Incentives in vain? Firms' response to output-based regulation: The case of electricity distribution in Italy

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Motivation

- “Standard” incentive regulation: focus on productive efficiency
- Additional regulated outputs: service quality, innovation, sustainability
  - Ofgem (2010) RIIO model: Revenues, Innovation, Incentives, Outputs
  - Similar reforms in Italy (AEEGSI, 2011) and Australia (ACCC/AER, 2012)
- Service quality: example of a regulated output that requires additional expenditures
- More than a decade of quality regulation in Italy:
- **Our main question**: How output-based incentives affects firm’s investment and, in turn, service quality? Are rewards and penalties both needed to spur investment?

This paper

- Regulators set targets for enhancing quality over a country and introduce specific incentives in order to affect firms' operational and capital expenditures to enhance quality.
- In this paper we test the relationship between output-based regulatory incentives and firm's capital and operational expenses.
- We use a unique database for the period 2004-2009 with micro-data collected with the support of AEEG SI
- *Policy goal*:
  - a) evaluate the impact of output-based regulatory schemes on firm's investment and operational expenditures;
  - b) understand whether *rewards and penalties* are jointly needed to spur expenditures and, in turn, service quality, or if they simply push (and subtract) money towards companies for their past superior (inferior) performance.

Agenda

- Introduction
  - Regulatory framework and dataset
  - Literature
- Research question & Methodology
  - Determinants of service quality
  - Interplay between regulatory incentives and (operational and capital) expenditures
  - Effect of rewards/penalty incentives on investment
- Results and conclusions

Electricity distribution

- More than150 Distribution System Operators (DSOs)
- Total energy delivered: 280 TWh (2009)
- *Enel Distribuzione*: 86.2% of distributed energy
  - *A2A Reti Elettriche* (4.1%), *ACEA Distribuzione* (3.6%), *Aem Torino Distribuzione* (1.3%)
- *Enel* is present in all regions of Italy and it is organized in 115 Zones (11 Territorial Units and 4 macro Areas)
- DSOs are regulated by AEEG

