Cost Efficiency in Periodic Tariff Reviews: The Reference Utility Approach and the Role of Interest Groups ♣

Hamilton C. D. Silva *

This Version: March 2011

Abstract

This paper uses efficiency estimates obtained from both a parametric and a non-parametric benchmarking model to examine the application of the Model Company approach in periodic tariff reviews and check for potential determinants of firms' bargaining power in the rate setting process. The investigation indicates a role for political pressures in driving regulatory decisions, points to a possible inaccuracy of the cost parameters employed in the engineering Model Company method and reveals that the regulator's objectives might not have been welfare maximizing in some situations. The results reveal the influence of more affluent consumers during the rate setting and show that firms which operate in more densely populated areas received substantially lower prices than the economic benchmarking methods would recommend. On the other hand, the findings indicate that significantly higher prices might have been given to companies with the opposite characteristics, to concessionaries which make part of a specific economic group and to firms initially submitted to the review process.

Key words: efficiency, periodic tariff review, reference utility approach, stochastic frontier analysis (SFA), data envelopment analysis (DEA), benchmarking, interest groups.

JEL Classification: D72, L51, L94

1. Introduction

One of the main tasks in the implementation of a price-cap regime resides in the establishment of cost-based prices at the scheduled tariff reviews, where the regulator faces imperfect and asymmetric information regarding firms' cost saving opportunities. A social welfare maximizing regulator would face pressures from customers and utility investors, leading to decisions that are more likely to balance the conflicting interests of powerful stakeholders (so rulings are likely to reflect the political economy of regulation). On the other hand, as price-caps provide incentives for efficiency improvements, at the rate review the regulator's intention to extract

♣This paper was conducted while I was a Research Associate at PURC, Public Utility Research Center, during my time as a PhD student in the Department of Economics at the University of Florida. I am grateful to Sanford Berg, Lawrence Kenny, and Chunrong Ai for their helpful comments and advice. I am also grateful to two anonymous referees and Lawrence White, for their constructive suggestions for revision, which greatly improved the paper.

* Senior Analyst, Tribunal de Contas da União (*Federal Audit Office*), Brazil. Email: hamiltonds @ tcu.gov.br.

part of the firms' rents for the benefit of consumers and society has to be balanced against the objectives of promoting (1) allocative efficiency (prices that reflect minimum incremental costs), (2) financial sustainability (meeting each firm's break-even constraint), and (3) further productivity gains (through strong incentives for cost containment).

The model company (or reference firm) approach, which consists of a bottom-up efficiency study based on the engineering knowledge of the industry process, is a form of yardstick regulation which has been employed to tackle the cost benchmark issue. The present study draws upon the approach's usage in the Brazilian electricity distribution industry first periodic tariff review to investigate whether the methodology has effectively enabled the attainment of the aforementioned regulator's objectives. The method's implied performance scores are compared to those obtained using alternative methodologies—Statistical Frontier Analysis (SFA) and Data Envelopment Analysis (DEA)—, with the focus on the greater discrepancies. The study examines the degree of consistency in efficiency estimates and rankings provided by the two methods, the procedure adopted for firms which experienced the highest—and the lowest—productivity gains in the period before the review, and the possibility that the regulator's decision might have threatened the firms' financial sustainability.

In sequence, the study focuses on the possible causes of the divergences found. The empirical analysis checks for possible problems in the cost parameters employed by the regulator's model and for the influence of interest groups on the regulatory outcomes. It is also examined a potential external monitoring impact on the regulator's decisions.

The findings are consistent with the predictions that political influence affects the level of prices and point to a possible inaccuracy of the cost parameters employed in the engineering Model Company approach. In addition, the study presents evidence that the aforementioned regulator's objectives at the rate review might not have been accomplished in some situations. On the one hand, the results indicate that some firms, mainly the ones operating in more densely populated areas (and possibly those facing stricter local regulatory standards and a greater share of residential customers serviced), received substantially lower tariff adjustments than the economic benchmarking methods would recommend, pointing to a possible violation of firms' break-even constraints. On the other hand, the findings reveal that significantly higher tariffs might have been given to companies with the opposite characteristics, to concessionaries which make part of a specific economic group and to firms initially submitted to the review process. As some of them do not appear in the top ten of the economic benchmarking efficiency rankings, weaker performers seem to be rewarded.

The study's contributions are the following: the investigation adds to the limited literature on the impacts of the use of the model company methodology, and improves upon previous empirical studies which examined the determinants of regulatory decisions, by using an identification strategy which allows a more direct test for the influence of interest groups on the regulatory results. In addition, the paper's findings are relevant for future tariff reviews in Brazil and elsewhere.

The following section describes the regulator's methodology and presents the resulting figures obtained. Section 3 explains the methodology and the data set employed to perform the SFA and the DEA approaches, presents the corresponding results, and explores their use to examine the regulator's decisions taken on the basis of the engineering method. Section 4 describes the econometric model and presents the results. Section 5 concludes.

2. The Model Company Method and its application in the Brazilian Electricity Distribution Industry

In the model company approach, prices are set on the basis of the estimated costs of a hypothetical efficient firm facing the same operating conditions of the concessionary under the review process.[1] As future prices are not linked to realized costs, the method has the merit of

[1] The model company approach has been employed to calculate electricity distribution tariffs in Spain, Sweden, and some Latin-American countries, mainly Chile, Peru, Argentina, El Salvador, and Brazil (Jadresic, 2002).

preserving the efficiency improvement incentives brought by the price-cap regime. Other possible advantages include the control for heterogeneity in operating conditions, the fact that the regulator does not need to base its decisions on cost information provided by firms, and the possibility of aggregation of operating and maintenance expenditures, capital expenditures, quality of service, and network losses in a single model [ANEEL (2003), Galetovic and Bustos (2002), and Jamasb and Pollitt (2007)].

The approach's usage, however, is not fully endorsed in the literature. Weisman (2000) asserts that the estimation of efficient costs is an untenable target, given the existing informational asymmetry between the regulated firm and the regulatory agency, and Gomez-Lobo and Vargas (2001) claim that the method is excessively detailed, time-consuming, resource intensive and contributes negatively to the transparency and objectivity of the regulatory process. Jamasb and Pollitt (2007), on their turn, point that the engineering model cannot reflect the flexibility, dynamism, synergies, and innovation drive of real firms and comparators.

Few studies have assessed the methodology's impacts empirically. Serra (2002), and Fisher and Serra (2002) find that the method's usage led to rate of returns well above the firms' cost of capital, and consider this finding as an indication of a persistent regulatory flaw, Grifell-Tatjé and Lovell (2001) conclude that the engineering model was much less costly to operate than the real companies, but did not have their inputs allocated in a cost-efficient manner, and Jamasb and Söderberg (2009) find that the engineering-designed efficient firms seem to reflect the main network features, demand characteristics, and capital stock of real utilities in Sweden.

2.1. The Brazilian experience

In Brazil, the method was used to estimate efficient operating costs of 61 electricity distribution companies, in the first periodic tariff review that took place from April 2003 to February 2006.

The Brazilian electricity sector regulator (ANEEL) established that the percentage increase which would be applied to firm's tariffs would be given by the ratio of the firm's revenue requirement in the12-month period after the rate review date to the revenue the firm would obtain if tariffs were kept the same. The revenue requirement, on its turn, was defined as the revenue needed to cover efficient operating costs and to provide an adequate return over investments prudently made [ANEEL (2003)].[2]

The methodology employed to come up with the operating costs figures consisted in determining, for each firm, an optimal organizational structure which would allow the concessionary to efficiently fulfill its goal of effectively delivering electricity at the required service quality levels. Thus, efficient operating costs were given by the sum of the costs estimated for administration (ADM), commercialization (COM), and operation and maintenance (O&M) activities performed by a hypothetical efficient firm facing the same operating conditions of the concessionary under exam.

In theory, the efficient operating cost provided by the engineering approach should correspond to the point in the efficient frontier associated to the firm under exam. Thus, if the approach employed effectively enabled the regulator to figure out the firms' efficiency targets, in spite of the information asymmetry, it follows that the methodology at the periodic tariff review determined the firms' one-time adjustment on their operating costs (instead of a progressive path towards the efficient target), a fact that raises concerns over the financial sustainability constraint of those firms which the regulator's approach revealed as the most inefficient.[3]

[2] The return on capital was obtained through the application of a rate of return of 17.07% on a rate base computed under a Depreciated Optimized Replacement Cost (DORC) methodology.

[3] The situation gets worse if the model company resulting figure does not correspond to the firm's efficiency target, and the target is set at a level that is excessively (and unreasonably) high. Given that the cost parameters needed to implement the engineering model are difficult to be precisely estimated, and also subject to firm's misreporting, the estimated efficient operating costs may indeed not match the "true" values, particularly in the present case, where the method and the corresponding parameters employed were used for the first time and not debated in advance with the distribution companies.

