

PERFORMANCE ANALYSIS OF THE ELECTRICITY INDUSTRY IN SUB-SAHARAN AFRICA

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Received:28/12/2019/ **Accepted** 11/02/2020 /**Published online:** 01/06/2020

ABSTRACT: In this article, we study the productivity of electricity companies in 17 African countries by measuring Malmquist's productivity index. We also identify the determinants of the change in total factor productivity (TFP) for the period 2002-2016. We note that the TFP index for all pay is negative for the period 2002-2016. Regarding the determinants of TFP change, our study shows that the connection of electricity industries from one country to another (pool variable), rain, hydropower and urbanization increase TFP. Privatization has a negative impact on PTF. The theoretical debate between a company's ownership regime and its performance has led to mixed results in the electricity sector in SSA. African countries should encourage the creation of energy pools that can provide additional benefits in terms of reducing capital expenditures, reducing electricity supply costs, improving the reliability of the system, and achieving success integration policy.

Key words: electricity industry; ownership regime; total effectiveness of factors; determinants of effectiveness; Malmquist indices; GMM

JEL Classification: L33, P18, Q41

1. INTRODUCTION

Energy is essential to economic development. A metaphor compares its role in the economy to that of "blood in the body." In addition, it has been established that better energy supply is essential for business development and economic growth (Melike 2012, Atangana and Nsoe 2014, Slim and Mohamed 2014). However, more than twenty years later, and despite the structural changes that have mostly resulted in privatizations, African countries still have an undeniable energy deficit (Niyibizi, 2015, Osaretin and Ebiton, 2016). Also, it is pertinent to focus on the energy issue that remains relevant in developing economies. Indeed, the results obtained after more than twenty years of privatization for some countries do not meet the expectations of governments. The average rate of household access to electrical service in SSA countries is 16% and less than 5% in rural areas (AFD, 2012). Inopportune power cuts and poor quality of electricity are major causes of companies losing competitiveness due to rising costs and low productivity (Caderon Cesar and Luis Servan, 2009, Briceno -Garmendia et al., 2011, AfDB, 2014).

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However, it is observed that African countries that have not privatized their national electricity companies today have the highest electricity access rates: Botswana 39%; South Africa, 70% (AFD, 2012). This finding, which opens the debate on the link between the ownership regime and the energy performance in a singular way, raises a general question about the performance factors in the electricity industry in SSA.

This work is devoted to assess the evolution of productivity electricity in 17 African countries for the period 2002-2016. This exercise also aims to help the understanding of the main determinants of total factor productivity change. The rest of our work is organized as follows: in section 1, we present the literature review ; the section 2 is devoted to the methodology and the last section, we present the results of the study.

2. LITERATURE REVIEW

There is growing recognition that the privatization of the electricity sector has not necessarily eliminated its deficiencies (Malgras and Eberhard, 2011) observations made in countries such as Kenya and Zimbabwe show that the use of well-structured performance contracts, in a context where the state retains ownership of the electricity companies, can still be effective in improving overall performance of the electricity sector (OXFAM, 2017).

This observation on a purely theoretical level brings the main point of the debate to a question of regulation which opposes the private property to public property. Indeed, three main currents support the thesis of the superiority of the private form of property. The theory of property rights (Alchian and Demsetz, 1973), public choice theory (Buchanan and Tollison, 1972; Tullock, 1976), and agency theory (Jensen and Meckling, 1976). On the empirical level, however, the results of the many studies carried out so far are, on the whole, ambiguous and therefore do not allow us to conclude, unequivocally, that there is a relationship between the form of ownership and performance (for a review of the empirical literature on the subject, see, among others, Aharoni 1986, Vining and Boardman 1992, Domberger and Piggott 1994, Gathon and Pestieu 1996, Tittenbrun 1996, Megginson and Netter 2001; Lopez-de-Silanes and Chong, 2003 and Bozec, 2004).

Performance between publics and private firms is generally compared without considering the difference in business objectives (Kim 1981, Funkhouser and Macavoy 1979, Reeves and Ryan 1998). Public enterprises do not aim at maximizing profits. At best, when they are commercial, they will try to improve them (profit-seeking). Also, we anticipate an increased measurement problem for the studies that will have based their comparisons on business profitability. Private enterprise should, by definition, be more profitable in this case.

In the electricity sector, the supremacy of the public enterprise compared of the private enterprise seems to be established. Indeed, Bozec (2004) has identified numerous studies carried out over the past 40 years in the countries of Asia, America and Europe to verify the relationship between the form of ownership and the performance of companies in different sectors. In the electric power sector, 64% of these studies suggest that the public company is more efficient than the private enterprise. At the same time, 18% of them show results where private companies perform more than public ones, while the remaining 18% find no difference between companies. The general trend emerging from these studies is the increasing use of efficiency as a measure of performance in the electricity sector. Following this approach, the company's performance is compared with the performance of a group of companies in the same industry. We will then talk about a relative measure of performance that can be based on either costs or productivity.