The regulatory setting

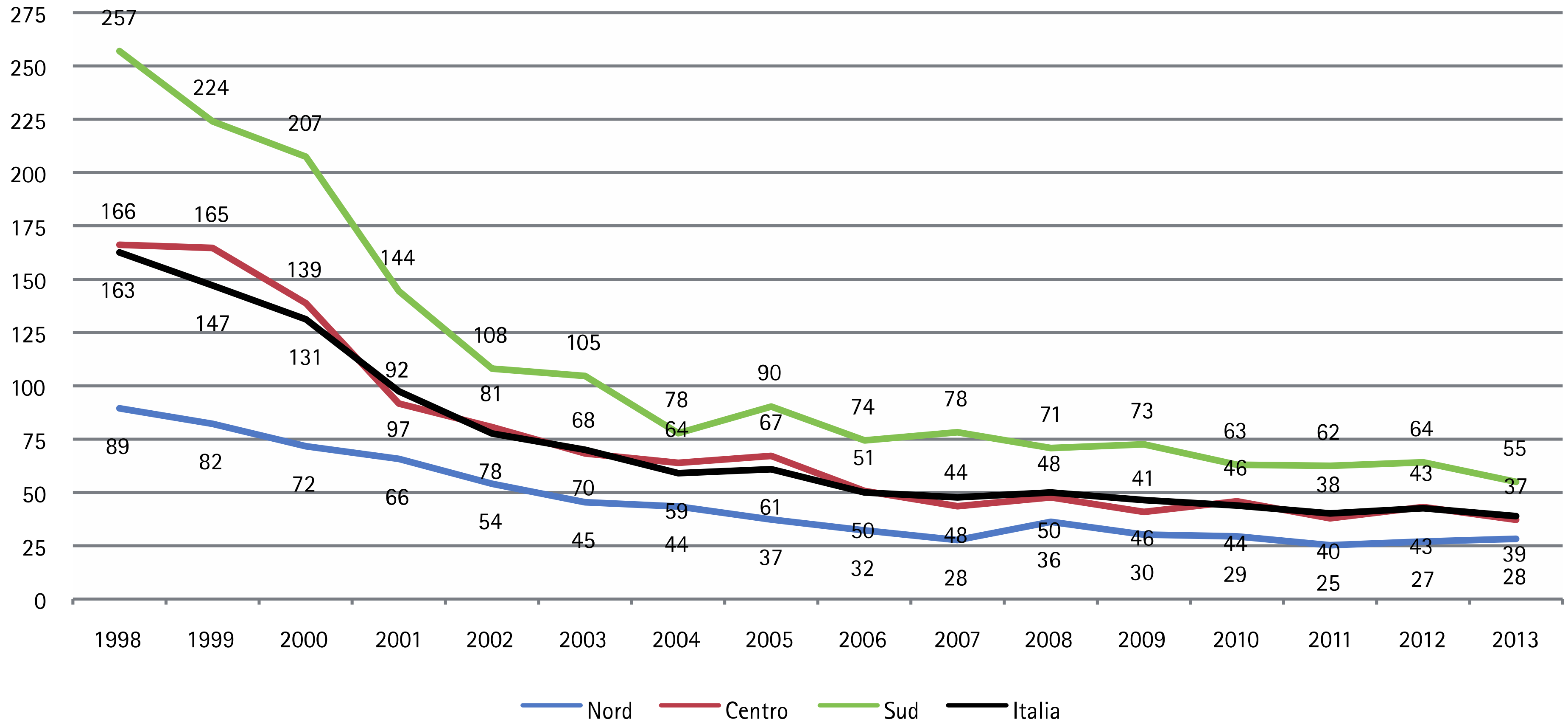
- Electricity distribution tariff is unique across Italy
- Productive efficiency:
  - Hybrid incentive scheme
- Quality regulation
  - Output-based incentives for quality: 2 regulatory periods (2004-2007; 2008-2009)
  - Average duration of interruptions per consumer – SAIDI - for long (longer than 3 minutes), unplanned interruptions (net of Force Majeure), measured in 300 territorial districts
  - Target-SAIDI
    - Convergence in performance of all districts with equal population density to the same quality level (the national standard) in the medium term (12 years from 2004)
    - Rewards (and penalties) are larger when quality is more distant from the Target-SAIDI

Dataset

- Comprehensive and balanced panel for 115 Zones of *Enel Distribuzione*, tracked from 2004 to 2009. Dataset built with the support of AEEGSI (dedicated data collection)

- For each Zone and year:
  - **Technical data**
    - Number of LV consumers and Energy consumption for LV and MV load (in MWh)
    - Area served (in km^2); Network length for LV and MV feeders (in km)
  - **Accounting data** (in €)
    - Revenues from tariffs and new connections
    - Operating costs for labor, services, materials and other costs
    - Capital expenditures
  - **Quality data** (per district)
    - Number of long and short interruptions (cause and origin)
    - Duration of long interruption (cause and origin)
    - *Rewards and penalties* (RP)

The effect of regulation on service quality



Empirical Literature on quality regulation

- Sappington (2005, JRE)
  - "The empirical literature provides mixed conclusions regarding the impact of incentive regulation on service quality" (Page 136)
- Ter-Martirosyan and Kwoka (2010, JRE)
  - Incentive regulation is associated with some reductions of both operational and maintenance expenses, the level of which in turn affect the average duration of outage per customer
  - Quality standards seem relevant in ensuring that firms achieve cost savings without an adverse effect on quality (see also Reichl et al., 2008, En Pol)
- Comparison of the level of regulatory incentives (per unit of quality) with the estimated (unit) cost for quality improvements (Jamasb et al., 2012 En Pol; Coelli et al., 2013, En Pol)
- <u>None of these papers study the effect on quality-related incentives on investment and use micro-data on rewards and penalties</u>

Research question

- We explicitly analyze the strategy that firms pursue in order to obtain higher service quality
- We depart from previous papers (e.g Jamasb et al., 2012) in what we consider rewards *received* or penalties *paid* at the end of the year, since they generate cash in-flows or out-flows and influence the decisions taken by the firm for the following year.
- Problems to consider:

1. Causality: incentives → expenditures → quality → incentives;
2. An increase in expenses can be associated with both an increase and a decrease in quality (*corrective* and *preventive* costs);
3. Measurement problems for calculating the investment rate.

