

# THE POLITICAL ECONOMY OF (DE)REGULATION: THEORY AND EVIDENCE FROM THE U.S. ELECTRICITY MARKET.\*

Carmine Guerriero

Department of Economics and ACLE, University of Amsterdam

September 9, 2011

## Abstract

The choice of whether to regulate a market or let firms compete is a key issue in economics. Whenever the demand is sufficiently inelastic, competition produces lower allocative distortions but also lower expected profits and, thus, weaker incentives to invest in cost-reduction than regulation does. Hence, the likelihood that a society chooses competition is higher: (i) the less salient cost-reduction is; (ii) the more limited the extent of asymmetric information and, thus, the expected profits under regulation are; (iii) the stronger the political power of the consumers is. This prediction is consistent with U.S. electricity market data. During the 1990s, deregulation was enacted where generation costs were historically lower and politicians were more pro-consumer. Also, GMM estimates show that restructuring made significantly more likely that the firms with the lowest costs served the market to the detriment of cost-reducing investments. This evidence sheds new light on the slowdown of the deregulation wave.

*Keywords:* Regulation; Competition; Electricity; Accountability.

*JEL classification:* L11; L51; L94; P16.

---

\*I would like to thank Serra Boranbay, Anna Creti, Mikhail Drugov, Kira Fabrizio, Giulio Federico, Sander Onderstal, Clara Poletti, Carlo Scarpa, Sandro Shelegia, and seminar participants at FEEM, CSEF, UVA and at the 2010 ESNIE meeting in Cargese for useful comments. The first draft of this paper was completed while I was visiting the IEFÉ at Bocconi University. To the last extent, I gratefully acknowledge the Institution's support. Address: Roetersstraat 11, 1018 WB Amsterdam, The Netherlands. Phone: +31 (0)205254162. Fax: +31 (0)205255318. E-mail: c.guerriero@uva.nl

“Competition is not only the basis of protection to the consumer but is the incentive to progress. However, [...] destructive competition [...] may impoverish the producer and the wage earner” (Herbert Hoover, *States of the Union Address*, December 2, 1930).

## 1 Introduction

Economists have long maintained that, even if competition assures allocative efficiency, regulation could be better suited to stimulate the firm’s cost-reducing investment. Hence, a benevolent government should choose between competition and regulation optimally trading off allocative efficiency and investment inducement. Yet, market institutions are designed by more or less pro-shareholders politicians and the extent of asymmetric information is a function of the activity of regulators accountable to special interest groups and not to the society at large. How, therefore, do politicians’ and regulators’ incentives shape the allocative efficiency-investment inducement trade off when market institutions are designed?

This paper lays out a theoretical framework for thinking about this issue, and explores its empirical implications using U.S. electricity data. In the model, I build on a wide literature on incentives and competition (see Armstrong and Sappington, [2006]), and I compare two market institutions in a world in which the demand is inelastic and the firms can commit a cost-reducing investment before privately learning their cost. Under competition, production is assured by two firms. Each firm serves all the market at the price proposed by the opponent when able to undercut it. When the bids are the same, the two firms split the market. Under regulation, instead, production is assured by a local monopoly. In equilibrium, competition produces lower allocative distortions but also lower expected profits and, thus,

weaker incentives to invest in cost-reduction than regulation does. Hence, the likelihood that a society chooses competition is higher the less salient cost-reduction is and the more limited the expected profits are because regulators have stronger political incentives to reveal the firm's private information. When, instead, investments affect asymmetrically the firm's costs and profits, a tension between consumers and shareholders arises and competition is more often adopted the more powerful consumers are. Finally, because competition serves better static efficiency—i.e., minimizing allocative distortions—and worse dynamic efficiency—i.e., stimulating investments, the relation between the average cost and market institutions is undecided. The model's message remains similar when competition is a' la Cournot.

In order to test these predictions, I look at the restructuring of the U.S. electricity market. I analyze a panel of 503 plants owned by investor owned utilities—IOWs hereafter—operating in 43 states over the period 1981 to 1999. Public Utility Commissions—PUCs hereafter—have classically set prices in order to assure a specific return on investment after recouping all operating costs recognized as reimbursable during rate reviews. After having experimented incentive regulation in the 1980s, many U.S. states enhanced more radical reforms in the mid-1990s. As a result, today, several IOWs own only a small fraction of the total generation capacity and retail rates often follow the prices clearing auction-based wholesale markets (Fabrizio, Rose and Wolfram, 2007). Consistent with the model, deregulation was enhanced in states where generation costs were historically lower and politicians were more pro-consumer. Also, GMM estimates suggest that deregulation had a significant and strong negative medium term effect on labor and fuel inputs and an insignificant effect on the plants' efficiency to transform fuel inputs into power. This evidence, along with the fact that the new capacity entered service in the last two decades was built mainly by IOWs operating in

non restructured markets (Joskow, 2008), confirms the model's intuition according to which competition assures that the firm with the most efficient technology serves the market for a given cost distribution but that the latter will be more favorable under regulation. These results shed new light on the recent slowdown of the deregulation wave (EIA, 2003).<sup>1</sup>

