

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

Hamilton C. D. Silva \*

*This Version: October 2007*

## 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 the Brazilian electricity distribution sector periodic tariff reviews. The study tests for possible causes of the identified divergences in efficiency assessments and checks for potential determinants of firms' bargaining power in the rate setting process. The investigation reveals that the regulator's objectives might not have been welfare maximizing in some situations. The results indicate that firms with a lower proportion of electricity delivered to industrial customers, which serve wealthier consumers and operate in more densely populated areas, had lower bargaining power in the tariff setting and received substantially lower prices than the economic benchmarking methods would recommend. On the other hand, the findings show that significantly higher prices might have been given to companies with the opposite characteristics. The study reveals that the joint use of a comparative efficiency analysis technique might contribute to promote greater transparency to the process and credibility for the results obtained with the application of the Model Company method.

**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 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

---

\* 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.

\* Senior Analyst, Tribunal de Contas da União (*Federal Audit Office*), Brazil. Email address: [hamiltonds@tcu.gov.br](mailto:hamiltonds@tcu.gov.br). Tel.: 55-27-9946-0602; fax: 55-27-3324-3966.

rulings are likely to reflect the political economy of regulation). On the other hand, as price-caps provide incentives for efficiency improvements,<sup>1</sup> at the rate review the regulator's intention to extract 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).

A form of yardstick regulation which has been used to tackle the cost benchmark issue consists of a bottom-up efficiency study based on the engineering knowledge of the industry process.<sup>2</sup> In the model company (or reference utility) 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. As future prices are not linked to realized costs, the method has the merit of preserving the efficiency improvement incentives brought by the price-cap regime.<sup>3, 4</sup> Other possible advantages include the control for heterogeneity in operating conditions and the fact that the regulator does not need to base its decisions on cost information provided by firms.<sup>5</sup>

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 (or the consultants hired to perform the task), and argues that it represents a major retrogression from the price-cap approach, as

---

<sup>1</sup> Under a price-cap regime, prices are fixed. The firm and its managers are the residual claimants on production cost reductions, and bear the disutility of increased managerial effort. It is thus assumed that the conditions and incentives for efficiency improvement and for the possible achievement of second best prices are settled (Joskow, 2005).

<sup>2</sup> The model company approach has been employed to calculate electricity distribution tariffs in Spain and some Latin-American countries, mainly Chile, Peru, Argentina, El Salvador, and Brazil (Jadresic, 2002).

<sup>3</sup> When a price-cap plan links future prices directly to realized costs and the time between schedule reviews is relatively short, the incentives under a price-cap regime are similar to the ones under rate of return regulation (Sappington, 2002).

<sup>4</sup> Under a model company approach, the efficiency improvement incentives come from the fact that firms appropriate rents when their actual costs are inferior to the estimated efficient operating costs.

<sup>5</sup> See Galetovic and Bustos (2002), and ANEEL (2003).

the posited efficiency gains need have no foundation in actual market behavior. Gomez-Lobo and Vargas (2001), on their turn, claim that the method is excessively detailed, time-consuming, resource intensive and contributes negatively to the transparency and objectivity of the regulatory process.

It is therefore important to investigate whether the use of the model company methodology has effectively enabled the attainment of the aforementioned regulator's objectives. The evidence so far is limited. Serra (2002), and Fisher and Serra (2002) look at the experience in the telecommunications and electricity distribution sectors in Chile, and consider the findings that the method's usage led to rate of returns well above the firms' cost of capital as an indication of a persistent regulatory flaw. Grifell-Tatjé and Lovell (2001), on the other hand, examine the issue in the context of the electricity distribution in Spain and find that the engineering model was much less costly to operate than the real companies, by virtue of a smaller network and lower input prices, but did not have their inputs allocated in a cost-efficient manner. The study indicates that actual companies were more cost efficient than the hypothetical efficient firms, and concludes that the engineering procedure had understated potential cost savings by nearly one-third.

The present study contributes to fill the literature gap by analyzing the results obtained with the use of the model company approach to estimate efficient operating expenditures in the Brazilian electricity distribution industry periodic tariff review. The implied performance scores are compared to those obtained using alternative methodologies—Statistical Frontier Analysis (SFA) and Data Envelopment Analysis (DEA)—under the rationale that some minor divergences might result from problems in these other methods, but greater discrepancies could reflect deficiencies in the application of the engineering approach, particularly when they are independent of the method employed for comparison.

The Brazilian case provides an exceptional opportunity to perform the investigation, as the number of distribution companies allows the use of sophisticated comparative efficiency techniques and the consequent computation of efficiency scores and analysis of their evolution over time. Thus, efficiency estimates and measures of firms' productivity improvements obtained in a previous benchmarking study portraying the distribution firms' performance in the period of six years immediately before the tariff review (Silva, 2006b) are employed to examine the results provided by the engineering approach. Particular attention is given to 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 to the possibility that the regulator's decision might have threatened the firms' financial sustainability.

In sequence, the study checks for the possible causes of the divergences found. At this point, the investigation explicitly recognizes that regulatory decisions are taken by a utility maximizing regulator that operates in a situation of asymmetric information. It is also considered that the regulator has opportunities to exercise discretion, is potentially influenced by interest groups, and is subject to direct supervision of its actions. Consequently, the analysis of regulatory outcomes addresses the possible impact of these factors, in addition to the effects of the methodology employed.

The study presents evidence that the monitoring of the regulator's activities does not lead to decisions contrary to the concessionaires' interests. In addition, the investigation shows that the aforementioned regulator's objectives at the rate review might not have been accomplished in some situations where the firms' efficiency assessments differed markedly from the ones suggested by the economic benchmarking approaches. On the one hand, the results indicate that some firms, mainly the ones serving more affluent consumers, operating in more densely populated areas and having a lower proportion of electricity delivered to industrial customers, received substantially lower

repositioning indexes than the economic benchmarking methods would recommend. As a low repositioning index basically serves as a price adjustment that reduces allowed revenues, the evidence points to a possible violation of firms' break-even constraints. On the other hand, the findings reveal that significantly higher repositioning indexes might have been given to companies with the opposite characteristics: managers of firms granted higher allowed prices can see that cash flows are enhanced, even when efficiency (measured using other techniques) is not high compared with the performance of other firms. Usually, incentive systems give weaker-performing firms lower prices since there is scope for efficiency improvements. Some of the companies benefiting from ANEEL's use of the repositioning index based on engineering models do not appear in the top ten of the economic benchmarking efficiency rankings, so weaker performers seem to be rewarded.

The following section describes the methodology adopted by the regulator in the periodic tariff review and presents the resulting figures obtained. Section 3 explains the methodology and the data set employed to perform the stochastic frontier approach, presents the corresponding results, and explores their use to examine the regulator's decisions taken on the basis of the engineering approach. Section 4 describes the econometric model and presents and interprets the results. Section 5 explains the robustness check performed with the use of the DEA methodology. The final section provides concluding observations.

## **2. Institutional Background and the ANEEL Model Company Method**

The power sector reforms in Brazil began in 1995. While constitutional amendments abolished the public monopoly over infrastructure industries and allowed foreign companies to bid for public concessions, the Law 8,987/95 (General Law of Concessions) set the stage for the beginning of the privatization process, represented by the auctions of Escelsa in 1995 and Light in 1996. By the end of 2000, a total of 20 distribution companies had been privatized.

In addition, part of the implementation of a new regulatory framework involved the establishment of an independent regulatory agency (ANEEL) in late 1996 and, in the same year, the commission of an international consultancy to study and propose a new model for the electricity sector. The consultant's report was released in 1997, and its proposals were incorporated into Law 9,648, issued on May of 1998.<sup>6</sup> One of the measures introduced by the approved model was the use of the price-cap regime to regulate distribution tariffs, replacing the previous cost-of-service system. Price-cap regulation was implemented through the signature of new concession contracts, which took place from 1998 to 2000, and scheduled the first tariff review for after five (for contracts signed in 1998) or four years.<sup>7</sup> As a result, 61 companies were submitted to a tariff review process from April 2003 to February 2006.

## 2.1. The Tariff Review Methodology

Despite defining the first regulatory lag, the concession contracts were silent about the cost methodology that would be applied at the periodic review. The obligation to solve the methodological vacuum rested with the regulatory agency, which, after a long and heated discussion process,<sup>8</sup> established that the repositioning index for firm  $i$  ( $RI_i$ ) would be calculated as follows:

$$RI_i = \frac{RR_i - RS_i - ER_i - OR_i}{RD_i} \quad i = 1, \dots, n \quad (1)$$

where  $RR_i$  corresponds to the revenue requirement for firm  $i$  in the 12-month period after the tariff review date,  $RS_i$  stands for firm  $i$ 's revenue from supply activities,  $ER_i$  and  $OR_i$  denote extra-concession and other revenues of firm  $i$  projected for the same period, respectively, and  $RD_i$  is the

---

<sup>6</sup> See Ferreira (2000), Mota (2003), and de Oliveira (2003), for detailed descriptions of the new model's characteristics.

<sup>7</sup> Companies Escelsa and Light constituted an exception to this rule. Light was the first to have price-cap regulation applied, by order of the concession contract signed in November 1996, in which the first tariff review was scheduled to occur after seven years. Escelsa was submitted to price-cap regulation in August of 1998, and had tariff reviews every three years thereafter. Except for Escelsa, all companies had the X factor set equal to zero in the first period prior to the first full review.

revenue from distribution activities that firm *i* would obtain if distribution tariffs were kept the same. The repositioning index represented the percentage increase which would be applied to firm's tariffs at the rate review. In this case, a higher revenue requirement implies a higher repositioning index and, consequently, higher prices.

The revenue requirement was defined as the revenue needed to cover efficient operating costs and to provide an adequate return over investments prudently made, corresponding to the following:

$$RR = EC + TC + OC + ROC + DEP + T \quad (2)$$

where EC and TC are considered non-controllable costs and stand for the projected costs of buying energy and paying the tariff charges, respectively, OC is operating costs, ROC is the return on capital (in monetary units), DEP is depreciation, and T is the firm's taxes.

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. The operating costs allowed to be passed on to tariffs, on their turn, 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. The estimated rate base and efficient operating costs were, therefore, the main determinants of the authorized price increases at the rate review.

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. In order to estimate the costs associated to COM and O&M activities, all processes and activities (P&A) which the reference utility should perform were identified, along with the

---

<sup>8</sup> Peano (2005) provides a detailed description of the process implemented by the regulatory agency to define the tariff review methodology. Foster and Antmann (2004), and Byatt (2004), in turn, discuss the particularities of the deep controversy that surrounded the regulator's choice of the asset valuation methodology.

human and equipment resources needed to carry out each P&A. The process/activity's cost was calculated considering the respective frequency of occurrence, by valuing the required resources at market prices. Then, the final cost estimates resulted from the application of each P&A cost to the firm's volume of capital (for O&M) and number of customers (for COM). The ADM costs, on their turn, were estimated on the basis of firms' volume of capital, number of customers, and geographical dispersion, with the identified amount of human and equipment resources required also being valued at market prices.