Research question and Methodology

- To solve these issues, three-steps procedure:
  1. ***Analysis of the determinants of the average duration of service interruptions*** (SAIDI); we estimate the relationship between SAIDI and firms' capital and non-capital resources using both physical and economic variables → **fixed effect model;**
  2. ***Granger causality test*** to determine the relationship between capital, as well as operational, expenditures and regulatory incentives
  3. ***Dynamic accelerator model of investment*** to test the impact of output-based incentives on the investment rate.
     - we test whether incentives received still affect the investment rate after controlling for other determinants;
     - we verify whether penalties and rewards present a symmetric or asymmetric effects on the investment rate for all zones with different quality levels

Determinants of quality of supply (SAIDI)

Dep. Variable: *SAIDI*	(1) Physical Equipment	(2) Operational expenditures	(3) Physical Equipment and Operational expenditures	(4) Controlling for regulatory periods
UNDER	-519.49*	-	-406.27**	-295.05
	(219.48)	-	(201.43)	(238.59)
AUTO_LVcons	-46.55**	-	-48.42**	-51.05*
	(23.20)	-	(22.79)	(27.85)
PC_LVcons	-3.183	-	-1.290	-1.969
	(4.29)	-	(4.089)	(3.927)
OPEX_LVcons	-	1.281***	1.148***	1.125***
	-	(0.323)	(0.306)	(0.316)
PERC_NR	101.97	117.11	129.57	188.18
	(132.08)	(124.130)	(124.36)	(137.37)
UNDER*REGII	-	-	-	9.35
	-	-	-	(17.48)
AUTO_LVcons*REGII	-	-	-	13.07
	-	-	-	(22.54)
PC_LVcons*REGII	-	-	-	1.164
	-	-	-	(4.009)
OPEX_LVcons*REGII	-	-	-	-0.598**
	-	-	-	(0.267)
Constant	375.01	-110.10	186.57	70.32
	(184.70)	(95.81)	(186.60)	(220.77)
Unit dummies	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
R-squared	0.338	0.350	0.368	0.377
Observations	690	690	690	690
Number of units	115	115	115	115

Causality test/1: Investment and incentives

Investment and Incentives			
Dep. Variable: *IK*		Dep. Variable: *INC*	
α_{t-1}	-0.324	α^{IK}_{t-1}	-38.178
	(0.418)		(37.644)
α_{t-2}	-0.160*	α^{IK}_{t-2}	-8.880
	(0.086)		(8.290)
β^{INC}_{t-1}	-0.001	β_{t-1}	0.202
	(0.002)		(0.135)
β^{INC}_{t-2}	0.005**	β_{t-2}	0.348
	(0.002)		(0.221)
Constant	0.082**	Constant	3.099
	(0.035)		(3.021)
P-value test on H0: $\beta^{INC}_{t-1} = \beta^{INC}_{t-2} = 0$	0.038	P-value test on H0: $\alpha^{IK}_{t-1} = \alpha^{IK}_{t-2} = 0$	0.558
P-value test on H0: $\beta^{INC}_{t-1} + \beta^{INC}_{t-2} = 0$	0.079	P-value test on H0: $\alpha^{IK}_{t-1} + \alpha^{IK}_{t-2} = 0$	0.299
Obs. [Nr. Unit]	345 [115]	Obs. [Nr. Unit]	345 [115]
Hansen test	0.648	Hansen test	0.293
AR1	0.910	AR1	0.218