2.2. The Model Company Performance Estimates

The analysis of the results provided by the engineering approach was limited by availability of data and by the decision to exclude some very small utilities, which deliver less than 100,000 MWh per year. From the 61 companies subjected to the tariff review process, nine were dropped from the sample due to small size; data for three others were unavailable. Therefore, the sample includes 49 companies, responsible for 99.24% of the total electricity delivered in the country in year 2003.

For each company in the sample, a measure of the regulator's efficiency index (*ANEELEFF*) is computed as the ratio of realized operating costs reported by the concessionary to operating costs estimated for the corresponding hypothetical efficient firm.[4] *ANEELEFF*'s computed values are displayed in Table 1-A, and varies in the wide range of 0.848 to 1.986, with mean 1.202. The fact that the 50% percentile is at 1.180 denotes that the mean has been moved up by a few instances where the estimated efficient operating costs are well below realized costs (highly inefficient firms).

On the other hand, the engineering method resulted in the allocation of some rents to the seven highly efficient companies which had tariff adjustments based on estimated operating costs higher than their realized costs.[5] It is important, therefore, to check whether these firms identified as highly inefficient or highly efficient under this engineering "Model Company" methodology also show up in the worst or best performers grouping of economic benchmarking efficiency rankings.

3. Comparative Efficiency Analysis

In comparative efficiency studies, a firm's efficiency is given by a measure of the distance of the observed practice to the efficient frontier, with the frontier estimation being implemented with either a parametric or a non-parametric technique. The present study makes use of both a parametric

[4] The higher is ANEELEFF from unity, the more inefficient is the firm, under the regulator's model company approach.
[5] According to the regulator's methodology, an allowed risk-adjusted rate of return of 17.07% would be given to firms operating at the model company's efficient operating costs levels. It follows that returns below 17.07% were assigned to all firms whose estimated efficient costs were below their actual costs (*ANEELEFF* >1). On the other hand, returns above the 17.07% standard could be earned by the seven firms whose estimated efficient costs were higher than actual operating costs.

(Stochastic Frontier Analysis – SFA) and a non-parametric (Data Envelopment Analysis – DEA) method to examine the results provided by the engineering approach.[6]

3.1. SFA Model and Data

The SFA model employed here is detailed in Silva (2007). It is based on an unbalanced panel of 52 companies, responsible for 99.47% of the total electricity delivered in the country in year 2003, with the data being collected for the period of 1998 to 2003. The model employs a variable cost specification, reflecting the fact that transformer capacity and network length constitute capital inputs that are fixed in the short run. Environmental variables are included as arguments of the variable cost function, instead of as mean inefficiency parameters, to control for differences in firms' operating conditions. In addition, in light of the rejection of the null hypothesis of homoskedasticity, the variance of the inefficiency error component is conditioned on a proxy of firm size, given by total electricity delivered (*Q*).

The specification adopted is then the following:

$$\begin{aligned}\ln E_{it} &= \beta_0 + \beta_y \ln y_{it} + \sum_n \beta_n \ln w_{nit} + \frac{1}{2}\beta_{yy}(\ln y_{it})^2 + \frac{1}{2}\sum_n\sum_k \beta_{nk} \ln w_{nit} \ln w_{kit} + \sum_n \beta_{yn} \ln y_{it} \ln w_{nit} \\ &+ \beta_c \ln Cap_i + \beta_l \ln Len_i + \sum_j \beta_j \ln Z_{jit} + \beta_t t + \beta_{yt} \ln y_{it} t + \sum_n \beta_{nt} \ln w_{nit} t + \frac{1}{2}\beta_{tt} t^2 + v_{it} + u_{it}\end{aligned} \tag{3}$$

where *E* and *y* are the cost and output measures, respectively, *w* is the vector of factor prices, *Cap* stands for transformer capacity, *Len* represents network length, *Z* is the vector of environmental variables, and it is assumed that $v_{it} \sim N(0, \sigma_v^2)$ and $u_{it} \sim N^+(0, \sigma_{uit}^2)$, with σ_{uit}^2 specified as

$$\sigma_{uit}^2 = \varphi_0 + \varphi_Q Q_{it}$$

The modeling of technical change in the way shown in equation 3 attempts to obtain evidence of technological change over the period considered. For the computation of firms' efficiency indices

[6] The SFA is employed as the primary source for comparison, given that the investigation is conducted in an environment where random shocks were present.

and the consequent analysis of efficiency change, however, the study turns to the use of time-fixed effects, to control for possible changes in macroeconomic factors which might have affected firms' performance during the period under investigation.

The observed technological change (ΔTC) and technical efficiency change (ΔTE) are then combined to provide a more complete picture of the productivity improvements which occurred in the period under examination, through the computation of Malmquist productivity indices. [7] For each firm, the Malmquist index of productivity change between two consecutive periods is given by

$MI_j = \Delta TE_j \cdot \Delta TC_j$, where

$$\Delta TE = -\left\{ \left(\frac{Eff.Index_{j,t+1}}{Eff.Index_{j,t}} \right) - 1 \right\} + 1 \qquad \text{and} \qquad \Delta TC = \left\{ \left(1 + TC_{j,t}\right) \cdot \left(1 + TC_{j,t+1}\right) \right\}^{1/2}$$

The dependent variable is given by the operating costs of distribution and retail service activities (*Opex*), computed as the sum of labor, materials and third party service contracts expenses, as reported in the income statement. Electricity delivered, in MWh (*Q*), is the output measure and average wage, calculated as total labor expenditure divided by the number of employees, is used as a proxy for the price of labor (*LP*). For the prices of materials (*MP*) and third party services (*SP*), the work uses two price indices provided by Brazilian Institute of Statistics (IBGE). The materials' price index reflects the observed change in the price of a basket of items used in civil construction, by state, while the third party service's index portrays the observed change in the salaries paid to an electrician, also by state. The variables *Opex*, *LP*, *MP*, and *SP* are expressed in 1998 values, being deflated by a general price index (IGP-DI).

Transformer capacity is given in MVA, and network length corresponds to the sum of high-voltage and low-voltage lines, in kilometers. The environmental variables incorporated in the modeling are the following: customer density (*CusDen*), given by number of customers divided by

[7] The computation follows the methodology proposed by Coelli, Prasada Rao, and Battese (1998) for stochastic frontier methods, adapted to a cost frontier context.

network length; share of electricity delivered to industrial customers (*IndShare*); residential density (*ResDen*), computed as electricity delivered to residential customers divided by the number of residential customers; service area (*Area*), in Km^2; ratio of underground to overhead lines (*Undergrd*); and income per capita, by state (*Income*), to control for variations in socio-economic conditions among states.[8]

The data were assembled from the regulatory agency, the companies' Web sites, the financial statements provided to the Sao Paulo Stock Exchange, the Brazilian Association of Electricity Distribution Companies (ABRADEE) and IBGE.

3.2. SFA Results and Comparison

Tables 2 and 4 provide the descriptive statistics and the results from the models estimated, respectively. While the difference between minimum and maximum values of observations collected for almost all variables employed indicates the considerable heterogeneity among firms in the sample, the estimated coefficients have the expected sign, with most of them being significant. The time elasticity provides a measure of technological change. The evidence shows that there was technological progress during the sample period, with an annual rate of technological change of around 6.55%, on average, which denotes that the efficient frontier has shifted considerably from 1998 to 2003.

The comparison between the economic benchmarking and the Model Company efficiency indices is limited to the 49 firms included in Table 1. Another restriction comes from the fact that in some cases the indices to be compared do not refer to the same period, since *ANEELEFF* relates to the month/year the tariff review takes place (April/2003 to November/2005) and our SFA estimates

[8] The variables above are included among the most frequently cost driving factors employed to model electricity distribution, according to Jamasb and Pollitt (2001) in their survey of the empirical literature on comparative efficiency analysis.

only go up to 2003. In the analysis that follows, the SFA efficiency indices obtained for year 2003 are used for comparison (*SFA2003*).[9]

The efficiency rankings provided by the SFA and the engineering approaches (Table 1) are not significantly correlated ($\rho = 0.0682$, p-value = 0.6417). The rankings show some consistency in terms of the best performers, as *Enersul*, *Coelce*, *RGE*, and *CAT-LEO* appear in both top ten extracts. Nonetheless, only *Eletropaulo* and *Jaguari* appear in both models in the bottom ten.

SFA efficiency estimates are significantly smaller than *ANEELEFF,*[10] varying in the 1.045 to 1.506 interval but concentrated in the 1.045 to 1.127 (75% percentile) range, with mean 1.110. It follows that the engineering approach has considered firms to be, on average, more inefficient than indicated by the SFA economic benchmarking technique. The result is not unexpected, given that one method centers on an ideal context, while the other draws upon actual practice.