The tariff review process also included the definition of the X-factor for the time period for which the formula would be in effect. The analysis of the corresponding methodology employed is beyond the scope of the present study, but it is important to stress, in this respect, that the X-factor comprised the productivity gains estimated for the period up to the next tariff review ( $X_e$ ), adjusted by a quality factor ( $X_c$ ), with  $X_e$  being given by scale economies resulting from projected increases in output, net of investments required to meet expected increases in demand. The rationale, here, was that firms' operating costs were already adjusted to their efficient levels (with the use of the engineering approach), and no further significant technical efficiency improvements should be observed thereafter.

It is interesting, at this point, to look at the ANEEL's methodology in the context of an efficient frontier framework. 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 not only determined the firms' one-time adjustment on their operating costs, but also assumed that there would not be any frontier shifts in the future. In that case, the non-adoption of a progressive path towards the efficient target raises concerns over the financial sustainability

constraint of those firms which the regulator's approach revealed as the most inefficient. Note, here, that 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.

On this respect, it should be noted that the estimated efficient operating costs might not match the "true" values. As stated before, the engineering model is very detailed and provides estimates for each process/activity performed by a virtual efficient firm operating in the same conditions than the company under exam. Given the asymmetric information context, the cost parameters needed to perform the task are not only difficult to be precisely estimated (taking into account the specificities of each firm's operating conditions), but also are subject to firm's misreporting. Consequently, it is indeed possible that the parameters employed to estimate the efficient costs do not satisfactorily capture the effect of some cost drivers on firms' actual costs.<sup>9</sup>

## **2.2. Model Company 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 a tariff review process from April 2003 to February 2006, 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.

The operating costs estimated for the hypothetical efficient firms are shown in Table 1, along with the realized operating costs reported by the concessionaries and the computed regulator's efficiency index (*ANELEFF*), given by the ratio realized OPEX to estimated OPEX. Here, two points are worth noting: the wide range observed in the regulator's efficiency indexes and the fact

---

<sup>9</sup> This possibility was augmented in the Brazilian experience under exam, as the method and the corresponding parameters employed were used for the first time and not previously debated with the distribution companies before the beginning of the tariff review process, increasing the chance of "errors."

that, under the regulator's view, seven firms were operating more efficiently than the virtual efficient company.

The variable *ANELEFF* varies in the range of 0.848 to 1.986, with mean 1.202. The fact that the 50% percentile is at 1.180 denotes that the distribution of regulator's efficiency indexes is skewed to the right, and the mean has been moved up by a few instances where the estimated efficient operating costs are well below realized costs. It is useful to check whether these firms identified as highly inefficient using this engineering "Model Company" methodology also show up in the worst performers grouping of SFA and DEA efficiency rankings.

Note that the engineering method resulted in the allocation of some rents to the seven companies which had repositioning indexes based on operating costs higher than their realized costs.<sup>10</sup> In such cases, the comparison with the results provided by the economic benchmarking approaches takes on special relevance because only the most efficient firms should be allowed to keep part of their productivity gains, as an incentive for further efficiency improvements. If these seven firms are not ranked highly by alternative methodologies, the procedure is called into question. The finding would indicate that the higher tariffs given to these firms constituted an unjustified benefit, to the detriment of customers and without regard to the efficiency improvement incentives embedded in the price-cap regime.

### **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. Non-parametric methods, like Data Envelopment

---

<sup>10</sup> According to the repositioning index formulae (equations 1 and 2), the allowed risk-adjusted rate of return of 17.07% would be given to firms operating at the model company's efficient operating costs levels (at the "efficient frontier"). It follows that returns below 17.07% were assigned to all firms whose estimated efficient costs were below their actual costs (*ANELEFF* > 1), with the rate of return being smaller, the greater was the firm's distance to the regulator's estimated frontier (the greater *ANELEFF* was from unity). 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.

Analysis (DEA), use mathematical programming techniques and neither require the specification of production or cost functions nor the imposition of behavioral assumptions. These methods are generally easy to implement, but carry an implicit restriction in the number of variables that might be used. Furthermore, they do not allow for random shocks.

Parametric methods, in turn, entail applying an *a priori* functional form to the frontier, estimated with econometric tools. They allow for hypothesis testing,<sup>11</sup> enabling the analyst to investigate the validity of the model specification. Tests of significance can be performed for the functional form and for the inclusion or exclusion of factors, which are of special relevance for the electricity distribution industry, where the inclusion of several factors is theoretically justifiable. Moreover, with a parametric method it is possible to allow for stochastic factors or measurement errors, which avoids the assumption that all deviations from the best practice frontier involve inefficiencies. For instance, with Stochastic Frontier Analysis (SFA) a mix of one-sided and two-sided error terms is employed, with the former capturing the firm's inefficiency and the latter capturing the effects of random variation in the operating environment.

Ideally, the decision regarding the appropriate method depends on the purposes of the study and the context under examination. In case, we are interested in investigating the evolution of efficiency from 1998 to 2003; the investigation is conducted in an environment where random shocks were present and the inclusion of several variables in the model specification, besides being theoretically justifiable, is advisable due to the great heterogeneity in operating conditions. These considerations suggest the use of a stochastic frontier approach, defined in terms of an input orientation, given the output exogeneity that characterizes the electricity distribution industry.

---

<sup>11</sup> In non-parametric models, a bootstrap technique may be used to produce confidence intervals around the estimated individual efficiency and thereby assess statistical properties of the efficiency scores generated (Simar and Wilson, 1998).

### 3.1. SFA Model and Data

The SFA model employed here is detailed in Silva (2006b). 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; this approach reflects the interest in having efficiency measures net of factors that impact firms' performance but are beyond the control of the concessionaries. 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:

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

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  $\sigma_{uit}^2$  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 indexes 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. It is worth noting that the use of time-fixed effects explicitly allows the computation of efficiency indexes relative to yearly-specific frontiers.

The observed technological change ( $\Delta TC$ ) and technical efficiency change ( $\Delta TE$ ) 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. 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

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

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.<sup>12,13</sup> Electricity delivered, in MWh (*Q*), is the output measure<sup>14</sup> 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*).<sup>15</sup> For the prices of materials (*MP*) and third party services (*SP*), the work uses two price indexes provided by Brazilian Institute of Statistics (IBGE), and the Caixa Economica Federal (CEF), a public financial institution that is in charge of most of the social programs of the federal government and provides financing to housing

---

<sup>12</sup> The computed labor expenses include firms' contributions to pension funds and to health insurance plans, profit sharing payments, and management wages. Some firms already report these expenses under the classification of labor expenses, but most of them do not. The necessary adjustments were made on these cases.

<sup>13</sup> In case of vertically integrated companies, the computation of the operating costs of distribution and retail service activities was made possible by the fact that those companies are required by law to report their expenses separated by activity.

<sup>14</sup> The use of two measures of output was prevented by the fact that electricity delivered and number of customers showed up as highly collinear, with one of them always being dropped by the statistical software employed (Stata). A better specification was provided by the former, when compared to the latter.

construction projects. 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.<sup>16</sup> The environmental variables incorporated in the modeling are the following: customer density (*CusDen*), given by number of customers divided by 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<sup>17</sup> (*Area*), in Km<sup>2</sup>; ratio of underground to overhead lines (*Undergrd*); and income per capita, by state (*Income*), to control for variations in socio-economic conditions among states. 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.

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), IBGE, and CEF.

---

<sup>15</sup> Total labor expenditure is employed to compute average wage because it was not possible to obtain information related to number of employees segregated by sector activity, for the cases of firms that also operate on generation and transmission.

<sup>16</sup> Since these variables showed up as highly correlated with electricity delivered, the variables *Cap* and *Len* actually correspond to the residuals of the regression of transformer capacity on electricity delivered and network length on electricity delivered, respectively.

<sup>17</sup> The Brazilian case justifies the inclusion of both network length and service area in the modeling, and this is reflected in the statistical significance of both variables as either cost shifters or mean inefficiency parameters. While some companies have small service areas and relatively high network length (the ones that operate in the more densely populated states), others have high *Area* but relatively low *Len*, because they operate in states which are more sparsely populated and/or have a high share of the population not being served.

### 3.2. SFA Results and Comparison

Descriptive statistics are shown in Table 2. The difference between minimum and maximum values of observations collected for almost all variables employed indicates the considerable heterogeneity among firms in the sample, in terms of companies' size, system configuration, and customer structure. The evidenced disparity in firms' indicators corroborates the need to account for external factors in the comparative efficiency analysis.

Table 4 provides the results from the models estimated. The cost function satisfies the monotonicity condition with respect to output and factor prices at the mean, and 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.

Firms' efficiency indexes, computed for each year in the period examined, are portrayed in Appendix A, whereas the Malmquist measures of productivity change are reported in Appendix B. The results indicate that the Brazilian electricity distribution industry's productivity increased 38.5%, on average, from 1998 to 2003.<sup>18</sup> The mean productivity growth rate of 6.73% stands out when it is compared to the 0.9% mean total factor productivity growth rate of the economy found by Gomes, Pessôa, and Veloso (2003) for the period of 1992 to 2000.<sup>19</sup> Moreover, taking the results found by Mota (2004) as a proxy for the distribution companies' average productivity gains in the

---

<sup>18</sup> The above mentioned measure of productivity change does not incorporate the scale effect. On the basis of the computed output elasticity and the actual changes in output from year to year, we have estimated it to be equal to 3.56%, on average, from 1998 to 2003.

<sup>19</sup> The authors report that their result is consistent with the findings of two other studies that examined the subject.

period of 1994 to 1998 (around 5%),<sup>20</sup> it might be concluded that the sector's rate of productivity growth increased after 1998.

The comparison between the SFA and the Model Company efficiency indexes is limited to the 49 firms included in Table 1. Another restriction comes from the fact that in some cases the indexes 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 only go up to 2003. In the analysis that follows, the SFA efficiency indexes obtained for year 2003 are used for comparison (*SFA2003*), which 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.<sup>21</sup> The possible distortions, however, should not be relevant in the context of the present study, as the comparison of efficiency indexes focuses on the larger discrepancies in the two methods' results.

The efficiency rankings provided by the SFA and the engineering approaches (Table 5) are not significantly correlated (Spearman's  $\rho = 0.0682$ , 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. Note, in addition, that *CEMIG* figures in the bottom ten in one method, and in the top ten in the other.

