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Efficiency of urban water supply in Sub-Saharan Africa: Do organization and regulation matter?

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ABSTRACT

Using the model developed by Battese and Coelli (1995), we compare the technical efficiency of urban water utilities in Sub-Saharan Africa countries. We examine how private-sector participation, economic regulation, and their combination affects technical efficiency. We find that regulating water utility operations via performance contracts leads to higher technical efficiency compared to control by an independent regulatory agency. Private-sector participation in management has a positive effect on technical efficiency. However, there is no evidence of a statistically significant difference between the technical efficiency of publicly and privately owned utilities, respectively, when they are regulated by either an independent agency or a performance contract.

1. Introduction

The wave of reforms affecting infrastructure sectors around the world during the 1990s did not spare the water sector in Sub-Saharan Africa. These reforms, driven by international donor funds, were aimed at: improving the technical efficiency and financial sustainability of utilities as well as access to public water service (Shirley and Menard, 2002; Marty and Voisin, 2005; Araral, 2009).

In this context, new legislation and new institutional frameworks have been established and the missions of stakeholders clarified (AMCOW, 2006; AfDB-WPP, 2010). Thus, in each country, the Government remains responsible for the formulation of policies and strategies for the sector, while the water utilities are responsible for operations under either public ownership and management or contractual arrangements involving some form of private participation. These contracts differ according to the importance of the role of the private operator, as well as its responsibility for investment and its assumption of risk.

Public management prevails in most cases, though it takes different forms: a department within a local authority (Malawi, Namibia, Nigeria and South Africa), public enterprises owned by municipalities (Ethiopia, Kenya, Tanzania and Zambia), and state-owned agencies (Ghana and Uganda). In most of these countries, reforms have led to the commercialization and corporatization of water service with the expectation that it will lead to considerable improvement in performance. Alternatively, countries like Burkina Faso, Ghana, Mozambique, Uganda, and Rwanda made the choice to involve private actors in utility management (via contracts), while the assets remain under public ownership. The third mode of governance in the urban water sector in Sub-Saharan Africa involves the delegation of water-supply activities to the private sector through the implementation of affermage or lease arrangements (Ivory Coast, Niger, and Senegal) or concessions (Cape Verde) following a bidding process. When there is delegation of operations, the public authority transfers the responsibility of providing water services to a private operator.

The economic regulatory function takes three forms:

Abbreviations: Awsa, Addis Ababa Water and Sewerage Authority; Bwb, Blantyre Water Board; Crwb, Central Region Water Board; Electra, Empresa Publica de Electricidade e Agua; Electrogaz, Etablissement de production, de Transport et de Distribution d'Electricité, d'Eau et de Gaz; Gwc, Ghana Water Company; Kiwasco, Kisumu Water and Sewerage Company; Lwb, Lilongwe Water Board; Lwsc, Lusaka Water and Sewerage Company; Mwsa, Mwanza Water and Sewerage Authority; Nwsc, National Water and Sewerage Company; Nwasco, Nairobi Water and Sewerage Company; Onea, Office Nationale des Eaux et d'Assainissement; Sde, Sénégalaise Des Eaux; Seen, Société d'Exploitation des Eaux du Niger; Sodeci, Société de Distribution d'eau de Côte D'Ivoire; Swsc, Southern Water and Sewerage Company.

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- Self-regulation at the local level (Malawi, Namibia, Nigeria and South Africa);
- A performance contract supervised by a State Asset Holding Company[1] or a department within the line ministry (Burkina Faso, Ivory Coast and Senegal); or
- A national and independent regulatory agency, which may be sectorial or multi-sectorial (Ghana, Kenya, Mozambique, Niger, Rwanda, Tanzania and Zambia).

In the empirical literature, there is little quantitative cross-country research dealing with efficiency in the African water sector, except Estache and Kouassi (2002), Kirkpatrick et al. (2006) and Mbuvi et al. (2012).[2] Lack of data is the key reason for the limited number of studies. Using a Cobb–Douglas production function, Estache and Kouassi (2002) based their analysis of a sample of 21 water utilities (18 public and 3 private) during the 1995 to 1997 period. They found private water companies to be more efficient than public ones. Kirkpatrick et al. (2006) relied on a sample of water utilities[3] for the year 2000 and made use of both parametric (Cobb–Douglas cost function) and non-parametric (Data Envelopment Analysis, DEA) techniques. They found no statistically significant difference between publicly and privately owned water companies. In addition, independent regulation appeared to have no significant effect on efficiency. Mbuvi et al. (2012) assessed the performance (efficiency and effectiveness) and performance determinants for 51 water utilities in 2006 using the DEA technique. The results showed that the level of economic development is the most significant determinant of performance. Independent regulation, as well as regulation by a performance contract, had no significant effect on performance.

