REGULATORY SCHEMES FOR THE BRAZILIAN MARKET OF ELECTRICITY TRANSMISSION

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Introduction

Regulatory schemes should be designed to stimulate competition and improve efficiency in the transmission and distribution segment, in the electrical sector organized as a natural monopoly. Yet, in Brazil, the Regulatory Agency for Electricity (ANEEL) uses an ad-hoc scheme to remunerate the firms engaged on electricity transmission. In spite of the huge amounts involved in those reimbursements there is no evaluation of this scheme. Such an analysis is particularly relevant as the access to the transmission networks constitutes the base of a successful liberalization of the electricity markets. However, the presence of sub-additivity of costs, congestion, vertical scale economies with power generation and externalities brought about by the existence of loop flow among transmissions networks make difficult the regulatory design in this sector [1]. To account for these elements, different regulatory schemes have been proposed; they include long-term financial-transmission-right as well as those that incorporate incentive systems which permit to tackle with asymmetric information and strategic behavior. Our paper is inserted in this debate. Its objective is to evaluate the regulatory process in the electricity transmission sector in Brazil by combining contract theory and DEA (Data Envelopment Analysis) calculations. On that account we use a multi-product, multi-input regulatory cost-based framework to assess the performance of 14 firms operating in this segment during the period 2004-2007. We compute C-MDEA (Multiple Data Envelopment Analysis) efficiency and Malmquist productivity indexes to derive financial transfers to the firms and compare them with the ones actually paid by the regulator to those same firms.

Methodology: The Dynamic Yardstick Competition Model and the M-DEA Method

The Dynamic Yardstick Competition model [2] constitutes an extension of the yardstick competition model where the performance of a regulated utility is compared against that of a group of comparable utilities. Consider a principal that delegates the production of p outputs to an agent i (or Decision Making Unit). The agent will transform the input vector[1] $x \in R_+^{q_x}$ to produce the output $y \in R_+^{p_x}$. Input and output prices are given, respectively by $w^i \in R_+^{q_x}$ and $p^i \in R_+^{p_y}$; t = 1,...,T. The dynamic regulation model is a *blueprint incentive model* linked to a conditional revenue cap. The DEA-*Yardstick* is given by:

$$b_t^i = c_t^i + \rho^i \cdot [C^{DEA}(y_t^i \mid w_t^i) - c_t^i] \quad t = 1,...,T \qquad [1]$$

where b_t^i is a committed revenue cap, c_t^i is DMU's actual cost and ρ^i is an incentive parameter. Here, the regulator estimates a C_t^{DEA} cost function [3] for the firms and uses this information to determine revenues during the regulatory period. To avoid the ratchet effect, the DEA cost function is computed for the utility peers thus excluding the DMU analyzed. Hence, the cost efficiency is

$$\begin{aligned} & C_t^{DEA-i}(y \mid w) = \min_{x,\lambda} w \cdot x \\ s.a. \quad & x \geq \sum_{j \neq i} \sum_{s=0}^{t-1} (\lambda^{js} \cdot x^{js} + \lambda^{i0} \cdot x^{i0}) \\ & y \leq \sum_{j \neq i} \sum_{s=0}^{t-1} (\lambda^{js} \cdot y^{js} + \lambda^{i0} \cdot y^{i0}) \\ & \lambda \in \Gamma(r) \\ & j \neq i,\ s = 0,...,t-1 \end{aligned} \qquad [2]$$

We compute historic efficiency scores E_0^i,for each firm as:

$$E_0^i = \frac{C^{DEA}(y_0^i \mid w_0^i)}{w_0^i \cdot x_0^i} \qquad [3]$$

The cost function C^{DEA} is generated taking into account the whole set of information, including the ones of the analyzed utility. Assuming that the proportion of the initial inefficiency that the firm should suppress each year is δ, the cost norm becomes:

$$\frac{(1 - \delta \cdot (1 - E_0^i))^t}{E_0^i} \qquad [4]$$

δ should be defined to assure that the suppression total of the inefficiency along the regulatory period do not exceed the initial inefficiency for the *i-th* firm:

$$\frac{(1 - \delta \cdot (1 - E_0^i))^T}{E_0^i} \geq 1 \qquad [5]$$

Inserting [4] into [1] we have the dynamic yardstick revenue cap, R^{Yi}, that will be used for the analysis of the regulatory schemes in the Brazilian market of electricity transmission in Brazil:

$$R_t^{Yi} = c_t^i + \rho \cdot \left[(1 - \delta \cdot (1 - E_0^i))^t \cdot \frac{C_t^{DEA-i}(y_t^i \mid w_t^i)}{E_0^i} - c_t^i \right] \quad t = 1,...,T \qquad [6]$$

2.1 The M-DEA Model

As we have a limited number of firms and data is available only from 2004, the restricted size of the data base lead to the well known *curse of the dimensionality*. Moreover, the methodology uses a historic efficiency for each firm based on information prior to the regulatory contract, to be held constant during the negotiation periods t (t = 1,...,T), This requires the segmentation of the data base in two subsets, the first one representing information before the contract is formalized (t=1) and the second that refer to the period subject to the regulatory process. This limited information reduces the discriminatory power of the usual DEA calculations. For that reason we used instead an extension of the DEA techniques, the M-DEA methodology [4]. Below, we will briefly describe this approach.

The approach MDEA computes efficiency indexes for different combinations of inputs and outputs. This procedure gives efficiency spectra (frequency distributions) for each DMU, from which efficiency ranking can be extracted, together with confidence intervals. The method identifies the largest sets of Q inputs and P outputs as follows.

