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The low cost of quality improvements in the electricity distribution sector of Brazil

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HIGHLIGHTS

- The article focuses on the impact of quality improvements on operating costs.
- We find a very small tradeoff between quality improvements and operating costs.
- We find the impact of a large share of electricity losses on costs larger compared to the impact of longer outages.
- The results serve the regulator to adjust incentives for quality improvement.
- The results serve the regulator in tailoring regulatory values for electricity losses and outages.

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ABSTRACT

We analyze the impact of introducing output-based incentives in the price-cap regulatory regime of the Brazilian electricity distribution sector. We focus on the trade-off between operating costs and quality improvement, hypothesizing a positive relationship. Operating costs include maintenance and repair expenses. The regulator sets limits for service continuity and non-technical energy losses in each regulatory period. Service continuity refers to the average length of interruptions in electricity distribution. Non-technical losses refer to losses due to factors specific to the distribution segment. Quality incentives include peer-pressure and penalties/rewards for compliance with minimum quality standards. We model operating costs using a GMM framework to acknowledge endogeneity of variables. The model is dynamic given the inclusion of regulatory lags to recognize past cost behavior. Findings reveal a small trade-off between costs and quality. We conclude that quality improvements are not costly relative to the potential savings from complying with quality standards. We also find that the impact on operating costs is larger when energy losses increase compared to the cost effect due to increases in duration of outages. These findings suggest areas of attention in managerial decision making, and serve as valuable information to the regulator in tailoring quality incentives for this sector.

1. Introduction

Brazil experienced important changes in its electricity industry during the 1990s. Private participation and unbundling of vertical integrated electricity firms dominated the decade as a response to frequent power interruptions due to electricity rationing, and a desire for attracting investment to the area. Opening the sector to private participation was the response of federal government to an energy demand that was rising faster than generation capacity.[1] Brazil's hydropower plants account for around 80% of domestic electricity generation making the country's energy supply extremely susceptible to climate conditions. This leads to power interruptions with rationing periods, as in the water drought crisis of 2001. The government response to that crisis included energy

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[1] Silveira and Guerra (2001) provide details on this capacity shortage pointing out insufficient investments in the sector previous to 1995.

"blackout" periods that lead to a lasting decrease in energy demand (Tucci, 2004). This crisis prompted further reforms by the federal government. An energy system highly dependent on climate conditions such as the one in Brazil puts at risk economic activity, with long term consequences for economic growth. Energy demand in Brazil has grown parallel to GDP since 1990 (World Energy Outlook, 2013). Mendonça and Dahl (1999) provide details on the early sector reforms, and Xavier et al. (2015) discuss the recent situation of the sector.

In particular, we refer to some of the regulatory reforms related to the objective of this study. The National Electric Energy Agency (ANEEL) was created in 1996 with the responsibility of granting concessions in the distribution sector. This became a responsibility of the Ministry of Mines and Energy after 2003. Additionally, since 2003 the regulatory regime is structured in regulatory periods of a fixed term (on average 4–5 years). Regulatory periods are intrinsically connected to how the tariffs for the sector are revised for efficiency, and how they are repositioned in relation to the financial objective of the concessions' contract. Also in 2003, the federal government re-assumed the role of *planning and implementing energy policy* for the country. At that point, the main objectives for the regulatory process were "guaranteed energy (avoiding rationing), and low cost" (Tucci, 2004, p. 20).

According to regulatory theory, if costs and quality are positively related, companies under a price-cap regime will reduce quality to reduce costs. This cost reduction is incentivized by firms pursuing cost efficiency during a fixed regulatory period (Joskow, 2008). The challenge for the regulator is the inclusion of quality incentives in the price-cap regime that conflict with the cost efficiency incentives in place. At the center of this issue is the information asymmetry problem that exists at the time of defining desired levels of quality of service for both, the customers and the firms (Growitsch et al., 2010).

