

SECTOR ORGANIZATION, GOVERNANCE, AND THE INEFFICIENCY OF AFRICAN WATER UTILITIES¹

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Abstract

The paper analyzes the determinants of the efficiency levels reached by twenty-one African water utilities. Efficiency is assessed through the estimation of a production frontier for the sector in Africa. The efficiency estimates confirm much of the common perceptions from partial productivity indicators. They point to a great heterogeneity in the African water utilities' performances, the predominance of constant returns to scale and the great rate of technological progress. Moreover, the paper shows that the institutional capacity of the country as well as governance are significant driving factors in the performance of each firm.

Keywords: Water utilities, unbalanced panel data, efficiency analysis, stochastic frontier models.

JEL Classification: C22, E23, E27

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1. INTRODUCTION

Africa faces increasingly critical resource constraints in its effort to extend water services of acceptable quality to the vast majority of its people. (e.g., see Pouliquen, 2000; Sandelin, 1994; Snell, 1998; World Bank, 1999). The inefficiency of water utilities is often identified as one of the major factors. in explaining the slow progress and the many setbacks in improving access to water and water distribution (e.g., see Schuebeler, 1995; World Bank, 1999). Yet, there is a surprising dearth of literature attempting to measure the efficiency of operators in a way that would allow economic regulators to introduce explicitly performance incentives in the regulation of the operators in African countries. Perhaps because the partial productivity indicators, such as water losses or number of employees per connection, have generally been so poor that radical operational reforms were easy to propose, much of the attention of policymakers, donors and researchers seems to have focused on the institutional and financing aspects of water sector reforms. The need to mobilize additional resources for water through fees and other modalities of financing and the potential for an increased public-private partnership in the sector were particularly emphasized (e.g., World Bank 1999; UNDP-World Bank Water and Sanitation Program –West and Central Africa Office, 1998 and Snell, 1998)

The main purpose of this paper is to show that it is worth assessing more carefully the potential efficiency improvements that should result from the much emphasized reforms. This would allow quantitative assessments of the potential improvements in the overall use of inputs and a more analytical discussion of the optimal scale of operation. Both potential sources of efficiency gains could be set as targets for the restructured sectors and go a long way in cutting the financing requirements. This, in turn, implies that the need for tariff increases may not be as high as sometimes argued for some of the markets. Moreover, it implies that there is scope for regulatory supervision which ensures that the efficiency gains are not simply turned into pure rent for the new operators but are eventually shared with the consumers.

We assess the potential for efficiency improvements and the importance of the scale of operation by estimating a production frontier for the region. For lack of better data, we estimate this production function from an unbalanced panel of data for a sample of 21 African water utilities covering the 1995-1997 period. To contribute to the design of reforms, the

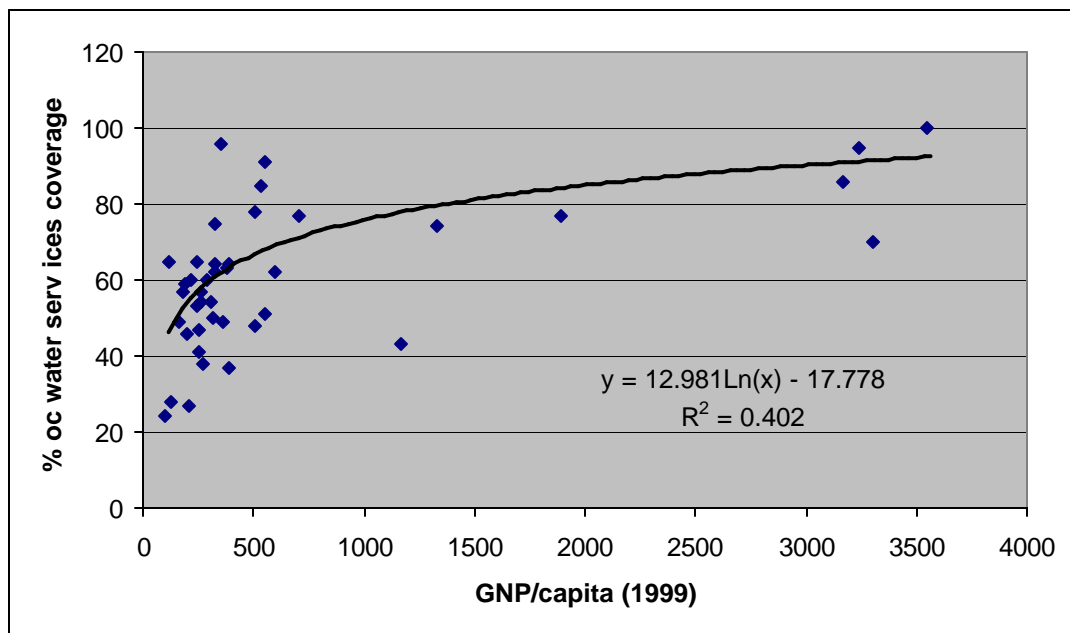
paper also quantifies the joint effect of various institutional sources of inefficiencies and in particular assesses the costs of the interactions between inefficiency and major institutional problems, in particular governance problems hurting many African countries.