According to the regulator's methodology, *Eletropaulo*, *Light*, and *CEB* are considerably more inefficient than shown by the benchmarking method, as *ANEELEFF* exceeds *SFA2003* by 0.8305, 0.7604, and 0.6312, respectively. *Eletropaulo* and *Light*, however, were the two firms with the highest productivity improvements in the 1998-2003 period[11] and, according to SFA, were not distant from the average performance of other firms, which raises serious concerns over their obligation to perform such profound further adjustments[12] and points to the existence of flaws in the application of the engineering approach. One possibility is underscored by the present study: the results suggest that the regulator's method might have been biased against firms which operate in

[9] The adopted procedure might introduce distortions to assessments based on reviews that occurred in late 2004 and in 2005, if the firm performs rather differently than the others in the period after December/2003. The possible distortions, however, should not be relevant in the context of the present study, as the comparison of efficiency indices focuses on the larger discrepancies in the two methods' results.
[10] The null of equality of means is rejected at the 1% significance level (p-value (H_1: ANEELEFF > SFA2003) = .0007).
[11] The computed Malmquist measures of productivity change indicate that the Brazilian electricity distribution industry's productivity increased 38.5%, on average, from 1998 to 2003. The estimates for Eletropaulo and Light were 114.45% and 90.02%, respectively.
[12] As indicated by the Model Company efficiency index (1.986), Eletropaulo would have to further reduce its operating expenditures by almost 50% to be able to reap the allowed risk-adjusted rate of return (17.07%).

more densely populated areas, since five firms, from the ten which had the highest positive difference between *ANEELEFF* and *SFA2003*, belong to the top ten customer density extract. [13]

The major situations where the implementation of the model company methodology resulted in firms being considered more efficient than portrayed by SFA were the cases of *Celesc*, *Coelba*, and the seven firms which had *ANEELEFF* below one (*Energipe, Enersul, Coelce, Cemat, Cemig, Santa Maria* and *Cat-Leo*). The benefit of securing a higher rate of return over their asset base, given to these nine firms,[14] would only be acceptable if they indeed figured in the group of best performers and had experienced high productivity improvements in the first regulatory period, since in this case the regulator would be allowing them to keep part of the efficiency gains as an incentive for further productivity increments.

Only *Cat-Leo*, *Enersul* and *Coelce*, however, show up in the SFA top ten segment. In the case of the other six firms, the SFA results indicate that the benefit given was probably unjustified and harmed customers through higher tariffs. The *Cemig*´s case is emblematic. In spite of the considerable productivity increments in the 1998-2003 period,[15] the firm still figured as the worst performer according to *SFA2003*. The fact that the engineering methodology shows the firm operating rather more efficiently (*ANEELEFF* is smaller than *SFA2003* by 0.5522) suggests the possibility of a differentiated treatment to publicly owned firms, [16] evaluated in section 4.

3.3. DEA Model and Results

The same dataset is employed to investigate firms' efficiency levels and their evolution over time using a DEA technique. Here, the main concern was to use a specification which could control for exogenous features of the operating environment and be comparable to the previous parametric

[13] This observation is consistent with Peano's (2005) finding. The author identified that the difference between the model company's OPEX and the actual OPEX of 12 firms submitted to tariff review in year 2003 was inversely related to firm's customer density.
[14] See footnote 5.
[15] Cemig's computed Malmquist measure of productivity change corresponded to 59.16%.
[16] Other publicly owned firms (*Celesc*, *Celg*, *CEEE*, and *Copel*) also appear in the *SFA2003* worst performers' group but occupy considerably better positions in the Model Company ranking.

modeling. The option was for the use of the approach proposed by Fried, Schmidt, and Yaisawarng (1999), based on a four-stage procedure to obtain measures of managerial inefficiency separated from the influence of external operating conditions.

The first stage involves the calculation of an input-oriented DEA frontier under variable returns to scale (VRS), using electricity delivered (*Q*) as the output, and *Opex*, *Cap*, and *Len* as inputs. Specific DEA frontiers are computed for each year in the sample. The procedure provides measures of the relative efficiency of each firm in each period by reference to yearly-specific frontiers, as well as information on input slacks and output surpluses of each observation. The efficiency scores obtained at this stage, however, do not account for differences in the operating environment across production units.

In a second stage, total input slacks are computed as the sum of radial plus non-radial input slacks of each observation, and expressed as percentages of input quantities, as total slacks may depend upon external environment as well as unit size. The resulting total input slacks measures are then regressed on the six environmental variables previously mentioned (*CusDen, IndShare, ResDen, Area, Undergrd,* and *Income*), with the purpose of identifying the effect of external conditions on the excessive use of inputs. Given that input slacks are censored at zero by definition, three tobit regressions (one for each input) are estimated separately. More formally:

$$TIS_j^k = f_j(Q_j^k, \beta_j, u_j^k), \qquad j = 1, \ldots, N; \qquad k = 1, \ldots, K$$

where TIS_j^k is unit *k*'s total radial plus non-radial slack for input *j* based on the DEA results from stage 1, expressed as a percentage of actual input *j* quantity, Q_j^k is the vector of variables characterizing the operating environment for unit *k* that may affect the utilization of input *j* , β_j is a vector of coefficients, and u_j^k is a disturbance term.

In a third stage, the regressions' estimated coefficients are used to predict total input slack for each input and for each unit based on its external variables. The predicted values represent the "allowable" slack, due to the operating environment.

$$\hat{TIS}_j^k = f_j(Q_j^k, \hat{\beta}_j) \qquad j = 1, \dots, N; \qquad k = 1, \dots, K$$

These predictions, in turn, are employed to adjust the primary input data for each unity according to the difference between maximum predicted slack and predicted slack, under the rationale of establishing a base equal to the least favorable set of external conditions.

$$x_j^{k\,adj} = x_j^k * \left[1 + \left(Max^k \left\{\hat{TIS}_j^k\right\} - \hat{TIS}_j^k\right)\right]$$

In the final stage, the adjusted input variables are employed to re-run the initial input-oriented DEA VRS model, and generate efficiency scores for each firm in each period net of factors out of management control. In line with the procedure adopted before, the DEA efficiency measures obtained for year 2003 (*DEA2003*) are used for comparison to the SFA and Model Company results.

DEA efficiency estimates are significantly higher than *SFA2003*,[17] varying in the range of 1 to 2.38, with mean 1.28 (Table 1). This fact, taken together with the evidenced similarity between *DEA2003* and *ANEELEFF* distributions,[18] suggests that the following factors might have occurred: some inefficiency is attributed to statistical noise in the SFA approach; the SFA efficiency indices are constrained by the half-normal distribution assumed for the inefficiency error term; or eventual random shocks' effects were considered as inefficiencies in the DEA method. On the other hand, even though *DEA2003* and *SFA2003* efficiency measures and rankings are not significantly

[17] The null of equality of means is rejected at the 1% significance level (p-value (H_1: *DEA2003* > *SFA2003*) = .0001). When the equality of *DEA2003* and *ANEELEFF* means is tested, however, the null is not rejected.
[18] Data on the respective mean and standard deviation are provided in Table 1. The difference in means is not statistically significant, as mentioned in the previous note, but *DEA2003's* distribution of efficiency indices is slightly more spread out than *ANEELEFF's*.

correlated,[19] there is some consistency in terms of best and worst performers. Five firms appear in both top ten extracts, and four firms in both bottom ten (Table 1).

The comparison between *DEA2003* and *ANEELEFF* corroborates the indication that the Model Company approach overstated some firms' efficiency indices. Similarly to what was found in the comparison to *SFA2003*, *ANEELEFF* of firms *Eletropaulo*, *Light*, *CEB*, *Eletroacre*, *Eletrocar, Piratininga*, *Boavista*, and *CPFL* are considerably higher than *DEA2003* in absolute terms. Additionally, some of the previously mentioned cases of undervaluation of firms' efficiency measures are confirmed as well, as the model company efficiency indices of firms *Enersul*, *Energipe*, *Cemig*, *Coelce*, *Celesc*, *Coelba*, and *Cat-Leo* are well below both *SFA2003* and *DEA2003*. On this respect, the DEA findings provide additional support to the indication that the benefit given to *Energipe*, *Celesc*, and *Coelba* was unjustified, since these firms do not belong to the DEA top ten segment either. As some of these firms make part of a same economic group, the analysis that follows examines the possibility of a consistent and differentiated treatment given to specific producers.

4. Econometric Modeling

For each firm, the variable *ANEELvsSFA*, computed as the ratio of *ANEELEFF* to *SFA2003*, expresses the divergence in the results provide by the two methods. *ANEELvsSFA* varies in the range of 0.633 to 1.719, with mean 1.087. Similarly, the variable *ANEELvsDEA* denotes the divergence in efficiency assessments performed by the engineering and the DEA approaches. *ANEELvsDEA* varies in the wider range of 0.459 to 1.986, with mean 0.986, and is significantly (1% level) correlated with the preceding divergence measure ($\rho = 0.7743$).