In 2011, as a result of stakeholder feedback, the regulatory regime for the distribution sector took steps toward output-based regulation by including incentives to improve quality in the sector. This shift aligns with the trend led by Great Britain's regulatory body for gas and electricity markets (Ofgem, 2010) with the introduction of RIIO (Revenue = Incentives + Innovation + Outputs).[2] Regulatory agencies in Europe and the U.S. are also moving in this direction (Cambini et al., 2016; Growitsch et al., 2010). RIIO involves the use of quality incentives that imply important reforms to the tariffs' structure in the industry.[3]

This study investigates the effect of quality incentives on operating costs in the price-cap regime of Brazil. Quality regulation requires clearly defined incentives (Sappington, 2005). The quality incentives included in the regulatory period of 2011 are peer-pressure, and monetary penalties for non-compliance with regulatory limits.[4] Peer pressure includes a publicly available ranking of companies based on their compliance with quality standards. The regulator sets limits for service continuity and non-technical energy losses in each regulatory period. Service continuity refers to the average length of interruptions (outages) in electricity distribution. Non-technical losses refer to energy losses due to factors specific to the distribution segment, such as fraud, energy theft, and mistakes in electricity reading due to damaged meters.[5]

Our main interest is to understand the relationship between quality incentives and operating costs. In particular, we focus on the trade-off between quality improvements and operating costs. To this end, we model operating costs. We hypothesize that quality improvements and operating costs are positively correlated. If our hypothesis is correct, low operating costs implies low quality, and as a consequence penalty values will be high.

If companies spend to maintain the level of quality that complies with regulation, we expect higher operating costs values caused by longer outages, and from higher levels of non-technical energy losses. Operating costs include maintenance and repair expenditures due to the usage of labor, contracting third party companies to perform maintenance duties, and purchasing materials used in repairs, among other items. We model costs on a short term, rather than long term analysis. The most commonly used assets in this industry have a life span longer than the eleven year period considered in the analysis. So, the model would not capture long term changes.[6]

Of course, low maintenance spending in the past can worsen today's duration of outages and electricity losses, causing an increase on today's level of operating costs. Moreover, given fixed regulatory periods, annual tariff adjustments serve companies to extract efficiency gains through allowed costs. This also originates a relationship between current and past year's operating costs. Fig. 1 displays operating costs from 2003 to 2012, evidencing a stepwise increasing trend within each regulatory period (from 2003 to 2007 and again 2008 to 2011). To control for past costs we include lagged operating costs in the model. This study is unique in that we empirically analyze the relationship between quality improvements and operating costs using a dynamic cost model that includes a regulatory lag to consider past operating cost.

According to Xavier et al. (2015), environmental variables are of great importance in the analysis due to sharp differences among Brazilian regions. Also, Growitsch et al. (2012) find that in the Norwegian electricity distribution sector, the impact of location-specific variables on utilities' cost can be as high as 30%. Our model includes dummies to control for regional differences in geography and climate, socioeconomic characteristics and size of the companies (see Table 1).[7] Similar to Cambini et al. (2016), we include the amount paid by companies as a variable (PENALTY) capturing the lack of compliance with quality standards in our model. Yet, unlike in Cambini et al. (2016) this variable is crucial in our analysis because it represents the importance of introducing quality incentives in the regulatory regime. Cambini et al. (2016) use a period of analysis of 6 years and their penalty variable is continuous during the period. Our analysis includes PENALTY as a semi-continuous variable from 2003 to 2013, with penalty amounts showing after the policy change in the last 4 years. Indeed, its coefficient indicates the relevance of the shift towards output-based regulation. The variable also captures the trade-off amount between quality improvements and operating costs. The magnitude of its coefficient indicates the percentage increase (or decrease) after one percent increase in quality, which is the tradeoff between the variables.

As a difference from Cambini et al. (2016), our analysis is performed only in one step. We use a Generalized Method of Moments (GMM) framework given that lagged costs and endogenous variables introduce *endo*geneity in the model.[8] The presence of heteroscedasticity in the disturbances and the small number of

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[2] OFGEM (2010).

[3] RIIO is designed for the transitioning of the industry to a low-carbon scheme with high incentives to improve investment. For main aspects of this regime see Fox-Penner et al. (2013).

[4] These monetary penalties are applied after 2010.

[5] Energy losses can also occur from energy dissipation during the transport process associated to the electricity transport sector, in which case they are called technical losses and are not considered in this study.

[6] Metering (Mechanical: 25 years; Electronic: 13 years); Structures (Poles: 28 years; Towers: 37 years); Transformers (Distribution transformers: 25 years; Power transformers: 35 years).

[7] The regulator classifies small companies as those delivering less than 1TW/h, and large companies those delivering more than 1TW/h.

[8] Cambini and Rondi (2010), Ter-Martirosyan and Kwoka (2010) and Cambini et al. (2016) elaborate on causality links and related issues.