The paper is organized as follows. Section 2 presents a brief overview on the African water utility sector. Section 3 discusses the analytical and conceptual framework and introduces the panel data method for unbalanced data analysis. Sector 4 explains the data and empirical model selection procedure. Section 5 presents the empirical results; Section 6 discusses the results. Section 7 concludes with some policy implications.

2. SOME STYLIZED FACTS ON AFRICA’S WATER SECTOR

Currently, only 64% of Africa’s urban population has access to safe water supply and 55% have access to sanitation. Of these, 14% have house connections and fewer have access to sanitation. The correlation of water coverage levels with income levels is clear as seen in Figure 1 but also more complex than many would expect since income levels explain only 40% of the differences in water coverage. This in turn suggests that there is more to improving access than waiting for growth to accelerate.

Figure 1: Access to Water and Income Level



One of the most obvious additional explanation for the differences in water coverage is the institutional arrangements adopted for the sector. Table 1 gives a snapshot of the organization of the sector in Africa during the period covered by this analysis. The data is collected from a survey of twenty one Africa water utilities. From a statistical viewpoint, it yields an unbalanced panel of twenty one utilities observed over the period 1995-1997 is representative of the total of one hundred and fifty water utilities in the region. The salient feature are that: (i) most utilities are in the public domain (85,71%); (ii) most of them are also water suppliers (77%); (iii) private sector participation in these utilities was very limited during the period analyzed (9.52%) .

Table 1: African Water Utility Firms 1995-1997

Country	Water Utility	Type of Utility	Area of Jurisdiction	Score of Activity	Private Sector Participation
Benin	SBEE	Public	Country	Water Supply	No
Burkina Faso	ONEA	Public	Country	Water Supply and Sewerage	No
Côte d'Ivoire	SODECI	Private	Country	Water Distribution	Leasing
Ethiopia	AA WSA	Public	Municipal	Water Supply	No
Ghana	GWSC	Public	Country	Water Supply	No
	CWA	Public	Country	Water Supply	No
Mauritius					
Morocco	ONEP	Public	Country	Water Supply	No
Morocco	RED	Public	Country	Water Supply	No
Namibia	WM	Public	Province	Water Supply and Sewerage	No
Niger	SNE	Public	Country	Water Supply	No
Nigeria	KdSWB	Public	Region	Water Supply	No
Nigeria	KtSWB	Public	Region	Water Supply	No
Nigeria	BoSWB	Public	Region	Water Supply	No
Nigeria	EdSWB	Public	Region	Water Supply	No
Senegal	SDE	Private	Country	Water Supply	Affermage
South Africa	UMGENI	Both Public and Private	Region	Water Supply and Sewerage	No
South Africa	RAND-W	Public	Region	Water Production	No
Togo	RNET	Public	Country	Water Supply	No
Tunisia	SONEDE	EPIC ²	Country	Water Supply	No
Uganda	NWSC	Public	Country	Water Supply	No
Zambia	LMSC	Public	Province	Water Supply	No