SFA efficiency estimates are significantly smaller than *ANEELEFF*,<sup>22</sup> 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

---

<sup>20</sup> Mota obtains annual average productivity gains of about 5% in the period of 1994 to 2000 using data only from these two years and from 14 privatized companies. Considering that the present study provides evidence of significantly higher privatized firms' productivity gains for the period of 1998 to 2000, Mota's result can be taken as an upper-bound measure for average productivity gains in the period of 1994 to 1998.

<sup>21</sup> Similar distortions may be present for the 17 companies which experienced tariff reviews along the 2003 year. We examined the issue using for the comparison the average SFA efficiency index for years 2002 and 2003 (*SFA0203*). As expected, *SFA0203* and *SFA2003* were highly correlated ( $\rho = .9674$ ). Moreover, the points raised in the analysis that follows were still present when the *SFA0203* efficiency indexes were employed.

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. Moreover, as the SFA method is based on strong distributional assumptions to disentangle the effects of inefficiency and random noise, it cannot be ruled out the possibility that some inefficiency is incorrectly attributed to statistical noise.<sup>23</sup> In the present study, however, the comparison of efficiency indexes is restricted to the cases of higher divergence.

According to the regulator's methodology, *Eletropaulo*, *Light*, and *CEB* are considerably more inefficient than shown by the benchmarking method, as *ANELEFF* 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 (Appendix B) 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<sup>24</sup> and points to the existence of flaws in the application of the engineering approach.<sup>25</sup> One possibility is underscored by the present study. In line with Peano's (2005) claim,<sup>26</sup> the results suggest that the regulator's method might have been biased against firms which operate in more densely populated areas, since five firms,

---

<sup>22</sup> The null of equality of means is rejected at the 1% significance level ( $p$ -value ( $H_1: ANEELEFF > SFA2003$ ) = .0007).

<sup>23</sup> As suggested by the comparison to DEA efficiency measures mentioned later on Section 5, it is also possible that SFA efficiency indexes are constrained by the half-normal distribution assumed for the inefficiency error term.

<sup>24</sup> 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%).

<sup>25</sup> Our previous study of the regulator's performance [Silva(2006a)] had already indicated that the repositioning index announced at *Eletropaulo*'s tariff review caused a negative surprise in the market, as if it were not a conceivable number.

<sup>26</sup> The author compared the model company's OPEX to actual OPEX of 12 firms submitted to tariff review in year 2003, and identified that the difference between the two measures was inversely related to firm's customer density. The author argued that the model company method might have been efficient in avoiding reimbursements of over-investments in more densely populated areas, and allowed an extra return to firms with less densely populated service areas, which incur higher costs to provide the service at the required quality levels. Peano noticed, however, that the positive X-factor given at the beginning of the tariff review cycle might impact negatively the incentives for efficiency improvements.

from the ten which had the highest positive difference between *ANEELEFF* and *SFA0203*, belong to the top ten customer density extract.

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, 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. In addition, the rulings did not provide the appropriate incentives for efficiency improvements in the following regulatory term. The *Cemig*'s case is emblematic. In spite of the considerable productivity increments in the 1998-2003 period, the firm still figured as the worst performer according to *SFA2003*. The fact that the engineering methodology shows the firm operating rather more efficiently ( $ANEELEFF - SFA2003 = -0.5522$ ) may derive from the company's low customer density index, but suggests the possibility of a differentiated treatment to publicly owned firms, evaluated in the next section, since *Celesc*, *Celg*, *CEEE*, and *Copel* also appear in the *SFA2003* worst performers' group but occupy considerably better positions in the Model Company ranking.

It is also worth noting that four out of the five best performers under SFA did not receive the same benefit of being able to keep part of the rents derived from accomplished productivity gains. On the contrary, the *ANEELEFF* indexes of two of them (*Manaus* and *Eletroacre*) were above 1.10,

signaling that they would have to further reduce their operating costs by more than 10% to be able to earn the allowed 17.07% rate of return. This apparently tough task, however, might not be difficult to achieve, as the regulatory scheme set forth for the subsequent regulatory lag ignored the acute frontier shifts observed in the 1998-2003 period. The expected high productivity gains brought by technological change should also alleviate the economic situation of firms which might have been unduly classified as more inefficient. Unfortunately, however, they will exacerbate the perverse effects of possible over-estimating firms' efficiency.

#### 4. Econometric Modeling

For each firm, the variable *ANEELvsSFA*, computed as the ratio of *ANEELEFF* to *SFA2003*, expresses the divergence in the results provided by the two methods. *ANEELvsSFA* varies in the range of 0.633 to 1.719, with mean 1.087 (Table 3). The higher the variable is (relative to unity), the more the firm was considered more inefficient under the regulator's Model Company approach, when compared to the SFA standard, and the more the firm was harmed by getting a lower repositioning index (price), assuming that the SFA results are a good representation of the true values.<sup>27</sup> Conversely, when the firm's indicator is smaller (relative to unity), the firm was considered less inefficient under the regulator's methodology (*ANEELEFF* < *SFA2003*). In this case, the result suggests that the regulator's efficiency index was lower than it should be. Consequently, the firm, being closer to the efficient frontier than shown by the economic benchmarking method, was benefited by getting prices higher than recommended by the SFA standard.<sup>28</sup> A ratio of .9, for example, indicates that the firm was considered 10% closer to the

---

<sup>27</sup> 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, therefore, 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. Later in Section 5, in order to ascertain the validity of this reasoning, the results' consistency is checked using performance indicators provided by an alternative methodology as the comparison parameter.

<sup>28</sup> The relation between the distance to the frontier and the resulting price assigned to the firm is detailed in footnote 10. Since *ANEELEFF* is given by the ratio of realized OPEX to the Model Company's estimated OPEX, it is important to stress, at this point, that when the firm shows up closer to the efficient frontier than it should be, it is because the Model

efficient frontier than shown by the SFA model, or that its resulting repositioning index was augmented by .1 times the operating costs' (OC) participation on the estimated revenue requirement (see equation 2). Logically, the "firm's benefit" gets higher for lower values of  $ANEEL_{vsSFA}$ . At the lower bound ratio of 0.633, for instance, the multiplicative factor goes from the aforementioned .1 to nearly .37.

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 focuses on some other possible causes of the observed divergence between the two indicators. The investigation 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. 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.<sup>29</sup>

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.

---

Company's estimated operating costs are overestimated, according to the SFA standard. Under the same reasoning, the engineering costs would be underestimated in the reverse case where  $ANEEL_{EFF} > 1$ . The analysis that follows investigates the possible causes of these over- and underestimations of the Model Company's operating costs.

Consequently, the investigation follows the line of previous empirical studies which focused on the determinants of regulatory outcomes, addressing the predictions of the economic theory of regulation associated with Stigler (1971) and Peltzman (1976) [Nelson, 1982; Primeaux, Filer, Herren, and Holas, 1984; Naughton, 1989, Nelson and Roberts, 1989; Klein and Sweeney, 1999].

The analysis, however, also accounts for the fact that the regulator's decisions were taken in the context of incomplete and imperfect information. As a result, the investigation not only examines the possibility of flaws in the engineering cost parameters employed to estimate the efficient costs, but also hypothesizes that, in the absence of the information necessary to promote the desired distribution of productivity gains among stakeholders,<sup>30</sup> the regulator might have employed some of the available data as signals for firms' profitability and cash flow availability. In addition, the empirical analysis examines a potential external monitoring impact on the regulator's decisions.

Hence, it is hypothesized that the divergences of the regulator's efficiency measure to the SFA standard reflect two main factors: (a) possible problems in the cost parameters employed by the engineering model, due to the difficulties posed by the imperfect information context or to regulator's decisions; or (b) the regulator's adjustments in the initial operating cost estimate, made on the basis of its utility function and the available information, in a context of pressure from interest groups and direct supervision of the regulator's job.

---

<sup>29</sup> This framework draws upon the contributions of Stigler (1971) and Peltzman (1976), which form the basis of the economic theory of regulation. 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. The authors' contribution helps explain the location of policy in the competitive price to the monopoly price spectrum. Generally speaking, consumers, being dispersed and having less at stake, face higher costs of organization than producers and usually do not have the required incentives to spend the necessary resources to become informed. In case, the prediction is that the producer interest should win the bidding for the services of a regulatory agency. However, consumers who spend a larger share of their income on a good have a higher incentive to participate in the regulatory process and should drop more votes for the politician in response to a price rise. Therefore, goods with a high share in the consumers' budget are more likely to have prices close to the competitive price.

<sup>30</sup> The Brazilian electricity sector regulator did not employ any kind of economic benchmarking procedure to estimate the productivity increments experienced by each firm during the regulatory period before the rate review.

The statistical tests are conducted through two complementary procedures: (a) an OLS regression of the divergence variable (*ANEEL* vs *SFA*) 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, the firm's reported OPEX, and the final (adjusted) OPEX. These numbers are used 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 can be expressed by the distance of the final OPEX to the corresponding initial estimate or, in other words, by the weight (*W*) given by the regulator to the initial OPEX estimated by the engineering model. The weight is computed as follows:

$$OPEX^A = W * OPEX^E + (1 - W)OPEX^C$$

$$W = \frac{OPEX^A - OPEX^C}{OPEX^E - OPEX^C}$$

where  $OPEX^A$  stands for the final operating costs defined by the regulatory agency (ANEEL),  $OPEX^E$  stands for the operating costs initially estimated with the application of the engineering model, and  $OPEX^C$  is the operating costs reported by the distribution companies. These variables' values, along with the corresponding *WEIGHT* computed for each firm's tariff review, are portrayed in Table 1. Note that *WEIGHT* is inversely related to the bargaining effect, since the firm's bargaining power can be said to be higher when the variable gets closer to zero.

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, possible signals employed for firms' profitability and cash flow availability, and proxies for a potential impact caused by both the external monitoring of the regulator's activities and a likely learning effect.

These same independent variables are employed in the OLS regression. In this case, though, an additional variable is included to control for a possible problem resulting from the labor price measure used in the SFA procedure.

The explanatory variables are the following: income per capita (*INCOME*),<sup>31</sup> share of electricity delivered to industrial customers (*INDSHARE*), the log of total electricity delivered, in GWh (*SIZE*), customer density (*CUSDEN*), given by the log of the number of customers divided by service area, a public company dummy (*PUBLIC*), percentage growth in residential consumption per capita from 1998 to 2003 (*CONSUMPTION*), output growth in the same period (*GROWTH*), a categorical variable indicating whether or not the Tribunal de Contas da Uniao has monitored, or not, the tariff review process (*TCU*), the number of rate reviews occurring before the firm's review (*LEARNING*), and the ratio of SFA labor price to Model Company labor price (*LPDIFF*).