In SSA, there are very few studies related to the performance of the electricity sector. Overall, they focus on the productive performance of companies in the more specific context of privatization. The logic that would justify this orientation, where much more emphasis has been placed on the change of status, would come from the fact that the comparison between the public enterprise (enterprise before privatization) and the private enterprise (privatized enterprise) would be more objective and the measurement error is weaker.

The reasons cited by economists for the disappointing results of the liberalization of the electricity industry in SSA are multiple. For some, it is early enough to draw conclusions about the relevance or otherwise of the liberalization of power grids in SSA. The major argument for the latter is that the liberalization of the sector is part of a long-term process. It would therefore be ill-advised to evaluate the performance of the liberalized electricity sector in the short term because the efficiency gains are rather part of a long-term horizon (Tchapga, 2002 and Finon, 2010). For others, however, the early start of the process would justify the unsatisfactory results known. Indeed, Angelier (2006) considers that as long as a network has not reached the stage of maturity, the old paradigm of the vertically integrated public monopoly is the most effective institutional organization.

3. METHODOLOGY

In this section, we will present the data source and some descriptive statistics, the Malmquist productivity index and the approach used to identify the determinants of total productivity change.

3.1. Data source and some descriptive statistics.

Data used in this study come from Association of Power Utilities of Africa (APUA) and World Bank. APUA was created with the purpose of promoting development and integration of the African power systems through the interconnection of networks, the exchanges of experiences and know-how as well as the pooling of energy resources in a win-win approach for all members. Since 2002, APUA has adopted a new vision according to which, UPUA must henceforth be the primary catalyst of the realization of access to electricity for all the peoples of Africa. The APUA dataset provides statistics on the main variables used in this study for 17 African countries and for 2002-2016 periods, see table 0.

Table 0 : Sample

Country	Membership pool	privatized	Number of operators	IRE	IRARU
Angola	No	No	1	No	No
Benin	Yes	No	1	No	Yes
Botswana	Yes	No	1	No	No
Cameroon	No	Yes	1	Yes	Yes
Democratic Republic of Congo	Yes	Yes	1	No	No
Ivory Coast	Yes	Yes	2	Yes	No
Ethiopia	No	Yes	1	Yes	Yes
Gabon	No	Yes	1	No	No
Ghana	Yes	Yes	2	No	No
Kenya	No	Yes	1	Yes	Yes
Mozambique	Yes	No	1	No	No
Nigeria	No	No	1	No	No
Senegal	Yes	No	1	Yes	Yes
Sudan	No	No	1	Yes	No
Togo	Yes	Yes	1	Yes	No
Zambia	Yes	Yes	1	yes	Yes
Zimbabwe	Yes	Yes	1	Yes	Yes

Note: IRA is independent regulatory agencies, IRARU is independent regulatory agencies for rural area.

Source: Authors

Table 1 presents some descriptive statistics. It shows that the average growth rate of tariffs is 913% because of Zimbabwe without this country, the average growth rate of tariffs is 10% . Concerning the tariffs one can distinguish two groups of countries. In the first group, the growth rate of tariffs is low. Belong in this group, countries like Senegal (2.03%); Gabon (2.06%); Cameroon (2.37%); Togo (2.77%); Ivory Coast (2.79%) and Benin (3.06%). in the second group, the growth is very high. Belonging to this group are countries like Republic Democratic; Mozambique (10.85%); Nigeria (12.24%); Zambia (14.88%) of Congo (16.26%); Zimbabwe (25574%). In average, African electricity companies of our sample employ 3399 persons. The main source of electricity production is petroleum (100% for Botswana and 42.6% for the whole sample) and hydraulic (55.33% for the whole sample). The average number electricity interruptions is 20.84 per month. Summary statistics of the balanced panel for the whole 2002-2016 period are presented in Table 1; overall, 255 observations are available for dynamic panel analysis and 153 observations are available for Malmquist analysis.

Table 1: descriptive statistics

Variable	Obs	Mean	Min	Max
Growth of Tariffs(sale price of electricity) with Zimbabwe in dollars	255	913.1447	-1.409401	39454.28
Growth of Tariffs(sale price of electricity) without Zimbabwe	255	10.3825	-1.409401	108.2569
Average number interruption of electricity per month	255	20.84187	3.242558	56.45514
% of electricity produced by petroleum source	255	42.62094	0.076637	100
% of electricity produced by hydro-source	255	55.33516	0 99.	92.336
Number of customers	153	2.96E+07	1290532	1.58E+08
Sales (kWh)	153	5.13E+09	5.00E+08	2.16E+10
Length of electricity grid (km)	153	294027.9	3500	1687972
Number of employees	153	3399.575	147	25542
Installed of operational capacity operational	153	689024.7	7191.781	2981849
Losses (kWh)	153	1.01E+09	7.45E+07	8.09E+09
Population density	255	48.274	1.434791	171.4967
Household final consumption per year in dollars	255	1981.69	282.503	179651.5

source: Our estimation

3.2. The Malmquist productivity index

To assess the evolution of productivity electricity distribution sector in some African countries, we will use the Malmquist productivity index, Fare and Grosskopf (1990) cite its advantages over the Fisher or Tornqvist indexes. First, since both the Fisher and Tornqvist indexes require price and quantity data on both inputs and outputs, they might be difficult to use in electricity and other industries where output prices, for example, are not available. The Malmquist indirect productivity index, on the other hand, does not require output price data which makes it the more practical choice for electricity research. The second advantage is the fact that, unlike the Fisher and Tornqvist indexes, the Malmquist index can be applied to cases where profit maximization is not presumed to prevail.