1. Choose, sequentially, different subsets of inputs and outputs such as $q \in \{1,...,Q\}$ e $p \in \{1,...,P\}$. As we have $\binom{Q}{q}$ possibilities to choose a subset containing q inputs (from a total of Q), there are $\sum_{q=1}^{Q}\binom{Q}{q} = 2^Q - 1$ possible choices. Similarly, there are $\sum_{p=1}^{P}\binom{P}{p} = 2^P - 1$ output choices.
2. Compute DEA $\Omega \equiv (2^Q - 1)(2^P - 1)$ scores for all combination of inputs and outputs, each one corresponding to a specific input output set.
3. Define the final DEA efficiency score, for a given DMU, as the average on ω (1,...,Ω) from the computed scores:

$$C^{MDEA} = \sum_{\omega=1}^{\Omega} C_{\omega}^{MDEA} / \Omega \qquad [7]$$

Data

Firm's costs, for the period 2004 to 2007 for seven public utilities (federal and state owned companies), six private firms and one public firm that was privatized during this period (CTEEP). Yearly data were taken from BMP (Balancete Mensal Padronizado), a detailed financial statement that concessionaires must deliver periodically to ANEEL. To compute efficiency scores (E_t^i), we considered only controllable costs, such as personnel, subcontracts, rental, equipment and general purchase, which includes all the expenses that companies had to manage in order to operate and maintain their transmission lines. On the other hand, we considered as "actual costs" all controllable and not controllable costs (which include financial expenses, depreciation, taxes, etc), since they are supposed to be completely covered by the regulatory revenue (RAP). In general, public firms also run electricity production plants and lower tension transmission lines that are not covered by RAP. Obviously, costs related to these businesses were not considered. Costs are in 2004 prices. Annual wage costs were deflated by the Consumer Price Index (IPCA). The other operational expenses were deflated by a wholesale price index, the IGP-M (Índice Geral de Preços). The other information used in this paper was taken from public reports, delivered annually by the transmission companies.

Table 1 describes inputs and outputs for electricity transmission. A measure for transported electricity, that constitutes the output of the transmission firms, is the power of the line. However, this information is not available. For that reason, we computed a proxy for total power that take into account topological and technical characteristics of the transmission lines and use this variable as a measure of transported electricity. A line power is proportional to the square of its tension ($P \alpha V^2$). We assumed that all transmissions lines have the same physical configuration, same reactance and phase angle equal to 90º (which results in maximum potency transmission). Moreover, the transmissions lines have been unitized, that is each circuit = 1Km. Under those hypothetical conditions, the energy transportation capacity (ETC) for a given firm is computed as:

ETC = 69KV x 69KV x length of the line 69KV + 88KV x 88KV x length of the line 88KV + ... + 750KV x 750KV x length of the line 750KV.

We also used as outputs the substations' capacity (sum of transformers ratings) and the network density. As for inputs, we used in this analysis: total controllable costs, financial costs, the length of the lines and the quantity of substations.

Table 1: Inputs and Outputs – Transmission System – 2004-

Inputs/Outputs	Description	Source
Inputs		
Length of the lines	Total length of the lines 69 to 750 KV	Annual Report
# Substations	Total of substations	Annual Report
Total Controllable Costs	Operational Expenditures	BMP – ANEEL
Financial Costs	Financial expenses (except those relative to monetary variations)	BMP – ANEEL
Outputs		
Capacity of Energy Transportation (Lines)	Proxy computed by the formulae: ETC= Σ [$(\text{tension})^2$ x length]	Annual Report
Capacity of the Substations	MVA (mega volt -ampere)	Annual Report
Network Density	Length of the Line /Area	Annual Report

Table 2 presents descriptive statistics for inputs and outputs. Notice the heterogeneity of the data base in which small and new utilities coexist with huge companies. The high standard deviations as well as the big differences between minimum and maximum values illustrate this point.

Table 2: Descriptive Statistics – Inputs and Outputs – Transmission System – 2004-2007

Input/Outputs	Dimension	Mean	Standard Error	Minimum	Maximum
Inputs					
Length of the lines	Km	6.800,50	7.096,55	253,00	18.894,00
# Substations		42,29	44,15	0	125,00
Total Controllable Costs	($R\$x10^6$)	154,14	173,61	2,55	544,92
Financial Costs	($R\$x10^6$)	82,95	57,17	10,71	209,05
Outputs					
Capacity of Energy Transportation (Lines)	V^2xKm	835,31	1.105,03	63,25	4.064,10
Capacity of Energy Transformation (Substations)	MVA	17.641,60	25.601,39	0	92.978,00
Network Density	[(Km) /(Km^2x10^3)]	14,55	18,93	2,50	72,61

Results

Efficiency results are summarized on Table 3. As we suppose that during the period analyzed the scale of production is variable we used the constant returns to scale (CRS) MDEA model. Notice here, the relative stability of the efficiency scores across the period analyzed, as attested by the small variation of mean scores. However, such aggregate result is misleading as the efficient paths are quite different across firms. [2] Indeed, the analysis of Figure 1 shows three distinct groups of utilities: the new private firms (TSN, ETEO, EATE, ECTE, ETEP, and EXPANSION), the public ones (CEEE, COPEL, CEMIG, ELETRONORTE, ELETROSUL, FURNAS, CHESF) and the CTEEP, privatized in 2006. The superior performance of the first group reflects the substantial cost reductions obtained primarily by subcontracting services required for the transmission process, which results in lean operational and administrative structures. Moreover, they provide only electricity transmission thus allowing them to grasp the benefits derived from specialization.

