ECONOMICS BULLETIN

Public Versus Private Water Utilities: Empirical Evidence for Brazilian Companies

Ricardo Coelho Faria
Catholic University of Brasília

Geraldo da Silva Souza
University of Brasília

Tito Belchior Moreira
Catholic University of Brasília

Abstract

This paper compares the technical efficiency of Brazilian public and private companies in water supply. To measure efficiency a stochastic production frontier model is estimated using two competitive distributions for the inefficiency error component: truncated normal and exponential. The exponential distribution showed a superior fit and was used to assess differences in technical efficiency between public and private companies. The statistical results show that private companies are only marginally more efficient than public ones.

Address for correspondence: Dr. Tito Belchior S. Moreira, Catholic University of Brasilia – UCB, SGAN 916, Modulo B, Brasilia−DF, CEP: 70.790−160, Brazil, e−mail: tito@pos.ucb.br

Citation: Faria, Ricardo Coelho, Geraldo da Silva Souza, and Tito Belchior Moreira, (2005) "Public Versus Private Water Utilities: Empirical Evidence for Brazilian Companies." *Economics Bulletin,* Vol. 8, No. 2 pp. 1−7
Submitted: January 24, 2005. **Accepted:** January 26, 2005.
URL: http://www.economicsbulletin.com/2005/volume8/EB−05H00001A.pdf

1 Introduction

Several studies have focused on the performance of public and private providers in the water and sanitation services. They have compared the efficiency of both providers (Crain and Zardkoohi, 1978; Feigenbaum and Teeples, 1983; Byrnes, Grosskopf, and Hayes, 1986; Fox and Holfler, 1986, Estache and Rossi, 2002). These studies of the water utility industry have provided conflicting empirical evidence on the effect of type of ownership on efficiency. The majority of empirical evidence is based on US data. There is also some information related to privatization in England and other studies involving Asian countries.

There aren't any studies, based on Brazilian data, investigating the performance of the public and private water and sewerage companies. Brazilian policymakers have debated on the gains from recent privatization of water utilities and they are increasingly interested in assessments of the efficiency of public and private water utilities. To address this point, it is necessary a comparative study of the efficiency of publicly and privately owned water utilities via estimation of cost or production functions. This kind of evaluation is important to public policies, since Brazil has initiated the privatization of the water and sewerage companies without a regulatory regime.

Until the beginning of the last decade, the Brazilian policy for water and sanitary services was based on the National Plan for this sector entitled "Plano Nacional de Saneamento Básico" - PLANASA (1971-1992). PLANASA was a model administrated by the federal, state, and local government aiming to provide water and sewer services. The source of recourses for PLANASA was provided by the public sector via tax revenues and via internal and external loans. The coordination and planning of the basic sanitation policy changed and the federal government became the policymaker (INFUB, 1995). PLANASA expanded the supply of water and sewer in a short time and defined the policy of public tariffs for the sector. The state companies - Companhias Estaduais de Saneamento Básico (CESBs) – coordinated and provided the public sanitation services. Pagnoccheschi (2000) argues that during the PLANASA period the services of providing water improved more than the sewer services did.

At the beginning of the 90's, the desire of a state reform spread through all the country. The idea was to change from the interventionist state to the regulator state. Several sectors traditionally managed by the state were privatized or became managed by the private sector through public concessions. However for the sanitary sector, this process isn't advancing. The Congress has been discussing this issue since the middle 90's and has not voted the regulatory process for the sector yet. Even without a regulatory system defined, some local governments have opted to provide services by means of concessions to the private sector[1].

This paper intends to shed light on the issue of whether or not efficiency gains can be noticed as a result of the private sector utilities participation in 2002. This is achieved with the statistical fit of production stochastic frontiers (Coelli, Rao, Battese, 1998).

The article is composed of five sections including the introduction. Section 2 is literature review on the issue of comparison of technical efficiency between public and private companies. Section 3 describes the statistical models considered to fit stochastics

[1] See Tupper and Resende (2004)

frontiers. Section 4 is on data analysis. Finally, Section 5 provides a summary of the results and conclusions.

2 Public versus private Water utilities: a literature review

Crain and Zardkoohi (1978) investigate economic efficiency in public and private companies using data on water utilities in the United States. They use a cross-sectional sample consisting of 112 firms, 24 being private, and 88 being public, from 38 states in 1970 and estimated a cost function. The results show that operating costs are significantly higher in water utilities that are publicly owned. Further, they show that lower productivity per unit of labor input in the public firms would imply that relatively more employees would be required for any given expansion of output than in comparable private firms.