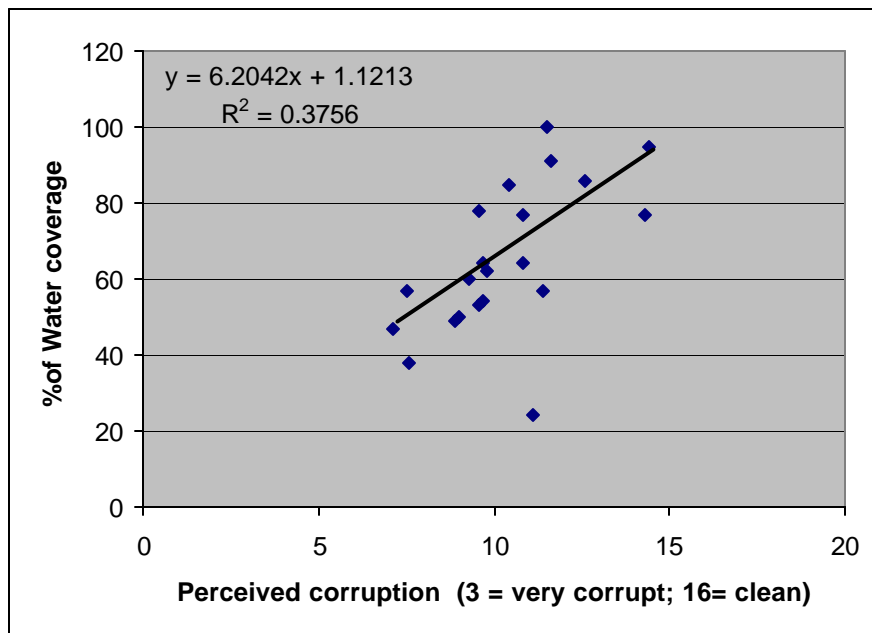
Notes: a Public enterprise but with a privatized management.

What the table does not tell (partially because there is little specific data on this topic), is that the organization of the sector is shifting towards a community-driven development

approach, ignoring the basic traditional assumption in the sector that economies of scale justify large utilities in order to reduce costs by making the most of economies of scale. This preference for smaller scale operations is clear in rural and peri-urban areas but it is also increasingly important in urban areas which continue to be under the control of more traditional water utilities. Indeed, even for these utilities, the need for constant interfaces with the users to ensure that supply meets the demand and willingness to pay leads to actual payments is now recognized as a necessary, although not a sufficient, condition for success.

The fact that utilities follow the demand orientation path adopted for rural and peri-urban approaches also reflect a desire to increase accountability with the hope that it will indeed improve and accelerate access to water services. This would imply that lower corruption or governance problems levels are expected to be associated with better coverage levels. Figure 2 provides a naïve confirmation of this intuition (with the notable exception of Ethiopia where geological conditions offset the benefit of a good governance score).

Figure 2 Correlation between Water Coverage and Governance Problemsn



This quick, and somewhat naïve, overview of the sector shows that the frustrated demand is likely to be great as revealed by the low coverage rates but also that the

organizational structure of the sector and governance quality are likely to be important factors to account for. A more subtle third message is that it may be useful to have a more quantitative view of the supply side of this market to ensure that cost are minimized. Finally, it is also important to check the extent to which the institutional arrangements contribute to the reduction of these costs and hence to the better use of the resources available to expand and accelerate the investments needed to meet the frustrated demand.

3. ANALYTICAL AND CONCEPTUAL FRAMEWORK

In spite of the diversity of experiences with water sector provision in Africa, the overview presented in section 2 reveals the need to tackle four main policy issues. The authorities responsible for the water sector need to be able to: (i) compare as rigorously as possible the firms they are responsible for with similar firms in the region as, implying that an efficiency ranking of firms would be useful, (ii) assess fully potential efficiency gains for individual firms from better joint uses of all inputs, (iii) assess the efficiency costs of ignoring potential scale economies by focusing on smaller scale operations and (iv) assess the efficiency effects of governance problems.

While partial productivity indicators generally prove to be useful instruments to get a quick overview of the performance of any enterprise, they can often be misleading when comparing various firms. Not all partial indicators necessarily yield the same ranking and this is why we need to have a joint assessment of the effects of the key inputs if robust ranking are expected. Second, when setting targets for operational improvements and in particular cost reductions, once more, we need to account for the joint effect of all inputs rather than for the effects specific inputs and to come up with a single sector or firm specific figure which will serve as a target. Third, in view of the institutional changes which seem to spreading throughout the region and resulted in the decision to go for smaller scale operations, we also need to have an instrument that allows a fair assessment of the opportunity cost in terms in terms of economies of scale to be tapped. Finally, the limits of what can be done when corruption interferes with the process of reform must be recognized and assessed as well if targets are to reachable. The focus on technical efficiency as defined by economists allows us to address all of these issues.

3.1 Technical Efficiency: Concept and Measurement

The measurement of efficiency in the water sector is complicated by the nature of the production process (e.g, see Sengupta and Monsour , 1986; Eglal et al., 1996; Hunt and Lynk, 1995; Bishop and Thompsom, 1992; and Ashton, 2000). Complications arise from the fact that water production is a function of many variables, many of which are exogenous to the water sector – for example household income, chemical products prices, and intra-household decisions etc.