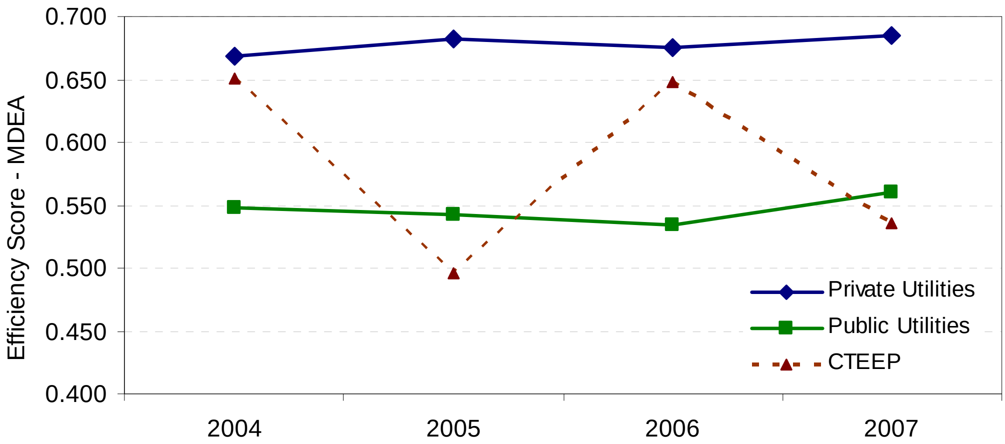
Table 3: Efficiency Scores - Descriptive statistics - MDEA Efficiency Scores – Constant Returns to Scale (CRS) -2004/2007

Years	Minimum	1º Quartile	Median	Mean	3º Quartile	Maximum
2004	0,386	0,521	0,586	0,607	0,659	0,833
2005	0,383	0,506	0,566	0,599	0,680	0,843
2006	0,345	0,510	0,580	0,603	0,679	0,831
2007	0,413	0,501	0,604	0,612	0,705	0,845

[2] Efficiency results are summarized in Table A-1, Annex I, ranked by the efficiency index of the initial year (E_0 -2004).

Compared with their private counterparts, the public enterprises are characterized by lower efficiency scores. The relatively lower performance of those public utilities is due to the fact that those firms have relatively higher labor costs – including fringe benefits received by the former civil servants – that represent fixed costs that could not be reduced by efficiency improvements. The exception is FURNAS that presents the second highest efficiency score in the initial period (Table A-1). However, as this firm is a vertically integrated company that operates in the generation and transmission segments, she may appropriate inaccurately its transmission costs by putting them on the generation accounts. Hence, this artificial cost reduction leads to spurious efficiency scores. Notice also that CTEEP presents a quite irregular behavior. This may be explained by erratic variations in its financial costs and by the increase in labor costs. For instance, in 2006 – year of its privatization – we observe an increase in labor costs due to the adoption of a voluntary dismissal program but a relatively higher reduction of financial costs due to debt restructuring, that were followed by an augmentation in 2007. Finally, results shown in Table 4 suggest that efficiency levels are not influenced by the size of the enterprise pointing out to the existence of divisibilities in electricity transmission.

Figure 1: Efficiency Indexes for Public and Private Utilities Transmissions in Brazil – 2004-2007



Hence, those findings tend to support the ones found for the distribution of electricity (Tannuri-Pianto et al., 2008, Hallison e Sampaio de Sousa, 2008). To complement previous analysis, let us examine the evolution of firm productivity by using a Malmquist (M) productivity index for the period 2004-2007 and its components: (a) the efficiency change index (EC), that gives the *catch-up effect*, refers to the relative movement of the observed firm into the frontier and (b) the index of technological changes (TC). These efficiency changes measures are computed by using the CRS model.

Table 4: MDEA-CRS Efficiency Scores by Size (Km of Lines), Substations and types of lines: Yearly averages (2004- 2007

Length of the line(Km)	# firms	Mean	# Substations	# firms	Mean	# Types of LV and HV connections (Kv)	# firms	Mean
0 -499	2	0,765	0	4	0,678	1	6	0,678
500-1999	4	0,634	1-49	4	0,641	3	2	0,533
2.000-10.000	5	0,498	50- 99	4	0,510	4	3	0,456
+ 10.000	3	0,639	+ 100	2	0,580	+ 5	3	0,658
Total	14	-	Total	14		total	14	

Table 5 presents the evolution of these measures for the period 2005-2007, ranked by the TPF index. Values greater (lower) than one for this index indicate productivity improvements (decreases). Notice firstly that the average 5.1 of total productivity growth, during the period analyzed, is mainly due to the *catch-up effect,* measured by changes in the technical efficiency scores. Indeed, for the whole set of firms, the technological frontiers are relatively stables.

Table 5: Malmquist Indexes and its Components for Power Transmissions Firms – 2005/2007

Firms	E_0	2007/2005 Malmquist Index (M)	Efficiency Changes (EC)	Technological Changes (TC)
Publics				
CEEE	0,573	0,881	1,019	0,864
CEMIG	0,526	1,273	1,240	1,027
CHESF	0,485	0,768	0,750	1,024
COPEL	0,520	1,121	1,069	1,049
ELETRONORTE	0,527	1,193	1,155	1,033
ELETROSUL	0,386	1,394	1,354	1,029
FURNAS	0,822	1,083	1,011	1,071
Mean	0,549	1,102	1,085	1,014
CTEEP	0,650	1,010	1,084	0,931
Privates				
EATE	0,598	0,914	0,945	0,967
ECTE	0,833	1,022	1,005	1,016
ETEO	0,637	1,148	1,064	1,079
ETEP	0,662	0,975	0,992	0,984
EXPANSION	0,769	0,931	0,977	0,953
TSN	0,514	0,994	0,994	1,000
Mean	0,669	1,010	1,084	0,931
Global Mean	0,607	1,051	1,047	1,002

Nevertheless, a more detailed analysis of the results shows a differentiated pattern of productivity ameliorations, with several power transmission utilities experiencing a productivity decline for the period 2005/2007. This fact illustrates well the difficulties in implementing regulatory schemes based on *ad-hoc* fixation of the productivity parameters.

