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Output-based incentive regulation in electricity distribution: Evidence from Italy

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ABSTRACT

Incentive regulation in electricity distribution is expected to enlarge its scope, from an input-oriented instrument to one that includes additional, output-based incentives. This creates a potential conflict with more traditional concerns for productive efficiency. In the case of Italy, together with input-oriented instruments, output-based incentives have been applied to indicators of quality for over a decade. Using micro-data from the largest Italian distribution company, we conduct an assessment of the effects of this regulatory framework. The aim of this work is threefold. First, we measure performance in terms of cost-efficiency and find that similar cost-reducing efforts were exercised in all distribution units. Second, we measure performance with respect to the overall regulatory framework. Using quality-related rewards and penalties, we find that more cost-efficient areas were also more successful in earning rewards/avoiding penalties: favorable external conditions have similar, positive effects on both cost and quality performance. Using the cost of the energy not supplied, we find no evidence of a conflict between cost efficiency and social cost efficiency. Results indicate, however, that itis preferable to use social costs when measuring a single unit's performance. From these results we derive specific policy indications.

1. Introduction

Current technical changes in electricity distribution networks prompted a lively debate, in Europe and elsewhere, on how incentive regulation should evolve. Since liberalization, regulatory incentives have focused almost exclusively on the use of inputs (operational and capital expenditures). Current concerns for network innovation and sustainability are being addressed, instead, with incentives that focus on output measures of companies' performance (network reliability, environmental impact, ability to connect dispersed generation, etc.). The best-known example in this regard is the new regulatory scheme recently adopted by Ofgem, the *Revenue, Innovation, Incentives and Output* (RIIO) model (Ofgem, 2010); the Italian regulatory authority and other regulatory agencies, for instance the Australian energy regulator, are moving in this direction as well (ACCC/AER, 2012; AEEG, 2011a).

On the one hand, given the regulator's asymmetry of information, output-based regulation has an important advantage: leaving the decision on the use of the resources to the regulated firm, it minimizes inefficiencies in the use of inputs. On the other hand, it forces the regulated firm to increase expenditures, to meet the additional goals set by the regulator (in contrast with the cost efficiency objective). Moreover, it presents implementation complexities and requires adequate regulatory powers, budget and skills (Glachant et al., 2013).

In the case of Italy, together with incentives aimed at productive efficiency, output-based incentives have been applied to indicators of quality for over a decade. Under the current regulatory reform, this represents an interesting case to investigate how a regulated firm responds to such an incentive scheme. The debate around this issue is, indeed, quite recent (Coelli et al., 2013; Growitsch et al., 2010; Jamasb et al., 2012).

Moreover, when network operators are required to meet potentially conflicting objectives, also the assessment of their performance becomes more complex. Since the adoption of incentive regulation in infrastructure industries, benchmarking analysis has been extensively used to measure firms' efficiency (Haney and Pollit, 2009; Jamasb and Pollit, 2001; Joskow, 2008). Nevertheless, the question of including additional output measures of performance (e.g., quality of supply) has been scarcely explored by regulatory authorities and academics as well.

Finally, as for Italy in particular, anecdotic evidence indicates that after a period of rapid increase in performance, the level of quality varied at a much slower pace, while the rules for assigning output-based

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Table 1
Benchmarking with quality in electricity distribution.

	Input variables	Output variables	Quality variables	Database	Benchmarking approach
Jamasb and Pollit (2003)	OPEX; TOTEX;(network length)	Energy supplied; num. customers; (network length)	Energy losses	Cross-section 1999 International	DEA, COLS and SFA
von Hirschhausen et al. (2006)	Labor; network length; peak load capacity	Energy supplied; num. customers; inverse density index	Energy losses	Cross-section 2001 National	SFA and DEA
Growitsch et al. (2009)	TOTEX	Energy supplied; num. customers	CML	Cross-section 2002 International	SFA
Giannakis et al. (2005)	OPEX; TOTEX	Energy supplied; num. customers; network length	NINT and TINT	Panel 1991/92–1998/99 National	DEA and Malmquist index
Coelli et al. (2007)	Capital replacement value; OPEX	Energy supplied; num. customers; network length	NINT	Panel 2003–2005 One company	SFA and DEA
Miguéis et al. (2012)	SOTEX	Energy supplied; num. customers, others	Cost of ENS	Panel 2004–2007 National	DEA and Malmquist index
Growitsch et al. (2010)	TOTEX; SOTEX	Energy supplied; num. customers	Cost of ENS	Panel 2001–2004 National	DEA
Coelli et al. (2013)	Capital replacement value; OPEX	Energy supplied; num. customers; area size	NINT	Panel 2003–2005 National	SFA, parametric linear programming

Note: CML: customer minutes lost; NINT: number of interruptions; TINT: duration of interruptions; ENS: Energy Not Served; OPEX: operating expenditures; TOTEX: operating and capital expenditures; SOTEX: TOTEX plus cost of ENS.

incentives have remained unchanged.[1] Although from a technological perspective such a trend is to be expected, it has also prompted the question of how this regulatory scheme should evolve in the future.