The Malmquist productivity index computes the change in performance between t and $t+1$. Given the output distance functions defined as the generalizations of a production function to the multiple output case. They provide a complete description of technology and also have a built-in interpretation as a performance measure: they are reciprocals of Farrell (1957) technical efficiency measures. Caves et al. (1982) (CCD) proposed measuring productivity as the ratio of two distance functions at periods t and $t+1$. CCD makes the assumption that there is no technical inefficiency. Fare et al. (1989) relax this assumption and express the output-based Malmquist productivity index as the geometric mean of two CCD indexes.

There are several different methods that could be used to measure the distance function which make up the Malmquist total factor productivity (TFP) index. The input-oriented Malmquist compares the input requirements for producing output level Y_t with period t technology, with the input that would have been required if the production technology was the same as that in a later period, s . Thus, X_t is essentially being compared with what would have been required under technology s . If we let the two periods be $s > t$, C and V denote the constant and variable frontier, and being the vectors of inputs and outputs

in each period X and Y, respectively. In the case of output orientated, the question is how much can output quantities be proportionally expended without altering the inputs quantities. When constant return to scale exist, the input and output orientated will provide equivalent measures the technical efficiency. The productivity change of a DMU between two years is calculated by using the ratios of distances of DMUs in each period for each technology, then the MPI. for ith firm (DMU) is given by:

$$I_{s/t} = \frac{d_v^t(y_t, x_t)}{d_v^s(y_s, x_s)} \left[\frac{d_v^s(y_s, x_s)}{d_v^t(y_t, x_t)} \frac{d_c^t(y_t, x_t)}{d_c^s(y_s, x_s)} \right] \left[\frac{d_c^s(y_t, x_t)}{d_c^t(y_t, x_t)} \frac{d_c^s(y_s, x_s)}{d_c^t(y_s, x_s)} \right]^{1/2} \quad (1)$$

A value greater than one will indicate positive TFP ($I_{s/t}$) growth from period t to period t+ a decline in productivity will produce an index that is less than one. a decline in productivity will produce an index that is less than one.

The equation (1) defines the total factor productivity change (TFPch). From this equation, it is possible to obtain the following indexes:

$$\left[\frac{d_c^s(y_t, x_t) d_c^s(y_s, x_s)}{d_c^t(y_t, x_t) d_c^t(y_s, x_s)} \right]^{1/2}$$

(a) Technical efficiency change (Effch), a ratio of two distance functions which measures the change in the technical efficiency between the periods of change.

(b) Technological change (Techch), a measure of the technological change in the production technology, an indicator of the distance covered by the efficient frontier from one period to another.

Considering the hypothesis of variable returns to scale technology, the technical efficiency change (Effch) index may be further decomposed into two components, the pure technical efficiency change (Pech), shifts in the frontier and the scale efficiency change (Pech), outputs plants move closer the frontier.

(c) Pure technical efficiency change $\frac{d_v^t(y_t, x_t)}{d_v^s(y_s, x_s)}$ (Pech), a component of the

technical efficiency changes and obtained by re-computing efficiency change under the variable return to scale

$$(d) \text{ Scale efficiency change } \left[\frac{d_v^s(y_s, x_s)}{d_v^t(y_t, x_t)} \frac{d_c^t(y_t, x_t)}{d_c^s(y_s, x_s)} \right] \text{ (Sech), the ratio of}$$

efficiency under constant return to scale and the same efficiency under variable return to scale. Both sech and Pech are components of Effch.

The two component measures have a similar interpretation. As mentioned earlier we use DEA type techniques to estimate the indirect output distance functions used to construct the productivity index. These productivity indexes allow us to look at whether performance under site-based management improved over the 2002–2016 time period.

Choice of inputs and outputs

The electricity distribution firms use two inputs *labor* and *capital* to deliver electricity to end users. Besides these inputs, the quality aspect of the service is also taken into account, since the design and maintenance of the network result in losses. Technical quality of the service is therefore represented by losses and is included in the model as an input. Labor input is estimated as *number of employees*. Capital input is approximated by the extension of the existing electricity *grid (in km)* and *the operational capacity installed*. *Losses* (in KWh) consist of technical and commercial losses related to the amount of electricity required; it consists on the difference between the electricity required and the electricity distributed to end users. Output is defined both as the amount of electricity distributed (in KWh) and the total number of customers served (Ramos-Real, 2009).