Even if several studies (Aghion et al., 2005; Alesina et al, 2005; Bushnell and Wolfram, 2005; Zhang, 2007; Fabrizio, Rose and Wolfram, 2007; Parker, Kirkpatrick and Zhang, 2008) have reported evidence suggesting that deregulation can deliver lower input uses and costs, no previous paper has developed a formal theoretical and empirical framework to shed light on its introduction.<sup>2</sup> In this perspective, the key contribution of the present paper is to prove, for the first time, that the choice of market institutions is essentially based on an allocative efficiency-investment inducement trade off and to explore the related political economics.<sup>3</sup> The rest of the paper is organized as follows. Section 2 describes the institutions of the U.S. electricity market as an example of the general setting studied in the model. Section 3 illustrates the basic static versus dynamic efficiency trade off solved by society when designing market institutions. Section 4 evaluates the role of regulators' and politicians' incentives. Section 5 states the predictions which are tested in section 6; section 7 concludes. The appendix gathers the proofs, the tables and a detailed description of the data.

---

<sup>1</sup>The present paper also explains the start of 20th century switch from a municipal regulation with its typical hold-up problems to a state regulation assuring a fair rate of return on investment: these reforms were enhanced where capacity shortages were more severe and residential penetration rates lower (Knittel, 2006).

<sup>2</sup>Recent papers (Teske, 2004; Duso and Röller, 2003; Knittel, 2006; Zhang, 2007; Belloc and Nicita, 2010; Craig and Savage, 2010; Guerriero, 2011b; Potrafke, 2010) provide empirical evidence of the relevance for regulatory reforms of the mechanisms identified in my model. Also, Benmelech and Moskowitz (2010) shows that the extent of financial regulation falls with its costs and the political power of wealthy incumbents who are interested in limiting political entry by applying restrictions to lending.

<sup>3</sup>As a consequence, the present paper is complementary not only to the well-known literature on sub-additive costs (Baumol and Klevorick, 1970) and to the classic contributions on market failures (Stiglitz, 1989) but also to a wide body of research seeing the rise of the regulatory state as a response to the risk that the majority of market participants is coerced by a subgroup of more powerful special interests (Stigler, 1971; Glaeser and Shleifer, 2003) or of similarly powerful untrustworthy agents (Aghion et al., 2010; Pinotti, 2010).

## 2 Institutions

*Reforming the U.S. power market: firms', regulators' and politicians' incentives.*—As anticipated above, restructuring initiatives have fundamentally changed the way plant owners earn revenues. At the wholesale level, plants sell through either newly created spot markets or long-term contracts based on expected spot prices. In the spot market, plant owners bid a supply schedule for power. The dispatch order is set by the bids, and the bid of the marginal plant is paid to all plants that are dispatched. Hence, high-cost plants are forced down in the dispatch order, reducing expected revenues. The details of the restructuring initiatives and, in particular, whether to disintegrate the firm, whether to participate in a pool of wholesale markets, and the duration of each deregulation phase are decided during rate reviews (Shumilkina, 2009). The latter are structured in quasi-judicial hearings presided by the PUC commissioners, open to all the interested parties—i.e., the firms, consumer advocates, and the media, and usually triggered either by IOUs in response to cost shocks or periodically by the PUC. In the case of restructuring, almost all reviews have been required by one or both state houses with the intention of obtaining a final decision assuring “adequate, safe, reliable, and efficient energy services at fair and reasonable prices” (EIA, 2003, page 24). Accordingly, the focus of the regulatory orders preceding any legislative decision has been on the impact of restructuring on both expected prices and expected investment levels.<sup>4</sup>

During the hearings the commissioners examine experts and collect the evidence: given the extensive media coverage, this information-gathering role is the key task considered for the selection and retention of these officials (Gormley, 1983; Friedman, 1991).<sup>5</sup>

---

<sup>4</sup>Coherently with the message of the model discussed below, the expectation of heavy dynamic inefficiencies was considered the main obstacle to the deregulation processes in Louisiana and Mississippi (EIA, 2003).

<sup>5</sup>This role is coherent to the US Administrative Procedure Act (APA) prescriptions: “the proponent of a

*From institutions to theory.*—On top of the above discussion, I will assume that the choice between competition and regulation is taken by a planner who maximizes a weighted average of the net consumer surplus and the firm’s utility, and that the weight attached to the latter increases with the saliency of cost-reduction. Also, when investment are not in the interest of consumers, such weight is higher the stronger is the political power of shareholders. This setting captures the objective of the rate reviews and the fact that, even if during the hearings the widest consensus among parties is needed, politicians can bias the institutional choice in order to favor their constituency. Finally, in accordance with the institutional role of commissioners, I maintain that the regulatory contract can be contingent on a signal whose observable precision increases with the effort exerted by a regulator. Should the latter be the case, the regulator will be rewarded on the basis of such precision.

### 3 The Static Versus Dynamic Efficiency Trade Off

The model builds on Laffont and Tirole (1993), and Armstrong and Sappington (2006). First, I will compare competition and regulation in a world in which the firm can sink cost-reducing investments before observing its production efficiency and the regulator acts as perfect agent of society. This exercise stresses the relation between dynamic inconsistency in investment and the design of regulatory institutions. Next, I will evaluate the role played by the regulator’s career concerns and by the preferences of the politicians constituency.

