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Can public sector reforms improve the efficiency of public water utilities?

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ABSTRACT. Privatization of public water utilities is increasingly being viewed as a strategic solution to the observed inefficiency of the water sector in developing countries. However the link between private ownership and efficiency is unclear in the water sector, given the monopolistic nature of the service and the need for public regulation. This study poses the question whether public sector reforms could improve the operational efficiency of water utilities as an alternative to privatization.

Using Data Envelopment Analysis we find that neither the decentralization of the responsibility for water operations to the municipal level nor the establishment of an autonomous regulator had a positive impact on the efficiency of Mexican water utilities. We conclude that the enacted reforms should have been combined with reforms that introduce competition and reduce the informational asymmetries in the urban water sector.

1. Research motivation

In many developing countries there is a pressing need to reform the urban water sector due to the low operational efficiency of existing public water and sewerage companies, which ultimately leads to environmental degradation and health risks. High levels of water losses can be observed in the public distribution network (with unaccounted for water levels above 50 per cent) as well as very low wastewater treatment levels (between 5 and 15 per cent in Latin America against 60 to 70 per cent in developed countries). As the population density increases in urban areas, the negative health and pollution externalities deriving from inefficient water distribution and wastewater treatment are bound to rise rapidly.

Spiller and Savedoff (1997) describe the current status of the urban water sector in many developing countries as a ‘low-level equilibrium’ in which low operational efficiency leads to low quality service and low willingness to pay (WTP) by the population. Many practitioners in international development banks (for example the World Bank, the Inter-American

Development Bank) view private sector participation (PSP) as the best solution for breaking out of this 'low-level equilibrium'. Their objective is to move to a 'high-level equilibrium' characterized by high efficiency and service quality, high WTP and cost-covering tariffs.

The main argument in favor of PSP is that the private operator, who is a profit-maximizing agent, will be more efficient than the public operator, who pursues multiple objectives (for example maximizing employment or political power). However, as argued by Vining and Boardman (1992), while privatization is likely to have a positive effect on efficiency for small firms in competitive and unregulated markets, this is not necessarily the case for large firms in monopolistic and regulated markets (like water companies). Large firms, public or private, generally have principal–agent problems that cause inefficiencies. In addition, in a monopoly the private owner might choose to be inefficient in order to maximize his leisure time (see Leibenstein, 1966). Finally, in the case of a regulated sector with information asymmetry the private operator might be inefficient in order to increase the cost-covering prices that he is granted by the regulator (see Averch Johnson, 1962; Vishny and Shleifer, 1985).

A review of 12 empirical studies on the relative efficiency of public versus private water utilities confirms that the effect of privatization is ambiguous for the water sector: only four of these studies conclude that private ownership is more efficient than public ownership;[1] three studies find no significant difference in performance;[2] four studies actually reach the opposite conclusion that public ownership is more efficient than private ownership;[3] finally, one study (Bhattacharyya *et al*., 1995) finds that public ownership is more efficient for large water companies, but less efficient for small ones.

The fundamental hypothesis underlying the present study is that the inefficiency of public water utilities depends not on the type of ownership, but rather on the lack of competitive pressures and on information asymmetry, which creates principal–agent problems between managers and owners as well as regulatory distortions. Instead of analyzing the effects of privatization, we therefore evaluate the effect of public sector reforms (for example decentralization, autonomous regulation) on the efficiency of public water utilities. In particular, an empirical analysis of public reform process implemented in Mexico's water sector at the beginning of the 1990s is conducted.

2. The reform of Mexico's water sector

Historically, the Mexican water sector has been highly centralized and all water systems were operated by one national company. Initial steps towards decentralization of the sector were taken in the late 1950s with the

[1] Morgan (1997), Crain and Zardkoohi (1978), Raffie *et al*. (1992), Estache and Rossi (1998).

[2] Feigenbaum and Teeples (1983), Byrnes, Grosskopf, and Hayes (1986), Teeples and Glyer (1987).

[3] Mann and Mickesell (1976), Bruggink (1982), Lambert, Dichev, and Raffie (1993), Bhattacharyya *et al*. (1994).

creation of municipal potable water committees. More concrete steps followed at the beginning of the 1980s, when the responsibility for the operation of water utilities was formally passed from the federal level to the state governments and a further transfer to the municipalities was envisaged.[4] However, the states blocked the process by establishing statewide water agencies, which became the maximum authority for water management and tariff setting.