The variables *INCOME* and *INDSHARE* are 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. 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

---

<sup>31</sup> The state income per capita was employed for 24 companies in the sample (19 state monopolies plus five concessionaries which serve more than 90% of the consumers in the state). For the remaining 25 companies, *INCOME* corresponded to the weighted average income per capita of the ten biggest municipalities in the company's service area.

political participation is proportional to income.<sup>32</sup> As a result, income per capita should be negatively associated to both *WEIGHT* and *ANEELvsSFA*.<sup>33</sup> 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. Of course, the price structure (reflecting cost allocation rules across customer categories) may be more important here than the general price level, but the two are not unrelated.

The *SIZE* variable is a proxy for the producer's lobby, under the rationale that larger companies should possess greater ability to influence regulatory decisions. Here, however, as suggested by Klein and Sweeney (1999), it is conjectured that the expected effect of firm size is indeterminate, as large utilities are more likely to receive careful scrutiny from the regulatory agency.<sup>34</sup>

The *CUSDEN* and *PUBLIC* variables were 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. It is thus expected that *WEIGHT* and *ANEELvsSFA* increases with *CUSDEN* and decreases with *PUBLIC*.

*CONSUMPTION* and *GROWTH*, on their turn, represent possible signals employed by the regulator for firms' profitability and cash flow availability. The study tests the hypothesis that the regulator may have wanted to pass on to consumers some of the rents derived from economies of scale. Here, the expectation is that *GROWTH* contributes positively to both *WEIGHT* and *ANEELvsSFA*. On the other hand, the residential consumption growth (*CONSUMPTION*) captures

---

<sup>32</sup> Knittel (2006), however, hypothesizes that wealth per capita is positively correlated with the degree of residential interest group activity.

<sup>33</sup> The lower the income, the closer should be *W* to one, denoting a lower firm's bargaining power, and the lower should be the probability that *ANELEFF* is smaller than *SFA2003*.

<sup>34</sup> The *SIZE* variable also controls for a possible endogeneity in the TCU monitoring, detailed below, since the closer supervision of the regulator's activities during the tariff review process concentrated in the larger firms' cases.

the rationing effect. Brazil experienced an unforeseen electricity crisis in 2001, which led to an energy rationing in the period of June 2001 to February 2002.<sup>35</sup> The rationing measures significantly reduced the amount of electricity delivered and the average residential consumption, bringing financial losses to concessionaires that operate in a sector where the high fixed costs cannot be adjusted (or avoided) to compensate for the reduction in revenues. As the rationing effect differed among firms,<sup>36</sup> the observed change in residential consumption per capita is used as a proxy for firms' losses and included in the model to test the hypothesis that the least affected firms (the ones with higher *CONSUMPTION*) might have had relatively low price increases (higher *WEIGHT* and *ANEELvsSFA*), under the rationale that the concessionaires which had lower reductions in their cash flows had lower bargaining power in the tariff review process and, consequently, were the ones most susceptible to rent extraction to the benefit of consumers. Thus, the expectation is that *WEIGHT* and *ANEELvsSFA* vary directly with *CONSUMPTION*.

A singular feature of the Brazilian regulatory environment consists of the existence of a governmental body (Tribunal de Contas da Uniao) which supervises the regulatory agency's

---

<sup>35</sup> The rationing aimed at a 20% reduction in energy consumption, and was implemented through a quota system where monthly energy consumption targets were established for almost all consumers (poor residential consumers were exempted). The scheme instituted penalties for non-accomplishments and bonuses for overachievements, besides allowing the trading of quotas for nonresidential consumers. The quota system met its objectives and avoided the occurrence of blackouts. Consumption levels from June to December 2001 showed a 20% load reduction, compared to the previous year's consumption, and a 25% reduction if it is taken into account the new customers that entered the system in 2001 (Maurer, Pereira, and Rosenblat, 2005).

<sup>36</sup> The differentiated effect among firms came mainly from the fact that the rationing measures varied among electric zones. The quota system was initially applied to the Northeast and Southeast/Center-West sub-markets only, with more stringent quotas being assigned to the former, when compared to the latter. Subsequently, the rationing was extended to part of the North region, encompassing softer rules than the ones applied previously. The rationing in that region was limited to the July to December 2001 period. The South region, in turn, was not included in the rationing. Compared to the same period of the previous year, energy consumption in the Southeast, Northeast, Center-West, North, and South sub-markets declined 31%, 28%, 25%, 10%, and 7% in the period of August to December 2001, respectively (Bardelin, 2004). As stated by Maurer, Pereira, and Rosenblat (2005, p. 72), the South, despite not being forced to ration, engaged in the load reduction effort as a result of appeals in the media and for fear of more drastic measures in the upcoming dry season.

performance.<sup>37</sup> This study takes advantage of the fact that TCU closely monitored only some of the periodic tariff review processes to examine whether this external monitoring has produced an effect on regulator's decisions.<sup>38</sup> The intention is to shed light on the consequences of having an institution performing oversight of the regulatory agency's procedures, and possibly contribute to the literature that focuses on the optimal institutional regulatory framework. The supervision's expected effect is indeterminate, though. One might conjecture that the monitoring reduces the regulator's discretion and leads to figures closer to the ones portrayed by SFA, assuming the SFA results are good representations of the true values. In this case, however, it is not possible to anticipate the effect on the weight measure. Nonetheless, 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 *WEIGHT* and *ANEELvsSFA*).

The *LEARNING* variable is incorporated in the modeling to avoid attributing to firm's bargaining power (or lack of it) an effect due to "improvements" in the Model Company method's usage. This was the first time ANEEL employed the Model Company approach. It is thus reasonable to expect adjustments in the employed engineering cost parameters as more rate reviews were carried out, resulting in large changes in *OPEX<sup>E</sup>* at the first rate reviews, and progressively smaller changes at the reviews conducted later on. The *LEARNING* variable should then be directly related to *WEIGHT*. It is not possible, however, to anticipate the variable's effect on *ANEELvsSFA*.

---

<sup>37</sup> 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 audits and reviews administrative decisions of the government to ascertain that all legal procedures and rules have been followed. TCU is not a court, but the current legislation attributes to the organ the power to order the review of some procedures undertaken and to impose sanctions and penalties in cases of strong infractions to the law. TCU exercises an oversight over the regulatory agencies and has examined both the procedures and substance of regulatory decisions.

<sup>38</sup> In the specific cases it decided to closely monitor the tariff review process, TCU requested ANEEL to submit the correspondent technical notes and all other documents which supported the proposed repositioning indexes right after they were released, in order to ensure a concomitant supervision of the actions undertaken.

The continuing definition of the engineering cost parameters may either make the corresponding efficiency estimate converge to the economic benchmarking estimate, or not.

In the computation of *LPDIFF*, the Model Company labor price was given by total labor expenses estimated for the reference utility divided by the corresponding number of estimated employees.<sup>39</sup> The variable is incorporated in the OLS regression only, to check whether the divergences in results provided by the two approaches 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 firm's efficiency under SFA and, therefore, the higher should be the *ANEELvsSFA* measure.

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 tariff review processes examined, and 15 of the companies included in the sample are publicly owned. The average residential consumption growth of -18.3% portrays the rationing effect, whereas the computed *WEIGHT* varies in the interval of 0 to 0.998, with mean 0.641.<sup>40</sup>

As expected, *WEIGHT* is negatively and significantly (at the 1% level) correlated with the adjustment made in the initial OPEX estimate ( $\rho = -0.6371$ ), expressed by the ratio  $OPEX^A$  to  $OPEX^E$  (Table 1).<sup>41</sup> The adequacy of the variable's usage as a measure of firms' bargaining power is corroborated by its positive and significant correlation (at the 1% level) to the divergence

---

<sup>39</sup> For each of the hypothesized reference utilities, total labor expenses were computed on the basis of market salaries especially gathered by a commissioned consultancy firm, considering the service area's specificities. In addition, the estimated figure did not include some benefits actually paid by some concessionaries (additional vacation in excess of the one-third disposed in the Constitution and profit sharing, for example).

<sup>40</sup> In order to be able to run the GLM model, *W* was set equal to zero in the seven cases where the computed *WEIGHT* was negative, shown in Table 1. In these cases,  $OPEX^A$  showed up higher than  $OPEX^E$  essentially by virtue of revisions implemented by the regulator after the end of the "standard tariff review procedure," under the claim of offering to firms which had reviews in the beginning of the periodic tariff review (year 2003) the same treatment (engineering cost parameters) given to firms which had reviews later on (years 2004 and 2005).

<sup>41</sup> The higher the adjustment, the lower is *W* and the higher is the firm's bargaining power.

measure *ANEELvsSFA* ( $\rho = 0.6324$ ), a result that confirms the association between higher bargaining power (lower *W*) and overvaluation of firms' efficiency levels (lower *ANEELvsSFA*), and vice-versa.

The variable, however, is not free of problems. There are some cases where *W* denotes a high bargaining power in spite of a small percentage change from  $OPEX^E$  to  $OPEX^A$ ,<sup>42</sup> and the data provides evidence that the mentioned adjustments are related to the “improvements” in the engineering cost parameters through time, as the average percentage change on  $OPEX^E$  decreased steadily as more rate reviews were carried out, from 16.5% (for the first 12 firms in the periodic tariff review process) to 1.6% (for the last 13 firms). These facts endorse the inclusion of *LEARNING* as an additional explanatory variable, and support a research strategy employing two investigation procedures; the approaches employed in the present study can be viewed as complementary ways to address a complex topic.

#### 4.2. Results Analysis

Regression results are remarkably consistent among the GLM and OLS procedures (Table 6). The evidence uncovers four main explanatory factors for the methodologies' divergences in efficiency assessments. Initially, the positive and significant *LEARNING* coefficient on both GLM and OLS models suggests that the firms' order in the periodic tariff review had implications for regulatory decisions (and thus for the financial well-being of companies). The first companies that went through the rate setting experienced higher changes in their initial OPEX estimates and were benefited by the adjustments in the engineering cost parameters made through time. When *LEARNING* decreases from the variable's mean value to a value equal to the mean minus one standard deviation, the predicted *WEIGHT* decreases from 0.6902 to 0.3621 (- 47.5%), and the

---

<sup>42</sup> In these cases,  $OPEX^E$  was not far from  $OPEX^C$ . Thus, the final OPEX ( $OPEX^A$ ), despite representing only a small percentage increase on  $OPEX^E$ , was very close to  $OPEX^C$ , leading to a small *W*. See, for example, the cases of CAT-LEO, CELB, and CFLO in Table 1.

divergence measure *ANEELvsSFA* falls 0.074 points (6.8% of the mean value). These results indicate that the earlier-reviewed firms ended up obtaining prices higher than recommended by the economic benchmarking method. Conversely, later-reviewed firms were considered more inefficient under the regulator's approach, compared to the SFA standard, as if the regulator had become stricter after performing more and more rate-making processes.