*Preliminaries.*—The representative demand for the homogeneous good is  $q(p) > 0$  for  $p \in [0, \bar{p})$  and 0 for  $p \geq \bar{p}$  with  $q'(p) < 0$  for  $p \in [0, \bar{p}]$ . Both  $q(p)$  and  $p$  are common knowledge.

---

rule or order has the burden of proof [...] a rule or order [needs to be] supported by and in accordance with reliable, probative, and substantial evidence” (Title 5, Pt. 1, Chapter 5.II, 556(d)).

Production is assured by either one regulated firm or two competitive ones. The marginal and average cost  $c_i$  equals either  $c_L$  or  $c_H < \bar{p}$  with the same probability and  $\Delta \equiv c_H - c_L > 0$ . While the cost distribution is common knowledge, the realization of  $c_i$  is private information of the firm.<sup>6</sup> Should the correlation between types be positive or the probability of having low cost be generic, none of the model's results will be affected (see footnote 10 and 12).

Firms maximize the rent,  $U_i$ , which is the sum of the profits  $\pi(p, c_i) \equiv q(p)(p - c_i)$  and a transfer  $t \geq 0$  which can be positive only under regulation. The social welfare is given by the consumer gross surplus  $S(p) = \int_p^{\bar{p}} q(x) dx$  plus  $\alpha \in [0, 1)$  times the firm's rent minus the transfer evaluated at the shadow cost of public funds  $1 + \lambda > 1$ :  $S(p) + \alpha U - (1 + \lambda)t$ . Two are the key features of this welfare function. First, the assumption that society values consumer welfare at least as much as that of shareholders can be justified by the fact that consumers are less wealthy and can be relaxed provided that  $\alpha < 1 + \lambda$  (see Armstrong and Sappington, [2007]). Second, a transfer  $t$  reduces the social welfare by  $(1 + \lambda)t$  because it is financed through distortionary taxes. Should the regulated firm be private as in the market studied below, then only the model's interpretation will change: i.e.,  $t$  will represent the firm manager's reward and  $\lambda$  the shadow cost of the managerial moral hazard constraint (see Joskow and Schmalensee, [1986]). I also assume that the expected social welfare function is strictly concave and I focus on the empirically relevant case of inelastic demand:

**A1:** *The demand satisfies  $q''(p)(\bar{p} - c_L) + q'(p) < 0$  and  $\varepsilon_{p,q} = -q'(p)p/q(p) < 1$ .*

*The timing.*—The design of institutions and production proceeds according to this time line:

$t = 1$ .—The planner chooses between regulation and competition on the basis of the

---

<sup>6</sup>Two key avenues for future research are: 1. to include in the model the indirect effects of market pressures working through the reduction of agency costs within the firms (Baggs and de Bettignies, 2007); 2. to have  $c_i$  linearly decreasing with a contractible cost reducing effort as in Laffont and Tirole (1993). In the last case, the model's results will depend on the properties of both the disutility of effort and the demand function.

sum of the expected welfare and a mean zero shock  $\delta$  to her preferences for regulation;  $\delta$  is distributed according to the density  $f$  on the support  $[-\infty, \infty]$ . If regulation is chosen, a regulator, who acts as a perfect agent of the planner, offers the monopoly a menu of  $(t_i, p_i)$  pairs conditional on the firm's report of its type but not on eventual investments.

$t = 2$ .—Each firm eventually commits an unobservable investment  $I$  which, at the cost  $\psi(I)$ , increases the probability of  $c_L$  to  $(1 + I)/2$ . The firms' investment choices are contemporaneous under competition. The function  $\psi(\cdot)$  is increasing, strictly convex and such that  $\psi(0) = 0$ ,  $\psi(I) > 0$  for all  $I > 0$  and  $\lim_{I \rightarrow 1} 2\psi'(I) \geq S(c_L) - S(c_H)$ .<sup>7</sup>

$t = 3$ .—Each firm discovers its piece of private information, which is the realization of  $c_i$ .

$t = 4$ .—Under regulation the planner asks the firm to report  $c_i$  and the corresponding contract is executed. Under competition each firm bids a price and the firm with the lowest bid serves the whole market at the price played by the opponent. If the two bids are equal, the market is evenly split. Clearly, the equilibrium is the same as under symmetric information.<sup>8</sup>

In interpreting the generality of the foregoing, several observations should be borne in mind. First, the shock  $\delta$  captures the existence of long-lived determinants of regulation, like the level of trust in the society (Aghion et al., 2010; Pinotti, 2010), unrelated to technological and political forces. Second, because the firm's cost-reducing investments are financed through the expected rent,  $\alpha$  is a measure of society's dynamic efficiency concerns. Third, the assumption according to which the regulator is benevolent can be relaxed as clarified in section 4.2. Finally, I focus on Bertrand competition because this conduct bears the closest

---

<sup>7</sup>Such investment technology has been extensively studied within both regulated (Laffont and Tirole, 1993) and competitive (Raith, 2003; Baggs and de Bettignies, 2007; Vives 2008) environments.