Moreover, for the new (and private) utilities efficiency gains (EC) were much lower; some of them show a productivity decline during the period. Observe that frontier shifts are consistent with the entry of new utilities in the power transmission. Finally, remark that starting from low efficiency levels, ELETROSUL, CEMIG and ELETRONORTE show impressive productive improvements by means of both, the catch up effect and significant switches of the technological frontier.

Let us now compare two regulatory regimes: the current Brazilian regime, given by a revenue cap given by an ad-hoc maximum permitted revenue, (Receita Annual Permitida (RAP)), granted by the ANEEL and the M-DEA based dynamic yardstick reimbursement scheme, R^{Y}. To compute this norm, the slack valuation, given by the parameter ρ is 0.5, thus implying that the regulatory agency agrees to reimburse half of the excess costs ($C^{MDEA\text{-}i}$ – Actual costs). The value for δ - the parameter that measures the part of the inefficiency that the firm is able to eliminate in each year – is 0.1. Hence, for the *i-th* firm, the M-DEA revenue scheme was computed by using equation [5] plus the gross profits before tax in the base year, given by $RAP_0 - c_0$:

$$R_t^{Y,i} = c_t^i + (RAP_0 - c_0) + \rho^i \cdot \left[(1-\delta^i \cdot (1-E_0^i))^t \cdot \frac{C_t^{DEA-i}(y_t^i \mid z_t^i, w_t^i)}{E_0^i} - c_t^i \right] \quad t = 1,\ldots,T$$

[8]

RAP_0 *and* c_0 represent, respectively, the Maximum Permitted Revenue (RAP) and actual cost in the initial period. As previously mentioned, this regulatory regime induces firms to minimize costs because they retain part of the productivity gains. Figures 2 to 4 show the both the reimbursement schemes, the *MDEA-Yardstick (*R^{Yd}) and the RAP as well actual costs (c^i_t) of power transmission for the three groups of firms considered. For the public utilities, increases in the RAP go with the rise in costs that attains a maximum in 2006; afterwards, the cost reductions combined with the relative stability of the RAP for those firms lead to higher profits. Regarding the yardstick norm, as the initial efficiency scores (E_0) of these utilities are low and the adjustment factor, δ is 10%, the revenue generated by the *MDEA-Yardstick,* regime is inferior to the RAP during the period analyzed and do not present significant changes up to 2006. For the private utilities, gross profits are higher and increasing in 2004/2007. Observe that for these firms, the M-*DEA-yardstick* reimbursement norm follows closely the costs that decrease monotonically during the period.

Figure 2: Costs and Reimbursements – *MDEA-Yardstick* (R^{Yd}) and RAP – Public Utilities

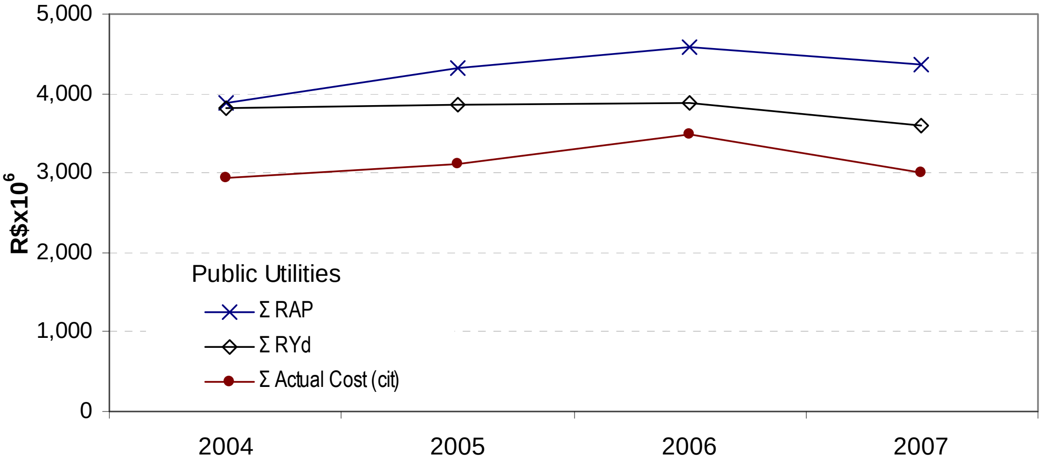


Figure 3: Costs and Reimbursements – *MDEA-Yardstick* (R^{Yd}) and RAP – Private Utilities