The public sector reform process that is analyzed in this paper started in 1989 with the creation of the 'Comisión Nacional de Agua' (CNA). This federal commission was given the task of defining policies aimed at increasing the efficiency of public water utilities. The main reforms introduced by CNA were: (i) the *de-facto* decentralization of water supply and sewerage operations from the state to the municipal level; (ii) the establishment of an autonomous regulator; and (iii) allowing utilities to cut the water supply in case of non-payment of the water bill by customers.

Data on the operations (inputs, outputs, operating characteristics) of 110 urban water supply and sewerage utilities was obtained for the year 1995. The sample represents 15 per cent of the 730 water utilities existing in Mexico at that time, which served 25 million people (33 per cent out of the total population of 1995) and supplied 1,800 million cubic meters (40 per cent of the total consumption volume). The data exclude rural areas.

Since the degree of implementation of the reforms varied significantly across the various Mexican states, different types of public water companies and different regulatory and legal frameworks could be observed in 1995. This data set made it possible to compare the effects of the reforms on operating efficiency.[5] In particular, 80 of the 110 firms were under municipal responsibility, while 30 were still operated by state companies; 46 firms were controlled by an autonomous regulator, while in 64 firms operations and regulation were still carried out together; and in 22 firms it was allowed to cut the water supply in case of non-payment, while in 88 firms this was forbidden.

The data come from a questionnaire, which was developed by CNA and filled out by the mangers of the water utilities. A part of the data set was used previously by Ozuna and Gomez (1998) for an econometric cost function study of Mexican water utilities. They concluded that only decentralization had a positive effect on efficiency. The present paper proposes to verify the effect of the Mexican reforms by using Data Envelopment Analysis instead of econometrics and introducing additional explanatory variables in the analysis.

[4] In 1983 an addition to the article 115 of the constitution established that the municipalities should have the responsibility of providing water and sewerage services.

[5] No panel data set was available. In order to use cross-sectional data, it is necessary to control for the different operating characteristics of the water companies.

3. Research objective

The objective of this study is to determine whether the public sector reforms implemented in Mexico have managed to improve the efficiency of public water utilities. Theoretically, the following positive effects of the reforms on efficiency could be expected: (i) the administrative decentralization of water utilities could limit the principal–agent problem by bringing the manager of the utility (the agent) closer to the customers (the principal); (ii) the establishment of an autonomous regulator could reduce the conflicts of interest emerging in self-regulated utilities; and (iii) allowing the utilities to cut the water supply could improve the collection rate and increase the cash available for more efficient operations.

4. Research methodology

The methodology used in this study to measure the efficiency of the Mexican water utilities is Data Envelopment Analysis (DEA). DEA is a non-parametric method that applies linear programming to input and output data in order to estimate a piece-wise linear approximation of the production frontier. The technical efficiency of each firm is measured as its distance from the frontier made out of the firms in the sample.

The main advantage of DEA over econometrics is that it measures the efficiency of each firm with respect to a frontier made of a convex combination of existing firms, and not—like econometrics—with respect to a fictitious frontier, which depends on an *ex-ante* specification of a particular functional form (for example, Cobb–Douglas or Translog). However, full reliance on the observed data points is also the main drawback of DEA compared to econometrics. Due to the lack of a random error term and the deterministic nature of the linear program, the efficiency measures obtained from DEA will be more sensitive to the omission of firm-specific characteristics than those obtained from econometrics. When evaluating the efficiency measures obtained from the DEA it is therefore necessary to control for the different operating conditions of the various firms in a second step of the analysis.