Note that a ratio *ANEELvsSFA* greater than one means that the firm was considered more inefficient under the regulator's Model Company approach, when compared to the SFA standard. If

[19] The correlation statistic and the Spearman's rank correlation amount to -0.0579 (p=.6927) and -0.0751 (p=.5966), respectively.

it is assumed that the SFA results are a good representation of the true values,[20] it follows that the firm was harmed by getting a lower tariff adjustment at the rate review. Conversely, when the ratio is smaller than one (*ANEELEFF< SFA2003*), the result suggests that the regulator's efficiency index was lower than it should be, and the firm, consequently, was benefited by getting prices higher than recommended by the SFA standard.[21]

Differences in the results provided by the Model Company and economic benchmarking approaches are expected, as the engineering model does not account for substitution possibilities. Here, though, the analysis concentrates on some other possible causes of the observed divergence between the two indicators.

The investigation follows the line of previous empirical studies which focused on the determinants of regulatory outcomes[22] and assumes the existence of a principal-agent relationship between the Congress (or the Government) and their delegated "representatives" in regulatory agencies. In this system, interest groups can influence regulatory outcomes.[23] In addition, information asymmetries raise the possibility that the parameters employed to estimate the efficient costs do not satisfactorily capture the effect of some cost drivers on firms' actual expenditures, and affords the regulator some discretion to make choices that maximize its utility.[24]

---

[20] This assumption draws upon the soundness of the parametric model employed, which controls for heterogeneity in operating conditions, influence of macroeconomic factors, and random shocks. The rationale is that minor differences in efficiency assessments might be due to eventual SFA inconsistencies, but bigger divergences should be accounted to problems in the application of the engineering approach, mainly when they are confirmed with the use of an alternative methodology as the comparison parameter.

[21] The interpretation of *ANEELvsSFA* values might be further explored. Since *ANEELEFF* is computed as a ratio (realized operating costs to engineering estimated operating costs) where the numerator is given, this measure of efficiency will be understated when its denominator is overestimated, and vice-versa. Thus, when *ANEELEFF* is smaller than *SFA2003* (*ANEELvsSFA* < 1), it means that the Model Company's operating costs are overestimated, according to the SFA standard.

[22] Nelson (1982), Nelson and Roberts (1989), Delorme, Kamerschen, and Thompson (1992), Kaserman, Mayo, and Pacey (1993), Dion, Lanoie, and Laplante (1998), Klein and Sweeney (1999), Tanguay, Lanoie, and Moreau (2004), and Knittel (2006), among others.

[23] This framework draws upon the contributions of Stigler (1971) and Peltzman (1976), which form the basis of the economic theory of regulation. In essence, the authors posit that stakeholders face costs of organization and information, and regulators are self-interest maximizers which allocate benefits across interest groups optimally, attempting to equate political support and opposition at the margin.

[24] The tariff review process presented two main opportunities for the regulator to exercise its judgment, possibly reflecting the influence of the industry and its customers: in the definition of the model company cost parameters and right after the announcement of the efficient operating cost initial estimates, when deciding upon the acceptance or rejection of firms' revision claims.

The statistical tests are conducted through two complementary procedures: (a) an OLS regression of the divergence variable on proxies for the explanatory factors mentioned above; and (b) an examination of the possible determinants of the regulator's adjustments in the OPEX estimate made during the rate setting, a more direct test for the influence of interest groups on the regulatory results. In this case, the investigation employs the disclosed information regarding the initial OPEX estimated via the Model Company engineering model and the final (adjusted) OPEX to compute a measure of firm's bargaining power, which is then regressed on the political variables (and some other possible explanatory factors). These procedures are detailed below.

4.1. Specification and Data

A measure of firm's bargaining power (*BARGPW*) can be expressed by the adjustments made by the regulator in the initial OPEX estimated with the application of the engineering model (*ENGOPEX*), or, in other words, by the percentage change in *ENGOPEX* obtained by the firm during the rate review. *BARGPW*, therefore, is computed as (*FINOPEX-ENGOPEX*)/*ENGOPEX*, where *FINOPEX* stands for the final operating costs defined by the regulatory agency.

As the dependent variable is a fraction between zero and one, the estimation follows the procedure suggested by Papke and Wooldridge (1996) and employs a generalized linear model (GLM), estimated by the maximum likelihood method, assuming a binomial distribution for *W* and a logit link function. The modeling includes, as independent variables, proxies for the potential influence of interest groups, factors related to possible problems identified in the application of the engineering model, and proxies for a potential impact caused by both the external monitoring of the regulator's activities and a likely learning effect. Moreover, the investigation makes use of the disclosed information regarding the firm's reported OPEX (*REPOPEX*) to check whether the discrepancy between this measure and the initially estimated OPEX has contributed to increase the firm's bargaining power.[25]

Except for the last one, the same independent variables are used in the OLS regressions. In this case, though, some other features are explored. An additional variable is included to control for a possible problem resulting from the labor price measure used in the SFA procedure, and the initial OPEX estimated with the application of the engineering model is employed to compute new divergence measures (*ENGvsSFA* and *ENGvsDEA*), given by the ratio of *ENGEFF* (calculated as REPOPEX/ENGOPEX)[26] to the efficiency estimates provided by the economic benchmarking approaches. The use of these new dependent variables improves the analysis by allowing an additional check at the moment before the OPEX adjustments made during the rate review.

The explanatory variables are the following:

a) income per capita (***INCOME***), and share of electricity delivered to industrial customers (***INDSHARE***), proxies for the consumer's participation in the regulatory process. It is hypothesized that low-income residential customers should exert a higher opposition to a price increase, when compared to high-income customers.[27] For *INDSHARE*, however, an opposite effect is expected, since a rise in the share of electricity delivered to industrial customers should similarly lead to more opposition to high prices, as the industry has a greater stake in lobbying for lower electricity prices than residential or commercial customers.

b) the log of total electricity delivered, in GWh (***SIZE***), a proxy for the producer's lobby, under the rationale that larger companies should possess greater ability to influence regulatory

---

[25] Given the context of incomplete and imperfect information, the investigation also examined whether the regulator, in the absence of the information necessary to promote the desired distribution of productivity gains among stakeholders, might have employed some of the available data as signals for firms' profitability and cash flow availability. Both the output growth from 1998 to 2003 (under the hypothesis that the regulator might have wanted to pass on to consumers some of the rents derived from economies of scale) and the percentage growth in residential consumption per capita in the same period (a proxy for firm's losses due to the energy rationing in years 2001 and 2002, under the hypothesis that the least affected firms might have had relatively low price increases) were included in the modeling, but neither of these variables showed significance in any of the formulations tested.

[26] *ENGEFF* might be considered the "true" efficiency measure computed by the engineering method, before subsequent adjustments made by the regulator.

[27] Since the income elasticity for electricity is less than one, poor families spend a greater share of their income on electricity and thus have a greater incentive to oppose high prices, assuming the time cost of political participation is proportional to income.

decisions. The expected effect of firm size, however, is indeterminate, as large utilities are more likely to receive careful scrutiny from the regulatory agency [Klein and Sweeney (1999)].

c) a dummy variable to express the allegiance of the political leader in the company's region (***PARTY***)[28] and the percentage of deputies in the company's state aligned to the President's party (***DEPUT***), measures of the political party in power in the company's region. It is expected that tariffs vary inversely with government's alignment. Consequently, both variables should be negatively associated to *BARGPW*, and positively associated to the divergence measures.

d) the index of service provision (***UNIVSERV***), computed as the ratio of consumer units serviced to the total number of consumer units in the company's service area. As the regulatory decision could endanger the long-standing policy objective of universal service, it is conjectured that firms with low *UNIVSERV* might have had higher bargaining power and benefited with higher tariffs than recommended by the economic benchmarking comparators.

e) economic group's dummies (***CPFL***, ***REDE***, ***ENERGISA***, ***ELETROBRAS***), to test whether there was a consistent and differentiated treatment to concessionaries which belong to a same economic group, with indeterminate expected effect.

f) customer density (***CUSDEN***), given by the log of the number of customers divided by service area, and a public company dummy (***PUBLIC***), included in light of the points made earlier: the Model Company's results might have been biased against firms which operated in more densely populated areas, and may possibly have favored publicly owned firms.

g) percentage of underground lines (***UNDERGRD***), used as a proxy for differences in regulatory standards faced by the concessionaries. Under the assumption that these differences were not captured by the regulator's engineering method, the variable should be positively related to the divergence measures.

