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Urban water sector performance in Africa: A step-wise bias-corrected efficiency and effectiveness analysis☆

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ABSTRACT

Productivity analyses focus on either efficiency or effectiveness. This paper provides a step-wise approach for evaluating utility performance. In a first step, utilities' technical efficiency is estimated. In a second step, we examine utilities' effectiveness in meeting existing customer demands for drinking water services within their licensed jurisdiction. The difference between inefficiency and ineffectiveness is decomposed in a third step. A final step explores country-specific (e.g., income per capita), sector specific (e.g., regulation) and utility-specific (e.g., density economies) inefficiency and ineffectiveness determinants. The four steps are applied to the African drinking water utilities. The results indicate that the utilities face technical inefficiency rather than ineffectiveness challenges. This is consistent across the various African regions. Economic development is positively and significantly associated with increased technical efficiency and effectiveness levels.

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1. Introduction

The natural monopolistic nature of the urban water sector and the recent organizational and institutional developments across the sector in most developing countries urge for productivity assessments in the sector. For water utilities, as with any other company or utility, it is imperative to operate efficiently and effectively.

Following Farrell (1957), a utility's overall efficiency is a product of both allocative efficiency and technical efficiency.[1] This paper focuses on the latter and defines (technical) efficiency as the equiproportionate physical output expansion with given (physical) inputs.[2] Utilities' effectiveness reflects the extent to which sector objectives are met within each utility's licensed jurisdiction. In other words besides obtaining a maximal output with the given resources (i.e., efficiency), utility managers need to universally meet their customer demands for quality (i.e., non-contaminated) and reliable (constant daily flow) water supply services (i.e., effectiveness).

Effectiveness can loosely be stated as '*doing the right things*'. The need for effectiveness is made clear by looking at service delivery levels. By 2006, African urban water utilities only delivered water to about 65 percent of the population within their licensed jurisdiction (WSP-WB, 2009). This is low when compared to other developing regions that served on average 73 (East Asia and Pacific region), 85 (Central Asia region) and 85 (Latin America and the Caribbean region) percent of their urban populations with safe piped water services in 2006 (WSP-WB, 2009). This paper examines whether

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[1] For more information on how these components are decomposed when either output maximization or cost minimization objectives are considered, see also Fried et al. (2008).

[2] Or physical input minimization for a given (physical) output level - in the alternative case where policy makers aim to minimize firms inputs for a given output level.

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utility managers in the different African countries (can) meet the demand for qualitative and reliable water supply.

Efficiency can loosely be stated as '*doing things right*'. The call for an efficient use of inputs is clear when one looks at utilities' costs and revenues. At the cost side and owing to the increasing multi-sectoral competition for the shrinking renewable water resources, production costs are increasing over time (AfDB-WPP, 2010; UNESCO and Earthscan, 2009). At the revenue side, water utilities often incur low cost-recovery levels as most user tariffs are centrally regulated (Madhoo, 2007). Albeit increasing costs and decreasing revenues do not influence efficiency directly, but they create pressure on utility managers to use their existing inputs in a better and, thus, more efficient way. This paper explores to what extent utility managers are using their inputs to produce outputs. That is if utilities would produce as efficiently as the best practice observation(s), how much more outputs would they produce with their given inputs?

This paper proposes an approach to measure efficiency and effectiveness trends over time. We rely on productivity analysis techniques that enable us to identify utilities' efficiency and effectiveness. We further decompose utilities' ineffectiveness from inefficiency. This enables us to identify the highest (and lowest) performing water utilities (hereafter WUs). Moreover, it allows us to identify specific performance improvement areas that can potentially inform and facilitate sector restructuring, reorganization and targeted decision making (on tariffs, quality standards) while limiting inevitable sector conflicts (Berg, 2007), adverse selection and moral hazard incentive problems (Bogetoft and Otto, 2011). To further explain WU's performance, the influence of different environmental factors on WUs' efficiency and effectiveness levels is explored. Here, we consider different national, sector and utility-specific environmental factors that are beyond the control of WU managers but potentially influence managers' abilities to transform fixed inputs into controllable outputs.

We focus on the African urban water sector that has incurred increased organizational and institutional restructuring since the 1990s. Among other objectives, these reforms aim at improved utility efficiency and effectiveness (Estache and Kouassi, 2002; Kirkpatrick et al., 2006; AfDB-WPP, 2010; Mwanza, 2010). Subsequently, most African urban water sectors are governed by similarly orchestrated water legislations that define the respective key sector mission(s) and provide clear mandates (regarding service provision, regulation and policy making, among others) for the different sector stakeholders.