The results also indicate that the employed proxies for the consumers' participation in regulatory decisions are statistically significant. In both cases, however, the evidence is contrary to some interpretations of interest group theory. The *INDSHARE*'s negative coefficients indicate that firms with a higher proportion of electricity delivered to industrial customers had a higher bargaining power in the rate review (lower *W*) and were considered more efficient than shown by SFA, receiving higher prices. The estimated impact is higher for higher values of the variable.<sup>43</sup> Moreover, when *INDSHARE* increases from the variable's mean value to a value equal to the mean plus one standard deviation, *ANEELvsSFA* falls 0.115 points (10.6% of the mean value). The findings, in case, suggest that industrial demanders may have received higher prices than would have been approved under a SFA approach to benchmarking.

The positive coefficients on the variable *INCOME* reveal that companies which serve more wealthy customers tend to have lower bargaining power in the tariff setting and were harmed by getting lower prices, i.e., prices seem to be lower (compared to the prices that would arise under benchmarking using SFA) when customer incomes are higher. A one-standard deviation increase in *INCOME* over its mean value shifts the predicted *WEIGHT* from 0.692 to 0.8151. Additionally, a one-unit and a one-standard deviation increase in *INCOME* augments *ANEELvsSFA* by 13.2% and 0.074 points (6.8% of the mean value), respectively. The evidence, here, is consistent with the

---

<sup>43</sup> As reported in Table 6, a one-unit increase in *INDSHARE* over its mean value decreases *W* by 7.4%. When the marginal effect is computed for a value one-standard deviation above the mean, the result indicates that a one-unit increase in *INDSHARE* decreases *W* by 8.5%.

association between wealth per capita and the degree of residential interest group activity suggested by Knittel (2006), as if the variable were 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.

The anticipated impact of customer density on the regulator's results is confirmed as well. The results indicate that the more densely populated the service area, the lower the company's bargaining power (here the coefficient estimate is only marginally significant) and the more harmed was the firm by receiving a repositioning index lower than the SFA benchmarking procedure would recommend. On the other hand, companies operating in less densely populated areas were considered more efficient than shown by the SFA method and, consequently, benefited from higher prices. The estimated impact is nontrivial, as 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 *ANEEL*<sub>vs</sub>*SFA* measure by 0.122 points, roughly 11.2% of its mean. This finding corroborates Peano's (2005) claim that the regulator may have wanted to provide an extra return to firms serving less densely populated service areas. However, the result might also indicate a technical problem in the definition of the cost parameters employed in the engineering model, which overstated the costs incurred by firms operating under this condition.

Some other results should be highlighted. The aforementioned potential problem associated to the SFA labor price variable is not confirmed and neither is the conjectured favorable treatment given to publicly owned firms. In addition, although the regulator knew in advance which reviews would be closely monitored,<sup>44</sup> the results indicate that supervision did not affect the types of decisions in a systematic way, suggesting that ANEEL was consistent, regardless of specific

---

<sup>44</sup> See footnote 38.

oversight. In particular, the evidence does not support the hypothesis that the external monitoring may have made the regulatory agency be more strict in its analysis, to the detriment of the distribution companies. 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. Finally, the positive and marginally significant coefficient found for the *SIZE* variable, in both GLM and OLS models, does not support the conjectured producer's influence on regulatory decisions, as it points to larger firms receiving prices lower than would have been approved under a SFA benchmarking. Here, the evidence suggests that large utilities possibly received greater scrutiny from the regulatory agency.

### **5. Robustness Check: DEA**

Since the discussion above rests on the assumption that SFA estimates are good representations of the true efficiency measures, the results' robustness is checked by performing the analysis with the use of efficiency estimates provided by an alternative benchmarking procedure. In case, 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 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. Therefore, 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.<sup>45</sup> 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:

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

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  $j$ ,  $\beta_j$  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.

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

---

<sup>45</sup> The definition of the total input slack measure in terms of percentage of actual input quantities is recommended by Fried et al. (1999, note 19) for the situation where the firm size differs significantly among firms in the sample.

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.<sup>46</sup>

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

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 (Appendix A). 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*,<sup>47</sup> varying in the range of 1 to 2.38, with mean 1.28. This fact, taken together with the evidenced similarity between *DEA2003* and *ANEELEFF* distributions,<sup>48</sup> suggests that either some inefficiency is attributed to statistical noise in the SFA approach, or the SFA efficiency indexes are constrained by the half-normal distribution assumed for the inefficiency error term. On the other hand, even though *DEA2003* and *SFA2003* efficiency measures and rankings are not significantly correlated,<sup>49</sup> 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 5).

---

<sup>46</sup> With this procedure, a firm with external variables corresponding to this base level would not have its input vector adjusted at all, and a firm with external variables generating a lower level of predicted slack would have its input vector adjusted upward to put in on the same basis as the firm with the least favorable external environment. In other words, predicted slack below the maximum predicted slack is attributable to external conditions more favorable than the least favorable conditions prevailing in the sample for that input. By increasing the input vector and leaving the output vector unchanged, the firm's performance is purged of the external advantage (Fried et al., 1999).

<sup>47</sup> The null of equality of means is rejected at the 1% significance level (p-value ( $H_1: \text{DEA2003} > \text{SFA2003}$ ) = .0001). When the equality of *DEA2003* and *ANEELEFF* means is tested, however, the null is not rejected.

<sup>48</sup> Data on the respective mean and standard deviation are provided in Table 5. The difference in means is not statistically significant, as mentioned in the previous note, but *DEA2003*'s distribution of efficiency indexes is slightly more spread out than *ANEELEFF*'s.

<sup>49</sup> The correlation statistic and the Spearman's rank correlation amount to -0.0579 (p=.6927) and -0.0751 (p=.5966), respectively.

The comparison between *DEA2003* and *ANEELEFF* corroborates the indication that the Model Company approach understated some firms' efficiency levels. 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 overevaluations of firms' efficiency are confirmed as well, as the model company efficiency indexes of firms *Energip*, *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.

The robustness check employs the same OLS model described in the previous section, with the difference that the dependent variable is now given by a new divergence measure (*ANEELvsDEA*), computed as the ratio of *ANEELEFF* to *DEA2003*. *ANEELvsDEA* varies in the range of 0.459 to 1.986, with mean 0.986 (Table 3), and is significantly (1% level) correlated with the preceding divergence measure ( $\rho = 0.7743$ ). As reported in Table 6, the fitted model is not as well specified as before (smaller  $R^2$ ), but the Wald specification test still rejects the null that the coefficient estimates are all equal zero (p-value = 0.0006). The results confirm the previously noted effects of *Industrial Share*, *Income*, and *Customer Density* variables. The findings, however, do not support the *Learning* effect identified before, or the possible impact of the *Size* variable.

## **6. Concluding Observations**

The present study examines the application of the Model Company approach in the Brazilian electricity distribution sector periodic tariff reviews (April/2003 to February/2006). The resulting firms' efficiency measures are evaluated with the use of efficiency estimates obtained from both a parametric and a non-parametric benchmarking model and indices of productivity changes

experienced in the six-year period before the rate review. In the process, the study tests for possible causes of the identified divergences in efficiency assessments and checks for potential determinants of firms' bargaining power in the rate setting process.

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 (Jadresic, 2002). 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: extracting part of the firms' rents for the benefit of consumers and society, achieving allocative efficiency, and offering incentives for further productivity improvements.

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 indicate that firms with a lower proportion of electricity delivered to industrial customers, which serve wealthier consumers and operate in more densely populated areas, had lower bargaining power in the tariff setting and were harmed by getting prices

lower than recommended by the economic benchmarking methods. These results are consistent with the economic theory of regulation which posits that political influence affects the level of prices. On the other hand, firms with opposite characteristics had higher bargaining power and benefited from higher prices. The evidence is consistent with an association between per capita income and the effectiveness of residential interest group activity. Moreover, the findings point to a possible inaccuracy of the cost parameters employed in the engineering Model Company approach; the parameters may inaccurately capture the effect of consumers' dispersion (customer density) on firms' operating costs, due to either the technical difficulty in defining the "true" parameter in a context of imperfect and asymmetric information, or a deliberate intention 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 (Peano, 2005).

This benefit given at the beginning of the tariff review cycle impacted negatively the incentives for efficiency improvements provided to firms 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. Moreover, the rulings (and associated price trajectories) ignored the significant frontier shifts of almost 7% per year revealed by the parametric modeling, a point that would exacerbate the perverse effects of the hypothesized over-evaluations of firms' efficiency.

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.

It should be stressed that the results outlined above are robust to the choice of benchmarking methodology (SFA or DEA) to employ as a comparison parameter. Moreover, the results do not support those who are concerned with possible limitations of the SFA methodology. However, for those who are more hesitant to abandon engineering models, at a minimum the present investigation presents a way to promote greater transparency to the process and credibility for the results obtained with the application of the Model Company method. Once the divergences in efficiency assessments are identified, and possible explanatory factors are uncovered, it remains the regulator's job to justify the choices made or demonstrate that the divergences do not come from deficiencies in the application of a particular methodology.

The proposed joint use of a comparative efficiency analysis technique benefits all stakeholders including the regulator; the agency could employ other benchmark techniques to alleviate potential adverse selection problems and consequently come up with more reliable approximations of firms' break-even points. It would then be possible to better exploit the price-cap incentives for efficiency improvements<sup>50</sup> and promote the desired allocation of productivity gains among stakeholders. Note, on this topic, that the redistribution of rents should ideally be based on information regarding the productivity increments of each firm during the whole regulatory period prior to the next review, information that the model company approach alone cannot provide.

The experience so far on setting price caps has indicated that quantitative benchmarking techniques may at least serve as an additional tool to the regulator, whose importance is underscored by information contained in comparisons available from having a large number of

companies in the regulated industry.<sup>51</sup> Thus, there appears to be no reason for not using them in the Brazilian electricity distribution industry.

---

<sup>50</sup> The efficiency improvement incentives associated to the price-cap method are often hindered by the regulator's uncertainties about firms' inherent costs, which usually lead to tariffs set at a too high level, given the fear of violating firms' financial sustainability constraint. Comparative efficiency analysis helps reduce the regulator's informational disadvantage and enables the definition of better participation constraints, thereby allowing a more fruitful use of high-powered incentive mechanisms.