[28] The Governor was considered the political leader in the 34 "state level" companies (the ones which provide service to more than 25 cities in the State and to more than 200.000 consumer units). For the remaining 15 firms, the political leader corresponded to the Mayor of the main city (the one where the firm's main office is located) in the company's service area.

h) a categorical variable indicating whether or not the Tribunal de Contas da Uniao has monitored the tariff review process (***TCU***).[29] This study examines whether this external monitoring has produced an effect on regulator's decisions, with the intention to possibly contribute to the literature that focuses on the optimal institutional regulatory framework. The supervision's expected effect is indeterminate, though.[30]

i) the number of rate reviews occurring before the firm's review (***LEARNING***). Here, it is conjectured that differences in firms' bargaining power (and the divergences in efficiency assessments) might have resulted from improvements in the employed engineering cost parameters as more rate reviews were carried out or, alternatively, from the fact that the regulator's confidence on the engineering efficiency estimates increased with the practice in applying the new methodology.[31] *LEARNING* should then be inversely related to *BARGPW*.

j) the percentage difference between the reported and the initially estimated OPEX (***OVERREPOPEX***), computed as (*REPOPEX-ESTOPEX*)/*ESTOPEX*. It is hypothesized that the probability of firms' revision requests be accepted by the regulator increases with the difference between estimated and reported costs, given the regulator's concern with the company's long-term sustainability constraint. The variable, therefore, should have a positive effect on *BARGPW*.

k) the ratio of SFA labor price to Model Company labor price (***LPDIFF***), incorporated in the (SFA) OLS regression to check whether the divergences in results are related to the fact that the SFA labor price was computed on the basis of firms' actual salaries and benefits paid, not accounting for possible inefficiencies brought by the payment of values above the market price. The higher the computed variable, the higher should be the upward bias in the SFA firm's efficiency.

[29] TCU is an independent organ of the state, which assists in the external control that the Congress possesses over the whole public administration. The agency exercises an oversight over the regulatory agencies and has examined both the procedures and substance of regulatory decisions.

[30] TCU closely monitored only some of the periodic tariff review processes. The regulator knew in advance the processes which would be monitored. Thus, one might conjecture that the monitoring reduces the regulator's discretion and leads to figures closer to the ones portrayed by SFA. However, it is also possible that the external monitoring has made the regulator exercise a higher scrutiny in the monitored cases, resulting in lower bargaining power and lower estimates of efficient operational costs (higher *ANEELvsSFA*).

[31] In case, the regulator would be more susceptible to accept firms' revision claims in the first reviews than in the last ones.

The data were assembled from the same sources employed to perform the SFA study. Summary statistics are shown in Table 3. The TCU monitoring occurred in 12 out of the 49 cases examined, 15 of the companies included in the sample are publicly owned, and the computed *BARGPW* varies in the interval of 0.0007 to 0.2835, with mean 0.0935.

4.2. Results Analysis

In light of the small sample, and the need to preserve valuable degrees of freedom, tests of significance were performed to guide the decision regarding the inclusion or exclusion of factors.[32] The final GLM and OLS models, as well as their corresponding results, are portrayed in Table 5.

The GLM procedure indicates that the residential consumers' participation in the regulatory process, the firm's order in the tariff review and the difference between reported and estimated operating costs were among the main determinants of the regulator's adjustments in the OPEX estimate made during the rate setting. Additionally, the results show that the six Eletrobras' distribution companies had significantly lower bargaining power than the other firms in the sample, possibly reflecting two facets of state-owned firms' managers: lower incentives to argue for cash flow enhancing regulatory decisions and greater political pressure to keep prices down [Berg, Lin and Tsaplin (2005)].

The *INCOME* result reveals that companies which serve more wealthy customers had lower bargaining power in the tariff setting. The evidence is contrary to the previously mentioned prediction based on the interest group theory, and is consistent with the association between wealth per capita and the degree of residential interest group activity suggested by Knittel (2006).[33]

The *LEARNING* coefficient, on its turn, shows that the first companies that went through the rate setting experienced higher changes in their initial OPEX estimates, suggesting either

[32] The likelihood ratio tests did not support the inclusion of *LEADCOAL*, *DEPCOAL*, *UNISERV*, *CPFL*, *REDE*, and *LPDIFF*, in any of the models tested.
[33] The variable should be capturing the high discrepancy in the residential customers' (average) education levels across the different regions in Brazil, under the rationale that more educated customers face lower costs to become informed and participate in the tariff review process.

continuous improvements in the employed engineering cost parameters or a less rigorous regulator's position at the first rate-making processes (we will return to this point later), whereas the observed *OVERREPOPEX*'s significance denotes that uncertainties about firms' inherent cost opportunities has made the regulator employ the divergence between estimated and reported costs as an indication of possible imperfections in the engineering cost estimates. This finding points to potential benefits secured by firms which strategically inflated their costs near the periodic tariff review.[34] However, it is not possible, in the present study, to ascertain whether the observed divergence between estimated and reported costs is due to overstated costs or not.

The statistics provided by the SFA and the DEA regressions show that the SFA fitted model is better specified than the DEA (higher R^2).[35] The results uncover two main explanatory factors for the divergences in efficiency assessments provided by the Model Company and economic benchmarking approaches. On the one hand, the anticipated impact of customer density on the regulator's efficiency estimates is confirmed, indicating that the more densely populated the service area, the more harmed was the firm by receiving a tariff adjustment lower than the economic benchmarking procedures would recommend.[36] The evidence, in case, suggests a technical problem in the definition of the cost parameters employed in the engineering model, which understated the costs incurred by firms operating under this condition, or a deliberate intention to avoid compensating investors in utilities operating in regions of higher consumer concentration and to provide an extra return to firms serving less densely populated areas [Peano (2005)].

On the other hand, concessionaries which belong to the Energisa group were considered more efficient under the regulator's approach and consequently received higher tariffs than recommended

---

[34] This type of regulation game, associated with the periodic aspect of incentive-based regulation, is known to regulators and was reported in the survey conducted by Jamasb, Nillesen, and Pollitt (2003).

[35] In both models, the Shapiro-Wilk test does not reject the null of normally distributed residuals (even at the 10% level) and the variance inflation factor does not suggest the presence of multicollinearity.

[36] The estimated impact is nontrivial. According to the computed standardized beta coefficients, the *CUSDEN*'s change from the variable's mean value to a value equal to the mean plus or minus one standard deviation shifts the *ANEELvsSFA* and the ANEELvsDEA predicted values by 0.083 and 0.125 points, respectively (7.6% and 12.7% of their means).

by both the SFA and the DEA standards,[37] a finding that points to the conclusion that the Energisa group, as a producer, exerted a more efficient lobby and showed a greater ability to influence regulatory decisions than the other distribution utilities.[38]

Other factors revealed strong significance in explaining the divergences between the Model Company and the SFA efficiency measures. Despite not being corroborated by the DEA robustness check, the results should be taken as an indication of a possible impact of these factors in the rate review under examination, given the soundness of the SFA method employed. The evidence suggests that the regulator's efficiency assessments favored publicly owned firms and did not fully consider the specificities of local regulatory standards faced by the concessionaries, as shown by the negative *UNDERGRD* coefficient. Moreover, the results indicate that the firms' order in the periodic tariff review had implications for regulatory decisions (and thus for the financial well-being of companies). The positive *LEARNING* coefficient, examined in conjunction with the variable's results in the GLM and the ENGvsSFA models, [39] denotes that earlier-reviewed firms benefited from prices higher than recommended by the SFA method, probably by virtue of the hypothesized more lenient regulator´s position in the first applications of the model company approach. Conversely, later-reviewed firms got lower price increases, as a result of more stringent engineering cost parameters and a stricter regulator's analysis of their revision claims.

The SFA investigation also revealed a significant *INDSHARE*'s negative coefficient. The result implies that industrial users may have been harmed with higher prices and is contrary to the prediction resulting from the interest group theory. In order to examine whether this unexpected

[37] The results are expressive, as they indicate that Energisa companies' divergence measures were 0.17 points (in the SFA comparison) and 0.23 points (in the DEA) smaller than the mean divergence observed for the other companies (the fitted models yielded predicted values of 1.087 and 0.986, for *ANEELvsSFA* and *ANEELvsDEA*, respectively).
[38] The discrepancy in efficiency assessment results from distortions in the model company cost parameters, and not from adjustments made in the initial OPEX estimates during the rate review processes, as evidenced by the results provided by the GLM (where the variable is not significant) and the *ENGEFF* fitted models (Table 5).
[39] The positive and marginally significant *LEARNING* coefficient in the *ENGvsSFA* model goes against the previously hypothesized continuous improvements in the employed engineering cost parameters through time. Moreover, the variable turns out to be strongly significant in the *ANEELvsSFA* formulation as a result of the higher changes in initial OPEX estimates experienced by the first companies that went through the rate setting.

finding could be explained by the highly negative *INDSHARE*'s correlation with the share of electricity delivered to residential customers – ***RESSHARE*** (ρ = -.8614), new regressions were performed using this new variable in place of the former one. The outcomes are portrayed in Table 6 and show that the substitution improves the GLM (higher χ^2) and the SFA fitted models (higher R^2). The positive and significant (at the 1% level) *RESSHARE* coefficient may have either a technical or a political origin. The engineering cost parameters might not have fully captured the higher metering and billing costs associated with a greater share of residential customers serviced or there might have been a deliberate intention to exchange favorable price concessions for residential customers' political support [Delorme, Kamerschen, and Thompson (1992)].

A final note should be made regarding the TCU monitoring results. Although the regulator knew in advance which reviews would be closely monitored, the evidence indicates that supervision did not affect the types of decisions in a systematic way, suggesting that ANEEL was consistent, regardless of specific oversight. This finding is important, as it corroborates the view that the TCU's supervision of the regulator's activities does not increase firms' regulatory risk.