5. The specification of the water and wastewater technology using DEA

DEA is well suited to analyze a multi-output/multi-input technology like that of water and wastewater utilities. As shown by Banker, Charnes, and Cooper (1984), the linear program used in DEA to represent the graph of the technology T of a production process with n inputs x and m outputs y, which is observed for a convex combination of s firms, can be written as in equation (1)

$$T = \left\{ (x, y)\; y_k \le \sum_{j=1}^{s} \lambda_j y_{jk},\; x_i \ge \sum_{j=1}^{s} \lambda_j x_{ji},\; \sum_{j=1}^{s} \lambda_j \;= 1;\; \lambda_j > 0; \right. \\ \left. i = 1,\ldots,n;\; k = 1,\ldots,m;\; j = 1,\ldots,s \right\} \tag{1}$$

Our sample included firms that only supplied potable water (water only firms) and firms that in addition treated wastewater (water and waste-

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water firms), either at the primary or at the secondary level.[6] In order to distinguish between these firms, three outputs (water supply, primary treatment, and secondary treatment, that is $m = 3$) were included in the linear program. As is clear from the output constraint in the above linear program, each firm will only be compared to a convex combination of firms that produce at least the same level of all three outputs. This excludes that a bigger firm is compared with a smaller firm and that a water and wastewater firm is compared with a water-only firm.[7]

With respect to inputs, our specification of the technology included the following seven operating inputs ($n = 7$):

1. Personnel (number of people): which represented 40 per cent of total operating costs.
2. Electricity (amount of Kilowatt-hour): which represented 20 per cent of total operating costs.
3. Materials (in US$): which represented 16 per cent of total operating costs.
4. Chemicals (in US$): which represented 3 per cent of total operating costs.
5. Outside services (in US$): which represented 6 per cent of total operating costs.
6. Other costs (in US$): which represented 13 per cent of total operating costs.
7. Specific wastewater treatment costs (in US$): which represented only 2 per cent of total operating costs.

Note that capital was not included as an input, since data on the capital stock was not available. It might however be assumed that there is a fixed proportion between capital and at least one of the included inputs (for example a Leontieff technology between capital and personnel). In this case the omission of capital from the linear program would not represent a problem, since the constraint on capital in the Linear Program of equation (1) would be redundant with the constraint on the related operating input. In addition, the focus of our analysis is on the efficiency in the use of operating inputs, and not on the long-term efficiency of the investment program.

As is common in most applications of DEA in the literature, we assumed free disposability of inputs and outputs. This is a realistic assumption since we are only considering inputs and outputs that are 'economic goods'. In addition, we assumed a convex graph of the technology and variable returns to scale. The convexity of the graph implies convexity of the input set (a decreasing marginal rate of substitution among inputs)

[6] Primary treatment consists of filtration and sedimentation and reduces Biological Oxygen Demand (BOD) of wastewater by 35 per cent. Secondary treatment instead requires more chemicals and reduces BOD by almost 90 per cent.

[7] In order to measure the relative efficiency of firms, it is important to avoid comparing a water and wastewater firm with a water-only firm. It is instead possible to compare a water-only firm with the water division of a water and wastewater firm.

and of the output set (an increasing marginal rate of transformation among outputs). The latter are standard economic assumptions. The assumption of variable returns to scale instead implies the existence of economies of scale in the water sector and was confirmed by using Banker's test (Banker, 1996).

6. The measurement of technical efficiency using DEA

The present paper focuses on the concept of technical efficiency in the input space (that is the minimum physical inputs that are required to produce a given output vector), distinguishing it from the concept of allocative efficiency (that is the minimum cost that is necessary to produce a given output vector).[8] In an output-regulated industry, like the water sector, technical inefficiency implies that a firm is using an excessive amount of inputs to produce the fixed output levels. Allocative inefficiency instead implies that a firm, which might be fully efficient from a technical point of view, is using an economically sub-optimal input combination and is therefore not cost minimizing. While technical inefficiency can be blamed on inefficient managers, allocative inefficiency might instead be caused by exterior environmental constraints under which the managers operate (that is shadow prices for the inputs which are different from the market prices).

With seven inputs infinite directions exist in the input space in which one could measure the distance to the isoquant. We chose the Debreu (1951)–Farrel (1957) radial efficiency measure $FI(y,x)$, which has the advantage of being independent of the units of measurement of the various inputs (allowing us to mix physical and monetary input data). In addition, by using a radial measure of technical efficiency, each operator is compared with a point on the frontier that uses the same input mix. He can therefore not justify his technical inefficiency by exterior environmental conditions that force him to use a particular combination of inputs, since this would cause allocative and not radial technical inefficiency.