<sup>8</sup>The interaction is strategically similar to a second price auction and both types prefer truth-telling. Indeed, while the  $c_H$  type is indifferent, the  $c_L$  type strictly prefers to report the truth when faced with a  $c_H$  opponent and weakly prefers to play  $c_L$ , in order to exhaust any incentive to undercut, if faced with a  $c_L$  counterpart.

resemblance to the functioning of the second-price auction based wholesale markets used to price power in the restructured U.S. electricity markets and illustrated above. Building, however, on data from the same market, Bushnell, Mansur, and Saravia (2008) stress the relevance of considering capacity constraints and long-term contracts to correctly assess the impact of restructuring on market outcomes. To the last extent, section 4.3 will explain why the model's main message is preserved when it is assumed, instead, that the competition is a' la Cournot and/or the regulator can commit to reimburse investment expenses.

*Regulating a monopoly with unknown costs.*—Under regulation, the planner grants a reservation wage of 0 to the regulator and a legal monopoly to one firm. The regulator exploits the revelation principle (Myerson, 1979) and announces that she will set price  $p_i$  and deliver a transfer  $t_i$  whenever the report is  $c_i$ . Because the planner dislikes leaving a positive rent to the firm and prefers to let both firms produce,<sup>9</sup> the equilibrium envisions a binding low cost firm's incentive compatibility constraint—i.e.,  $q(p_L)(p_L - c_L) + t_L = q(p_H)(p_H - c_L) + t_H$ —and a binding high cost firm's individual rationality constraint—i.e.,  $U_H = 0$ . The first constraint assures that a low cost firm truthfully reports its type, the second that a high cost firm operates. Thus, the low cost firm enjoys a rent  $U_L = \Delta q(p_H) > 0$ . Let  $w_i(p_i, c_i) = S(p_i) + (1 + \lambda) \pi_i(p_i, c_i)$ . For a given equilibrium investment  $\hat{I}^R$ , the planner maximizes 
$$W^R = (1/2) \left(1 + \hat{I}^R\right) [w_L(p_L, c_L) - (1 + \lambda - \alpha) \Delta q(p_H)] + (1/2) \left(1 - \hat{I}^R\right) w_H(p_H, c_H).$$

Differentiating this expression with respect to  $p_L \geq 0$  and  $p_H \geq 0$  reveals that the high cost firm's allocation is distorted in such a way that the regulator is able to achieve the exact level of expected welfare were the firm's costs observable but the high marginal cost equal

---

<sup>9</sup>This is always the case whenever the planner, if indifferent between giving up production by the  $c_H$  type and offering a contract to both types, prefers the second option. Indeed, the planner will never strictly prefer the first option for every probability  $(1 + v)/2$  of  $c = c_L$  and every  $\bar{p}$  because  $(1 - v) S(\hat{c}_H(v)) \geq 0$ .

to  $\hat{c}_H \equiv c_H + (1 + \hat{I}^R) (1 - \hat{I}^R)^{-1} [1 - \alpha(1 + \lambda)^{-1}] \Delta > c_H$ . While the regulator increases  $p_H$  over  $c_H$  and reduces  $t_H$  in order to limit the informational rent, she does not distort the firm's activities when the report is  $c_L$  because there is no incentive to understate the cost. The equilibrium is achieved through the Ramsey price obtained maximizing  $w_L(\cdot)$  for cost  $c_L$  and  $w_H(\cdot)$  for cost  $\hat{c}_H$ . Thus, the regulator fixes  $p_L = c_L$  and  $p_H = \hat{c}_H$  (the monopolist price) when  $\lambda$  is zero (large) because transfers entail no social costs (large distortions).

*Competition.*—Following Vives (2008), I focus on symmetric investment profiles. Given an equilibrium investment level  $\hat{I}^C$ , the price will equal  $c_H$  except when both firms have low cost. Also, the firm's rent will be positive only when it has the low marginal cost while its rival has the high one, which happens with probability  $(1/4) \left[1 - (\hat{I}^C)^2\right]$ . In this case, the firm's rent will be  $\Delta q(c_H)$ . As a result, the expected social welfare under competition is:

$$W^C = \frac{(1 + \hat{I}^C)^2}{4} S(c_L) + \frac{(1 - \hat{I}^C)^2 + 2 - 2(\hat{I}^C)^2}{4} S(c_H) + \frac{1 - (\hat{I}^C)^2}{2} \alpha \Delta q(c_H).$$

### 3.1 Comparison

I maintain in the following that  $\lambda$  equals 0: this last assumption is relaxed in section 4.3.

The firm chooses  $\hat{I}^j$  with  $j \in \{R, C\}$  to maximize expected rents minus investment costs.