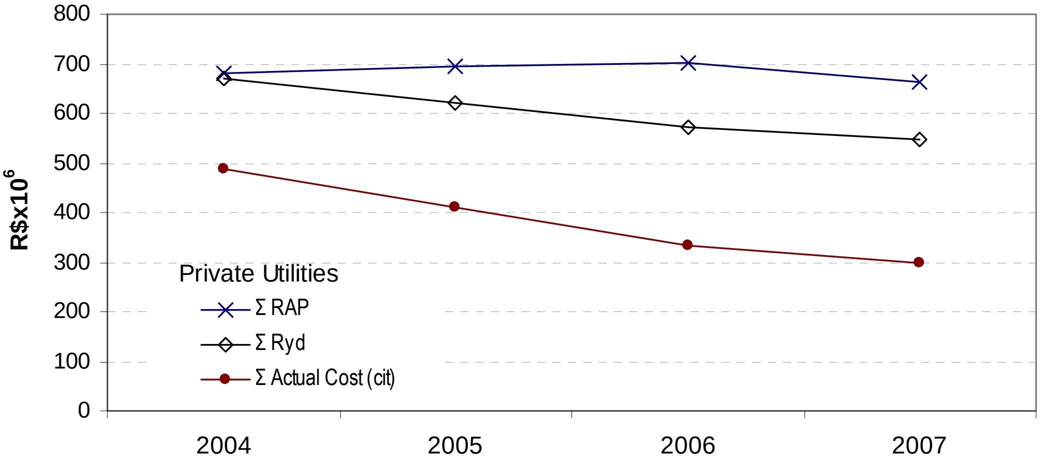


Figure 4: Costs and Reimbursements – *MDEA-Yardstick* (R^{Yd}) and RAP – CTEEP

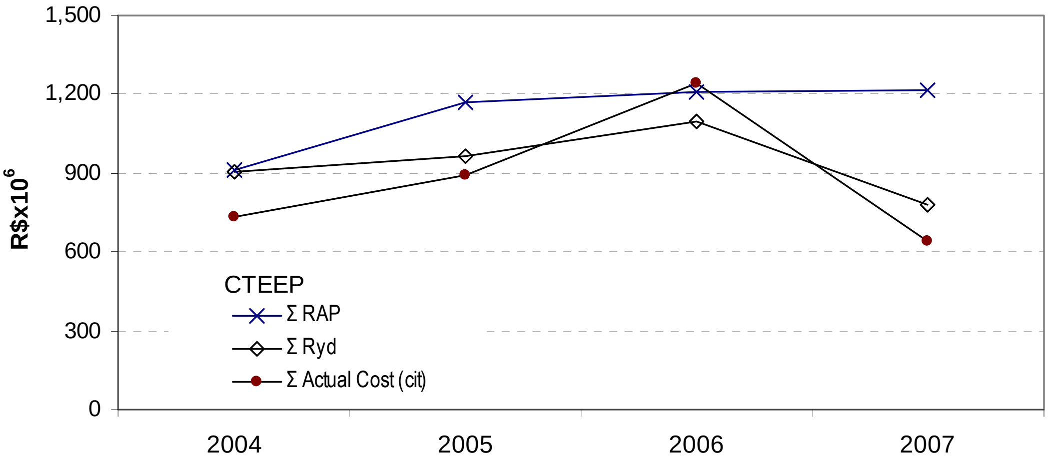


Table 6 presents the information rents extracted by the transmissions firms based on the *RAP* and the *MDEA-Yardstick* regimes for the period 2004/2007. Firstly, for nearly all firms, revenue extractions are positive both on the RAP and the yardstick regulatory schemes. The exceptions are ELETRONORTE and CEMIG due to the fact that for these utilities, the increase in the maximum revenue permitted has been inferiors to cost rises. As for the ELETRONORTE, the RAP is insufficient to cover its costs thus justifying the company´ pressures to augment its remuneration. These high costs are due to the fact that this utility, besides operating in the Amazon Region, where consumers are scattered in a huge territory, this government enterprise act as a social partner in the area. Concerning the CEMIG, the 2006 losses may reflect the desverticalization of this firm in 2005 that separated into distinct companies, the segments of distribution and generation/transmission. The substantial cost increase after this societal reorganization suggest that part of the transmission costs were, indeed, accounted as transmissions expenses. Such a change restricted the possibility of appropriating the transmission expenses on the distribution costs, thus contributing to reduce the efficiency scores for CEMIG-Transmission.

Table 6: Information Rents Extracted by the Power Transmission Firms under the RAP and the MDEA-Yardstick

	Information Rents - R$ millions - june/2004							
	Current Rents = RAP – Costs				*Yardstick Rents* = R^{Yd} – Costs			
Firms	2004	2005	2006	2007	2004	2005	2006	2007
Publics								
CEEE	57,3	75,6	82,0	112,2	4,1	36,8	57,4	69,6
CEMIG	59,0	32,5	-16,4	114,8	5,6	10,7	-1,4	56,4
CHESF	45,1	141,3	247,8	140,2	17,6	106,8	243,8	196,4
COPEL	70,7	184,2	152,5	204,4	3,7	110,3	111,4	131,2
ELETRONORTE	-5,1	-27,0	-244,0	-18,9	12,0	31,8	-15,7	100,9
ELETROSUL	74,9	121,0	127,6	193,2	10,5	65,2	107,7	148,0
FURNAS	627,6	675,0	752,0	608,5	7,3	102,5	205,1	51,5
Total I	929,4	1202,7	1101,6	1354,4	60,8	464,0	708,3	753,9
CTEEP	184,3	282,7	-29,4	573,1	12,8	206,8	112,5	432,0
Privates								
EATE	41,0	88,3	92,1	107,3	3,1	33,1	38,9	43,3
ECTE	23,0	25,9	27,7	28,5	0,2	1,9	3,9	3,6
ETEO	53,0	53,7	53,9	53,7	0,5	2,5	4,4	3,0
ETEP	11,2	23,6	25,0	26,7	0,6	8,7	10,5	10,7
EXPANSION	21,3	37,9	60,2	50,0	0,8	11,7	25,4	18,8
TSN	43,4	53,8	109,4	101,9	4,5	14,6	46,8	39,4
Total	192,9	283,1	368,4	368,1	9,6	72,5	129,8	118,7
Total	1306,6	1768,5	1440,6	2295,6	83,2	743,3	950,6	1304,6

Observe that overall, the information rents are lower and less erratic in the MDEA-Yardstick regime because this scheme, not only distributes in a better way the flow of revenues, also take into account the specific productivity conditions for each utility. Notice also that for the new firms, in both regulatory regimes, the information gains increase monotonically during the period 2004/2007, contrasting with the variability shown by their public counterparts.