<sup>51</sup> The use of benchmarking techniques on regulatory price reviews is discussed by Rossi and Ruzzier (2000), Pollitt (2005), Stern (2005), and Dassler, Parker, and Saal (2006), among others.

## References

- ANEEL (2003), “Metodologia e Cálculo da “Empresa de Referência” relativa à área de concessão da AES SUL”, Nota Técnica N° 047/2003/SRE/ANEEL, Anexo I.
- Byatt, I. (2004), “Regulation and Asset Valuation”, Report, The World Bank.
- Dassler, T., D. Parker and D.S. Saal (2006), “Methods and trends of performance benchmarking in UK utility regulation”, *Utilities Policy* 14, 166-174.
- de Oliveira, A. (2003), “The Political Economy of the Brazilian Power Industry Reform”, Working paper.
- Ferreira, C.K.L. (2000), “Privatizacao do Setor Eletrico no Brasil”, in Pinheiro, A. C. and K. Fukisaku (eds.), *A privatizacao no Brasil: o caso dos services de utilidade publica*, Rio de Janeiro: BNDES / OCDE.
- Fisher, R. and P. Serra (2002), “Evaluación de la regulación e las telecomunicaciones em Chile”, *Perspectivas*, 6 (1), 45-78.
- Foster, V., & Antmann, P. (2004), “The Regulatory Challenge of Asset Valuation: A Case Study from the Brazilian Electricity Distribution Sector”, *ENERGY Working Notes*, 2, World Bank.
- 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.
- Gomes, V., S. A. Pessôa and F. A. Veloso (2003), “Evolução da Produtividade Total dos Fatores na Economia Brasileira: Uma Análise Comparativa”, mimeo.
- 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. and M. G. Pollitt (2001), “Benchmarking and Regulation: International Electricity Experience”, *Utilities Policy* 9, 107-130.
- Joskow, P. L. (2005), “Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks”, mimeo.
- 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.
- Maurer, L., M. Pereira, and J. Rosenblatt (2005), “Implementing Power Rationing in a Sensible Way: Lessons Learned and International Best Practices”, Report 305/05, The World Bank.

- Mota, R. L. (2003), “The Restructuring and Privatisation of Electricity Distribution and Supply Businesses in Brazil: A Social Cost-Benefit Analysis”. Working Paper, Churchill College, University of Cambridge.
- Mota, R. L. (2004), “Comparing Brazil and U.S.A. Electricity Distribution Performance: What was the Impact of Privatisation?”, Working Paper, Churchill College, University of Cambridge.
- Naughton, M.C. (1989), “Regulatory preferences and two-part tariffs: the case of electricity”, *Southern Economic Journal*, 55, 743-758.
- 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), “Regulação 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.
- Pollitt, M. (2005), “The role of efficiency estimates in regulatory price reviews: Ofgem’s approach to benchmarking electricity networks”, *Utilities Policy* 13, 279-288.
- Primeaux, Jr. W.J, J.E. Filer, R.S. Herren, and D.R. Hollas (1984), “Determinants of regulatory policies toward competition in the electric utility industry”, *Public Choice*, 43, 173-186.
- Rossi, M.A. and C.A. Ruzzier (2000), “On the regulatory application of efficiency measures”, *Utilities Policy* 9, 81-92.
- Sappington, D. (2002), “Price Regulation”, in *The Handbook of Telecommunications Economics. Volume I: Structure, Regulation, and Competition*, edited by M. Cave, S. Majumdar, and I. Vogelsang. Amsterdam: Elsevier Science Publishers, 225–293.
- Serra, P. (2002), “Regulación del sector eléctrico chileno”, *Perspectivas*, 6, 11-43.
- Silva, H.C.D. (2006a), “An Empirical Assessment of the Regulator’s Performance in the Brazilian Electricity Sector”, University of Florida, mimeo.
- Silva, H.C.D. (2006b), “Privatization, Incentive Regulation, and Efficiency Improvements in the Brazilian Electricity Distribution Industry”, University of Florida, mimeo.
- Simar, L., & Wilson, P. (1998). “Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models.” *Management Science* 44: 49–61.
- Stern, J. (2005), “UK regulatory price reviews and the role of efficiency estimates”, *Utilities Policy* 13, 273-278.
- Stigler, G.J. (1971), “The Theory of Economic Regulation”, *Bell Journal of Economics and Management Science*, 2, 3-21.
- Weisman, D.L. (2000), “The (in)efficiency of the “efficient-firm” cost standard”, *The Antitrust Bulletin*, Spring, 195-211.

Table 1. Initially Estimated OPEX, Final OPEX, and Firm's Reported OPEX

COMPANY	OPEX <sub>E</sub> (A)	OPEX <sub>A</sub> (B)	OPEX <sub>C</sub> (C)	ANELEFF <sup>1</sup>	WEIGHT <sup>2</sup>	ORDER <sup>3</sup>	(B) / (A)	(A) / (C)
AES-SUL	152,378,578	168,526,897	213,700,000	1.2680	0.7367	2	10.60%	71.30%
BANDEIRANTE	178,748,147	200,857,495	254,995,034	1.2695	0.7100	6	12.37%	70.10%
BOA VISTA	19,299,948	19,312,706	26,152,813	1.3542	0.9981	24	0.07%	73.80%
BRAGANTINA	22,762,688	27,599,813	35,211,066	1.2758	0.6114	9	21.25%	64.65%
CAIUÁ	34,405,902	39,736,410	48,111,601	1.2108	0.6111	9	15.49%	71.51%
CAT-LEO	69,812,982	73,173,281	73,047,000	0.9983	-0.0390	12	4.81%	95.57%
CEAL	145,326,676	146,266,520	175,019,103	1.1966	0.9683	22	0.65%	83.03%
CEB	127,222,668	145,601,583	257,359,512	1.7676	0.8588	16	14.45%	49.43%
CEEE	231,085,795	235,718,790	266,328,472	1.1299	0.8685	17	2.00%	86.77%
CELB	26,293,985	27,302,875	29,812,883	1.0919	0.7133	19	3.84%	88.20%
CELESC	411,731,525	440,713,597	520,128,813	1.1802	0.7326	15	7.04%	79.16%
CELG	455,583,137	483,121,893	580,123,409	1.2008	0.7789	23	6.04%	78.53%
CELPA	229,717,734	269,031,550	310,500,443	1.1541	0.5133	5	17.11%	73.98%
CELPE	374,778,267	379,210,684	476,485,325	1.2565	0.9564	20	1.18%	78.65%
CELTINS	74,420,106	82,065,329	94,330,458	1.1495	0.6160	14	10.27%	78.89%
CEMAR	212,939,949	217,204,197	258,866,541	1.1918	0.9072	22	2.00%	82.26%
CEMAT	172,964,954	197,274,615	187,200,000	0.9489	-0.7077	1	14.05%	92.40%
CEMIG	808,746,752	936,572,499	893,609,000	0.9541	-0.5063	1	15.81%	90.50%
CENF	19,073,913	19,748,356	22,158,000	1.1220	0.7813	12	3.54%	86.08%
CEPISA	140,241,902	141,016,014	160,151,652	1.1357	0.9611	22	0.55%	87.57%
CERJ	278,164,419	297,502,578	391,983,902	1.3176	0.8301	8	6.95%	70.96%
CERON	122,533,378	122,743,263	130,521,640	1.0634	0.9737	25	0.17%	93.88%
CFLO	10,983,263	11,658,505	12,462,079	1.0689	0.5434	9	6.15%	88.13%
COELBA	341,063,413	431,347,472	437,000,000	1.0131	0.0589	3	26.47%	78.05%
COELCE	244,517,894	282,727,424	260,000,000	0.9196	-1.4680	3	15.63%	94.05%
COPEL	588,545,532	606,611,885	688,548,640	1.1351	0.8193	13	3.07%	85.48%
COSERN	97,792,392	113,400,305	136,100,000	1.2002	0.5926	3	15.96%	71.85%
CPFL	328,589,815	421,760,792	549,100,000	1.3019	0.5775	1	28.35%	59.84%
ELEKTRO	323,531,823	348,509,294	436,873,603	1.2535	0.7796	5	7.72%	74.06%
ELETROPAULO	588,395,853	645,184,235	1,281,200,000	1.9858	0.9180	4	9.65%	45.93%
MANAUS	87,650,951	87,948,585	102,481,654	1.1652	0.9799	24	0.34%	85.53%
ENERGIPE	68,983,023	82,571,280	70,000,000	0.8478	-12.3614	3	19.70%	98.55%
ENERSUL	112,343,069	130,154,623	113,300,000	0.8705	-17.6132	1	15.85%	99.16%
ESCELSA	209,658,844	217,182,804	275,672,979	1.2693	0.8860	15	3.59%	76.05%
LIGHT	463,351,823	516,334,111	944,760,674	1.8297	0.8899	7	11.43%	49.04%
NACIONAL	19,052,515	22,337,700	29,134,454	1.3043	0.6742	9	17.24%	65.40%
PIRATININGA	170,825,329	191,017,669	265,380,252	1.3893	0.7864	6	11.82%	64.37%
RGE	157,117,648	170,367,818	174,089,900	1.0218	0.2193	2	8.43%	90.25%
SAELPA	185,395,425	190,428,585	214,242,000	1.1251	0.8255	22	2.71%	86.54%
SANTA CRUZ	40,012,199	44,081,288	48,887,827	1.1090	0.5415	9	10.17%	81.84%
SANTA MARIA	16,498,783	19,771,653	19,299,425	0.9761	-0.1686	10	19.84%	85.49%
V. PARANAP.	31,929,120	37,622,908	45,725,014	1.2154	0.5873	9	17.83%	69.83%
CSPE	17,823,015	19,150,347	23,078,303	1.2051	0.7474	9	7.45%	77.23%
DMEPC	16,750,348	17,466,270	19,635,723	1.1242	0.7519	13	4.27%	85.31%
ELETROACRE	31,603,551	32,045,408	35,519,561	1.1084	0.8872	25	1.40%	88.98%
ELETROCAR	11,932,292	11,958,308	16,844,993	1.4086	0.9947	21	0.22%	70.84%
JAGUARI	10,677,128	11,157,355	15,783,997	1.4147	0.9060	9	4.50%	67.65%
MOCOCA	12,246,733	13,167,147	16,895,193	1.2831	0.8020	9	7.52%	72.49%
XANXERÊ	10,165,730	11,223,622	12,416,298	1.1063	0.5299	15	10.41%	10.41%