Network technical loss input: technical losses are estimated in kWh. Technical losses equal to non charged energy. But, within the framework of the study and given the specificity of involved firms, we consider them as inputs. Indeed, we assume that technical losses depend on the investment on network maintenance. Therefore, higher technical losses indicate that few resources have been devoted to the network. Therefore, technical losses approximate operating expenses devoted to the network.

Capacity installed input: capacities installed are expressed in kW. Operational capacities installed only report the real capacities of operating power plants. This study will only use operational production capacities or at least the duration of their effective service in a year because in Africa most installed capacity are not operational because a defectives generators.

In brief, we use four inputs: 1) *number of employees*, 2) the extension of the existing electricity *grid (in km)*, 3) *Losses* and 4) *operational capacity installed*.

Two outputs : 1) *the amount of electricity distributed (in KWh)*, 2) *the total number of customers served*.

3.3. The determinants of total factor productivity growth of electricity companies in Africa: Dynamic panel analysis

As our basic rule, factors that can more easily be influenced by the electricity compagny are included in the original Malmquist model and those outside the decision making power of compagnies, i.e. the influence of environment, are taken as factors explaining TFP differences. The Malmquist TFP index (the dependent variable in this study) does not suffer from boundary problems, such as those for DEA efficiency scores, its estimates are seriously affected by serial correlation (Simar and Wilson, 2007). This problem

can be solved by implementing a bootstrap procedure in the first stage or by using econometric methods able to control for serial correlation (Pompei, 2013). In the second case (econometric method), one can use Arellano and Bond (1991) specification. The Arellano and Bond or DIFF GMM provides asymptotically efficient inference assuming a minimal set of statistical assumptions. Thus, if we analyse the determinants of the growth rate of Malmquist index of , the ΔTFP_{it} equation can be written as follows:

$$\Delta TFP_{it} = \phi \Delta TPF_{i,t-1} + \sum_{j=1}^k \gamma_j X_{j,t} + n_i + \psi_t + \varepsilon_{it} \quad (2)$$

where

$i = 1 \dots 17$ African countries; $t = 2003 \dots 2010$; $j = 1 \dots k$ number of independent variables.

ΔTFP_{it} is the growth rate of TFP, that is $TFP - 1$

$\Delta TPF_{i,t-1}$ is the lagged dependent variable.

$X_{j,t}$ is the set of independent variables; n_i is the country level unobserved effect.

ψ_t are the time dummies; ε_{it} is the idiosyncratic error.

ϕ and γ_j are parameters to be estimated.

In addition, the presence of serial correlation causes lagged TFP to also be correlated with the contemporaneous error term. For these reasons, lagged TFP must be treated as an endogenous variable. We can thus use the difference GMM to identify the determinants of TFP change. But, despite the optimal asymptotic properties of GMM statistics, their behaviour in finite samples can be rather peculiar due to weakness and/or abundance of moment conditions and dependence on crucial nuisance parameters. It has been well documented that the DIF GMM estimator can have very poor finite sample properties in terms of bias and precision when the series are persistent, as the instruments are then weak predictors of the endogenous changes. Blundell and Bond (1998) argued that the SYS GMM estimator performs better than the DIF GMM estimator because the instruments in the LEV model remain good predictors for the endogenous variables in this model even when the series are very persistent. They showed for an AR(1) panel data model that the reduced form parameters in the level model do not approach 0 when the autoregressive parameter approaches hereas the reduced form parameters in the GMM estimator do. The use of extra moment conditions that rely on certain stationarity conditions of the initial observation, as suggested by Arellano and Bover (1995). When these conditions are satisfied, the resulting system (SYS) GMM estimator has been shown in Monte Carlo studies by e.g. Blundell and Bond (1998) and Blundell, Bond and Windmeijer (2000) to have much better finite sample properties in terms of bias and root mean squared error (rmse) than that of the DIF GMM estimator. In addition, The SYS GMM method it identifies the endogenous model variables and therefore instruments and fixed delays limit the differentiated instruments used as dependent variables. Because of the good performance of the SYS GMM estimator relative to the DIF GMM estimator, this method will be used in this study.

As mentioned above we use population density, the ratio of dependence on natural resources, that is the ratio of exportation of primary goods and services on the total value of

exportations and class household final consumption in our dynamic models to explain TFP growth because these factors determine the demand of electricity. We also consider two sources of electricity namely hydro-source and petroleum. It is often assumed that hydropower could be economically used to provide energy for the increasing population. The average annual distribution of the rain will also be used because the size of river basins is the most important factor that determines the production. Two dummy variables, one for privatization and the last for pool, will be used. The last variable will be used to test the benefit effect of regional integration on TFP postulated by Gnansounou (2007). The tariff also will be used to test its impact on TFP assumed by (Atangana and Nsoé, 2014).