Finally, the high gains obtained with the regulatory regime adopted by the ANEEL suggest that, for the more efficient utilities, the RAP is overestimated. This overestimation may be due to the fact that the new entrants they won the right to operate their lines in the begin of the decade, where the required return to capital were considerably higher because of higher interest rates and country's risk, prevalent in the period 1999-2003. With respect to FURNAS, the underestimation of costs distorts efficiency results and profits.

Detailing the information contained on Table 6, Table 7 presents incentive bonuses for electricity transmission firms. These bonuses – given by the expression ρ $(C_t^{*i} - c^i_t)$, where $C_t^{*i} = ((1-\delta(1- E_0))^t \cdot C^{MDEA-i}/E_0)$ corresponds to the minimum costs required by the regulatory agency in period t, - represent substantial fund transfers among these utilities and the ANEEL. For the more inefficient public utilities, reimbursement would be inferior to their costs. The reason is that with $\rho = 0,5$, they would have the receipts reduced by an amount equivalent to half its excess costs $(C_t^{*i} - c^i_t)$, for each year.

Table 7: Yardstick Incentive Bonuses - 2004 a 2007

Firms	*Yardstick* Incentive Bonuses = ρ $(C_t^{*i} - c^i_t)$			
	2004	2005	2006	2007
Public Utilities				
COPEL	-3,67	3,21	-29,51	2,51
CEMIG	-5,60	-37,11	-73,99	-0,65
CEEE	-4,11	-18,52	-32,81	-14,70
ELETROSUL	-10,54	-19,12	-55,02	-29,66
FURNAS	-7,35	-54,99	-80,56	-70,58
CHESF	-17,55	-10,58	-41,04	-101,28
ELETRONORTE	-12,01	-53,66	-223,23	-114,61
Total	-60,83	-190,77	-536,16	-328,97
CTEEP	-12,78	-108,45	-326,17	-43,16
Private Utilities				
EATE	-3,08	14,26	12,34	23,04
TSN	-4,46	-4,28	19,16	19,07
EXPANSION	-0,77	4,82	13,51	9,87
ETEP	-0,58	3,75	3,26	4,83
ECTE	-0,17	0,99	0,85	1,88
ETEO	-0,51	-1,78	-3,46	-2,23
Total	-9,57	17,76	45,66	56,46
Total	-83,18	-281,46	-816,67	-315,67

Obs.: $C^{*i} = ((1-\delta(1- E_0))^t C^{MDEA-i} / E_0)$;

Such a penalty would attain mainly the CHESF, ELETRONORTE and FURNAS, because these firms did not reduce their costs in the same proportion as their "reference firm". Yet, even in such a case, the ANEEL would pay for the other half of excess costs, which indicates substantial expenses, particularly, when the CTEEP is included. The gains of the regulatory agency, arising from the fact that the reduction of the electricity transmission effective costs are superior to the required reduction, are not sufficient to compensate expenses generated by the inefficiency of the public utilities. Indeed, this occurs not only because the private, more efficient utilities hold a smaller volume of resources in the electricity market but also because these firms keep half of the excess costs reduction as they have an equivalent rise in their revenues.

Finally, let us proceed to a sensitivity analysis by changing the incentive power, ρ, which indicates the relative value attributed to the inefficiency in terms of profits. As this parameter is fixed by the agency, it is relevant to examine the impact of its different values on the yardstick reimbursement norms. Figures 5 and 6 present these norms for values of ρ between 0 e 1, in 2005. As previously stated, the more efficient utilities with respect to their reference counterparts gained bonuses: COPEL, EATE, EXPANSION, ETEP and ECTE. Remark that those more efficient firms would prefer contract with a higher ρ because they could extract larger revenues (higher R^{Yd}). On the other hand, the under-performing utilities would like to have less powered contract, characterized by lower values of ρ. This clear when we analyze the trajectories of FURNAS and ELETRONORTE, inefficient firms that maximize their revenue

Figure 5: M-DEA Reimbursement Norms for Different Values of ρ – Public Utilities and CTEEP

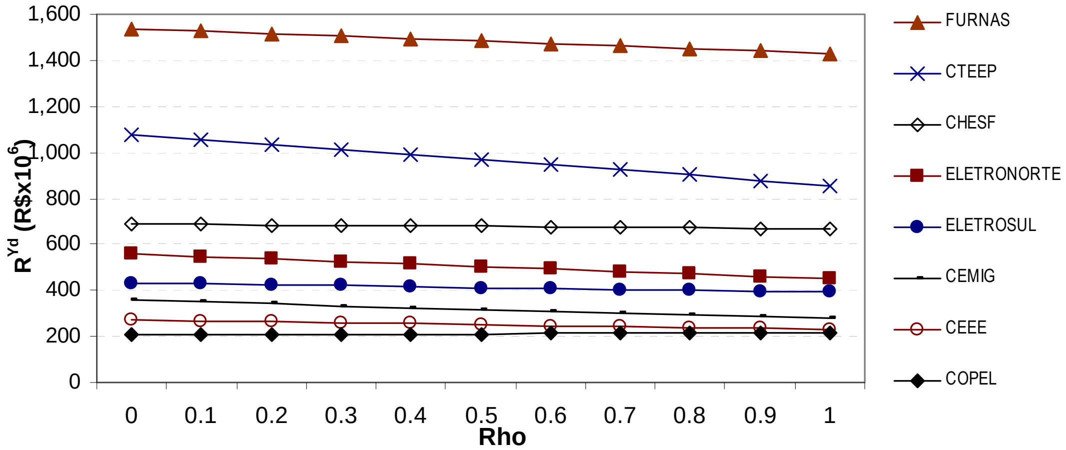


Figure 65: M-DEA Reimbursement Norms for Different Values of ρ – Private Utilities