Farell (1957), drawing upon the work of Debreu (1951) and Koopmans (1951), introduced a measure of productive efficiency that avoids the problems associated with traditional average productivity measures (ratios). He proposed that efficiency relative to a best-performance frontier determined by a representative peer group. In the Farell framework, a firm's efficiency is measured relative to the efficiency of all other firms in the industry, subject to the restriction that all firms are on or below the frontier. A firm is regarded as technically efficient if it is operating on the best-practice production frontier in the industry. The degree of technical efficiency is given by the ratio of the minimal input required to the actual input use, given the input mix used by the firm. It tells the utility manager the amount by which all inputs could be reduced without a reduction in output. Technical efficiency takes the values between zero and one ($0 = TE_i = 1$). Technically inefficient production units have a TE_i value less than one, while the efficient ones have a TE_i value of 1.

As seen in the foregoing discussion, empirical estimates of efficiency measures involve two steps: (i) estimation of the frontier and (ii) calculation of the individual water utility deviations from the frontier. Currently, there are two approaches used in estimating frontiers (see for instance, Coelli et alt 1998 or Coelli et alt. 2001). These are the *parametric* approach, which relies on econometric methods, and the *non-parametric* approach, which involves *linear programming* techniques. The *stochastic* and *parametric* frontiers are considered in the present study, and computed through panel estimation techniques.

3.2 Stochastic Frontier Models and Unbalanced Panel Data

Our empirical work focuses on the estimation of a stochastic frontiers for a panel of data. This implies, among other problems, having to make assumptions about the distribution

of the technical efficiency, also accepting that the distribution of the technical efficiency of a firm and the regressors (inputs) are independent. This assumption is very restrictive because it is reasonable to think that if the firm knows its inefficiency level, the selected quantities of the inputs can be affected. The statistical analysis of econometric models with panel data allows applications to the estimations of frontier models to be developed and, with them, one can partially solve the estimation problems².

Schmidt and Sickles (1984) established the basic idea and Cornwell extended it in 1990 (Cornwell et al., 1990). The model suggested was as follows: if we have a data panel composed by T temporal observations for N productive units, we can represent the technology with the following production function (we assume a linear technology for simplicity):

$$y_{it} = \mathbf{a} + \sum_{k=1}^K x_{kit} \mathbf{b}_k + \mathbf{e}_{it}, \quad i = 1, \dots, N; \quad t = 1, \dots, T; \quad k = 1, \dots, K \quad (1)$$

where

$$\mathbf{e}_{it} = \mathbf{u}_{it} - u_i \quad (2)$$

where y denotes the output, x_k represents the kth inputs and β_k stands for the output elasticity with respect to the kth input. Finally, ε is a composed error terms; v_{it} is a disturbance term with the usual characteristics [iid, $N(0, \sigma^2_v)$] that captures the random factors that can explain the divergence between the observed and the potential output enumerated above and u_i captures the time-invariant latent individual effects. Then, the u 's are positive and iid with mean μ and variance σ^2_u and they are independent of v_{it} . That is, $[u_i \approx D(\mu, \sigma^2_u)]$.

Therefore the parameter μ represents the latent average inefficiency level of technology. We can also estimate (or not) a particular distribution for u , and we can assume (or not) that inefficiency is correlated with the inputs. The technical efficiency measurement of an ith firm will be obtained from

$$ET = e^{-u_i} \quad (3)$$

This model is a simple generalization of the stochastic frontier models corresponding to the usual literature of panel data models with individual effects. The only difference with the standard panel data models is that in Equation 1 the individual effects (u_i) are one-sided.

² Simar's article (1992) constitutes a good survey of the frontier methodology with panel data, with an application of the different methods and estimators proposed.

Following Schmidt and Sickles (1984) the model can be managed in the following way. Since we know that $E(u_i) = \mu > 0$, we can define:

$$\mathbf{a}^* = \mathbf{a} - \mathbf{m} \quad (4)$$

$$u_i^* = u_i - \mathbf{m} \quad (5)$$

and consequently u_i^* is independent and identically distributed with $E(u_i^*) = 0$. Therefore, the model (1) can be expressed as follows:

$$y_{it} = \mathbf{a}^* + \sum_{k=1}^K x_{kit} \mathbf{b}_k + u_{it} - u_i^* \quad (6)$$

Now, the two errors have mean zero and therefore we can directly apply all the results of panel data models. As a result, we can use the different estimators proposed in the econometric literature of panel data, the fixed effects model or the random effects models. The choice between these two models, as is well known, will depend on the possible correlation between the individual effects and the observable explanatory variables, in this case, the inputs (x_k).