Same results hold with *Rewards* only

Causality test/2:
Operational expenxes and incentives

Operational expenditures and Incentives			
Dep. Variable: *OpK*		Dep. Variable: *INC*	
α_{t-1}	0.819***	α_{t-1}^{OpK}	13.768
	(0.301)		(13.318)
α_{t-2}	0.121***	α_{t-2}^{OpK}	5.230
	(0.035)		(5.843)
β_{t-1}^{INC}	0.002*	β_{t-1}	0.259**
	(0.001)		(0.107)
β_{t-2}^{INC}	-0.003***	β_{t-2}	0.105
	(0.001)		(0.071)
Constant	0.025	Constant	-2.465
	(0.043)		(2.378)
P-value test on H$_0$ $\beta_{t-1}^{INC} = \beta_{t-2}^{INC} = 0$	0.007	P-value test on H$_0$: $\alpha_{t-1}^{OpK} = \alpha_{t-2}^{OpK} = 0$	0.582
P-value test on H$_0$: $\beta_{t-1}^{INC} + \beta_{t-2}^{INC} = 0$	0.597	P-value test on H$_0$: $\alpha_{t-1}^{OpK} + \alpha_{t-2}^{OpK} = 0$	0.301
Obs. [Nr. Unit]	345 [115]	Obs. [Nr. Unit]	345 [115]
Hansen test	0.513	Hansen test	0.027
AR1	0.100	AR1	0.014

Investment and Incentives: quartile statistics (by SAIDI)

Service Quality (SAIDI, minutes)	*Investment/ Capital Stock (IK)*	*Operation Exp./ Cap. Stock (OpK)*	*Incentives/ Cap. Stock (INCK)*	*Incentives/ Op.Ex/*	*Rewards/ Investment (%)*	*Penalties/ Investment (%)*
$SAIDI < 32$	0.066	0.149	0.015	10.1%	22.8	0.002
$32 \leq SAIDI < 47.7$	0.062	0.140	0.010	7.1%	18.3	0.074
$47.7 \leq SAIDI < 73.9$	0.058	0.143	0.005	3.5%	12.8	0.79
$SAIDI \geq 73.9$	0.058	0.138	0.003	2.2%	9.5	1.92

- Zones with good quality (SAIDI < 32 min) spend more in capex and opex and received more incentives
- Rewards represent 22.8% of investment outlays at the top quartile (best performers) and only 9.5% at the bottom quartile.
- Penalties are in practice nonexistent among top performers, and mount to almost 2% of the investment outlays for units with the lowest quality performance.

Investment model

- We estimate the following model:

$$IK_{i,t} = \alpha_0 + \alpha_1 IK_{i,t-1} + \alpha_2 \Delta SK_{i,t} + \alpha_3 \Pi K_{i,t} + \alpha_4 INCK_{i,t-1} + I_t + \mu_i + \varepsilon_{it}$$

with *lagged investment ratio* ($IK_{i,t-1}$), *demand growth* ($\Delta SK_{i,t}$), the operating cash flow to capital stock ratio ($\Pi K_{i,t}$) to control for *financing constraints*, as well as the aggregate incentive variable (INC_t/K_{t-1}) - replaced by $REWARDK_{i,t-1}$, $PENALTYK_{i,t-1}$ - I_t and μ_i are the Zone and year dummies, while ε_{it} is the error term.

- Dynamic panel analysis (GMM-SYS) with internal *and* external instruments ($\rightarrow$ perc. non res users; population density; area covered by forest; North dummy)

- Two-step procedure (Wintoki, *et al.*, 2012) to test the weak identification of the instrument set.