Feigenbaumand and Teeples (1983) compare estimates from a hedonic cost function with estimates derived from a non-hedonic production specification. Despite differences in production technology of water operations, both the hedonic and non-hedonic models suggest that there is no difference in cost-of-service equations for government versus private companies. They use data for 1970, including 57 US private and 262 US public water companies.

Byrnes, Grosskopf, and Hayes (1986) avoid the cost function approach and focus on the measurements of technical and scale efficiencies relative to a production technology by means of programming techniques. They find no significant difference in efficiency across ownership types. Their sample comprises 68 government owned and 59 privately owned water utilities operating in the US in 1976. Likewise, Fox and Hofler (1986) concludes that, in terms of aggregate cost, no statistical difference can be found between technical efficiency estimates for public and private firms, although allocative efficiency differences were observed. The authors use US cross-section data for 1981 with a sample of 156 publicly and 20 privately owned utilities.

Bhattacharyya, Parker, and Raffiee (1994) presents empirical evidence on the issue of efficiency of the private/public sector examining costs of 225 public and 32 private US water utilities using the data from a 1992 survey on the water industry. The statistical findings provide evidence that public water utilities are more efficient than private utilities on average, but are more widely dispersed between best and worst practices.

Saal and Parker (2001) evaluate the productivity and price performance for the privatized water and sewerage companies of England and Wales. Estimates of productivity growth, derived with quality adjusted output indices, suggest that despite reductions in labor usage, total factor productivity growth has not improved since privatization in 1989. Furthermore, total price performance indices reveal that increases in output price have outstripped increases in input costs, a trend which is largely responsible for the increase in economic profits that has occurred since privatization. They use non-parametric methods to determine labor and total factor productivity growth rates for both the 1985-1990 pre-privatization period and the 1990-1999 post-privatization years.

The article of Estache and Rossi (2002) provides further evidence on the difference between public and private utilities estimating a stochastic cost frontier for a sample of Asian and Pacific regional water companies. The results show that efficiency is not significantly different between private and public utilities. The sample covers 50 firms surveyed in 1995 in 19 countries.

Argentina National Government and over half of its provinces initiated major reforms of its water and sanitation services during the 1990's. In this context, Estache and Trujillo (2003) show that it is possible to come up with a reasonable upper bound for the estimates of the technical efficiency gains achieved by the operators of various water companies in Argentina. For the two provinces for which data is available, the gains in efficiency are roughly 2% per year. The authors argue that if these gains can be sustained, they represent quite significant contributions from the reforms of the sector in these provinces.

3 Methodology

To measure and compare the technical efficiencies of the Brazilian water supply companies we choose to estimate a production[2] function in an environment defined by a stochastic frontier model. Specifically, the response (output) y, measured by the annual volume of water supply, in m^3, satisfies the statistical model (Cobb-Douglas)

$$\ln(y_t) = \beta_o + \beta_{t1}\ln(x_{t1}) + \beta_2 \ln(x_{t2}) + \varepsilon_t - u_t \quad (1)$$

Here $t = 1,...,n$, x_{1t} is capital for firm t, x_{t2} is labor for firm t and the ε_t are *iid* $N(0,\sigma_\varepsilon^2)$. The u_t are independent inefficiency components also independent of the ε_t. Their distributions have support in $(0,+\infty)$. The constants β_i are unknown elasticities.

Two competitive statistical formulations were considered for the specification of the technical effects in the inefficiency component u of the model. A formulation defined by the truncated normal (at zero), $u_t \sim N^+(\mu_t,\sigma_u^2)$, where $\mu_t = z_t^! \delta$ and a formulation de fined by the exponential distribution with probability density given by $\lambda_t \exp(-\lambda_t u)$, where $\lambda_t = \exp(-\mu_t)$. In both cases, the linear construct μ_t is defined by the vector of technical effects z_t. This is composed of regional and nature of operation (public/private) indicators. In other words, the covariates defined by z represent a set of indicator variables (*dummies*) associated to the effects of interest. Specifically $z_t = (1, d_{t1}, d_{t2}, d_{t3,} d_{t4}, d_{t5})$ where d_1 is an indicator variable of the nature of the firm ($d_1 = 1$ for a public utility and zero otherwise) and $(d_2,...,d_5)$ are similarly defined regional indicators (North, Northeast, Center-West, Southeast, and South). The variable corresponding to the North region was eliminated from the analysis to avoid singularities. The vector δ is an unknown parameter vector.