If this correlation exists, the parameters of the model Equation 5 can be estimated with the within groups (WG) estimators. The individual effects can be defined as

$\alpha_i = \alpha^* - u_i = \alpha - u_i$ and their estimation will be obtained from the within estimators of the parameters of the model $\left(\hat{\mathbf{b}}_k^{WG} \right)$.

From this estimation of the N independent terms $\left(\hat{\mathbf{a}}_1, \hat{\mathbf{a}}_2, \dots, \hat{\mathbf{a}}_N \right)$ an estimation of the independent term and the level of (in) efficiency (u_i) can be obtained from a simple procedure:

$$\hat{\mathbf{a}} = \max(\hat{\mathbf{a}}_i) \quad (7)$$

$$u_i = \hat{\mathbf{a}} - \hat{\mathbf{a}}_i \quad (8)$$

$$ET_i = e^{-u_i} \quad (8)$$

This transformation is necessary in order to obtain positive values for all the u_i . It is a translation of the frontier suggested by Greene (1980). With this operation the technical efficiency index of the most efficient firm will be equal to one³.

The second way to estimate Equation 5 proposed in the panel data literature is the random effects models Generalized Least Squares (GLS) estimator. These models must be used when unobservable individual effects are not correlated with the regressors because they are more efficient than the within estimators. Thus, the problem of this estimator lies in the necessity to assume that the individual effects (efficiency level of the firms) and the explanatory variables (inputs) are not correlated. That is, in this case, one does not admit the possibility that if the firm know its inefficiency level it will be conditioned to choose the quantities of inputs in its productive process.

From this GLS estimation of the parameters $\left(\hat{\mathbf{b}}_k^{GLS} \right)$, one can recover the individual effects from the residuals, and with them one makes the same operation as in the fixed effects models to recover the technical efficiency index. Note that this procedure also gives us an estimation of σ_u^2 .

4. EMPIRICAL SPECIFICATION

We specify a Cobb-Douglas production frontier. Output is measured by the yearly water production, and labor, capital and materiel quantities are the main inputs considered. Other variables of interest are: the energy cost and the number of connections. Taking logarithms from this Cobb-Douglas production function we have:

$$y_{it} = \mathbf{a} + \mathbf{b}_K k_{it} + \mathbf{b}_M m_{it} + \mathbf{b}_L h_{it} + \mathbf{b}_{EC} ec_{it} + \mathbf{b}_{PS} ps_{it} + \mathbf{a}_{CU} cu_{it} + \mathbf{g} + \mathbf{e}_{it} \quad (10)$$

$$\mathbf{e}_{it} = \mathbf{u}_{it} - u_{it} \quad (11)$$

where y , k , m and h represent, respectively, the logarithms of the real output, the real capital stock, the materials in constant prices, the hours of work, the energy costs in constant prices and the number of connections; the coefficients β_K , β_M , β_L , β_{EC} and β_{NC} are the output

³ We can find a problem of inconsistency as theory tells us that α_i estimations will be consistent if $T \rightarrow \infty$.

elasticities of inputs, and the sum of them gives us the elasticity of scale, which indicates the returns to scale. There is also the variable cu which is a measurement of capacity utilization; the role of this measure is to introduce links with input flows, and t is a variable added here to measure the Hicks-neutral technical change, that is common among firms in the same sector. The composed error term combines ε_{it} , which is assumed to be normally distributed and uncorrelated with the u and with the explanatory variables, with u , which captures the level of inefficiency of the water firm and so it will be greater or equal to zero.

The main justifications for the selection of this specification of a water production function for Africa are the following. First, in most African countries, the production cost structure is not known or the degree of uncertainty surrounding cost structures is relatively high, therefore it is better to estimate a production function rather than a cost function. Second, in most classical papers, capital and length of network are two key variables; while in the present case, those two variables are highly correlated (multi-colinearity issue). That means that one of these two variables should be used but not both of them. Third, in the specific context of African countries, the number of connections is a very important variable since the average size family is between 7 and 9 for some African countries and even more for others (free rider issue). Finally, the variable t should capture technological impact within the water industry in Africa.