Investment analysis/1

Dep. Variable: $IK_{i,t}$	(1) *Incentives*	(2) *Rewards*	(3) *Penalties*
$IK_{i,t\text{-}1}$	0.107	0.105	0.118
	(0.089)	(0.089)	(0.085)
$\Delta SK_{i,t}$	0.133***	0.133***	0.134***
	(0.024)	(0.024)	(0.022)
$\Pi K_{i,t}$	0.066***	0.068***	0.081***
	(0.018)	(0.019)	(0.015)
$INCK_{i,t\text{-}1}$	0.241	-	-
	(0.196)	-	-
$REWARDK_{i,t\text{-}1}$	-	0.233	-
	-	(0.207)	-
$PENALTYK_{i,t\text{-}1}$	-	-	-1.552**
	-	-	(0.679)
Constant	0.033***	0.033***	0.030***
	(0.006)	(0.006)	(0.006)
Unit dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
AR1 *(p-value)*	0.006	0.006	0.005
AR2 *(p-value)*	0.556	0.559	0.735
Hansen test of over-identification *(p-value)*	0.454	0.477	0.673
Diff-in-Hansen test of exogeneity *(p-value)*	0.900	0.802	0.922
Number of Instruments	25	25	27
Cragg-Donald weak identification test statistic (levels)	31.49	31.19	40.88
Cragg-Donald weak identification test statistic (first-diff)	67.50	61.36	75.89
Observations	460	460	460
Number of units	115	115	115

Investment analysis/2: subsamples

Dep. Variable: $IK_{i,t}$	(1) *High performance Units* (SAIDI ≤ 32) I Quartile	(2) *Average performance Units* (32 < SAIDI < 73.9) II-III Quartile	(3) *Average performance Units* (32 < SAIDI < 73.9) II-III Quartile	(4) *Poor performance Units* (SAIDI ≥ 73.9) IV Quartile
$IK_{i,t-1}$	0.099	0.173	0.112	0.342
	(0.072)	(0.199)	(0.152)	(0.276)
$\Delta SK_{i,t}$	0.160***	0.169***	0.168**	0.585**
	(0.021)	(0.066)	(0.085)	(0.245)
$\Pi K_{i,t}$	0.074**	0.186**	0.189***	0.074
	(0.030)	(0.080)	(0.071)	(0.077)
$REWARDK_{i,t-1}$	0.417**	-0.226	-	-
	(0.212)	(0.185)	-	-
$PENALTYK_{i,t-1}$	-	-	-0.704	-1.459*
	-	-	(1.015)	(0.767)
Constant	0.030***	0.003	0.006	0.017
	(0.008)	(0.016)	(0.017)	(0.026)
Unit dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
AR1 *(p-value)*	0.009	0.054	0.047	0.053
AR2 *(p-value)*	0.744	0.907	0.832	0.780
Hansen test *(p-value)*	0.155	0.365	0.414	0.107
Diff-in-Hansen test of exogeneity *(p-value)*	0.100	0.115	0.226	0.355
Number of Instruments	25	21	21	21
Observations	138	238	236	86
Number of units	44	83	83	36

Conclusions & Discussion/1

- The physical assets as well as the level of operational expenditures have a significant effect on quality improvements
- Output-based incentives Granger-cause capital expenditures (and not vice-versa). No clear effect for Opex.
- Output-based incentives have a significant effect on the use of the firm's resources:
  - Areas which received a penalty responded to the output-based incentives with an increase in capital expenditures, especially so in low performance areas.
  - Rewards did not appear to play any significant role in modifying the firm's investment rate, apart for high-performance areas.
  - Asymmetric effect of incentive schemes

Conclusions & Discussion/2

- These results question the usefulness of maintaining a two-sided (positive and negative) incentive scheme over the entire range of output levels as well as the use of both types of incentives over a relatively wide output range, where they seem to be not effective (or no longer effective).
- These considerations appear relevant in light of the complex implementation of these incentive schemes and the associated costs incurred in practice by the regulatory authority.
- On the policy ground, our results also imply that in practice, regulators ought to assign incentives only for extremely high or low levels of performance and reduce them in areas where firms interpret rewards as a premium for achieving a desirable level of performance, but not as a stimulus to exert an additional effort