Across the African continent, urban piped water services are largely provided by public companies, either by the central government (e.g., in Eritrea), state owned agencies (Uganda and Ghana), full fledged water departments within local authorities (Namibia, South Africa and Zimbabwe) or public companies owned by municipalities (Kenya and Zambia; see WHO and UNICEF, 2000). A few African countries (including Cape Verde, Cote d'Ivoire, Gabon, Mozambique, Niger and Senegal) engage private actors through contractual arrangements other than service and management contracts (Mwanza, 2010). Following the commercialization reforms across most of these countries nonetheless, utilities are expected to operate efficiently -that is, expand outputs with given inputs. Moreover, utilities are required to work effectively: to reach their target in the form of complete coverage with quality and reliable water services for all customers within their licensed service areas.

Efficiency and effectiveness, and especially their interdependence in the context of the African urban water sector, have been explored only diminutively in previous literature. Exceptions are studies by Estache and Kouassi (2002) and Kirkpatrick et al. (2006). Using a Cobb-Douglas production function, Estache and Kouassi found the public owned African urban WUs less efficient than the privately-owned utilities. The latter (compared to the former) utilities were found less corrupt and well governed. They observed a total of 21 (18 public, 3 private) utilities between 1995 and 1997. Kirkpatrick et al. did not observe any efficiency differences between publicly and privately-owned African urban WUs. They compared results from both parametric (Cobb-Douglas cost function) and non-parametric (Data Envelopment Analysis, hereafter DEA) techniques on 14 utilities. Both studies quantified inefficiency between the publicly and privately-owned urban WUs.

For most public sectors (education, water supply, etc.), explicit market price information is missing or unreliable. In such cases, productivity analyses examine the extent to which utilities can technically increase their delivered outputs with given physical resources. Utilities' efficiency is then estimated against a frontier of best practice observations. In other words, with or without market price information, public utilities are supposed to operate efficiently and not waste scarce resources in such production process (Pestieau and Tulkens, 1993).

As for the African urban WUs, there might exist significant measurement error in the data. To mitigate the influence of measurement errors in a non-parametric framework, we determine a frontier consisting of best practice companies by the use of a double bootstrap technique based on the truncated maximum likelihood estimators (Simar and Wilson, 2007).[3] The double bootstrap approach permits the estimation of bias-corrected technical efficiency scores (with the bias arising from possible measurement errors) and allows for the examination of efficiency covariates. We distinguish various influences that characterize the observed utilities' operating environments. Identified inefficiency and ineffectiveness sources form the basis on which future performance improvement policies at the macro (country), meso (sector) and micro (utility) levels can be formulated.

We further disentangle utilities' ineffectiveness from inefficiency. We measure to what extent utilities are able to achieve their differently prioritized effectiveness goals for all customers within their licensed service areas. To do so, as noted in Lovell et al. (1995), it is necessary to aggregate all indicators into a single performance index. The latter helps us to summarize the multi-faceted goals into a single performance measure that is easy to interpret and easily useful to sector regulators and utility managers among other interested stakeholders, in designing and enforcing appropriate performance improvement policy strategies (Saisana and Tarantola, 2002).

To examine utilities effectiveness, we advocate a '*Benefit of the Doubt*' (hereafter *BoD*) analysis (Melyn and Moesen, 1991; Cherchye et al., 2007). This non-parametric technique aggregates observed effectiveness sub-indicators into utility-specific performance indexes. The data rely on the Water Operators Partnership (WOP) dataset. This rich dataset forms part of the WOP-Africa self assessment and benchmarking exercise facilitated by the Water and Sanitation Program (WSP) in 2006 across 134 African WUs (WSP-WB, 2009). WOP-Africa is part of the Global WOP Alliance provided by the Hashimoto Action Plan (UNSGAB, 2006). The latter was launched at the fourth World Water Forum (2005) and endorsed by the United National Secretary-General's Advisory Board on Water and Sanitation. Central to the WOP's initiative is the improvement of utilities' productivity (efficiency and effectiveness) mainly through peer-to-peer technical support partnerships.

Interestingly, the data collects homogenous information on the different production variables across African urban WUs. However, only quantity information on utilities water supply (distribution mains length, output levels, etc.) is consistently reported. Most observed utilities had some level of outsourcing

[3] Alternatively, one could estimate a (semi-)parametric frontier as Stochastic Frontier Analysis (see for e.g., Greene, 2008 for a discussion). However, as we do not have any *a priori* information on the specification of the production frontier, we rely only on non-parametric techniques.

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