As for the main issues relating to the estimation procedure, they can be summarized as follows. Since we have an unbalanced panel of data and water firms are of diverse size (small, medium and large), it is unlikely that the model would pass a test of homoskedastic variances. Even logarithmic specifications postulating percentage variation across cross-sectional units are likely to be heteroskedastic, because observations for lower output firms are likely to evoke larger variances [e.g., see Kumbhakar and Bhattacharyya, 1996; Baltagi and Griffin, 1988]. Moreover, the estimation of a seemingly unrelated regression model with an unbalanced panel of data set gives rise to some estimation problems [e.g., see Baltagi, 1995 and Schmidt, 1977]. For different time periods, there are different number of units (i.e., firms drop out without replacement) which change the ordering of observations. Since it dictates the structure of the variance-covariance matrix [e.g., see Baltagi, 1985], the ordering is important.

Furthermore, as $N \rightarrow \infty$ we can consistently separate the intercept α from the one-sided individual effects.

Therefore, the process of estimation proposed is the following: First, we estimate the model Equation (10) with the Within Group (WG) estimator. This estimator is consistent when the individual effects (inefficiency) are correlated with the other variables in the model (productive factors) or when this correlation does not exist. Second, one obtains Generalized Least Squares (GLS) estimators. This estimator is more efficient than the WG, when none of the variables are correlated with the individual effects. If this correlation exists, WG estimation is required. To determine the most suitable model, a Hausman test to decide whether to use one estimator or the other is provided.

Another problem presented in the estimation of a production function is the possible endogeneity of the explanatory variables. In general, one can expect that labor input may be simultaneously determined with output. In order to take this problem into account, the instrumental variable (IV) estimation of model Equation 10 is also presented. The instruments used in these estimations are based on energy costs (contemporaneous or one-period lagged). To check the endogeneity of labor a Hausman simultaneity test is also provided.

Additional problems exist with this last estimation procedure: for example, there is a question as to whether one should use differences or levels as instruments. Arellano (1989) gives evidence that the latter is preferable. More recently, Ahn and Schmidt (1993) observed that the IV estimator neglects quite a lot of information and is therefore inefficient. They thus proposed a more general estimator based on GMM.

5. RESULTS

The results summarized here provide an answer to each one of the policy concerns identified earlier. In addition, they allow to point to more structural issues in the sector thanks to an analysis of the shifts of the frontier during the period of analysis.

5.1 A synthetic indicator of Africa's water utilities

Table 2 displays the estimated coefficients and statistical significance tests. In addition, we also present the Hausman test result to discriminate among methods of estimation, based on econometric contrasts. We start by estimating Equation (10) based on the WG estimator. Then we apply the statistical tests on the residuals: tests for autocorrelation, tests for heteroskedasticity, tests for multicollinearity, tests for normality etc. The diagnostics

clearly indicate, as expected, a serious problem of heteroskedasticity. Second, as suggested by Greene (1980), we apply a transformation to the original data and re-estimate the model in order to get the GLS estimates. The results are very satisfactory. Out of six explanatory variables, four are significant. Capital input is not significant across all the estimations and has an unexpected sign. The explanation may be that the selected functional form is not adequate; and/or that there is a great heterogeneity among firms within the African water industry. It may also reflect to trend to focus more on small scale operations discussed earlier.

Results confirm the non-endogeneity of labor as seen from the Hausman simultaneity test. The estimation with the GMM has given similar results. Note also that the GLS is the favorite due to the absence of correlation between the individual effects and the explanatory variables confirmed by the Hausman test.

Table 2: Estimation Results and Diagnostic Tests

Dependent variable: Total water production				
Regressor	Specification (standard deviation)*			
	WG	GLS	GMM	IV
Constant	1.712 ^a (0.133)	0.001 ^a (0.125)	1.735 ^a (0.145)	1.775 ^a (0.135)
Capital	0.0017 (0.00037)	0.00016 (0.00034)	0.00015 (0.00033)	0.00015 (0.00034)
Materials	0.00092 ^a (0.00031)	0.00013 ^a (0.00030)	0.00014 ^a (0.0004)	0.00015 ^a (0.0005)
Labor	0.0016 ^a (0.00046)	0.0017 ^a (0.00044)	0.0016 ^a (0.00045)	0.0018 ^a (0.00047)
Energy Costs	-0.00006 (0.00018)	-0.00007 (0.00017)	-0.00006 (0.00019)	-0.0008 (0.0002)
Technology	-0.00037 (0.00039)	-0.00037 (0.0004)	-0.00037 (0.0005)	-0.00039 (0.0006)
Diagnostics				
Degree of Freedom	31	31	31	31
\bar{R}^2	0.38	0.39	0.27	0.28
S.e.e	2.30%	2.11%	2.40%	2.43%
Error auto-correlation***	1.81	1.86	1.83	1.79
Durbin 'h'				
LM (1)	$F_{6,31} = 0.63$	0.54	0.72	0.81
ARCH (1)**	$F(1,68) = 0.05$	0.02	0.04	0.05
Normality	$Z(2) = 0.76$	0.75	0.77	0.78
Reset (1)	$F(1,53) = 0.22$	0.18	0.25	0.27
Hausman Test				
?2(5)	6.86	1.21	2.23	NO

Notes : * 't' statistics are derived using heteroscedastic - consistent estimates of standard-errors.

