficiency; and δ_3 the effect of public infrastructure spending on efficiency.

Equation (7) is each time simultaneously estimated with one of the specifications of inefficiency (equations 9, 10 and 11) using one stage maximum likelihood method. This has been preferred to the Ordinary Least Squares due to the quality of the results provided.

4.2. **Data Used**

The data used is from the World Bank database (2011) and Regional Economic Outlook: Sub-Saharan Africa (2004, 2011). Data on national production have been approximated by real GDP of each economy in constant 2000 US dollars.

Data on the volume of private capital are also those estimated in terms of constant 2000 US dollars.

Data on public investment in infrastructure is the gross fixed capital formation in constant 2000 US dollars. Data volume of labor is not enough for the countries of the panel. The most informed fraction of the data on the volume of work is the labor force. This fraction is biased in endogenous growth theory because it does not sufficiently capture human capital. However, as in most studies on human capital and endogenous growth, we have chosen to use as proxy the portion of the active population having at least a secondary level of education or enrolled in a university institution (Benhabib and Spiegel 1994, Koop and al. 2000, Kumbhakar and Wang 2005).

Thus, the panel is made up of 27 countries divided into three categories represented by CEMAC, CEDEAO and COMESA. The relevance of the panel option data pool was verified by a homogeneity test which revealed a strong inter-group variability (Between variance = 0.385678) compared to the intra-group variability (Within variance = 0.183456). This result shows the high heterogeneity of the countries constituting the panel and therefore validates the choice of this method of analysis. The results of the estimates generated using econometric software FRONTIER 4.1 following one step maximum likelihood method are given in the next section.

5. Empirical Results and Discussions

The estimates, obtained by the method of one step maximum likelihood using data on national product, capital input, labor and public expenditure on infrastructure are presented in Tables 3 to 5. The estimation of the aggregate production function simultaneously with the efficiency models in order to assess the impact of public expenditure on infrastructure on technical efficiency in sub-Saharan Africa is presented in Table3 for the basic model, in Table 4 for the economic zone specific effects model and in Table5 for the business cycle effects model. The null hypothesis of no inefficiency $H_0 : \gamma = \delta_0 = ... = \delta_K = 0$ was rejected in all three models. The robustness of these results was verified by testing the presence of inefficiency using the likelihood ratio test, approximated by a mixed Khi-2 distribution reported at the bottom of the different tables of results.

The three specifications also indicate the presence of inefficiencies in the productive apparatus of the countries of the economic zones considered.

As concerns the basic model, shown in Table 3, the parameters of the aggregate production function are significant with the expected sign. The capital elasticity of the product is estimated at 0.312 while that of labor is 0.226. The inefficiency Model specification reveals a positive impact of public expenditure on infrastructure on the technical efficiency of enterprises. This means that public infrastructures spending in the economic zones considered have consistently improve the synergy of private factors during the period of study, or that private activities benefited from spillover effects of public capital. The problem now is to highlight the differences discovered in these effects as far as economic zones and business cycle are considered.

Table 3: Estimation Results of the Basic Model

Variables	Coefficients	Standard-error	t-ratio
β_0 (constant)	0,78531032	0,13339091	5,887285
β_1 (Capital)	0,31266959	0,00059836	522,545319
β_2 (Labour)	0,2266071	0,03100389	7,3089890
δ_0 (Inefficiency constant)	3,4513222	1,4625214	23,5439
δ_1(Infrastructures spending)	0,19886653	0,01767977	11,248256
σ^2	0,01545363	0,42477354	3,6380871
γ	0,99880783	0,00034366	2906,42

Sources: author calculations using frontier 4.1, Log likelihood function = 0.36426133E+02, LR test of one side error = 0,98177784E+02 (3 restrictions)

The results of the regional specific effects model shown in Table 4 confirm the existence of differences in the effects of public spending in infrastructures on efficiency among areas of economic groupings retained. Indeed observed, in Table 4, the coefficients of dummies of ECOWAS and COMESA regions are all positive and significant, while the coefficient of the dummy variable associated with the CEMAC zone is negative but not significant. It can be concluded that membership to the CEMAC zone hinders productive efficiency in sub-Saharan Africa, while those of ECOWAS and COMESA improve it. The explanation of these differences can be found in a conventional manner in the natural characteristics of the economies of these regions in terms of resources endowments, the incentive framework and organizational performance. But another important explanation may be found in the levels of economic integration of these different areas.