6. Concluding Observations

Despite the criticisms made to its subjectivity and complexity, the Model Company approach has become increasingly popular for the determination of electricity distribution tariffs in Latin America. It is therefore important to verify whether the methodology has both provided an opportunity for firms to meet their break-even constraints and enabled the attainment of a welfare maximizing regulator's rate setting objectives.

However, regulatory decisions are made by a regulator operating under information asymmetries, facing the influence of interest groups and, in the specific case examined here, subject to direct supervision of its actions. Thus, the analysis of regulatory outcomes addresses the possible impact of these factors, in addition to the effects of the methodology employed.

The investigation reveals that the regulator's objectives might not have been welfare maximizing in some situations. On the one hand, some firms were considered to be rather more inefficient than shown by both SFA and DEA models, resulting in substantially lower price increases: this result raises concerns over the companies' long-term financial sustainability. On the other hand, the results point to the existence of firms which the regulator's method considered to be much more efficient than suggested by the two widely-used benchmarking methodologies.

The study provides new findings on possible causes for these divergences in the context of a particular regulatory system. The results point to a possible inaccuracy of the cost parameters employed in the engineering Model Company approach; the parameters may have imprecisely captured the effect of consumers' dispersion on firms' operating costs, the specificities of local regulatory standards faced by the concessionaries and the higher metering and billing costs associated with a greater share of residential customers serviced. Moreover, the evidence supports the prediction that political influence affects the level of prices. A specific producer demonstrated a greater ability to influence regulatory decisions, more affluent consumers showed higher bargaining power during the rate setting, there is indication of a favorable treatment to publicly owned firms and the results signal a possible deliberate intention not only to avoid compensating investors in utilities operating in areas of higher consumer concentration (and to provide extra returns to firms working in less densely populated areas), but also to exchange favorable price concessions for residential customers' political support. Additionally, the findings suggest that the regulator employed the divergence between estimated and reported costs as an indication of possible imperfections in the engineering cost estimates, and that earlier-reviewed firms benefited from a less rigorous regulator's position in the first applications of the model company method.

The benefit given to some firms at the beginning of the tariff review cycle impacted negatively the incentives for efficiency improvements provided to companies which do not appear in the top ten segments of SFA and DEA efficiency ranking. The same disincentive was received by four of the top five firms in the SFA ranking, which could not keep part of the rents brought by their productivity improvements. In sum, the regulator's methodology imposed on firms a one-time adjustment to the virtual company's efficient operating costs, which in some cases were rather different than the ones estimated by the benchmarking methods.

Interestingly, the findings do not provide support to the hypothesis that the monitoring of the regulator's activities may lead to decisions contrary to firms' interests and increase firms' regulatory risk, one of the possible effects of having an institution supervise the regulator's job. Regulator's decisions were not affected in a systematic way by special oversight. Despite its specificity, the result adds to the literature on the optimal regulatory framework design.

References

ANEEL (2003), "Metodologia e Cálculo da "Empresa de Referência" relativa à área de concessão da AES SUL", Nota Técnica Nº 047/2003/SRE/ANEEL, Anexo I.

Berg, S., C.Lin, and V. Tsaplin (2005), "Regulation of State-Owned and Privatized Utilities: Ukraine Electricity Distribution Company Performance", *Journal of Regulatory Economics*, 28, 259-287.

Coelli, T., D. Prasada Rao, and G. Battese (1998), *An Introduction to Efficiency and Productivity Analysis*. Boston, MA: Kluwer Academic Publishers.

Delorme, C.D., D.R. Kamerschen, and H.G. Thompson (1992), "Pricing in the nuclear industry: Public or private interest?", *Public Choice*, 73, 385-396.

Dion, C., P. Lanoie, and B. Laplante (1998), "Monitoring of pollution regulation: Do local conditions matter?", *Journal of Regulatory Economics*, 13, 5-18.

Fisher, R. and P. Serra (2002), "Evaluación de la regulación e las telecomunicaciones em Chile", *Perspectivas*, 6 (1), 45-78.

Fried, H.O., S.S. Schmidt and S. Yaisawarng (1999), "Incorporating the Operating Environment Into a Nonparametric Measure of Technical Efficiency", *Journal of Productivity Analysis*, 12, 249-267.

Galetovic, A. and A. Bustos (2002), "Regulación pro empresa eficiente: ¿quién es realmente usted?", *Estudios Públicos*, 86, 145-182.

Gomez-Lobo, A. and M. Vargas (2001), "La regulación de las empresas sanitarias en Chile: una revisión del caso de EMOS y una propuesta de reforma regulatoria", Documento de Trabajo N 177, Departamento de Economía, Universidad de Chile.

Grifell-Tatjé, E. and C.A.K. Lovell (2003), "The Managers versus the Consultants", *Scandinavian Journal of Economics*, 105, 119-138.

Jadresic, A. (2002), "The Model Company Approach for Tariff Regulation in Electricity Distribution", Report, The World Bank.

Jamasb, T., P. Nillesen, and M. G. Pollitt (2003). "Gaming the Regulator: A Survey". *The Electricity Journal* 16, 68-80.

Jamasb, T. and M. G. Pollitt (2001), "Benchmarking and Regulation: International Electricity Experience", *Utilities Policy* 9, 107-130.

Jamasb, T. and M. G. Pollitt (2007), "Reference Models and Incentive Regulation of Electricity Distribution Networks: An Evaluation of Sweden's Network Performance Assessment Model (NPAM)", Cambridge Working Papers in Economics 0747.

Jamasb, T. and M.Söderberg (2009), "Yardstick and Ex-Post Utility Regulation by Norm Model: Empirical Equivalence, Pricing Effect, and Performance in Sweden", Cambridge Working Papers in Economics 0908.

Kaserman, D.L., J.W. Mayo, and P.L. Pacey (1993), "The political economy of deregulation: The case of instrastate long distance", *Journal of Regulatory Economics*, 5, 49-63.

Klein, C.C. and G. H. Sweeney (1999), "Regulator preferences and utility prices: evidence from natural gas distribution utilities", *Energy Economics*, 21, 1-15.

Knittel, C.R. (2006), "The Adoption of State Electricity Regulation: The Role of Interest Groups", *The Journal of Industrial Economics*, 54(2), 201-222.

Nelson, R.A. (1982), "An empirical test of the Ramsey theory and Stigler-Peltzman theory of public utility regulation", *Economic Inquiry*, 20, 277-290.

Nelson, J.P. and M.J. Roberts (1989), "Ramsey numbers and the role of competing interest groups in electric utility regulation", *Quarterly Review of Economics and Business*, 29, 21-42.

Papke, L.E., & Wooldrige, J. (1996), "Econometric methods for fractional response variables with an application to 401(k) plan participation rates", *Journal of Applied Econometrics* 11, 619-632.

Peano, C.R. (2005), "Regulacão Tarifária do Setor de Distribuição de Energia Elétrica no Brasil: Uma Análise da Metodologia de Revisão Tarifária Adotada pela Aneel", Dissertação de Mestrado, Universidade de São Paulo.

Peltzman, S. (1976), "Toward a More General Theory of Regulation", *Journal of Law and Economics*, 19, 211-40.

Serra, P. (2002), "Regulación del sector eléctrico chileno", Perspectivas, 6, 11-43.

Silva, H.C.D. (2007), "Privatization, Incentive Regulation, and Efficiency Improvements in the Brazilian Electricity Distribution Industry", in *Empirical Essays in the Economics of Regulation*, Ph.D Dissertation, University of Florida.

Stigler, G.J. (1971), "The Theory of Economic Regulation", *Bell Journal of Economics and Management Science*, 3-21.

Tanguay, G.A., P. Lanoie, and J. Moreau (2004), "Environmental policy, public interest and political market", *Public Choice*, 120, 1-27.

Weisman, D. (2000), "The (in)efficiency of the "efficient-firm" cost standard", *The Antitrust Bulletin*, Spring, 195-211.