It is the case that the log likelihood functions of interest to the study are given by,

$$L = -\frac{n}{2}(\ln 2\pi + \ln\sigma^2) + \sum_{t=1}^{n}\left\{\ln\left[\phi\left(\frac{-\gamma w_t + (1-\gamma)\mu_t}{\sqrt{\gamma(1-\gamma)\sigma}}\right)\right] - \ln\left[\phi\left(\frac{\mu_t}{\sqrt{\gamma\sigma}}\right)\right] - (w_t + \mu_t)^2 \frac{1}{2\sigma^2}\right\} \quad (2)$$

[2] Many authors favors the estimation of a cost function to assess economic efficiency. Moreover, as supported by Estache and Rossi (2002), the cost function approach is more compatible with the public sector, since the regulator defines the quantity to be produced, and the firms look for cost minimization. However, due to the absence of good proxies to measure the variables in the cost function, especially capital price, we decided to use the production function approach.

where $\gamma = \sigma_u^2 / \sigma^2$, $\sigma^2 = \sigma_u^2 + \sigma_\varepsilon^2$ and w_t is the regression residual for the normal-normal truncated specification and by

$$L = \sum_{t=1}^{n} \left[\ln \lambda_t + \ln \phi(-\frac{w_t - \lambda_t \sigma_\varepsilon^2}{\sigma_\varepsilon}) + \lambda_t (w_t + 0.5 \lambda_t \sigma_\varepsilon^2) \right] \quad (3)$$

for normal- exponential specification.

These two competitive models were evaluated according to the measures of goodness of fit defined by the Akaike and Schwarz information criteria and the correlation coefficient between observed and fitted values. As the normal exponential formulation shows a superior fit the analysis proceeded using this specification. We note that in this context the specific efficiency of each firm is given by the following expression:

$$\frac{\phi(\mu_t / \sigma_\varepsilon - \sigma_\varepsilon)}{\phi(\mu_t / \sigma_\varepsilon)} \exp\left(\sigma_\varepsilon^2 / 2 - \mu_t\right) \quad (4)$$

4 Data Analysis

The data we use to estimate the stochastic frontier models described in Section 3 was obtained from the Sistema Nacional de Informações sobre Saneamento – SNIS. It refers to the year of 2002. The sample is composed by 279 firms operating throughout the country. They are responsible for utility services for 133,8 million inhabitants, corresponding to more than 70% of the Brazil's population. From this sample, some firms were eliminated because they did not show all required information. A total of 148 firms were actually considered in the analysis with 135 being public and 13 being private.

Table 1 shows descriptive statistics. The average production is 81.5 thousand m^3 of water. The average capital (length of the piped network) is 2.3 thousand km, and average employment is 512 employees. One can see that, on average, the private firms are more productive, having a higher product/input rate for both input variables.

Table 1- Descriptive statistics

Statistics	Public	Private	Total
Quantity of firms	135	13	148
Product ion (Water volume in m^3/year)			
Mean	86,368	30,994	81,504
Standard Deviation	289,988	52,085	277,714
Capital (length of the piped network)			
Mean	2,506	801	2,357
Standard Deviation	7,022	926	6,727
Labor (number of employees)			
Mean	549	134	512
Standard Deviation	1,402	116	1,344
Productivity			
Production/Capital	34	39	35
Production/Labor	157	231	159

Table 2 shows statistical fits from the maximization of (2) and (3) in Section 3. The correlation (R) shown Table 2 is a correlation between the observed values ($\ln(y)$) and the predicted values by the corresponding stochastic frontier model. By predicted value we mean an estimate of the $E[\ln(y)]$. The fit of the normal-normal truncated specification was obtained using the software Frontier 4.1 (Coelli, Rao, and Battese, 1998), and the fit of the normal-exponential specification was achieved using SAS PROC NLMIXED.

Table 2 - Measures of Goodness of Fit

Statistic	Normal-Exponential specification	Normal-Truncated Normal specification
-2L	221.2	223.6
Parameters	10	11
AIC	241.2	245.6
BIC	271.2	278.6
Correlation R	0.957	0.894

The normal-exponential specification is clearly superior. Table 3 shows the results of estimation via maximum likelihood for this specification. The parameters β_0 (constant), β_1 (capital elasticity), and β_2 (labor elasticity) are statistically significant, according to the *t* statistic. The regional parameters (δ_2, δ_3, δ_4, δ_5) are not individually significant. They are not jointly significant as shown by the likelihood ration test seen in Table 4. Thus, there is no evidence of significant differences in terms of technical efficiency between firms of distinct regions. The negative signal in δ_1 is an indicative of higher efficiency for the private sector, although, at the 5% significance level, the parameter is not different from zero. The significance is marginal. The average efficiency estimated for the private sector is about 88% against 72% for the public sector with a standard deviation of 1,3% in both cases.