1. Regulator's Efficiency Index: ratio OPEX<sup>C</sup> over OPEX<sup>A</sup>

2. The Weight shows how close the Final OPEX (OPEX<sup>A</sup>) is to the Engineering Estimated OPEX (OPEX<sup>E</sup>).

3. Firm's order in the tariff review process.

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

<i>Continuous Variables</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Range</i>	<i>Categorical Variables</i>	<i>Value</i>	<i>Frequency</i>
<i>WEIGHT</i>	0.641	0.323	(0, 0.998)	<i>PUBLIC</i>	0	34
<i>ANEELVSSFA</i>	1.087	0.202	(0.633, 1.719)		1	15
<i>ANEELVSDEA</i>	0.986	0.298	(0.459, 1.986)	<i>TCU</i>	0	37
<i>CUSDEN(LN)</i>	2.825	1.511	(0.250, 7.019)		1	12
<i>LPDIFF</i>	0.978	0.414	(0.301, 2.474)			
<i>INCOME (LN)</i>	2.065	0.558	(0.856, 3.795)			
<i>INDSHARE</i>	0.322	0.158	(0.039, 0.644)			
<i>SIZE (LN)</i>	0.702	1.567	(-2.083, 3.491)			
<i>CONSUMPTION</i>	-18.297	10.474	(-65.217, 6.820)			
<i>GROWTH</i>	12.194	13.607	(-22.525, 37.771)			
<i>LEARNING</i>	22.694	14.585	(0, 47)			

Table 4. Stochastic Cost Frontier Results

Variable	Time-trend formulations			Time Fixed-Effects formulations		
	A	B	C	D	E	F
<i>LnOpex</i>						
<i>LnQ</i>	0.771*** (.025)	0.781*** (.023)	0.803*** (.035)	0.708*** (.018)	0.739*** (.017)	0.756*** (.017)
<i>LnLP</i>	0.442*** (.062)	0.403*** (.064)	0.409*** (.066)	0.395*** (.034)	0.348*** (.035)	0.366*** (.034)
<i>lnMP</i>	0.364*** (.116)	0.374*** (.112)	0.315*** (.114)	0.381*** (.068)	0.401*** (.069)	0.480*** (.069)
<i>Cap</i>	0.096*** (.027)	0.108*** (.027)	0.058* (.034)	0.103*** (.028)	0.102*** (.030)	0.080** (.028)
<i>Len</i>	0.561*** (.064)	0.561*** (.063)	0.522*** (.064)	0.534*** (.063)	0.525*** (.066)	0.516*** (.063)
<i>lnIndShare</i>	-0.007 (.034)	0.009 (.033)	-0.013 (.035)	-0.008 (.033)	-0.003 (.034)	0.009 (.033)
<i>lnResDen</i>	0.169* (.089)	0.157* (.088)	0.143 (.092)	0.131 (.089)	0.099 (.092)	0.145* (.087)
<i>lnIncome</i>	-0.179*** (.035)	-0.145*** (.037)	-0.186*** (.039)	-0.168*** (.037)	-0.139*** (.039)	-0.185*** (.040)
<i>lnArea</i>	0.072*** (.012)	0.074*** (.011)	0.066*** (.013)	0.074*** (.012)	0.073*** (.013)	0.073*** (.012)
<i>lnCusDen</i>	0.500*** (.061)	0.496*** (.061)	0.466*** (.064)	0.469*** (.062)	0.462*** (.064)	0.465*** (.061)
<i>Undergrd</i>	4.765*** (.589)	4.480*** (.582)	4.486*** (.563)	4.830*** (.602)	4.465*** (.611)	4.601*** (.583)
<i>T</i>	-0.054** (.027)	-0.052* (.026)	-0.051** (.025)			
<i>lnQ*t</i>	-0.015*** (.005)	-0.014*** (.005)	-0.007 (.005)			
<i>lnLP*t</i>	-0.012 (.017)	-0.010 (.017)	-0.014 (.017)			
<i>lnMP*t</i>	0.001 (.029)	0.001 (.027)	0.047 (.030)			
<i>Tsq</i>	-0.004 (.007)	-0.004 (.007)	-0.005 (.007)			
<i>Private</i>		-0.110** (.047)				
<i>Private*t</i>		0.006 (.012)				
<i>Privtzed</i>			-0.094* (.052)			
<i>Alwspriv</i>			-0.081 (.087)			
<i>D1999</i>				-0.039 (.033)	0.049 (.183)	-0.044 (.032)
<i>D2000</i>				-0.106*** (.033)	0.048 (.294)	-0.102*** (.033)
<i>D2001</i>				-0.150*** (.034)	0.029 (.346)	-0.147*** (.033)
<i>D2002</i>				-0.268*** (.035)	-0.075 (.355)	-0.273*** (.036)
<i>D2003</i>				-0.303*** (.036)	-0.137 (.337)	-0.308*** (.035)
<i>Cons</i>	-0.150** (.070)	0.001 (.052)	-0.142 (.089)	-0.200*** (.052)	-0.581 (.367)	-0.437*** (.105)
<i>lnsig2v</i>						
<i>Cons</i>	-3.964*** (.307)	-3.734*** (.080)	-4.242*** (.486)	-3.898*** (.242)		
<i>lnsig2u</i>						
<i>Q</i>	0.109* (.064)	0.606 (.761)	-0.063 (.102)	0.131** (.051)		
<i>Cons</i>	-4.423*** (1.193)	-15.104 (14.702)	-3.590*** (1.029)	-4.502*** (.956)		
<b>Statistics</b>						
<i>N</i>	306	306	306	306	306	306
<i>Ll</i>	128.429	136.29	144.157	120.077	124.98343	134.31818
<i>Chi2</i>	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. Efficiency Rankings and Indexes

Ranking	ANEELEFF		SFA2003		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 2	1.074	MOCOCA	1.073
15	SANTA CRUZ	1.109	CSPE	1.077	BANDEIRANTE 2	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 2	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
	<i>Mean</i>	1.202	<i>Mean</i>	1.110	<i>Mean</i>	1.283
	<i>Std. Deviation</i>	0.217	<i>Std. Deviation</i>	0.072	<i>Std. Deviation</i>	0.302
	<i>25% Percentile</i>	1.106	<i>25% Percentile</i>	1.074	<i>25% Percentile</i>	1.024
	<i>75% Percentile</i>	1.270	<i>75% Percentile</i>	1.127	<i>75% Percentile</i>	1.437

Table 6. Regression Results

<i>Variable</i>	<i>GLM</i>		<i>OLS</i>	
	<i>Coefficient</i>	<i>Marginal Effect</i>	<i>ANEELvsSFA</i>	<i>ANEELvsDEA</i>
<i>Industrial share</i>	-3.466** (1.560)	-0.741** (0.339)	-0.728*** (0.156)	-0.561** (0.271)
<i>Income (ln)</i>	1.223*** (0.468)	0.262** (0.103)	0.132** (0.050)	0.151* (0.075)
<i>Size (ln)</i>	0.313* (0.190)	0.067 (0.041)	0.048* (0.027)	0.039 (0.028)
<i>Consumption</i>	0.011 (0.018)	0.002 (0.004)	0.001 (0.002)	0.003 (0.002)
<i>Growth</i>	0.003 (0.016)	0.001 (0.003)	-0.001 (0.002)	0.001 (0.003)
<i>Customer density (ln)</i>	0.303* (0.176)	0.065* (0.038)	0.081*** (0.023)	0.124*** (0.040)
<i>TCU monitoring</i>	-0.694 (0.560)	-0.156 (0.132)	-0.058 (0.067)	-0.078 (0.104)
<i>Public company</i>	0.144 (0.488)	0.030 (0.102)	-0.075 (0.063)	0.078 (0.085)
<i>Learning</i>	0.094*** (0.020)	0.020*** (0.005)	0.005** (0.002)	-0.001 (0.003)
<i>Labor price effect</i>			-0.029 (0.097)	
<i>Intercept</i>	-3.515*** (1.232)		0.756*** (0.143)	0.533*** (0.172)
<i>Statistics</i>				
<i>N</i>	49		49	49
<i>Log pseudolikelihood</i>	-18.376			
<i>R<sup>2</sup></i>			0.634	0.522