Under regulation, this means solving the strictly concave program

$$\hat{I}^R = \arg \max_{I \geq 0} (1/2) (1 + I) \Delta q(\hat{c}_H(\hat{I}^R)) - \psi(I) \quad (1)$$

with  $\hat{c}_H \equiv c_H + (1 + \hat{I}^R) (1 - \hat{I}^R)^{-1} (1 - \alpha) \Delta$ . Under competition, instead, the firm solves:

$$\hat{I}^C = \arg \max_{I \geq 0} (1/4) (1 + I) (1 - \hat{I}^C) \Delta q(c_H) - \psi(I). \quad (2)$$

The appendix shows that: 1. both  $I^R$  and  $I^C$  are positive and strictly lower than the socially optimal investment level  $I^* < 1$ ; 2. the extent of underinvestment is wider under competition. In this last case, the firm obtains a positive rent on a larger demand but less often: in particular, half of the time when  $I^C = I^R = 0$ . Yet, whenever the demand is inelastic, the higher probability of rents, which is a price effect, more than compensates the fall in demand, which is a quantity one, and  $I^R > I^C$ . Also, underinvestment is worsened under Bertrand competition due to the mix of the positive correlation between types introduced by the investment technology, and the strategic complementarity between firms' pricing decisions.<sup>10</sup> In  $t = 1$  competition is chosen when  $W^C > W^R + \delta$  that, for  $\delta = 0$ , rewrites as:

$$2 \left(1 - \hat{I}^R\right) [S(c_H) - S(\hat{c}_H)] + 2 \left[1 - \left(\hat{I}^C\right)^2\right] \alpha \Delta q(c_H) > \left[1 + 2 \left(\hat{I}^R - \hat{I}^C\right) - \left(\hat{I}^C\right)^2\right] [S(c_L) - S(c_H)]. \quad (3)$$

For  $I^C = I^R = 0$  the comparison in (3) can be restated as

$$\frac{1}{2} \left[ \frac{S(c_L) + S(c_H)}{2} - \frac{S(c_L) + S(\hat{c}_H)}{2} \right] > \frac{1}{2} \left\{ \frac{S(c_L) + S(\hat{c}_H)}{2} - [S(c_H) + \alpha \Delta q(c_H)] \right\}.$$

As this last inequality shows, when investment are unavailable, competition always outperforms regulation if the firms have the same type (see the left hand side); when however the types are different, regulation could deliver a lower mean price when the demand is sufficiently elastic and  $\alpha$  is small (see the right hand side). Also for  $I^C = I^R = 0$ , a rise in  $\alpha$  undoubtedly enhances the likelihood that competition is adopted because it increases more the expected rent under competition than it curbs the distortions under regulation.<sup>11</sup>

<sup>10</sup>The incentives to invest are maximized when there is no ex post correlation between types and minimized when such correlation is the highest at  $\hat{I}^C = 1$ . Should the ex ante correlation between types be  $\rho > 0$ , the model's results will survive because the rent will be falling with  $\rho$  and thus still lower under competition.

<sup>11</sup>This is because  $\Delta(q(c_H) - q(\hat{c}_H)) > 0$ . Notice that, in this case, provided that  $2[S(c_H) - S(\hat{c}_H)] > S(c_L) - S(c_H)$ , competition will outperform regulation for every value of  $\alpha$ .

This comparison changes dramatically when firms can invest in cost reduction. As inequality (3) suggests, a rise in  $\alpha$  not only fosters investment under regulation but entails also a double countervailing impact on allocative distortions. The latter are relaxed due to the higher social value of investment inducement but also strengthen because of the more favorable distribution of types. As the appendix shows: 1. the social value of the last indirect effect is smaller than the one brought by the change in  $\hat{I}^R$ ; 2. provided that the investment technology is sufficiently effective, the social value of the fall in allocative distortions due to the higher investment concerns is higher than the extra value carried by the firm's rent under competition. As a result, the probability of adopting regulation rises with  $\alpha$  under the following mild condition, which can be relaxed at the cost of more cumbersome algebra:

**A2:**  $\psi'(1/2) \leq (\Delta/8) q(c_H)$ .

**Proposition 1:** *Under assumptions A1 and A2, the probability of competition is chosen falls with the society's investment concerns  $\alpha$ .*<sup>12</sup>

This belongs to a series of findings showing that institutions curbing rent-extraction could be optimal if expropriation of sunk investments is an issue. While, for instance, Sappington (1986) focuses on institutions preventing the planner from observing the firm's true costs, Guerriero (2011a) shows that appointment rules limiting the regulator's incentive to provide information on the firm's true cost are found where investment shortages are more dramatic.

Crucially, the model shows that the possibility of committing cost-reducing investments makes regulation more useful and transforms market design into a trade-off between static and dynamic efficiency. The more concerned society is with cost reducing investments—

---

<sup>12</sup>Clearly, the patterns summarized in proposition 1 as well those discussed in the remaining part of the theoretical section hold true when the probability of  $c = c_L$  is equal to the generic value  $(1 + v)/2$ ; in this case,  $\hat{c}_H$  will equal  $c_H + (1 + \hat{I}^R) (1 - \hat{I}^R)^{-1} (1 + v) (1 - v)^{-1} (1 - \alpha) \Delta$ .

because, for instance, past costs have been persistently high or higher than those in bordering regions—the lower is the probability of adopting competition. Yet, this statement needs to be qualified. Indeed, on one hand, regulation becomes less and less appealing the thinner is the asymmetry in information and so the stimulus to invest. On the other hand, a tension between shareholders and consumers arise when investment returns accrue more to the ex post rent than to the net consumer surplus. In the following, I will discuss these two points.

## 4 Information and Politics

Next, I will explore the political economics of the allocative efficiency-investment inducement trade off and assess how robust the model’s message is to alternative assumptions.