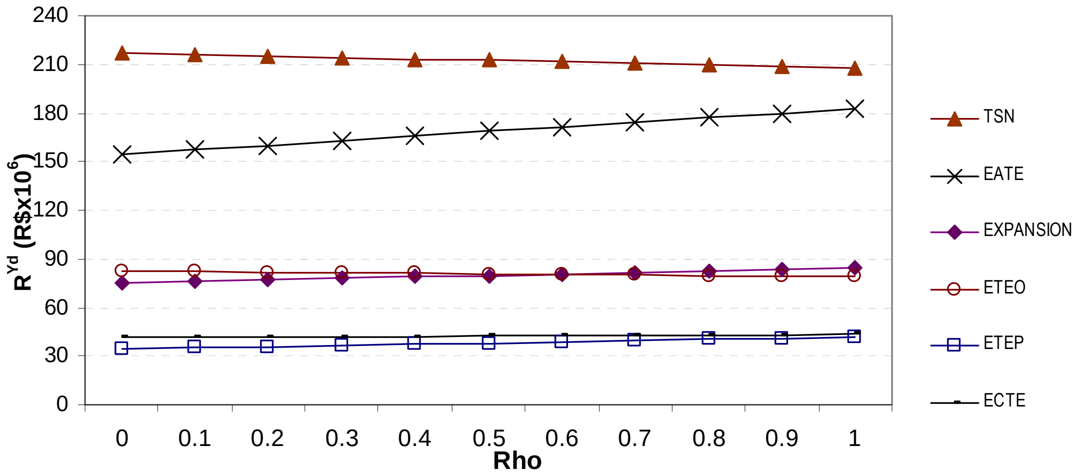
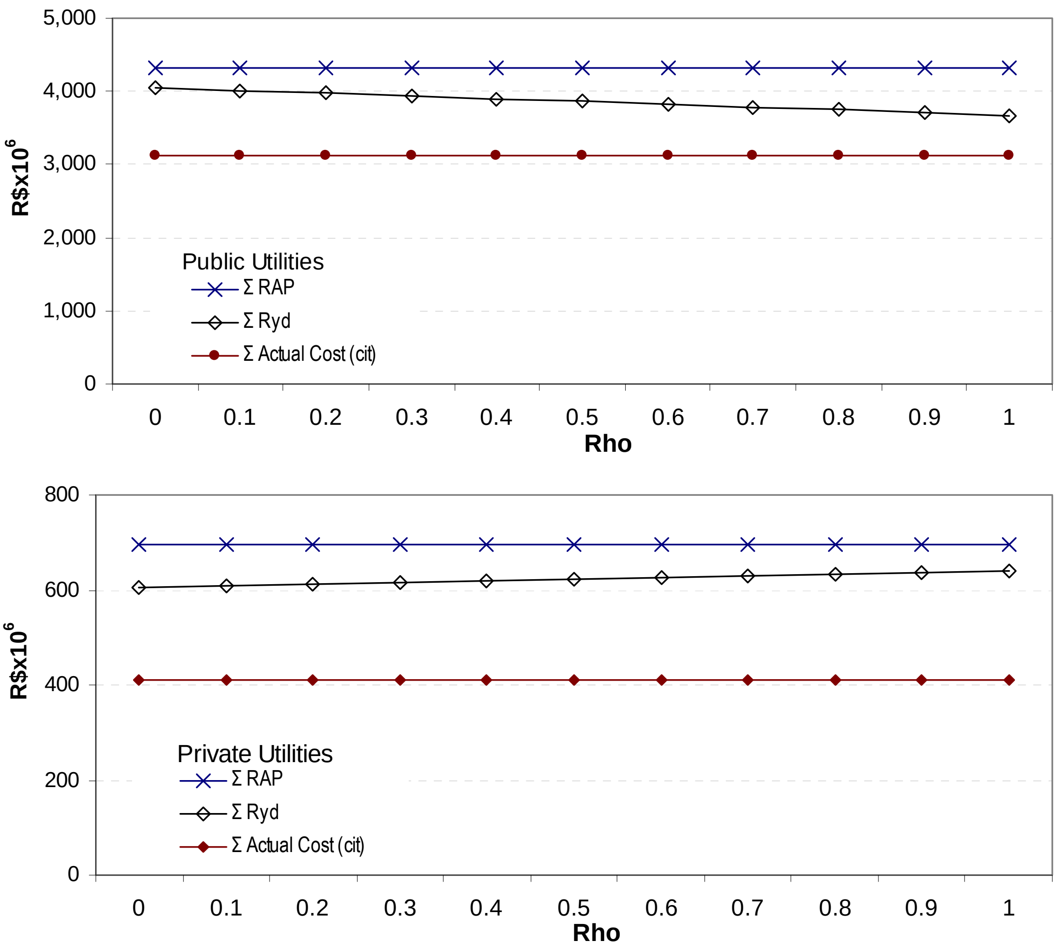


Figure 7 presents total revenues brought about by the yardstick and the RAP reimbursement norms (R^{Yd}), for the two groups of utilities: public and private. Notice that on aggregated terms it would be more profitable to the public utilities to ask for lower powered contracts while for the private utilities higher values of ρ would lead to higher revenues.