** the errors auto-correlation tests and the ARCH tests are all adjusted for gaps.

For the sample analyzed and the period covered, the average performance is only 54% which is not great and the standard deviation is .19. The top performers score high at 85 and 83% which is close to three times the score of the bottom performers who score between 30 and 35%.

5.2 Is Small Costly?

Table 3 reports the elasticity of scale and the rate of technical progress within the water sector. These two variables are important to the extent that they provide some insights on the trade-offs between a CDD approach to water management and a utilities based approach. The scale indicator suggests that constant return to scale prevails in the WSSUs in African water industry. This implies that there is no major reason to worry for the costs consequences of the leakage of clients from utilities towards smaller scale operations.

The second indicator is the rate of technical progress reveal. It turns out that the impact of technology is very limited in the context of WSSUs in African water industry during the period under analysis. Suggesting once more that the cost of the diversification of water supply providers is not costly at least in terms of not benefiting from technological improvement often expected from large utilities. This latter result should be taken with caution due to the sample size.

Table 3: RELEVANT PARAMETERS

Country	Water Utility	<i>Elasticity of Scale</i>				Rate Technical Progress (%)			
		<i>WG</i>	GLS	GMN	IV	<i>WG</i>	GLS	GMN	IV
Benin	SBEE	0.55	0.51	0.55	0.48	0.3 ^b	0.1 ^b	0.4 ^b	0.3 ^b
Burkina Faso	ONEA	0.43	0.44	0.47	0.40	0.5 ^b	0.4 ^b	0.3 ^b	0.8 ^b
Côte d'Ivoire	SODECI	0.44	0.41	0.40	0.39	0.2 ^b	0.3 ^b	0.3 ^b	0.9 ^b
Ethiopia	AA WSA	0.33	0.30	0.30	0.31	0.4 ^b	0.8 ^b	0.8 ^b	0.7 ^b
Ghana	GWSC	0.68	0.70	0.70	0.71	1.7	1.8	1.8	1.9
Mauritius	CWA	0.53	0.51	0.51	0.52	0.3 ^b	0.4 ^b	0.4 ^b	0.3 ^b
Morocco	ONEP	0.93 ^a	0.98 ^a	0.99 ^a	0.98 ^a	2.1	2.0	1.8	1.8
Morocco	RED	0.94 ^a	0.91 ^a	0.92 ^a	0.96 ^a	1.8	2.0	1.9	1.9
Namibia	WM	0.55	0.48	0.46	0.44	0.4 ^b	0.3 ^b	0.2 ^b	0.3 ^b
Niger	SNE	0.34	0.33	0.31	0.35	0.5 ^b	0.7 ^b	0.7 ^b	0.7 ^b

Nigeria	KdSWB	0.61	0.60	0.64	0.71	0.6 ^b	0.7 ^b	0.9 ^b	0.9 ^b
Nigeria	KtSWB	0.47	0.44	0.45	0.48	0.4 ^b	0.4 ^b	0.4 ^b	0.5 ^b
Nigeria	BOSWB	0.48	0.47	0.48	0.41	0.5 ^b	0.5 ^b	0.8 ^b	0.8 ^b
Nigeria	EdSWB	0.39	0.39	0.33	0.35	0.8 ^b	0.9 ^b	0.9 ^b	0.9 ^b
Senegal	SDE	0.41	0.40	0.41	0.41	0.7 ^b	0.6 ^b	0.5 ^b	0.4 ^b
South Africa	UMGENI	0.97 ^a	0.98 ^a	1.04 ^a	1.08 ^a	3.1	3.0	3.1	3.3
South Africa	RAND-W	0.96 ^a	0.97 ^a	1.03 ^a	1.09 ^a	2.4	2.3	2.3	2.5
Togo	RNET	0.31	0.30	0.30	0.33	1.1	1.1	1.5	1.5
Tunisia	SONEDE	0.88 ^a	0.86 ^a	0.86 ^a	1.01 ^a	1.7	1.8	1.8	1.9
Uganda	NWSC	0.76	0.77	0.78	0.79	1.2	1.2	1.0	1.3
Zambia	LMSC	1.01 ^a	1.05 ^a	1.05 ^a	1.06 ^a	1.5	1.4	1.3	1.2

5.3 Do Institutional factors such a ownership and governance matter?

Recent studies have shown that institutional factors at the discretion of the management as well as environmental factors beyond the control of managers or regulators affect water efficiency (e.g see Ferrier and Valdmanis 1996, Valdamnis 1992, Ozcan and Luke 1993, Rosko et al. 1995). Some of the factors that influence the efficiency of water utilities cited in the literature are: corruption (various indices), governance (various indices) etc. This can be tested from the results obtained here.