Table 3 – Maximum likelihood estimation of the exponential normal model

Parameter	Estimative	Standard Deviation	T statistic
β_0	3.4191	0.1855	18.4318
β_1	0.8655	0.0752	11.5093
β_2	0.2182	0.07482	2.9163
δ_0	-1.5083	0.7283	-2.0710
δ_1	-1.0508	0.7767	-1.3529
δ_2	0.3385	0.7602	0.4453
δ_3	0.7720	0.7959	0.9700
δ_4	0.5194	0.7258	0.7156
δ_5	0.9875	0.7570	1.3045
σ_ε	0.3757	0.03652	10.2875

Table 4 presents the $-2L$ values for the models, corresponding to the hypotheses of presence of all technical effects ($\delta = 0,\ \delta = (\delta_1,\ldots,\delta_5)$), respectively, and operational nature ($\delta_1 = 0$), adjusted by regional differences. Both hypotheses are marginally accepted.

Table 4 – Likelihood Ratio Tests

Model	-2L	DF	RV	p-value
Full	221.2			
Technical effects	229.6	5	8.4	0.1353
Operational nature	224.5	1	3.3	0.0693

5 Conclusions

This article assess technical efficiencies of Brazilian public and private water and sewerage companies. The study is original for Brazil where only recently the debate on the issue of efficiency of the private sector in providing these services has been a matter of concern. The article shows that private companies are only marginally more efficient than public ones. This evidence may provide a subsidy to the administrators in their discussions on the necessity of reviewing the Brazilian regulatory system of basic sewage.

References

- Bhattacharyya, Arunava; Parker, Elliott and Raffiee, Kambiz (1994). An Examination of the Effect of Ownership on the Relative Efficiency of Public and Private Water Utilities. *Land Economics*, May, 70(2): 197-209.
- Byners, P.,S. Grosskopf, and K. Hayes. (1986). Efficiency and Ownership: Further Evidence. *Review of Economics and Statistics* 68(2):337-41.
- Coelli, T.; Rao, D. S. Prasada and Battese, George E. (1998). An Introduction to Efficiency and Productivity Analysis. Kluwer Academic Publishers.
- Crain, W. Mark and Zardkoohi, Asghar (1978). A Test of the Property-Rights Theory of the Firm: Water Utilities in the United States. *Journal of Law and Economics* 21: 395-408.
- Estache, Antonio and Rossi, Martín A. (2002). How Different is the Efficiency of Public and Private Water Companies in Asia? *The World Bank Economic Review*, 16 (1): 139-148.
- Estache, Antonio and Trujillo, Lourdes (2003). Efficiency Effects of "Privatization" in Argentina's Water and Sanitation Services. *Working Paper*: World Bank.
- Feigenbaum, S., and R.Teeples. (1983). Public versus Private Water Delivery: A Hedonic Cost Approach. *Review of Economics and Statistics* 65: 672-78.
- Fox, W., and R. Hofler. (1986). Using Homothetic Composed Error Frontiers to Measure Water Utility Efficiency. *Southern Economic Journal* 53(2): 461-77.
- INFUB: Núcleo de Pesquisa em Informações Urbanas da Universidade de São Paulo. 1995. Fundamentos e proposta de ordenamento institucional. Brasília: Ministério das Cidades.
- Pagnoccheschi, B. (2000). A Política Nacional de Recursos Hídricos no cenário da integração das políticas públicas. *In*: MUÑOZ, H.R. (org). Interfaces da gestão de recursos Hídricos - Desafios da Lei de Águas de 1997. Brasília: Ministério do Meio Ambiente/Secretaria dos Recursos Hídricos.

- Saal, David S. and Parker, David (2001). Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales. *Journal of Regulatory Economics*: 20(1): 61-90.
- Tupper, Henrrique S. and Resende, Marcelo (2004). Efficiency and regulatory issues in the Brazilian water and sewage sector: an empirical study. *Utilities Policy* 12 , 12-40.