Infrastructure investment across economic areas and is not only an economic integration factor, but a way to boost efficiency in areas and national economies.

Table 4: Estimation Results of the Economic Zone Specific Effects Model

Variables	Coefficient	Standard-error	t-ratio
β_0 (constant)	3,2412924	0,1769923	18,313183
β_1(Capital)	0,52344723	0,01700378	30,784162
β_2(Labour)	0,28228677	1,60E-03	17,677284
δ_0(Inefficiency constant)	2,0940464	0,50027137	4,1858209
δ_1(Infrastructures spending)	0,27509386	0,0251994	10,9166847
δ_2 (dummy CEMAC)	-0,17929742	0,5042223	-0,5559208
δ_3 (dummy ECOWAS)	0,38099553	0,10749881	3,5441837
δ_4 (dummy COMESA)	0,18075764	0,02024839	8,9270129
σ^2	0,45281445	0,20004491	2,263563
γ	0,06083742	0,01159115	5,24861103

Sources: authors calculations using Frontier 4.1, log likelihood function = 0.85061616E+03 LR test of the one-sided error = 0.19544875E+02 number of restrictions = 6

Table 5 shows that the sign of the coefficient (δ_1 = -1.4711 E-11) of the dummy variable is negative but not significant (t-ratio = -0.02785808). This suggests that the phases of business cycles do not affect productive efficiency in sub-Saharan Africa. This result can however be refined when we consider the product of the dummy of the cycle and spending to question the effect of cyclicality of infrastructure spending on technical efficiency. The estimated (δ_3 = -5.0928 E-12) coefficient is not significant (t-ratio = -0.02603831), which implies the acyclicity of the effects of infrastructure spending on productive efficiency in sub-Saharan Africa.

Table 5: Estimation Results of the Business Cycle Effects Model

Paramètres	Coefficients	Standard-error	t-ratio
β_0 (constante)	2,2598026	0,99341734	2,2747767
β_1(Capital)	0,61515557	0,25510282	2,41140247
β_2 (Travail)	0,29909313	0,09273224	3,22534137
δ_0 (constante d'inefficience)	0,00069033	0,9997	0,00069054
δ_1 (dummy cycle)	-1,4711E-11	5,2808E-10	-0,02785808
δ_2 (Dépense Infrastructures)	6,1813E-06	0,99978125	6,1827E-06
δ_3 (Depinfras au cycle)	-5,0928E-12	1,9559E-10	-0,02603831
σ^2	0,63183209	0,09780348	6,46022121
γ	0,49961865	0,0988099	5,05636237

Sources: Authors calculations using Frontier 4.1, Log likelihood function = 0.48732137E+03
LR test of the one-sided error =   0.35071946E+02 number of restrictions = 5

Thus, the results in Tables 4 and 5 provide crucial information in the context of coordinating expenditure policies and economic convergence in regional or sub-regional groupings. A 1% reduction of public expenditure in infrastructure reduces efficiency by 19% in sub-Saharan Africa, it seems to have an insignificant effect on efficiency in the CEMAC zone while it deteriorates efficiency in the ECOWAS and COMESA zones. The chosen functional form from equation (8) allows for an interpretation from the definition of elasticity as follows:

$$\Delta\tau = -\tau\delta_i \frac{\Delta z_i}{z_i}$$

Thus, a one percent increase in infrastructure spending increases the technical efficiency of 19% across the sub-Saharan African region. However, this average reaction cover many disparities. Indeed, the rather erratic fluctuations observed in sections 2 above expenditure contrast with the more uniform change observed in Figure 4 and suggest likely disparate impacts