4. RESULTS

Two categories of results will be presented, the estimated values of Malmquist productivity index and the determinants of total productivity change.

4.1. The estimated values of Malmquist productivity index of african electricity companies

Table 2 - Malmquist Index Summary of Firm Means

Firm	Effch	Techch	Pech	Sech	TFPch	Privatize d
Angola	0.915	0.832	0.919	0.995	0.761	No
Benin	0.992	0.786	1	0.992	0.779	No
Botswana	1	0.874	1	1	0.874	No
Cameroon	0.958	0.888	0.97	0.988	0.851	Yes
Republic democratic of Congo	1	0.877	1	1	0.877	No
Ivory Cost	1.002	0.879	0.984	1.019	0.881	Yes
Ethiopia	0.985	0.922	0.975	1.01	0.909	Yes
Gabon	1	1.02	1	1	1.02	Yes
Ghana	0.987	1.024	0.996	0.992	1.011	Yes
Kenya	0.983	1.008	1.003	0.98	0.991	Yes
Mozambique	1	1.052	1	1	1.052	No
Nigeria	1.006	1.029	1	1.006	1.035	No
Senegal	1.041	1.034	1.088	0.957	1.076	No
Sudan	0.983	1.036	1.076	0.914	1.019	No
Togo	1	1.207	1	1	1.207	Yes
Zambia	1	0.944	1	1	0.944	Yes
Zimbabwe	1	1.075	1	1	1.075	Yes

Mean	0.9912941 2	0.9698235 3	1.0006470 6	0.9913529 4	0.9624705 9
Mean Public	0.992125	0.94	1.010375	0.983	0.934125
Mean private	0.9905555 6	0.9963333 2	0.992	0.9987777 9	0.9876666 7

Source: Our estimation

Table 2 summarizes the mean of indicators of the whole sample of firms and its components per year. It shows that all the index record a yearly negative growth in 2002-2016 period. For instance, the last row shows the simple average computed considering the indices of the whole period. It shows that TFP index records a yearly negative growth of 3.75% in 2002-2016 periods. Among the countries, Angola shows the worst average TFPch (-23.9%), and Togo the best (20.7%) followed by Senegal (7.6%). The estimated value of TFPch is 0.987 for the privatized companies and 0.934 for the public companies. The theoretical debate between a company's ownership regime and its performance has led to mixed results in the electricity sector in SSA.

Technical change showed a yearly average negative growth rate of 3.1% in the period. In this regard, the simple average results showed that the productivity evolution of the sample companies in the whole period depended much more on the frontier shift (i.e, technical change) due, for instance, to technological innovations or any other exogenous aspects, as regulation or any change in the economy, which affects all the firms equally than the catch up effect. Considering all the sample countries, 11.76% of them (2 in 17) showed an increase in TFP rates, and 35, 29% showed a decrease in TFP rates.

Table 3: Descriptive statistic of the Malmquist index

Variable	Obs	Mean	Std. Dev	Min	Max
TFP	255	.9624705	.1507672	.311	1.667
Effch	255	.9912941	.0779089	.721	1.392
Teffch	255	.0969823	.1333429	.311	1.667
Peff	255	1.000647	.048467	.698	1.212
Seff	255	0.9913529	.0666211	.721	1.323

source: Our estimation

These companies with negative performance can be divided in two different groups. The first one is composed of Angola, Cameroon, Ethiopia, Ghana, Kenya and Sudan. For this one the falling productivity is mainly explained by the efficiency change component. This indicates that the frontier shift was not favorable for them. On the other group, Ivory Coast, Nigeria and Senegal, the profile of efficiency change is positive (0.2% for Ivory Coast, 0.6% for Nigeria and 4.1% for Senegal) but the profile of technical efficiency change of Ivory Cost is negative (12.1%). For these countries, the key component behind the drop in productivity is technical efficiency, denoting that they got far from the production frontier. By decomposing technical efficiency into pure technical efficiency and scale change, it becomes clear that both factors have equally influenced their negative evolution of TFP. This conclusion means, one of the weaknesses of the electricity industry in SSA would be first and foremost a lack of infrastructure and not just a management or corporate governance problem.

The main descriptive statistics of the Malmquist index are presented in table 3.

4.2. The determinants of total productivity change of African electricity companies

The pool is mostly used by sellers and buyers of large amounts of energy. The latter, also called "power marketers" are new players in the electricity market. They reduce the risk of price fluctuations, which also reduces uncertainty about the future and facilitates decision-making for investment. Hence the positive impact that the pool has on total efficiency.

Household consumption per capita and the privatization of the sector exert a negative influence on factor productivity. Indeed, in a context where the energy supply does not keep pace with demand, increasing household energy consumption can contribute to increasing grid voltage and inducing load shedding. This fact can also explained the negative impact of population density on productivity. Furthermore, in the countries that constitute our sample, the maintenance of network is not regular due to budget restriction. The high density of the population in this case increases the impact of the Joule effect on network and therefore leads to technical losses.