Table 1. Efficiency Rankings and Indices

Ranking	***A*** *ANEELEFF*[1]		***B*** *SFA2003*		***C*** *DEA2003*	
	Company	**Eff. Index**	**Company**	**Eff. Index**	**Company**	**Eff. Index**
1	ENERGIPE	0.848	RGE	1.045	AES-SUL	1.000
2	ENERSUL	0.871	CAT-LEO	1.057	CEMIG	1.000
3	COELCE	0.920	CELB	1.059	COELCE	1.000
4	CEMAT	0.949	ELETROACRE	1.060	CPFL	1.000
5	CEMIG	0.954	ELN/AM (MANAUS)	1.062	ELETROPAULO	1.000
6	SANTA MARIA	0.976	ENERSUL	1.065	ELN/AM (MANAUS)	1.000
7	CAT-LEO	0.998	COELCE	1.068	LIGHT	1.000
8	COELBA	1.013	COSERN	1.069	PIRATININGA	1.000
9	RGE	1.022	LIGHT	1.069	RGE	1.000
10	CERON	1.063	CEAL	1.070	ELETROACRE	1.000
11	CFLO	1.069	CEMAR	1.072	ELETROCAR	1.000
12	CELB	1.092	CENF	1.072	JAGUARI	1.000
13	XANXERÊ	1.106	ESCELSA	1.074	DMEPC	1.024
14	ELETROACRE	1.108	BANDEIRANTE	1.074	MOCOCA	1.073
15	SANTA CRUZ	1.109	CSPE	1.077	BANDEIRANTE	1.096
16	CENF	1.122	BOA VISTA	1.080	XANXERÊ	1.116
17	DMEPC	1.124	PIRATININGA	1.081	CELB	1.120
18	SAELPA	1.125	ELEKTRO	1.082	CFLO	1.138
19	CEEE	1.130	MOCOCA	1.083	COSERN	1.144
20	COPEL	1.135	COELBA	1.084	CELPA	1.153
21	CEPISA	1.136	SANTA CRUZ	1.088	CELESC	1.170
22	CELTINS	1.149	ELETROCAR	1.090	NACIONAL	1.171
23	CELPA	1.154	CELPE	1.090	ELEKTRO	1.183
24	ELN/AM (MANAUS)	1.165	CPFL	1.092	CSPE	1.206
25	CELESC	1.180	ENERGIPE	1.093	BOA VISTA	1.217
26	CEMAR	1.192	AES-SUL	1.093	ENERGIPE	1.221
27	CEAL	1.197	CEPISA	1.093	CELPE	1.233
28	COSERN	1.200	CERON	1.094	SANTA MARIA	1.233
29	CELG	1.201	CELTINS	1.095	CERON	1.258
30	CSPE	1.205	DMEPC	1.096	SAELPA	1.259
31	CAIUÁ	1.211	SAELPA	1.097	CENF	1.266
32	V. PARANAPANEMA	1.215	CFLO	1.101	ESCELSA	1.274
33	ELEKTRO	1.254	SANTA MARIA	1.101	COELBA	1.284
34	CELPE	1.257	CEB	1.106	CEEE	1.337
35	AES-SUL	1.268	NACIONAL	1.113	CEMAR	1.340
36	ESCELSA	1.269	CERJ	1.115	CEB	1.379
37	BANDEIRANTE	1.270	CEMAT	1.127	CEMAT	1.437
38	BRAGANTINA	1.276	CELPA	1.129	CEAL	1.449
39	MOCOCA	1.283	COPEL	1.132	COPEL	1.499
40	CPFL	1.302	CEEE	1.133	CERJ	1.522
41	NACIONAL	1.304	CELG	1.140	CEPISA	1.577
42	CERJ	1.318	JAGUARI	1.147	BRAGANTINA	1.600
43	BOA VISTA	1.354	CAIUÁ	1.148	ENERSUL	1.618
44	PIRATININGA	1.389	BRAGANTINA	1.151	V. PARANAPANEMA	1.647
45	ELETROCAR	1.409	ELETROPAULO	1.155	SANTA CRUZ	1.656
46	JAGUARI	1.415	V. PARANAPANEMA	1.179	CELG	1.692
47	CEB	1.768	XANXERÊ	1.196	CAIUÁ	1.733
48	LIGHT	1.830	CELESC	1.283	CAT-LEO	2.174
49	ELETROPAULO	1.986	CEMIG	1.506	CELTINS	2.381
	Mean	1.202	*Mean*	1.110	*Mean*	1.283
	Std. Deviation	0.217	*Std. Deviation*	0.072	*Std. Deviation*	0.302
	25% Percentile	1.106	*25% Percentile*	1.074	*25% Percentile*	1.024
	75% Percentile	1.270	*75% Percentile*	1.127	*75% Percentile*	1.437

1. Regulator's Efficiency Index, computed as the ratio of realized operating costs reported by the concessionaries (REPOPEX) to the operating costs estimated for the hypothetical efficient firms (FINOPEX).

Table 2. SFA Descriptive Statistics

Variable	1998	1999	2000	2001	2002	2003	1998-2003	Range
OPEX	98,905 (132857)	85,773 (111025)	84,953 (113274)	74,258 (100497)	70,455 (97838)	70,134 (97273)	80,640 (108952)	[2490, 559072]
Q	5,074,129 (8442352	5,260,394 (8346455	5,520,603 (8719154	4,790,657 (7649132	5,063,016 (7569014	5,110,973 (7404106	5,137,639 (7970465)	[103191, 37540051]
LP	38.9052 (18.9536)	32.4873 (14.7348)	35.9164 (18.517)	34.0834 (14.7472)	39.2159 (22.3052)	41.9181 (21.2112)	37.1144 (18.7994)	[6.5398, 128.4681]
MP	78.6138 (6.7104)	72.8605 (4.419)	70.946 (3.9627)	70.9966 (3.5699)	68.4405 (3.2352)	68.595 (3.4071)	71.701 (5.5173)	[60.008, 96.620]
SP	74.0168 (17.9825)	66.802 (18.4658)	64.4161 (16.9462)	61.4267 (14.435)	53.5491 (11.4705)	58.3822 (12.7854)	63.022 (16.7229)	[29.434, 98.120]
CUSDEN	25.7095 (18.6995)	26.6959 (19.1257)	27.9056 (20.0373)	28.7718 (20.4782)	30.8484 (21.8955)	32.0821 (22.4005)	28.6965 (20.4544)	[6.747, 137.093]
INDSHARE	0.2959 (0.1461)	0.2980 (0.1434)	0.3068 (0.1432)	0.3132 (0.1413)	0.3308 (0.1498)	0.3257 (0.1568)	0.3119 (0.1463)	[.0333, .6438]
RESDEN	2.1026 (0.6267)	2.0789 (0.6282)	2.0028 (0.5139)	1.7162 (0.4687)	1.6803 (0.4625)	1.6774 (0.4167)	1.8749 (0.5537)	[.663, 4.572]
AREA	129,178 (242029)	129,210 (239567)	129,203 (239564)	131,495 (241463)	126,671 (237902)	126,725 (237882)	128,723 (237747)	[252, 1253165]
NUMCUST	828,166 (1099440	879,502 (1134211	919,894 (1188028	934,543 (1228822	979,891 (1255942	1,012,766 (1287816	926,545 (1193257)	[19625, 5744178]
INCOME	5,769.74 (2804.22)	5,086.45 (2351.86)	5,160.16 (2379.3)	4,996.71 (2272.11)	4,386.60 (1880.11)	4,642.68 (1989.73)	5,001.43 (2317.13)	[1060.012, 12747]
CAP	3,218.57 (4908)	3,269.12 (4872.48)	3,269.12 (4872.48)	3,142.07 (4835.87)	3,206.25 (4751.46)	3,206.25 (4751.46)	3,218.73 (4792.04)	[.1, 22728.4]
LEN	41,998.10 (65700.6)	42,957.20 (65399.9)	42,957.20 (65399.9)	42,959.70 (66063.9)	42,131.10 (64894.5)	42,131.10 (64894.5)	42,520.10 (64850.3)	[720.3, 379518.58]
UNDERGRD	0.006592 (.0246)	0.006462 (.0244)	0.006462 (.0244)	0.005940 (.0244)	0.006338 (.0241)	0.006338 (.0241)	0.006356 (.0241)	[0, .1391]
# OBSERV.	50	51	51	50	52	52	306	

Mean values reported for each year and for the period 1998-2003. Standard deviation in parentheses.

Table 3. GLM and OLS Descriptive Statistics

Continuous Variables	*Mean*	*Std. Deviation*	*Range*	*Categorical Variables*	*Value*	*Frequency*
BARGPW	0.093	0.072	(0.001, 0.284)	*PUBLIC*	0	34
ANEELvsSFA	1.087	0.202	(0.633, 1.719)		1	15
ANEELvsDEA	0.986	0.298	(0.459, 1.986)	*TCU*	0	37
ENGvsSFA	1.186	0.230	(0.734, 1.907)		1	12
ENGvsDEA	1.077	0.333	(0.481, 2.177)	*PARTY*	0	28
INDSHARE (SQRT)	0.549	0.146	(0.198, 0.802)		1	21
INCOME (LN)	2.065	0.558	(0.856, 3.795)	*CPFL*[1]	0	42
SIZE (LN)	0.702	1.567	(-2.083, 3.491)		1	7
DEPUT	55.963	10.414	(34.5, 81.8)	*REDE*[2]	0	40
UNIVSERV	95.056	6.834	(75.95, 100)		1	9
UNDERGRD	0.618	2.264	(0, 12.607)	*ENERGISA*[3]	0	44
CUSDEN(LN)	2.825	1.511	(0.250, 7.019)		1	5
LEARNING	22.694	14.585	(0, 47)	*ELETROBRAS*[4]	0	43
OVERREPOPEX	0.313	0.251	(0.009, 1.177)		1	6
LPDIFF	0.978	0.414	(0.301, 2.474)			
RESSHARE	0.307	0.075	(0.117, 0.484)			

1. CPFL group: CPFL, CSPE, JAGUARI, MOCOCA, PIRATININGA, RGE, SANTA CRUZ.
2. REDE group: BRAGANTINA, CAIUÁ, CELPA, CELTINS, CEMAT, CFLO, ENERSUL, NACIONAL, V. PARANAPANEMA.
3. ENERGISA group: CAT-LEO, CELB, CENF, ENERGISA, SAELPA.
4. ELETROBRAS group: BOA VISTA, CEAL, CEPISA, CERON, ELETROACRE, MANAUS.