Figure 4: Evolution of Average Technical Efficiency of the Economic Zones of Sub-Saharan Africa
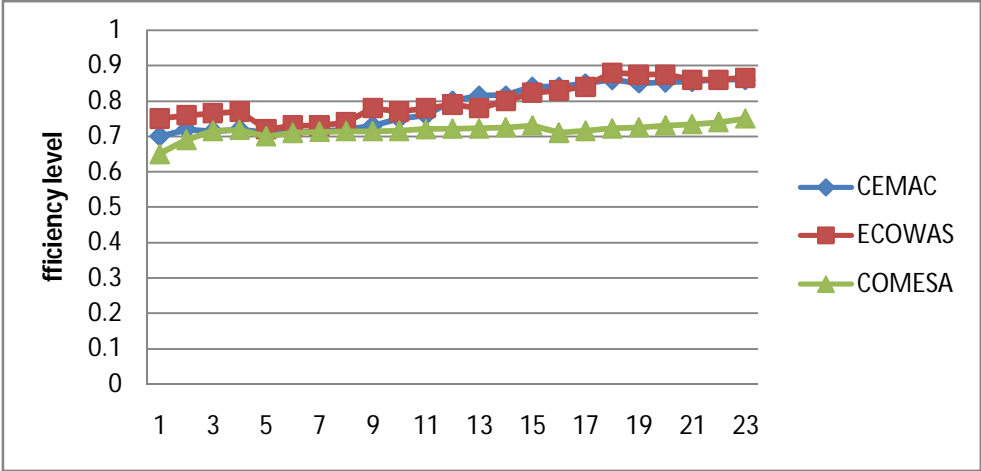
Sources: authors using estimation results

6. Conclusion

Three aspects of the impact of public spending on infrastructure on productive efficiency in sub-Saharan Africa have been studied in this article. From a triple specification of the inefficiency equation which resulted in a base model, an economic zone specific effects model and a business cycle effects model, the impact of public spending was measured on a panel of 27 countries divided into three economic zones, namely CEMAC, ECOWAS and COMESA. It is clear that public spending on infrastructure contributes positively and significantly to the technical efficiency of the productive sector of the countries of the panel (results of the base model). But this contribution (results of economic zone specific effects model) depends on whether the country is in CEMAC (not significant), ECOWAS (positive and significant) or COMESA (positive and significant). Thus, far from producing a crowding out of private investment, infrastructure investments are complementary and improve productivity, as already shown by Hulten and Schab (1993), Hall and Jones (1999), Acemoglu and al. (2001) or Mastromarco and Woitek (2006).

The effect of infrastructure spending in terms of the business environment (results of the business cycle effects model) has shown that the impact is more significant during the descending phase of the cycle. The advantage of the use of a cyclical factor in the analysis of changes in total factor productivity and the correlation of this productivity with business cycles has been highlighted in numerous studies (Basu, 1996; Basu and Kimball, 1997;Gali, 1999; and Basu and Fernald 2000). Therefore, from the dummy variable D_{it} we capture the impact of economic reversals on the impact of public spending in terms of productive efficiency, and consequently its efficiency in terms of stabilization and growth.

The use of the stochastic frontier approach allowed the identification of inefficiency variables and the obtaining relevant specifications of the inefficiency equation based on our three concerns earlier highlighted. Another approach would have led to similar results as in Cornwell and al. (1990) and Boussemart and Robert (1999), but would not allow the simultaneous estimation of the parameters of the production frontier and factors of efficiency which are fundamental for the robustness of the results.

In sum, as most empirical studies have shown since Barro (1990), public infrastructure has a positive effect on productivity and efficiency in the productive private sector, even in sub-Saharan Africa. In this region in particular, they help in the discovery and use of new sources of economic growth. They also contribute in enhancing financial and economic activities and the forming of human capital necessary for economic competitiveness. Far from being the same in all countries and economic zones, this impact depends on the resource endowment of countries, the quality of institutions and the dynamism of economic agents in making use of opportunities offered by infrastructural spending to improve on their efficiency. In this respect, sub-Saharan Africa, instead of austerity programs, public expenditure management and particularly those on infrastructure, needs more rationality in a strategic plan of exploiting productivity sources and creating an environment conducive for business.

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