Table 4: The determinants of TFP growth

1	2	3	4	5
TFP _{t-1}	-0.515*** (0.0795)	-0.433*** (0.0753)	-0.436*** (0.0791)	-0.392*** (0.0778)
tariff	1.538 (0.315)	1.802 (0.351)	1.692 (0.361)	1.912 (0.378)
privatization	-0.547*** (0.195)	-0.228 (0.157)	-0.547*** (0.211)	-0.201 (0.159)
pool	0.488* (0.268)	0.717*** (0.267)	-0.173 (0.334)	0.393 (0.296)
Household consumption per capita	-0.217*** (0.0670)	-0.246*** (0.0629)	-0.238*** (0.0638)	-0.225*** (0.0615)
Average precipitation per year	0.188** (0.0844)	0.499*** (0.121)	0.435*** (0.113)	0.627*** (0.139)
Population density	-0.546*** (0.175)	-0.772*** (0.192)	-0.419* (0.253)	-0.834*** (0.200)
Urban population	0.681*** (0.207)	1.180*** (0.266)	1.213*** (0.273)	1.366*** (0.281)
Dependence ratio on natural resources			-0.160 (0.0986)	-0.0887 (0.0690)
% of electricity produced by hydro- source		0.246*** (0.0771)		0.232*** (0.0797)
Rural electrification rate	-0.0363 (0.0771)	-0.180** (0.0843)	-0.476** (0.198)	-0.284** (0.120)
(privatization)*(rural electrification rate)			0.550** (0.222)	0.183 (0.123)
% of electricity produced by petroleum	-0.0932 (0.113)		-0.0226 (0.141)	
Observations	90	100	90	100
Number of pay	17	17	17	17
Sargan test	89(0.002)	95 (0.001)	94	87(0.002)
Wald chi2()	102	103	108	107

Prob > chi2

0.00000

0.00000

0.00000

0.00000

Note : *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Growth rate of TFP is a dependent variable

Source : Our estimation

One of the strong results of this study is that the privatization of the sector reduces the total efficiency of factors in the electricity industry. This result is in line with that of some authors, who recognize the limited effects of privatization (Plane, 1999; Finon, 2010; Angelier, 2005; Eberhard et al., 2008; Foch, 2012). However, it is possible to deduce that, although having been found efficient, some privatized sectors could have further improved their performance.

Connecting remote and sparsely populated areas to the grid represents a significant investment and is not economically viable for a private electricity company. This is why the company will focus its spending on high-density areas such as cities. Hence an increase in factor productivity that goes hand in hand with the urban population. Furthermore, urban population increase scale effect which impact positively the production system particularly in electricity sector where economies of scale played an important rôle.

The hydroelectricity variable leads to the deduction that, the option of producing electricity by water improves the efficiency and performance of national energy systems. It is obvious that the level of precipitation can positively influence the productivity of the factors with regard to the direct link that it has in the hydroelectric production systems. The study also shows that tariff does not influence the total efficiency of factors. This result appears contrary to the expected effect, as among the various regulatory instruments, the choice of a tariff regime is crucial and affects efficiency. This result leads to the conclusion that the tariff rule adopted by the countries in the sample is not appropriate. This is where the problem of regulation arises

5. CONCLUSION

The efficiency analysis of the electricity distribution companies is a relevant research subject since it allows assessing the impacts of reform processes and environmental factors. This paper has made use of a short panel data for which efficiency and total factor productivity analysis can be made. Two methods were used for the sensitivity exam, non-parametric analysis (Malmquist index) and dynamic analysis for the 2002-2016 period. Some relevant conclusions can be drawn.

Firstly, only 2 of 17 countries (Gabon and Nigeria) present a consistently high performance during the 2002-2016 period, 6 of 17 (Angola, Cameroon, Ivory Cost, Ghana, Senegal and Zambia) present a bad high performance.

Secondly, the TFP index records a yearly negative growth rate of -3.76% in the whole period under analysis. Pure efficiency was the main component behind this evolution, with an average negative growth of -3.02% in the whole period, while efficiency change presented a negative performance of -0.08%.

Thirdly, concerning the determinants of TFP change, our study shows that the connection of electricity industries from one country to the other (pool), rain (Average precipitation per year), hydroelectricity source, urbanization increase the TFP. However, the effect of population density and privatization on TFP is negative. In this perspective, reducing the cost of generating electricity could significantly improve the overall energy supply in Africa. However, this requires a multi-pronged policy intervention bringing together governments and industry players to ensure financial viability of power

utilities. Exploiting renewable energy sources and liberalizing the energy sector to attract private-sector participation could also improve the cost effectiveness of producing electricity. Improving the state of power infrastructure could also reduce transmission leakages and attendant costs.

African authorities need to undertake reforms to dismantle obstacles that constrain private investment in the electricity sector. Particularly; the regulatory bodies should reform the tariff structure.