Figure7: Reimbursement Norms for Transmission Utilities -Public, Privates Utilities for different values of de ρ – 2005.



Conclusions

We used a dynamic yardstick M-DEA model to analyze the revenue cap regulatory scheme adopted by the Brazilian government for the electricity transmissions utilities. Our results show that, in Brazil, the ad-hoc fixation of revenues by the regulatory electricity agency ANEEL leads to higher profits for some transmission firms when compared with ones derived from the proposed M-DEA regulatory scheme. This methodology, which combines the theory of contracts with nonparametric techniques to evaluate efficiency, permits to take into account asymmetrical information and strategic interactions among firms. We computed efficiency scores and Malmquist indexes for the Brazilian power transmission utilities that served as benchmark efficient reimbursement norms and the compared those norms with the one used by the regulatory agency, known as RAP.

Our results suggest that the new private utilities are more efficient when compared to their public counterparts. Furthermore, they kept this productivity differential across the period analyzed. Decomposition of the Malmquist index indicates that for all firms productivity increases derived, mainly, from improvements in technical efficiency. Our results also suggest that, for 2004/2005, revenues actually paid by the ANEEL, when compared to the ones implied by the yardstick competition, led to higher profits suggesting that productivity gains were captured by the agents. Besides, for the new and private utilities, these informational rents increase monotonically during the period analyzed in both, the actual regulatory regime and the M-DEA-Yardstick scheme.

Finally, our simulations suggest that, by reducing informational rents and coping with the ratchet effect, the proposed regulatory scheme led to lower costs and higher efficiency in the electricity transmission sector, in Brazil.

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ANNEX I

Table A-1: MDEA Efficiency Scores – Constant Returns To Scale (CRS) -

Firms	E-2004	E-2005	E-2006	E-2007
Public				
CEEE	0,573	0,562	0,496	0,496
CEMIG	0,526	0,508	0,503	0,602
CHESF	0,485	0,536	0,580	0,481
COPEL	0,520	0,571	0,561	0,658
ELETRONORTE	0,527	0,421	0,448	0,413
ELETROSUL	0,386	0,383	0,345	0,464
FURNAS	0,822	0,814	0,809	0,810
Mean	0,549	0,542	0,535	0,560
CTEEP	0,650	0,495	0,648	0,535
Private				
EATE	0,598	0,627	0,617	0,612
ECTE	0,833	0,843	0,831	0,845
ETEO	0,637	0,624	0,581	0,605
ETEP	0,662	0,697	0,690	0,721
EXPANSION	0,769	0,797	0,800	0,810
TSN	0,514	0,505	0,530	0,518
Mean	0,669	0,682	0,675	0,685
Global Mean	0,607	0,599	0,603	0,612

Table A-2: Reimbursement Norms – 2004-007 - R$1.000.000

	MDEA Yardstick Reimbursement Norm – R^{Yd}				Annual Permitted Revenues - RAP				Actual Costs - $Cost_t^{RB}$			
Utilities	2004	2005	2006	2007	2004	2005	2006	2007	2004	2005	2006	2007
Public												
CEEE	246,03	251,01	238,55	213,14	250,14	287,80	295,97	282,73	192,80	212,19	214,01	170,50
CEMIG	289,74	318,55	336,88	254,46	295,34	329,21	335,50	310,88	236,35	296,68	351,88	196,12
CHESF	709,23	678,16	619,14	660,51	726,79	785,00	862,90	856,89	681,71	643,67	615,10	716,71
COPEL	219,94	211,41	228,70	196,30	223,62	321,68	340,05	327,46	152,93	137,51	187,52	123,11
ELETRONORTE	490,72	504,53	564,55	439,35	502,73	536,34	548,89	540,23	507,85	563,30	792,89	559,08
ELETROSUL	408,09	412,31	411,45	371,38	418,63	477,47	519,18	519,35	343,72	356,51	391,56	326,12
FURNAS	1.448,16	1.483,47	1.479,96	1.468,14	1.455,51	1.585,93	1.685,01	1.519,65	827,96	910,90	932,97	911,17
Total	3.811,92	3.859,44	3.879,23	3.603,27	3.872,77	4.323,43	4.587,50	4.357,19	2.943,32	3.120,77	3.485,93	3.002,81
CTEEP	902,22	965,66	1.097,90	781,00	915,01	1.172,46	1.210,37	1.212,98	730,69	889,79	1239,75	639,84
Private												
EATE	190,90	168,54	164,06	148,20	193,97	201,65	202,92	191,48	153,02	113,33	110,78	84,21
ECTE	43,76	42,32	41,80	40,55	43,94	44,25	45,67	44,16	20,92	18,32	17,93	15,65
ETEO	80,69	80,77	80,49	77,87	81,20	83,22	84,88	80,83	28,21	29,56	30,96	27,11
ETEP	44,92	38,05	36,61	33,90	45,50	46,71	47,12	44,56	34,32	23,11	22,17	17,88
EXPANSION	87,36	79,78	69,18	71,73	88,13	91,51	94,57	90,49	66,81	53,65	34,35	40,54
TSN	222,47	212,35	180,42	173,92	226,93	226,95	227,24	213,34	183,51	173,20	117,83	111,42
Total	670,10	621,82	572,56	546,17	679,68	694,29	702,39	664,86	486,80	411,16	334,03	296,82
Total	5.384,24	5.446,91	5.549,69	4.930,44	5.467,45	6.190,18	6.500,26	6.235,03	4.160,81	4.421,72	5.059,71	3.939,46

Obs: values of R^{Yd} with gross margin equal to(RAP_0-c_0) in 2004

$\delta = 0,10$ e $\rho = 0,50$