Table 4. Stochastic Cost Frontier Results

Variable	Time-trend formulations			Time Fixed-Effects formulations		
	A	B	C	D	E	F
Ln*Opex*						
Ln*Q*	0.771***	0.781***	0.803***	0.708***	0.739***	0.756***
	(.025)	(.023)	(.035)	(.018)	(.017)	(.017)
Ln*LP*	0.442***	0.403***	0.409***	0.395***	0.348***	0.366***
	(.062)	(.064)	(.066)	(.034)	(.035)	(.034)
Ln*MP*	0.364***	0.374***	0.315***	0.381***	0.401***	0.480***
	(.116)	(.112)	(.114)	(.068)	(.069)	(.069)
Cap	0.096***	0.108***	0.058*	0.103***	0.102***	0.080**
	(.027)	(.027)	(.034)	(.028)	(.030)	(.028)
Len	0.561***	0.561***	0.522***	0.534***	0.525***	0.516***
	(.064)	(.063)	(.064)	(.063)	(.066)	(.063)
Ln*IndShare*	-0.007	0.009	-0.013	-0.008	-0.003	0.009
	(.034)	(.033)	(.035)	(.033)	(.034)	(.033)
Ln*ResDen*	0.169*	0.157*	0.143	0.131	0.099	0.145*
	(.089)	(.088)	(.092)	(.089)	(.092)	(.087)
Ln*Income*	-0.179***	-0.145***	-0.186***	-0.168***	-0.139***	-0.185***
	(.035)	(.037)	(.039)	(.037)	(.039)	(.040)
Ln*Area*	0.072***	0.074***	0.066***	0.074***	0.073***	0.073***
	(.012)	(.011)	(.013)	(.012)	(.013)	(.012)
Ln*CusDen*	0.500***	0.496***	0.466***	0.469***	0.462***	0.465***
	(.061)	(.061)	(.064)	(.062)	(0.064)	(.061)
Undergrd	4.765***	4.480***	4.486***	4.830***	4.465***	4.601***
	(.589)	(.582)	(.563)	(.602)	(.611)	(.583)
T	-0.054**	-0.052*	-0.051**			
	(.027)	(0.026)	(.025)			
ln*Q**t	-0.015***	-0.014***	-0.007			
	(.005)	(.005)	(.005)			
ln*LP**t	-0.012	-0.010	-0.014			
	(.017)	(.017)	(.017)			
ln*MP**t	0.001	0.001	0.047			
	(.029)	(.027)	(.030)			
Tsq	-0.004	-0.004	-0.005			
	(.007)	(.007)	(.007)			
Private		-0.110**				
		(.047)				
*Private**t		0.006				
		(.012)				
Privtzed			-0.094*			
			(.052)			
Alwspriv			-0.081			
			(.087)			
D1999				-0.039	0.049	-0.044
				(.033)	(.183)	(.032)
D2000				-0.106***	0.048	-0.102***
				(.033)	(.294)	(.033)
D2001				-0.150***	0.029	-0.147***
				(.034)	(.346)	(.033)
D2002				-0.268***	-0.075	-0.273***
				(.035)	(.355)	(.036)
D2003				-0.303***	-0.137	-0.308***
				(.036)	(.337)	(.035)
Cons	-0.150**	0.001	-0.142	-0.200***	-0.581	-0.437)***
	(.070)	(.052)	(.089)	(.052)	(.367)	(.105)
lnsig2v						
Cons	-3.964***	-3.734***	-4.242***	-3.898***		
	(.307)	(.080)	(.486)	(.242)		
lnsig2u						
Q	0.109*	0.606	-0.063	0.131**		
	(.064)	(.761)	(.102)	(.051)		
Cons	-4.423***	-15.104	-3.590***	-4.502***		
	(1.193)	(14.702)	(1.029)	(.956)		
Statistics						
N	306	306	306	306	306	306
Ll	128.429	136.29	144.157	120.077	124.98343	134.31818
Chi2	21833.984	23964.368	17857.736	21535.49	28332.588	17974.398

Legend: * $p<0.10$; ** $p<0.05$; *** $p<0.01$. Standard deviation in parenthesis. Coefficients on translog squared and interaction terms are omitted.

Table 5. Results from the GLM and OLS models

	GLM	OLS			
Variable	***BARGPW***	***ANEELvsSFA***	***ANEELvsDEA***	***ENGvsSFA***	***ENGvsDEA***
Industrial share (sqrt)	-0.472	**-0.419****	-0.272	**-0.479****	-0.309
	(0.984)	(0.168)	(0.339)	(0.196)	(0.357)
Income (ln)	**-0.436****	0.063	0.097	0.051	0.080
	(0.181)	(0.052)	(0.078)	(0.055)	(0.082)
Size (ln)	-0.065	0.032	0.034	0.034	0.039
	(0.084)	(0.019)	(0.026)	(0.021)	(0.029)
Customer density (ln)	-0.037	**0.064*****	**0.112*****	**0.067*****	**0.121*****
	(0.073)	(0.018)	(0.039)	(0.018)	(0.041)
TCU monitoring	-0.574	-0.078	-0.116	-0.099	-0.137
	(0.307)	(0.055)	(0.099)	(0.062)	(0.111)
Public company	0.393	**-0.132****	0.029	**-0.165*****	0.018
	(0.323)	(0.055)	(0.089)	(0.059)	(0.094)
Learning	**-0.047*****	**0.006*****	0.002	**0.003***	-0.002
	(0.008)	(0.002)	(0.002)	(0.002)	(0.003)
Undergrd	0.041	**0.030*****	0.019	**0.042*****	0.029
	(0.041)	(0.010)	(0.027)	(0.009)	(0.027)
Energisa		**-0.167*****	**-0.232*****	**-0.202*****	**-0.269*****
		(0.054)	(0.085)	(0.058)	(0.090)
Eletrobras	**-2.525*****				
	(0.524)				
Overrepopex	**1.128****				
	(0.501)				
Intercept	-0.327	**0.895*****	**0.588*****	**1.125*****	**0.787*****
	(0.487)	(0.112)	(0.172)	(0.112)	(0.178)
Statistics					
N	49	49	49	49	49
χ^2	158.89				
R^2		0.7328	0.5549	0.7606	0.5926

Robust standard errors in parentheses. Legend: * p<.1; ** p<.05; *** p<.01

Table 6. Results from the same models, with Resshare in place of Indshare

	GLM	OLS			
Variable	***BARGPW***	***ANEELvsSFA***	***ANEELvsDEA***	***ENGvsSFA***	***ENGvsDEA***
Residential Share	-1.681	**0.897*****	0.411	**0.912*****	0.398
	(1.670)	(0.273)	(0.542)	(0.297)	(0.588)
Income (ln)	**-0.564*****	0.073	0.092	0.054	0.070
	(0.214)	(0.051)	(0.075)	(0.053)	(0.080)
Size (ln)	-0.102	**0.031***	0.031	0.031	0.034
	(0.077)	(0.018)	(0.025)	(0.020)	(0.028)
Customer density (ln)	**-0.091***	**0.060*****	**0.107*****	**0.061*****	**0.115*****
	(0.050)	(0.016)	(0.037)	(0.018)	(0.039)
TCU monitoring	-0.430	**-0.098***	-0.121	**-0.117***	-0.140
	(0.325)	(0.055)	(0.098)	(0.064)	(0.110)
Public company	0.286	**-0.139****	0.023	**-0.173*****	0.011
	(0.334)	(0.054)	(0.089)	(0.060)	(0.095)
Learning	**-0.047*****	**0.007*****	0.002	**0.004***	-0.001
	(0.007)	(0.002)	(0.002)	(0.002)	(0.003)
Undergrd	0.064	**0.034*****	0.024	**0.048*****	0.035
	(0.043)	(0.008)	(0.025)	(0.007)	(0.024)
Energisa		**-0.209*****	**-0.262*****	**-0.253*****	**-0.305*****
		(0.045)	(0.097)	(0.049)	(0.104)
Eletrobras	**-2.298*****				
	(0.496)				
Overrepopex	**1.360*****				
	(0.423)				
Intercept	0.241	**0.387****	0.336	**0.595*****	**0.532***
	(0.889)	(0.170)	(0.257)	(0.184)	(0.278)
Statistics					
N	49	49	49	49	49
χ^2	165.89				
R^2		0.7565	0.5539	0.7724	0.5900

Robust standard errors in parentheses. Legend: * p<.1; ** p<.05; *** p<.01