As illustrated in equation (2), $FI(y_f,x_f)$, can be defined as the minimum proportion by which all the inputs x of a firm f can be radially shrunk, while still producing a given level of outputs y.

$$\begin{gathered} FI(y_f, x_f; T) = \inf_\theta \{\theta \mid (\theta\, x_f, y_f) \in T\} \\ \text{where } T = \{(x_f, y_f) \mid x_f \text{ can produce } y_f\} \end{gathered} \tag{2}$$

As shown by Banker, Charnes, and Cooper (1984) for a technology characterized by variable returns to scale the radial input measure of firm f can be obtained through the relatively simple linear program (LP) shown in equation (3). This LP minimizes the inputs needed for a certain level of outputs.

$$FI(y_f, x_f; T) = \text{Min}_{\theta_f; \lambda j}\, \theta_f$$

[8] The paper of Ozuna and Gomez (1998), which used an econometric cost function, did not manage to distinguish between these two concepts of efficiency.

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subject to

$$\theta_f x_{fii} \geq \sum_{j=1}^{s} \lambda_j x_{ji} \qquad i = 1,\ldots,n$$

$$y_{fk} \leq \sum_{j=1}^{s} \lambda_j y_{jk} \qquad k = 1,\ldots,m \qquad (3)$$

$$\sum_{j=1}^{s} \lambda_j = 1 \qquad j = 1,\ldots,s$$

$$\lambda_j > 0$$

where i is the index for the inputs x, k is the index for the outputs y, and j is the index for the firms, so that x_{ji} is the ith input of firm j and y_{jk} is the kth output of firm j.

The Debreu–Farrel measure will always be between 0 and 1, where 1 implies full efficiency and lower values imply less efficiency. The value of $1 - FI(y_f, x_f)$ indicates the proportion by which a firm should be able to reduce all its inputs, while still producing the same level of outputs.

The frequency distribution of the firm-specific radial input efficiency measures obtained for the 110 firms in our sample is shown in figure 1. These measures range from 0.3, which was attained by three firms (implying that they should be able to reduce their inputs by 70 per cent), to the fully efficient value of 1, which was attained by 51 firms.

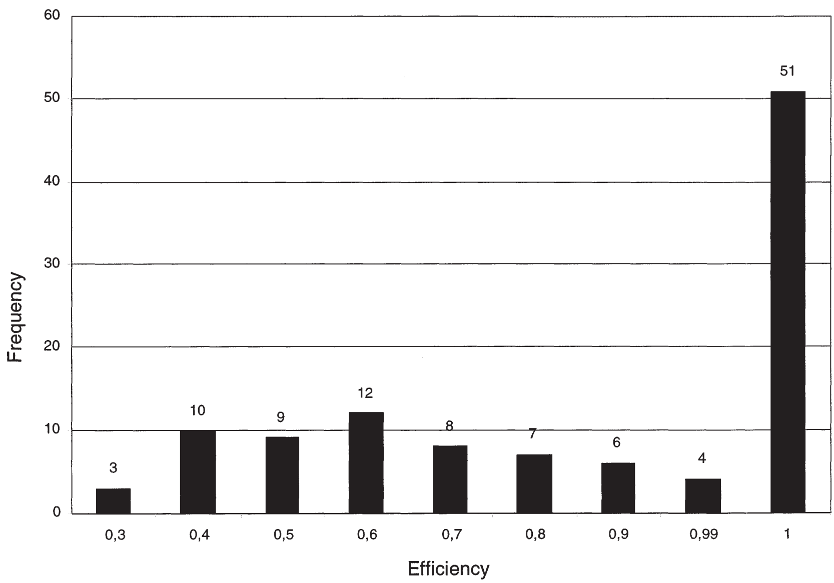

Figure 1. *The frequency distribution of radial technical efficiency measures*

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An attractive feature of DEA is that it allows the identification of the benchmark firms of each of the 59 inefficient water utilities. This can be done by verifying which of the 51 efficient firms were given a positive weight $\lambda j > 0$ in the linear program related to a particular inefficient firm. It is therefore possible to point the manager of an inefficient firm towards the firms on the frontier with which he is being compared and from which he might learn how to improve his operations.