Promoting inter-regional interconnections: Regional integration creates economies of scale, allowing lower costs across all aspects of infrastructure including power. Estimates show that cross-regional collaboration could reduce electricity costs in Africa by US \$2 billion per year. Given the strategic nature of power to the economy, African governments should build high levels of trust in order to share in the cost of developing power infrastructure for long-term benefits of their economies. African governments should also collaborate with their development partners in order to build a reliable power sector.

References

1. **AFD, (2012).** “Accès à l’électricité en Afrique subsaharienne : retours d’expérience et approches innovantes”. Document de travail n°122.
2. **AFDB, (2014).** “The High Cost of Electricity Generation in Africa”, Development Research Department of the African Development Bank
3. **Aharoni, Y. (1986).** “The Evolution and Management of State-owned Enterprises”, Cambridge, Harper and Row Publisher,
4. **Alchian, A. et Demsetz H., (1973)** “The Property Rights Paradigm “, The Journal of Economic History, pp.33-52
5. **Angelier J.-P., (2005),** “Électricité et gaz naturel : du monopole public à la concurrence réglementée. Une perspective historique “. Université Pierre-Mendès-France, UFR Economie, Stratégies, Entreprise, Grenoble. **p.36.**
6. **Angelier J.-P., (2006)** “Les changements institutionnels dans les industries de réseaux : une libéralisation prématurée dans les pays en développement “? Présentation dans le cadre du colloque « Institutions et croissance économique», Université d’Oran.
7. **Arellano, M. et Bond, S. (1991)** “ Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations”, Review of Economic Studies, Vol.58, p. 277-297.
8. **Arellano, M. et Bover, O., (1995)** ‘ Another look at the instrumental-variable estimation of error-components models ’, Journal of Econometrics, vol.: 68, p. 29-52.
9. **Atangana, O.H and Nsoe Nkouli JB, A. (2014)** ‘The effects of regulatory agencies of sub-saharan electricity companies on social welfare’ the journal of energy and development, vol. 39, no. 1/2, pp. 73-94.
10. **Blundell, R., and Bond, S. (1998),** ‘Initial conditions and moment restrictions in dynamic panel data models’, Journal of Econometrics vol. 87 p. 115–143.
11. **Blundell, R.W., Bond S.R and Windmeijer. F, (2000)** ‘Estimation in Dynamic Panel Data Models: Improving on the Performance of the Standard GMM Estimator’, in B. Baltagi (ed.), Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in Econometrics 15, JAI Press, Elsevier Science

12. **Bozec, R. (2004)** ‘L’analyse comparative de la performance entre les entreprises publiques et les entreprises privées : le problème de mesure et son impact sur les résultats’, *L’Actualité économique*, vol. 80, n° 4, p. 619-654.
13. **Briceno-Garmendia, C., C. Torres, C et Dominguez, C (2011)** ‘Infrastructures du Sénégal : une perspective continentale » ». Rapport pays de l’AICD, juin
14. **Buchanan, J. et Tollison, G. (1972)** “Theory of public Choice: political application of economics. The University of Chicago press.
15. **Calderon C. (2009)** « Infrastructure et croissance en Afrique ». Document de travail et de recherche sur les politiques, N° 4914, avril
16. **Caves, D.W., Christensen, L.R. and Diewert, W.E. (1982)** “The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity.” *Econometrica*, Vol.50, No.6, p.1393– 1414.
17. **Charnes, A., Cooper, W. W., and Rhodes, E. (1978)** "Evaluating program and managerial efficiency: an application of data envelopment analysis to program follow through", *Management Science*, Vol 27, PP 668–696.
18. **Domberger, S. et J. Piggott. (1994)** “Privatisation Policies and Public Enterprise: A Survey “, in M. Bishop, J. Kay et C. Mayer, *Privatization & Economic Performance*, New York, Oxford University Press), p. 32-61.
19. **Eberhard, A. and others. (2008)** “Review of the State of the Power Sector in Sub-Saharan Africa,” *Africa Infrastructure Country Diagnostic* .Washington: World Bank
20. **Estache, A., Tovar, B, and Trujillo, L., (2008)** " How efficient are African electricity companies? Evidence from the Southern African countries", *Energy Policy*, Volume 36, N° 6, p 1969–1979.
21. **Fare, R., and Grosskopf, S. (1990)** “Theory and Calculation of Productivity Indexes: Revisited”. Southern Illinois University at Carbondale, Economics Department Discussion Paper, Carbondale,, p. 90–98.
22. **Farrell, M. J. (1957)** "The measurement of productive efficiency". *Journal of the Royal Statistical Society*, 120A (3), 253–281.
23. **Finon D. (2010)** “Network industries and markets: From public service model to universal service obligations “ in M. Finger and R. Künneke ed, *Handbook of liberalized infrastructure sectors*. London, Edward elgar.
24. **Foch, A. (2012)** “ Un soutien appuyé malgré des effets limités ; comment expliquer le paradoxe des infrastructures de la BM en ASS”. Document de travail du Centre d’Economie de la Sorbonne
25. **Funkhouser, R. et P.W. Macavoy (1979)**, “ A Sample of Observations on Comparative Prices in Public and Private Enterprises”, *Journal of Public Economics*: vol. 9 p. 353-368.
26. **Gathon, H.J. et P. Pestieau, (1996)** “La performance des entreprises publiques. Une question de propriété ou de concurrence? “, *Revue Économique*, volume 47(6) p 1 225-1 251.
27. **Gnansounou, E., Bayem, H., Bednyagin, D., and Dong, J. (2007)** " Strategies for regional integration of electricity supply in West Africa", *Energy Policy*, Volume 35, N° 8, PP 4142-4153.
28. **Groot, R., Van der Veen, V. G., Sebitosi, A. B. (2013)** "Comparing solar PV (photovoltaic) with coal-fired electricity production in the centralized network of South Africa", *Energy*, Vol. 55, PP 823-837