### 4.1 *Capture and Regulators’ Implicit Incentives*

As seen above, top-level regulators respond to implicit incentives and not to performance-based contracts and, in the case of the market studied in the empirical section below, they are simply either elected or appointed on the base of their information-gathering effort. Building on these observations, I consider the following information gathering technology.

In  $t = 1$  the planner directly offers the firm a menu of  $(t_i, p_i)$  pairs conditional on the firm’s report and the realization of a signal on  $c_i$  that she observes between  $t = 3$  and  $t = 4$ . The signal is such that, if  $c = c_L$ , with probability  $\gamma \in [0, 1]$  the planner sees  $c_L$  and implements the full information contract and with probability  $1 - \gamma$  she remains uninformed. If  $c = c_H$ , she remains uninformed throughout.<sup>13</sup> Whenever uninformed she asks the firm

---

<sup>13</sup>Even if under different information structures the precision of the signal can increase allocative distortions (Boyer and Laffont, 2003), only the actual structure captures the fact that, in the U.S. electricity market, rate reviews are aimed at proving that the firm is of the  $c_L$  type. Accordingly, Fremeth and Holburn (2010)

to report its type. The observable precision has technology  $\gamma_s = \theta e_s$  where  $\theta \in [0, 1]$  is the regulator's random ability,  $e_s \in [0, 1]$  the information gathering effort, and  $s = \{E, A\}$  the type of implicit incentives to which the regulator is subject to. The ability  $\theta$  has mean  $\bar{\theta}$  and is drawn from a truncated normal density  $g$  with  $g(\bar{\theta}) > 1$ .<sup>14</sup>

Information gathering happens between  $t = 3$  and  $t = 4$ ; during this lapse of time, first Nature chooses  $\theta$ , then the signal is observed by the planner, finally the precision  $\gamma_s$  is revealed and the regulator rewarded on its base. The regulator maximizes  $B + \tau [T(e_s) - C(e_s)]$ , where  $\tau$  measures the value of the net implicit rewards relative to the bribes  $B$  offered by the firm and the effort cost function is such that  $C(0) = 0$ ,  $C' > 0$ ,  $C'(0) < \infty$ ,  $C'' > 0$ ,  $\lim_{e_s \rightarrow 1} C'(e_s) = \infty$ . For what concerns implicit rewards, as suggested by Alesina and Tabellini (2007), while elected officials are held accountable by voters, appointed ones are career concerned. In particular, elected regulators want to maximize the probability that the realized precision is higher than the one obtained by an incumbent with mean ability  $\bar{\theta}$  so that  $T^E(e_E) = \Pr\{e_E \geq \bar{\theta} e^{\text{exp}}\}$  where  $e^{\text{exp}}$  is the voters' expectation over effort. Appointed regulators, instead, want to maximize society's perception of their ability given the precision's realization or  $T^A(e_A) = E_\theta [E_\theta(\theta | \gamma_A, e_A^{\text{exp}})]$  where  $E_\theta[\cdot]$  denotes the regulator's unconditional expectation over  $\gamma_A$  and  $E_\theta$  society's expectation over  $\theta$  conditional on  $\gamma_A$ .

For a given equilibrium effort  $\hat{e}_s$ , the evaluators estimate  $\theta$  as  $\xi_s/\hat{e}_s$ . Hence, a rise in effort delivers marginal benefits  $\bar{\theta}/\hat{e}_A$  under appointment and  $g(\bar{\theta}) (\bar{\theta}/\hat{e}_E)$  under election.<sup>15</sup>

Differently from the case of appointment, under election the effect of a rise in effort on

---

find that better informed PUCs implement less often rate increases and more often rate decreases.

<sup>14</sup>This is a mild requirement in the market studied below being the regulators' biographies very similar (Gormley, 1983). Guerriero (2011a, b) shows that the model's message will be unaffected should: 1. the realization of  $\gamma_s$  be unobservable; 2. the precision technology be linear; 3. the regulator care also about social welfare.

<sup>15</sup>While the marginal benefit of effort always falls with  $\hat{e}_s$ , the marginal cost of effort is increasing: this implies that the solution to the regulator's problem is unique and interior (see Guerriero, [2011a]).

the estimated talent is multiplied also by the impact of a change of the estimated talent on the probability of re-election: this last marginal effect is  $g(\bar{\theta})$ . The higher the latter is the more effective is effort in swaying votes and assuring a higher probability of victory. When  $g(\bar{\theta})$  is greater than one, election leads to a higher equilibrium effort. This pandering incentive effect of election is complementary to the selection one proposed by Besley and Coate (2003) but, differently from the latter, it survives when the regulator can divert effort from information gathering to a less socially relevant task in exchange for bribes. Indeed, as shown in Guerriero (2011a), to preserve implicit incentives she will never exert effort only in the socially irrelevant task.<sup>16</sup> Thus,  $\gamma_E > \gamma_A$  and the impact of a reform from appointment to election on the planner's institutional choice is isomorphic to the one of a rise in the precision  $\gamma$ . The expected social welfare in the supervision regime—notice the apex  $S$ —is:

$$W^{R,S} = \frac{1+\hat{I}^{R,S}}{2} \left\{ \gamma S(c_L) + (1-\gamma) [S(c_L) - (1-\alpha) \Delta q(\hat{c}_H^S)] \right\} +$$

$$\frac{1-\hat{I}^{R,S}}{2} \left\{ S(\hat{c}_H^S) + (\hat{c}_H^S - c_H) q(\hat{c}_H^S) \right\} = \frac{1+\hat{I}^{R,S}}{2} S(c_L) + \frac{1-\hat{I}^{R,S}}{2} S(\hat{c}_H^S),$$

where  $\hat{c}_H^S \equiv c_H + \frac{1+\hat{I}^{R,S}}{1-\hat{I}^{R,S}} (1-\gamma)(1-\alpha)\Delta$ . The planner's choice is described by inequality (3) with  $\hat{c}_H^S$  in the place of  $\hat{c}_H$  and the equilibrium investment under regulation is given by:

$$\hat{I}^{R,S} = \arg \max_{I \geq 0} (1/2)(1+I)(1-\gamma)\Delta q\left(\hat{c}_H^S\left(\hat{I}^{R,S}\right)\right) - \psi(I). \quad (4)$$

As shown in the appendix, under assumption A1, a more precise signal crowds out ex ante investment incentives; as a result, on one hand, regulation becomes less efficient in insulating the firm from ex post expropriation of sunk investments; on the other, however, a more

<sup>16</sup>Guerriero (2011a) shows also that, when the regulator directly observes the signal, she will truthfully reports her information whenever implicit incentives are sufficiently important—i.e.,  $\tau$  is sufficiently high. This collusion-proofness property squares with broad evidence on the limited role of capture in the U.S. electricity market (see the study on pricing by Leaver [2009] and that on the rise of state regulation by Knittel [2006]).

limited extent of allocative distortion is needed to support incentive compatibility. While the latter is a quantity effect, the former is a price one. Again, provided that the demand is sufficiently inelastic, the price effect will prevail and the following will hold:

**Proposition 2:** *Whenever assumption A1 holds and  $\varepsilon_{p,q} < \min\{\bar{\varepsilon}_{p,q}, 1\}$ , the probability that competition is chosen rises with the signal precision  $\gamma$  and it is higher when the regulator is elected provided that her effort is sufficiently effective in swaying votes or  $g(\bar{\theta}) > 1$ .<sup>17</sup>*

This result is similar to that proposed by Guerriero (2011b) who documents a positive relation between the power in term of cost-reducing effort of incentive rules and the information gathering effort level. Yet, while such pattern is simply due to the lower need of allocative distortions, the relation documented in proposition 2 is more subtle as it goes through the effects of a more accurate information on both allocative distortions and cost-reducing investments.

## 4.2 Strategic Market Institutions Selection

Institutional design could be inefficient when the firm's investment expenses favor shareholders over consumers and both groups can influence the planner's decision. A striking example of these expenses are those not strictly related to service provision *per se*—e.g., marketing, diffusion of smart-metering technologies, reducing the fixed cost of transmission. In order to clarify the point in the sharpest way, I assume that: 1. the return from investment accrues only to the firm's rents without affecting the consumer surplus;<sup>18</sup> 2. the firm is infinitely risk averse in the range of negative ex post utilities; 3. the planner acts as an agent of

<sup>17</sup> $\bar{\varepsilon}_{p,q}$  could be either greater or lower than one depending on the degree of convexity of  $\psi$  and the size of  $\Delta$ . Even in the second case, requiring that  $\varepsilon_{p,q} < \bar{\varepsilon}_{p,q}$  would remain a mild assumption: in fact, reviewing previous contributions looking at the long run residential price elasticity in different U.S. and international markets, Espey and Espey (2004) report that the median of these estimates is 0.81.

<sup>18</sup>At the cost of cumbersome algebra, the idea extends to investments benefiting asymmetrically both groups.

the incumbent  $\tilde{m}$  between the pro-shareholder party  $Re$  and the pro-consumer  $De$ ; 4. the following two periods succeed the four steps studied in section 3.1:

5. The incumbent faces an election with exogenous winning probabilities  $x_{\tilde{m}}$ ; next, the winner  $m$  implements a fixed aid  $\rho_m > 0$  proportional to the firm's rent and paid out to the firm if the investment is committed. The ex post rent becomes  $(1 + \rho_m)U$ .
6. The firm eventually commits an investment of fixed cost  $\bar{I} > 0$ . The net expected value of the investment is  $\pi\bar{I}$ , with  $\pi \equiv \bar{\pi}\mu + \underline{\pi}(1 - \mu) > 0$  and  $\bar{\pi} > 0 > \underline{\pi}$ . In words, the investment is stochastic and leads to a loss  $\underline{\pi}\bar{I}$  with probability  $1 - \mu > 0$ .

Clearly, only the low cost firm invests whenever  $(1 + \rho_m)\hat{U}^j + \underline{\pi}\bar{I} \geq 0$ . Let's also suppose that a planner agent of a type  $\tilde{m}$  incumbent evaluates this ex-post participation constraint at the shadow price  $\chi_{\tilde{m}}$ , and the investment aid  $\rho_m\hat{U}^j$  at the shadow cost of public funds  $\lambda$ . In practice,  $\chi_{\tilde{m}}$  captures the incumbent's willingness to encourage ex post investments.