The efficiency scores of water utilities are examined using a *censored tobit model* to identify factors influencing inefficiency. The environmental variables are excluded as their numbers are not sufficiently large to undertake a multivariate analysis.

In the tobit model, for computational convenience it is preferred to assume a censoring point at zero (e.g. see Greene, 1993).

Formally, the tobit model is defined as follows:

$$\begin{aligned}
 y_i^* &= \mathbf{b}_i x_i + z_i \\
 y_i &= y_i^* \text{ if } y_i^* > 0 \\
 y_i &= 0 \text{ if } y_i^* < 0
 \end{aligned} \tag{12}$$

where $z_i \sim N(0, s^2)$, and

y_i is the observed inefficiency score;

β_i is a $k \times 1$ vector of unknown parameters;

x_i is a $k \times 1$ vector of explanatory variables.

The empirical model, therefore, takes the following form:

$$INEFF = b_0 + b_1CORRINDEX + b_2GOVERNINDEX + b_3DUM + V(13)$$

where:

INEFF is the inefficiency score;

CORRINDEX is the corruption index;

GOVERNINDEX is the governance index;

DUM is a dummy variable: = 1 if the water utility is private; = 0 otherwise.

Statistical analyses are performed using STATA 5 statistical software (Statacorp 1997).

Results are displayed in Table 7. An important feature of the results is that institutional variables are statistically significant at the five percent level; their signs are also as expected. An interpretation of these results corroborate the fact that corruption is negatively linked to efficiency while governance is positively linked. As a consequence, water utilities should also focus on institutional variables when trying to improve their efficiency scores.

Table 5: Inefficiency and Institutional Variables

Independent variable	Coefficient	Standard deviation
Constant	1.989**	0.508
Corruption	0.0344***	0.048
Governance	0.041**	0.0247
Dummy (Privately operated=1)	-0.028**	0.015
LR tes	35.28***	
Mc Fadden's R^2	0.348	

Notes: Numbers in parentheses are standard errors. Single, double, and triple asterisks (*) denote significance at the 10%, 5% and 1%, respectively.

A final interesting result is the effect of ownership on the efficiency of the firm.. In the present context, the dummy variable which captures the effect of privatization is statistically significant at the five percent level. In terms of policy implications, this suggests that privatization has had an impact on water utilities in the African context. This is in contrast to the results found by Estache and Rossi (2001) for Asia where no significant difference was found.

6. Conclusions

The results of this study provide preliminary empirical evidence on the performance of water utilities in many African countries. The findings suggest that many of the water utilities operate technical efficiency levels well below a best-practice frontier that is determined by the relatively efficient ones from the group. Only about 12.9 per cent of the water utilities operate efficiently as compared to their peers.⁴ This finding supports the commonly held view that Africa's water sector operate at unacceptable levels of technical inefficiency but may surprise some by the extent of the problem.

The policy implications can be summarized as follows. The improvement in the efficiency of the sector should go a long way in financing the need to improve access and/or quality of water production and distribution. Continuing the public or private financing of the sector without significant efficiency improvement is a major waste of scarce resources in the region. Efficiency savings exceeds revenue from user fees which implies that average tariff levels continue to be too high as compared to what they would be if firms were operated efficiently. The poverty alleviations implications are obvious. Water should become more accessible and more affordable with major improvements in the operation of the sector and private operators have so far been able to work in that direction, even if they did not operate the best performing companies during the period under study.

The main challenges are however not in the water sector. Governance issues and the weakness of institutions have been and continue to contribute to explain a large share in the excess of costs. These problems are just as important as the ownership debate and need to be addressed as well.

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⁴ Bear in mind that stochastic and parametric methods do not give a measure of absolute efficiency and that the efficiency scores only reflect the performance and production technology of the group. It is possible that the addition of more water utilities in the sample or increasing the panel is likely to increase the number of inefficient water utilities.

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