29. **Kim, K. (1981)** "Enterprise Performance in the Public and Private Sectors: Tanzanian Experience, 1970-75", *The Journal of Developing Areas* vol.7, p. 471-484
30. **Lopez-De-Silanes, F. et A. Chong. (2003)** "The Truth About Privatization in Latin America", Document de travail <http://papers.ssrn.com> .
31. **Malgas I, Eberhard A., (2011)**, "Hybrid power markets in Africa: Generation planning, procurement and contracting challenges". *Energy policy* Volume 39, Issue 6, pp 3191–3198.
32. **Jensen, M et W. Meckling. (1976)** "Theory of the firm: managerial behavior, agency costs and ownership structure" *Journal of Financial Economics*. Vol: 3. Pp 305-360.
33. **Meggisson W. et J. Netter. (2001)** "From the State to market: a survey of empirical studies on privatization" *Journal of Economic Literature* volume ;39. p. 321-389.
34. **Melike, E and. Bildirici. (2012)** "The relationship between economic growth and electricity consumption in africa: ms-var and ms-granger causality analysis", the *journal of energy and development*, vol. 37, no. 1/2, pp. 179-205
35. **Niyibizi alphonse** "swot analysis for renewable energy in africa: challenges and prospects renewable energy" *Law and policy review*, vol. 6, no. 4 (2016) , pp. 276-293
36. **Oneyji and M. Bazilian. (2013)**. "Contextualizing Electricity Access in Sub-Saharan Africa", *Clear Energy Solution Center*.
37. **Orvika Rosnes and Haakon Vennemo, (2012)** " The cost of providing electricity to Africa", *Energy Economics*, Vol 34, PP 1318-1328.
38. **Osaretin Aigbovo and Ebiton Ogboka, (2016)** "electric power sector reform act 2005 and the development of renewable energy in Nigeria", *renewable energy law and policy review*, vol. 7, no. 1 pp. 20-29
39. **OXFAM, (2017)**. "Le défi énergétique en Afrique subsaharienne: guide à l'intention des défenseurs et des responsables de politique"Deuxième Partie: faire face à la pauvreté énergétique". *Research Backgrounder*
40. **Plane, P. (1999)** "Privatization, Technical Efficiency and Welfare Consequences: The Case of the Cote d'Ivoire Electricity Company (CIE) ", *World Development*, Elsevier, vol. 27(2), p. 343-360.
41. **Ramos-Real, F.,j Tovar, B., Iootty, M., Fagundes de Almeida, E, Queiroz Pinto, H. (2009)** , "The evolution and main determinants of productivity in Brazilian electricity distribution 1998–2005: An empirical analysis", *Energy Economics*, Volume 31, N° 2, PP 298–305
42. **Reeves, E. et J. Ryan (1998)**. "A Benchmark Analysis of the Performance of State" Owned Review, vol 71, n° 2 pp 42-63..
43. **Simar, L., Wilson, P., (2007)** "Estimation and inference in two-stage, semi-parametric models of production processes". *J. Econom.* Vol 255, PP131–164.
44. **Slim M. and h Mohamed B. Ar. (2015)** "The importance of electricity consumption in economic growth: the example of african nations" *The journal of energy and development*, vol. 40, no. ½, pp. 99-110.
45. **Tchapga F., (2002)**. "L'ouverture des réseaux électriques des pays d'ASS aux capitaux privés. Choix organisationnels et contraintes institutionnelles ", *thèse de doctorat en Economie*, Université Paris 13,

46. **Tittenbrun, J. (1996)**, “Private versus Public Enterprise”. *In Search of the Economic Rationale for Privatisation*, Londres, Janus Publishing Compagny, 144 p. Toward a More Realistic View of Top Managers », *Journal of Management*, vol. 23, n° 3, p. 213-237
47. **Tullock, G. (1976).**” Private Wants, Public Means”, New York, Basic Books.University,
48. **Vining, A.R. and Boardman, A.E. (1992)** “Ownership versus Competition: Efficiency in Public Enterprise”, *Public Choice*, Vol: 73., pp 205-239.