In the above studies, researchers dealt with specific aspects of reforms, either ownership or regulation. In our study, we go beyond this binary categorization of water utilities to assess the joint effect of these two reform dimensions. From our observed data, three groups of water distribution providers can be distinguished. First are water utilities with private-sector participation in the management (operations) controlled by either an independent regulatory agency[4] or a performance contract. Second are public enterprises supervised by either an independent regulatory agency or a performance contract. A third reference category includes water utilities under public management and those with a private operator in the management (operations) but without any regulation by either an independent regulatory agency or a performance contract. Table 1 illustrates this observed typology.

This paper contributes to the empirical analysis of the effect of institutional variables on the efficiency of water utilities in Sub-Saharan Africa. It aims at assessing whether the observed sector reorganization has been an important factor in increasing the technical efficiency of urban water distribution. In this study, technical efficiency stands for the ability of a water utility to maximize its output given the quantities of available inputs.

To achieve the study's objective, we make use of the Stochastic Frontier Analysis (SFA) technique, namely the model developed by Battese and Coelli (1995). This model presents the advantage of the simultaneous estimation of both the production frontier and the parameters of the technical inefficiency model.

The remainder of this paper is as follows. The next sections present the methodology and describe the source of data and variables used for the estimation. Thereafter, the paper reports on the descriptive statistics, discusses the main results, and provides conclusions and policy recommendations.

2. Methodology

2.1. Technical efficiency and frontier concepts

We model the production process using the output orientation of the concept of technical efficiency as introduced by Farrell (1957).[5] In this case, technical efficiency is the ability of a firm to produce maximum outputs by making use of given quantities of input.[6]

We choose to estimate a production frontier because we are interested in the relationship between the physical quantities of inputs and the maximum achievable output quantities. In fact, quantitative data are easily comparable and they are reported consistently in the database from which we obtained our data. Moreover, they are assumed to be homogeneous and more reliable than financial data. Using physical quantities offers the advantage of avoiding the standardization of accounting rules and exchange rates, since the water utilities covered by our research are located in different countries. In addition, Pestieau and Tulkens (1993) and Pestiau (2009) pointed out that public-sector performance can be more consistently and reliably measured by using technical efficiency criteria. In fact, they showed that technical efficiency is the only objective that does not prevent the realisation of other public-sector objectives[7] that are multiple and sometimes contradictory (Mbangala, 2007).

If the production frontier is known, it is possible to measure the distance that separates each data point from the frontier by computing the amount by which the output vector, $\boldsymbol{y}$, can be expanded given the available input vector, $\boldsymbol{x}$. This measure represents the extent of technical inefficiency. In reality, the production frontier is unknown; it can be estimated for a sample of enterprises using either parametric or non-parametric methods. Technical efficiency scores are relative measures for a given sample. They are defined in reference to the estimated production frontier using the output distance function, as follows:

$$d_0(x,y) = Min\{\theta > 0 : (x, y/\theta \in P(x)\} \quad (1)$$

$$\text{where } P(x) = \{y : x \text{ can produce}\} \quad (2)$$

is the set of all non-negative vectors of outputs, $\boldsymbol{y}$, that can be produced using a given non-negative input vector, $\boldsymbol{x}$, (Coelli et al., 2005).

[1] Reforms transformed the public enterprise (former monopoly in charge of production and distribution of water) to a State Holding Company responsible for assets, investments and regulation of the water utility.

[2] See for example Abbot and Cohen (2009), Berg and Marques (2011) and Gonzalez-Gomez and Garcia-Rubio (2008) for a literature review and lessons learned after four decades of quantitative research of the urban water services. The literature also includes some studies related to specific countries in Africa (for example, Mugisha, 2008; Diakite and Thomas, 2013).

[3] The paper by Kirkpatrick et al. (2006) relies on 71 observations when using the DEA method and 76 for the Cobb–Douglas cost function.

[4] The independent regulatory agency oversees the utility monopoly, which is in turn respectable for the contracts in which it engages.

[5] Farrell (1957) introduced the concept of economic efficiency, which is technical efficiency multiplied by allocative efficiency.

[6] In the water sector, technical efficiency is usually defined using an input orientation. This approach is built on the assumption that water utilities minimize the input usage given output levels. In fact, water utilities are expected to satisfy demand. To be efficient, the main variables on which they can act are the quantities of inputs used. But, in Africa, the output orientation is accepted given the persistent needs to expand quantities and quality of safe drinking water offered to the population and to improve the service coverage rates (see for example, Mbuvi et al., 2012).

[7] Public-sector objectives include macroeconomic, allocative, and social equity objectives.