Robust standard errors in parentheses

Legend: \* p<.1; \*\* p<.05; \*\*\* p<.01

APPENDIX A  
SFA AND DEA EFFICIENCY INDEXES

COMPANY	SFA						DEA					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
AES-SUL	1.062	1.056	1.076	1.078	1.101	1.093	1.000	1.000	1.000	1.000	1.000	1.000
BANDEIRANTE	1.378	1.205	1.146				1.000	1.000	1.000			
BANDEIRANTE 2					1.077	1.074					1.000	1.096
BOA VISTA	1.071	1.101	1.057	1.046	1.085	1.080	1.238	1.381	1.333	1.196	1.205	1.217
BRAGANTINA	1.079	1.091	1.121	1.120	1.128	1.151	1.325	1.294	1.575	1.623	1.629	1.600
CAIUÁ	1.101	1.107	1.106	1.149	1.132	1.148	1.397	1.364	1.517	1.639	1.692	1.733
CAT-LEO	1.073	1.066	1.078	1.075	1.066	1.057	1.869	1.582	1.873	2.024	1.946	2.174
CEAL	1.090	1.079	1.084	1.073	1.071	1.070	1.575	1.464	1.555	1.656	1.664	1.449
CEB	1.113	1.096	1.103	1.105	1.097	1.106	1.443	1.376	1.359	1.295	1.393	1.379
CEEE	1.154	1.121	1.113	1.161	1.174	1.133	1.520	1.447	1.451	1.372	1.397	1.337
CELB	1.110	1.094	1.083	1.065	1.063	1.059	1.460	1.357	1.361	1.481	1.418	1.120
CELESC	1.424	1.358	1.353	1.304	1.512	1.283	1.572	1.447	1.420	1.218	1.261	1.170
CELG	1.065	1.135	1.171	1.181	1.126	1.140	1.536	1.515	1.828	1.984	1.761	1.692
CELPA	1.092	1.165	1.176	1.188	1.151	1.129	1.412	1.333	1.239	1.136	1.217	1.153
CELPE	1.227	1.202	1.124	1.098	1.102	1.090	1.381	1.304	1.307	1.387	1.399	1.233
CELTINS	1.089	1.096	1.085	1.118	1.100	1.095	2.410	2.058	2.257	2.801	2.525	2.381
CEMAR	1.083	1.108	1.123	1.118	1.081	1.072	1.377	1.460	1.451	1.441	1.433	1.340
CEMAT	1.063	1.114	1.135	1.145	1.112	1.127	1.818	1.445	1.618	1.678	1.575	1.437
CEMIG	1.422	1.620	1.593	1.493	1.498	1.506	1.000	1.000	1.000	1.000	1.000	1.000
CENF	1.157	1.124	1.129	1.135	1.090	1.072	1.309	1.309	1.316	1.403	1.441	1.266
CEPISA	1.111	1.139	1.138	1.094	1.129	1.093	1.748	1.706	1.642	1.692	1.724	1.577
CERJ	1.144	1.126	1.116	1.125	1.126	1.115	1.437	1.342	1.534	1.490	1.570	1.522
CERON	1.111	1.118	1.130	1.089	1.095	1.094	1.486	1.406	1.451	1.178	1.277	1.258
CFLO	1.048	1.059	1.079	1.071	1.084	1.101	1.047	1.227	1.107	1.075	1.124	1.138
COELBA	1.104	1.075	1.091	1.121	1.080	1.084	1.486	1.109	1.383	1.709	1.439	1.284
COELCE	1.114	1.097	1.103	1.081	1.068	1.068	1.115	1.060	1.100	1.120	1.096	1.000
COPEL	1.144	1.131	1.148	1.057	1.142	1.132	1.453	1.192	1.330	1.064	1.302	1.499
COSERN	1.081	1.056	1.062	1.064	1.072	1.069	1.300	1.009	1.235	1.326	1.318	1.144
CPFL	1.216	1.185	1.132	1.127	1.129	1.092	1.073	1.000	1.127	1.000	1.004	1.000
ELEKTRO		1.122	1.109	1.081	1.070	1.082		1.174	1.164	1.193	1.004	1.183
ELETROPAULO	1.489	1.289	1.390	1.210	1.131	1.155	1.000	1.000	1.000	1.000	1.000	1.000
MANAUS	1.051	1.098	1.058	1.074	1.061	1.062	1.000	1.160	1.136	1.000	1.000	1.000
ENERGIPE	1.091	1.070	1.098	1.111	1.112	1.093	1.342	1.062	1.316	1.404	1.387	1.221
ENERSUL	1.074	1.080	1.085	1.068	1.066	1.065	1.773	1.475	1.748	1.783	1.712	1.618
ESCELSA	1.108	1.135	1.114	1.095	1.078	1.074	1.208	1.074	1.215	1.295	1.171	1.274
LIGHT	1.233	1.179	1.148	1.131	1.105	1.069	1.000	1.000	1.055	1.000	1.000	1.000
NACIONAL	1.065	1.075	1.086	1.063	1.088	1.113	1.000	1.088	1.112	1.116	1.189	1.171
PIRATININGA					1.127	1.081					1.000	1.000
RGE	1.049	1.059	1.064	1.055	1.057	1.045	1.499	1.000	1.142	1.133	1.092	1.000
SAELPA	1.088	1.083	1.099	1.100	1.103	1.097	1.546	1.264	1.502	1.616	1.553	1.259
SANTA CRUZ	1.080	1.071	1.078	1.091	1.077	1.088	1.328	1.222	1.565	1.799	1.773	1.656
SANTA MARIA	1.091	1.081	1.080	1.103	1.083	1.101	1.182	1.067	1.182	1.282	1.224	1.233
V. PARANAP.	1.090	1.116	1.118	1.147	1.138	1.179	1.295	1.321	1.493	1.567	1.647	1.647
COCEL	1.115	1.087	1.083	1.092	1.100	1.132	1.000	1.000	1.000	1.000	1.000	1.000
CSPE	1.093	1.063	1.052	1.050	1.053	1.077	1.473	1.323	1.222	1.112	1.151	1.206
DMEPC	1.146	1.112	1.115	1.119	1.106	1.096	1.217	1.285	1.292	1.299	1.233	1.024
ELETROACRE	1.038	1.062	1.071	1.065	1.088	1.060	1.000	1.000	1.000	1.000	1.000	1.000
ELETROCAR	1.076	1.054	1.058	1.075	1.087	1.090	1.000	1.000	1.000	1.000	1.000	1.000
JAGUARI	1.135	1.081	1.068	1.091	1.099	1.147	1.000	1.000	1.000	1.000	1.000	1.000
MOCOCA	1.056	1.044	1.045	1.053	1.060	1.083	1.000	1.000	1.000	1.000	1.093	1.073
SULGIPE	1.047	1.066	1.071	1.096	1.103	1.146	1.000	1.181	1.235	1.292	1.321	1.471
CPEE	1.148	1.100	1.055	1.066	1.071	1.101	1.686	1.479	1.064	1.014	1.041	1.145
XANXERÊ	1.103	1.098	1.148	1.143	1.141	1.196	1.000	1.052	1.202	1.172	1.131	1.116
Mean	1.128	1.121	1.121	1.113	1.113	1.111	1.327	1.243	1.314	1.341	1.318	1.279
Std Deviation	0.100	0.092	0.092	0.072	0.084	0.070	0.299	0.224	0.269	0.354	0.314	0.298

APPENDIX B  
MALMQUIST TFP INDEXES

<i>COMPANY</i>	<i>1999/1998</i>	<i>2000/1999</i>	<i>2001/2000</i>	<i>2002/2001</i>	<i>2003/2002</i>	<i>2003/1998</i>
<i>AES-SUL</i>	8.48%	6.74%	8.45%	6.64%	10.27%	47.67%
<i>BANDEIRANTE</i>	23.83%	15.79%				43.39%
<i>BANDEIRANTE 2</i>					10.78%	10.78%
<i>BOA VISTA</i>	-0.44%	7.60%	5.24%	0.73%	5.80%	20.16%
<i>BRAGANTINA</i>	2.32%	1.18%	4.77%	4.55%	3.71%	17.61%
<i>CAIUÁ</i>	3.30%	4.37%	0.63%	6.68%	4.36%	20.78%
<i>CAT-LEO</i>	5.25%	3.89%	5.64%	6.83%	7.46%	32.62%
<i>CEAL</i>	6.88%	5.65%	7.59%	7.27%	7.97%	40.72%
<i>CEB</i>	9.12%	7.23%	8.28%	9.83%	8.73%	51.31%
<i>CEEE</i>	11.98%	10.12%	5.06%	8.85%	14.32%	61.21%
<i>CELB</i>	5.51%	5.95%	7.00%	5.65%	6.27%	34.29%
<i>CELESC</i>	13.76%	9.52%	13.50%	-6.77%	28.56%	69.48%
<i>CELG</i>	0.90%	5.12%	8.18%	14.80%	9.06%	43.65%
<i>CELPA</i>	0.00%	6.25%	6.69%	11.63%	10.90%	40.32%
<i>CELPE</i>	10.24%	15.50%	11.40%	8.97%	11.25%	71.96%
<i>CELTINS</i>	2.61%	4.84%	1.26%	6.67%	6.05%	23.23%
<i>CEMAR</i>	3.60%	5.31%	7.83%	11.25%	9.02%	42.70%
<i>CEMAT</i>	1.68%	4.97%	6.52%	11.00%	7.04%	35.08%
<i>CEMIG</i>	-4.75%	12.86%	18.56%	11.59%	11.91%	59.16%
<i>CENF</i>	5.56%	2.47%	2.73%	7.92%	6.17%	27.31%
<i>CEPISA</i>	3.00%	6.23%	10.55%	3.60%	11.25%	39.42%
<i>CERJ</i>	9.74%	9.64%	8.16%	9.28%	11.00%	57.86%
<i>CERON</i>	5.19%	4.97%	10.43%	6.60%	7.83%	40.16%
<i>CFLO</i>	1.00%	0.76%	3.90%	2.44%	2.64%	11.17%
<i>COELBA</i>	11.03%	7.22%	6.18%	13.60%	9.89%	57.77%
<i>COELCE</i>	9.61%	7.74%	11.11%	10.62%	9.98%	59.63%
<i>COPEL</i>	10.56%	8.11%	19.19%	2.18%	12.59%	63.90%
<i>COSERN</i>	9.47%	6.72%	7.51%	7.48%	9.19%	47.40%
<i>CPFL</i>	12.26%	14.95%	11.01%	10.75%	15.22%	82.79%
<i>ELEKTRO</i>		10.16%	12.03%	10.81%	8.90%	48.91%
<i>ELETROPAULO</i>	25.34%	2.29%	26.20%	19.81%	10.63%	114.45%
<i>ELN/AM (MANAUS)</i>	1.37%	11.13%	6.16%	9.46%	8.89%	42.55%
<i>ENERGIPE</i>	8.40%	3.84%	5.76%	7.43%	9.84%	40.48%
<i>ENERSUL</i>	6.10%	6.87%	9.36%	8.47%	9.01%	46.63%
<i>ESCELSA</i>	5.43%	10.50%	10.62%	11.05%	10.24%	57.77%
<i>LIGHT</i>	14.44%	13.09%	12.34%	13.60%	15.04%	90.02%
<i>NACIONAL</i>	1.98%	2.46%	6.13%	1.93%	2.55%	15.92%
<i>PIRATININGA</i>					15.38%	15.38%
<i>RGE</i>	6.43%	7.15%	9.23%	8.76%	10.82%	50.14%
<i>SAELPA</i>	6.36%	4.74%	6.79%	7.18%	8.34%	38.17%
<i>SANTA CRUZ</i>	4.20%	3.26%	3.38%	6.68%	4.80%	24.36%
<i>SANTA MARIA</i>	3.05%	2.53%	0.59%	5.23%	2.26%	14.36%
<i>V. PARANAPANEMA</i>	0.94%	3.77%	1.74%	5.89%	1.79%	14.86%
<i>COCEL</i>	4.13%	2.47%	1.62%	2.22%	0.32%	11.20%
<i>CSPE</i>	5.49%	4.12%	3.57%	3.35%	1.86%	19.76%
<i>DMEPC</i>	5.55%	2.73%	2.65%	4.60%	4.68%	21.86%
<i>ELETROACRE</i>	0.94%	2.98%	4.75%	2.26%	7.44%	19.63%
<i>ELETROCAR</i>	2.89%	0.93%	0.20%	1.46%	2.87%	8.61%
<i>JAGUARI</i>	7.74%	4.61%	1.53%	3.54%	0.16%	18.67%
<i>MOCOCA</i>	2.54%	1.80%	1.65%	2.59%	1.47%	10.45%
<i>SULGIPE</i>	-0.91%	0.90%	-0.62%	1.47%	-1.21%	-0.40%
<i>CPEE</i>	6.48%	6.64%	1.59%	2.55%	0.71%	19.13%
<i>XANXERÊ</i>	1.64%	-3.16%	2.58%	2.83%	-1.85%	1.90%
<i>Mean</i>	6.04%	6.03%	6.94%	6.88%	7.77%	
<i>Cumulative Index</i>	6.04%	12.44%	20.25%	28.52%	38.50%	