A remaining issue is how to distinguish among the 51 fully efficient firms on the frontier. As can be seen in an empirical study by Wood, Barrar, and Kodwani (1997) about water utilities in the UK, the number of fully efficient firms obtained in DEA is a direct function of the number of inputs and outputs being considered.[9] The same emerges from a review of other empirical articles that apply DEA in other economic sectors.[10] The technical explanation is that when we include more input and output constraints in the multi-dimensional Linear Program of equation (3), more firms will appear as being efficient because they have a unique input/output combination, that is due to the lack of an adequate comparison in the sample.

The following trade-off can therefore be observed in DEA: by considering less inputs and outputs, more inefficient firms are found, but the specification of the technology is less stringent and what appears as 'inefficiency' might simply be misspecification of the frontier; when instead more inputs and outputs are included, the specification of the technology is more precise but the number of inefficient firms decreases, and many fully efficient firms are obtained. In this regard Chambers *et al*. (1998) state that, 'DEA inherently has a degrees of freedom problem in the sense that for it to be able to effectively characterize the technology, the number of observations should be large compared to the number of inputs and outputs.' A rule of thumb mentioned by Cooper (private correspondence with Professor Chambers, 1995) is that the number of observations used in DEA should at least be three times bigger than the sum of the inputs and outputs.

In this article we have chosen to select the most accurate possible (given the data) characterization of the technology. We have therefore used seven inputs and three outputs, whereby our 110 observations should be sufficient to avoid any degrees of freedom problem. However the construction of a ten-dimensional frontier still implies that relatively many fully efficient firms are obtained. In order to distinguish between the fully efficient

[9] In the article by Wood, Barrar, and Kodwani the following relationship is observed: if only three inputs and outputs are considered, 5 per cent of the firms are efficient; if five inputs and outputs are used, 12 per cent of the firms are efficient; with seven inputs and outputs, 21 per cent of the firms are efficient; finally with nine inputs and outputs, up to 50 per cent of the firms are efficient.

[10] For example: Färe, Grosskopt, and Logan (1985) use four inputs and outputs and obtain that 18 per cent of the 153 electric firms considered are efficient; Smith (1990) uses five inputs and outputs and obtains that 28 per cent of 47 pharmaceutical firms considered are efficient; finally, when McCarty and Yaisawarng apply seven inputs and outputs instead of six to their analysis of district schools, the number of fully efficient schools goes from 11 per cent to 33 per cent.

firms that are real benchmarks and firms that are classified as being fully efficient due to the lack of comparable firms, we have therefore verified how often an efficient firm appears with a positive weight $\lambda j > 0$ when the linear program (3) is applied across all other firms. If it only appears once, we know that the firm is just being compared with itself. If it appears more than once, we can conclude that the firm is a benchmark to at least one other firm. We found that 17 of the 51 efficient firms were just being compared with themselves, while the remaining 34 were actually benchmarks of at least one other firm.

7. The effect of the reforms on the technical efficiency measures

We now turn to the question whether the institutional and regulatory reforms implemented in Mexico (the administrative decentralization, the establishment of an autonomous regulator, and the permission to cut water in case of non-payment) had a positive effect on the technical efficiency of the public water utilities. Two methods will be used to answer this question while controlling for different operating conditions: (i) second-step econometric regression, which regresses the technical efficiency measures obtained from DEA against dummy variable for the reforms, the observed operating conditions and an error term for any unobserved operating conditions; (ii) the Brockett–Golany method (1996), which consists of computing two separate production frontiers, one for the reformed and one for the non-reformed utilities, and establishing whether one frontier is clearly within or outside the other one.

7.1. Results from second step econometric regression

It is common practice in the literature (for example Ali and Flinn, 1989) to regress the efficiency measures obtained from DEA against a series of explanatory variables z. As in most applications in the literature we assumed that the error term ϵ is distributed as a Tobit, that is it is distributed according to the normal distribution but its likelihood function reflects the fact that the dependent variable $FI(x,y)$ is bounded between 0 and 1.