In this paper we address all three issues mentioned above.

We investigate how the largest Italian electricity distribution company has responded to the input-based and output-based incentives provided by the current regulatory framework. To our knowledge, this is the first assessment of this incentive regime since its introduction in the year 2000. To this end, we exploit on an original dataset, constructed with the support of the Italian regulatory authority (*Autorità per l'energia elettrica e il gas*, AEEG), by means of a dedicated data collection. It is a comprehensive and balanced panel for 115 distribution units (Zones), tracked from 2004 to 2009, which includes the amounts annually received in rewards (paid in penalties) for exceeding (failing to meet) quality-specific targets.

As for the analysis, we rely on a benchmarking approach and contribute to the debate regarding the inclusion of additional measures of performance. Specifically, we use two alternative measures of quality that provide different and complementary information regarding the efficiency of the observed distribution unit: in one case, efficiency is estimated in terms of response to regulatory incentives; in the second, in terms of social costs. While the latter was used in previous literature, the former has never been studied. From a methodological perspective, we apply a recent approach based on a two-stage, semi-parametric Data Envelopment Analysis (DEA) and bootstrapping techniques, where technical efficiency is estimated in the first stage and then regressed on a set of external variables in the second stage (Simar and Wilson, 2007). We also study the evolution of performance over time by means of Malmquist indices.

Our main finding is that the presence of quality regulation has not significantly altered the distribution units' behavior: those that responded well to cost efficiency incentives responded equally well to quality-related incentives and vice versa. After all, favorable external variables that have a significant and positive effect on cost efficiency (area size, load composition and network design) also influence the ability of a distribution unit to exceed the targets imposed by quality regulation. Nevertheless, this response to regulatory incentives appears in contrast with the long-term objective of quality regulation in Italy (convergence in performance). Hence, on the basis of the evidence provided throughout the paper, we derive two policy suggestions for the development of quality regulation in the medium and in the long term.

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature on benchmarking analysis in electricity distribution; Section 3 outlines the Italian regulatory framework; Section 4 presents the empirical methodology; Section 5 describes the dataset and presents our choice of variables for the benchmarking analysis; Section 6 discusses results in the context of the existing literature and derives policy implications; Section 7 concludes.

2. Selected literature review

A relatively small number of papers analyze efficiency in the electricity distribution sector using a benchmarking model which includes an indicator of service quality. While Table 1 summarizes all the main contributions with these characteristics, we concentrate here on five studies based on panel data.[2]

The first strand of literature focuses on performance measurements and explores one main question, namely, the potential trade-off between cost savings and the level of service quality at the firm level (i.e. the effects of incentive regulation on service quality). Additional questions explored in this literature regard: (*i*) the use of an integrated cost-and-quality benchmarking model vs. a cost-only approach, when assessing the progress of an incentive regulation regime and (*ii*) the analysis of productivity changes over time. The existing empirical studies do not provide clear cut evidence on any of these issues.

Using a panel of 14 electricity distribution utilities in the UK (tracked from 1991/92 to 1998/99) Giannakis et al. (2005) find that efficiency scores of cost-only DEA models do not show a high correlation with those of quality-based models (where quality is measured by the number and duration of service interruptions). In other words, cost-efficient firms do not necessarily exhibit high service quality. Malmquist indices indicate, however, that improvements in service quality have made a significant contribution to the sector's total productivity change. The authors conclude that itis "desirable to integrate quality of service […] in benchmarking […] of electricity networks" (Giannakis et al., 2005,

[1] In the first regulatory period (2000–2003) the national average duration of interruptions per customer decreased by over 60 min; in the second period (2004–2007) the improvement amounted to less than 20 min and, in the third period (2008–2011), to about 10 min.

[2] Benchmarking studies in electricity distribution which include a measure of quality, but rely on a cross-sectional sample, include the work by Jamasb and Pollit (2003) on 1999 international data, by von Hirschhausen et al. (2006) on 2001 German data (where quality is measured by network losses), and by Growitsch et al. (2009) on 2002 international data (where quality is measured by customer minutes lost).