The vector of explanatory variables z considered in our regression included three dummy variables for the reforms (*Municipal* = 1 if municipal form, 0 if state firm: *Regulation* = 1 if autonomous regulator, 0 if not; *Water cut* = 1 if cutting service is allowed, 0 if not) and the following three continuous variables:

1. *Unaccounted for water (per cent = water lost/water produced)*: The level of UFW can be interpreted as a proxy of the age of the capital stock (pipelines, tanks, …). It is assumed that a firm with an older capital stock will be more inefficient than a firm with a new capital stock.
2. *Population density (number people/hectare)*: Given the existence of economies of density in the distribution of water, the population density is expected to be positively related with efficiency.
3. *Non-residential users (per cent)*: As shown by Price (1993) and Stewart (1993), a firm with a higher percentage of non-residential customers is expected to be more efficient than a firm with many small domestic connections.

Table 1. *Second step econometric regression of technical efficiency*

Variable	*Coefficient*	*Standard error*	*T-statistic*
Constant	+0.919	0.16	+5.60
Municipal	−0.034	0.09	−0.35
Regulation	+0.098	0.10	+0.94
Water cut	−0.037	0.13	−0.28
UFW	−0.432	0.23	−1.82*
Population density	+0.00065	0.0005	+1.29
Non-residential users	+2.873	1.18	+2.42*

Note: * Significant at the 10 per cent level.

As shown in table 1, we found that only two variables were significant at the 10 per cent level. As expected the amount of water losses (UFW) had a significant negative effect on the efficiency of the operating inputs, since higher losses require more electricity and chemicals. The percentage of non-residential users instead had a significant positive effect on efficiency, confirming the existence of economies of scale in the delivery of water. However, the population density did not appear to affect the use of operating inputs.

More importantly, none of the three dummy variables representing the public sector reforms was significant. Using the likelihood-ratio test we even found that the three reforms were jointly insignificant (*Test statistic* = 1.18 vs. a critical value of 7.81 at the 5 per cent level of significance). The goodness of fit of the regression was evaluated by estimating $R = 1 - \ln L_U / \ln L_R$ (where L_R is the restricted likelihood with zero coefficients for all variables and L_U is the unrestricted likelihood) yielding a value of 35 per cent.

The observed lack of effect of the public sector reforms on efficiency might depend on the methodology used. The point is that by using dummy variables we are basically comparing *the average efficiency of reformed companies with the average efficiency of non-reformed companies*. This could cause the following problem: even if in theory a reform might have a positive effect on efficiency, the average efficiency level of the reformed companies might be lower than that of the non-reformed companies because of some unobserved negative environmental conditions (for example less capable managers in the reformed companies). A method to disentangle the effect of the unobserved omitted variables from the effect of the reforms was suggested by Brockett and Golany (1996) and is illustrated in the next section.

7.2. Results from the Brockett–Golany method

The non-parametric method proposed by Brockett and Golany (1996) consists of comparing two frontiers: one frontier is made of the reformed firms and the other one of the non-reformed firms. Note that by focusing exclusively on the efficient points on each frontier (those that benefit from the most favorable operating conditions) the suggested approach implicitly controls for exogenous variables. When applying the Brockett–Golany method it is therefore not necessary to include the operating conditions explicitly.

In practical terms the two frontiers are constructed by running DEA separately for the two sets of firms and adjusting their input levels to the fully efficient level. A 'joint frontier' is then built by pooling the data from the two separate frontiers. Finally, the ranking of the reformed and non-reformed firms with respect to the pooled frontier is compared. A test statistic is used to established whether the frontier of the reformed firms is clearly above or below the frontier of the non-reformed firms, that is whether the reform had a positive or negative effect on efficiency.

The null hypothesis of the test is that there is no difference between the two frontiers, in which case all the pooled final efficiency values should be equal to '1'. The observed distribution of efficiency ratings is therefore compared with a distribution of '1s' by using the Mann–Whitney rank test. Assuming a normal distribution, the test statistic t_1 for the group of reformed firms is given by the formula in equation (4)

$$t_1 = \frac{U_1 - 0.5 s_1 s_2}{(s_1 s_2 (s_1 + s_2 + 1)/12)^{0.5}}$$

$$\text{where} \tag{4}$$

$$U_1 = s_1 s_2 + \frac{s_1(s_1 + 1)}{2} - R_1$$

where s_1 is the number of reformed firms, s_2 the number of non-reformed firms, and R_1 is the sum of the ranks of the reformed firms. Both the number of reformed and of non-reformed firms need to be above 30 in order to be able to assume the normal distribution.[11]

The null hypothesis that the two groups have the same distribution of efficiency scores will be rejected at the level of significance α, if $z_1 \leq -Z_{\alpha/2}$ or $z_1 \geq Z_{\alpha/2}$ (where $Z_{\alpha/2}$ denotes the upper $\alpha/2$ percentile of the standard normal distribution). If the test is conducted for the firms s_2, we obtain by symmetry that the resulting test statistic will be $z_2 = -z_1$.

In order to evaluate the effect of decentralization on efficiency we compared the frontier of municipal water utilities with that of state water companies in our sample. With respect to the pooled frontier the average rank of the municipal companies was 53, while the average rank of the state companies was 62, which seems to suggest that the former are slightly more efficient than the latter. However on the basis of the value of the z statistic (see table 2), we cannot reject the null hypothesis that the two types of companies have the same distribution of efficiency measures (the

Table 2. *Brockett–Golany approach for state and municipal companies*

Type of firms	*Number of firms*	*Average rank*	*Mann–Whitney test (z-statistic)*
State	30	62	−1.28
Municipal	80	53	1.28

[11] We therefore could not use the Brockett–Golany method to evaluate the third reform (the permission to cut water in case of non-payment), since only $s_1 = 22$ firms in the sample had implemented this reform.

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Table 3. *Brockett–Golany approach for self-regulated and outside-regulated companies*

Type of firms	*Number of firms*	*Average rank*	*Mann–Whitney test (z-statistic)*
Self-regulated	64	56	0.15
Outside regulated	46	55	−0.15

critical value at the 10 per cent level is $Z_{10/2} = 1.65$). We therefore confirm the finding from the econometric regression (section 7.1) that decentralization did not have a significant positive effect on the technical efficiency of the Mexican water utilities.

In addition, we compared the frontier of the firms with an autonomous regulator to the frontier of the self-regulating firms. The average rank of the self-regulated companies was 56, while the average rank of the companies with an autonomous regulator was 55. Even in this case we could not reject the null-hypothesis that the distribution of the efficiency measures is the same for both types of companies (see test statistic in table 3). Again we confirmed the finding of the second step econometric analysis that the establishment of an autonomous regulator did not have a positive effect on the technical efficiency of Mexican water utilities.

8. Policy implications

The finding of this study that the Mexican reforms did not have a significant positive effect on the efficiency of public water utilities suggests that these reforms, even if they might represent steps in the right direction, were not sufficient by themselves. We hypothesize this to be the case for two main reasons:

(i) the reforms did not introduce competitive pressures, which would have given the managers of the monopolistic water utilities the incentive to be efficient; and
(ii) They did not reduce the informational asymmetry between the agent (the public manager) and the principal (the regulator or the local users).

The policy conclusion of our study is that the reforms enacted in Mexico should have been accompanied by reforms that increase competition and transparency in the water sector. Decentralization alone will not increase the pressure for efficiency by the local users, if they do not know how their water utility compares with other water utilities. The establishment of an autonomous regulator will not constitute a useful control mechanism, if the regulator has no valuable information on the relative efficiency of the various water utilities and cannot set prices accordingly.

Since real competition in the water sector is excluded by the fact that it would be anti-economical to duplicate supply systems, only virtual competition can be introduced through regulation. In order to overcome the information asymmetry, a regulator could publish the efficiency measures of the water companies in local newspapers and make the local users aware of the relative performance of their company. In order to introduce competitive pressures, the regulator could use the better-performing companies to set competitive price levels. As described by Shleifer (1985), the underlying principle of this type of price regulation (price-cap) is that the price granted to each firm should not be based on its costs (since this would promote cost-inflating behavior), but rather on the costs of a comparable firm (since this will promote indirect competition among the firms).

Concluding, it is emphasized that the multi-dimensional efficiency measures obtained from Data Envelopment Analysis and computed in this study are particularly adequate for competitive benchmarking. The reason is that DEA is based on existing firms, allows the ranking of firms, as well as the identification of the benchmark firms. Further research on the use of DEA measures for yardstick competition (see Bogetoft, 1997) is therefore encouraged.

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