Define  $\tilde{x} \equiv \rho_{De}x_{De} + \rho_{Re}x_{Re}$  and assume the following restrictions:

**A.3:**  $\rho_{Re} > \rho_{De}$ ;  $\chi_{Re} > \lambda > \chi_{De}$ .

All in all, for  $\delta = 0$  the planner will choose competition if:

$$\begin{aligned} (1 - \hat{I}^R) [S(c_H) - S(\hat{c}_H)] + \left[1 - (\hat{I}^C)^2\right] \alpha \Delta q(c_H) &> \frac{1+2(\hat{I}^R - \hat{I}^C) - (\hat{I}^C)^2}{2} [S(c_L) - S(c_H)] + \\ \Delta [\chi_{\tilde{m}}(1 + \tilde{x}) - \lambda\tilde{x}] &\left\{ \left(1 + \hat{I}^{R,S}\right) q(\hat{c}_H) - \left[1 - (\hat{I}^C)^2\right] q(c_H) \right\}. \end{aligned} \quad (5)$$

In interpreting the foregoing, several observations should be pointed out. First, the set up formalizes the existence of huge transfers from the federal and state governments to IOUs, financed out of distortionary taxes and aimed to solve energy externalities—e.g., air pollution,

roadway congestion. As discussed by Metcalf (2008), the total energy-related tax expenditures for major fuel categories investments, and the production tax credits for renewable and advanced coal-based power sources reached 3.46 billion dollars in fiscal year 2008.<sup>19</sup> Second, the fact that the winning party cannot reform the market institution is consistent with the existence of a commitment period typical of regulation (see Guerriero, [2011b]). Third, the exogeneity of  $x_{\tilde{m}}$  captures the basic idea, proposed by Besley and Coate (2003), that regulation is bundled at politicians election with more salient policies. Fourth, the fact that the pro-shareholder party is more willing to subsidize investment expenses incorporates into the model politicians' strategic incentives to propose and implement extremist platforms in order to empower their own supporters (Glaeser, Ponzetto, and Shapiro, 2005) or to buy votes through campaign contributions (Alesina and Holden, 2008). Again, under assumptions A1, the expected firm's rent would be lower under competition and:

**Proposition 3:** *Under assumptions A1, A2 and A3, the probability that competition is selected falls with the reformer hold on power  $x_{\tilde{m}}$  and is greater if she is pro-consumer.*

The actual pattern originates from the mix between the asymmetry in the parties' preferences and the uncertainty of elections, and it is similar to the strategic dynamic proposed by a lively political economy tradition (Persson and Svensson, 1989; Alesina and Tabellini, 1990; Hanssen, 2004). These authors claim that a lack of permanence in office can inspire policymakers to implement reforms aimed at tying the hands of future incumbents. In proposition 3, a higher probability of being re-elected and fixing a larger (smaller) aid, without facing the danger of facing a new reform, pushes a pro-shareholder (pro-consumer)

---

<sup>19</sup>The argument still holds when the government: 1. acts as a sponsor and increases the ex post firm's rents without monetary aids if  $\chi_{Re} > 0 > \chi_{De}$ ; 2. can decrease investment costs directed toward cost reduction, provided that the dynamic efficiency concerns more than outweigh the higher rent extraction needs.

incumbent to prefer regulation in order to guarantee an even higher profit to her constituency (curbing underinvestment). Clearly enough, this strategic dynamics can produce inefficient reforms (see also Faure-Grimaud and Martimort, [2003]) and, for instance, a pro-consumer party could lean for competition despite the effective danger of dynamic inefficiencies.

In the next section, I show that the qualitative message of proposition 1, 2 and 3 continues to stand when some of the basic model's assumptions are either relaxed or changed.

### 4.3 *Robustness to Alternative Assumptions*

*A generic number of Bertrand competitors.*—The welfare under regulation remains the same and so the direct and indirect—via both  $\hat{I}^R$  and  $q\left(\hat{c}_H\left(\hat{I}^R\right)\right)$ —impact on it of both  $\alpha$  and  $\gamma$ . Thus, in order to conclude that the model's patterns remain unaffected, it is enough to check that competition produces a lower expected rent, which is the case because, as it can be easily shown, such rent strictly falls with the number of firms  $N$  for every  $N > 2$ .

*Cournot competition.*—Let me assume, for simplicity, that: 1. the information about  $c$  is complete; 2. the firm's best replies are downward sloping or  $P' + P''q(c_i, l, N - l) < 0$  with  $P(\cdot)$  representing the strictly decreasing inverse demand and  $q(c_i, l, N - l)$  the output choice of a type  $c_i$  firm when, among the  $N$  entrants,  $l$  have type  $c_L$  and  $N - l$  type  $c_H$ ; 3. the entry cost, borne between stage 1 and 2, is  $\kappa \geq 0$ . Because the demand is inelastic, marginal revenues fall with the quantity sold; yet, when  $\varepsilon_{p,q}$  is not too small, an equilibrium price strictly greater than the average marginal cost exists and, for a sufficiently low entry cost and sufficiently efficient investment technology, the firm's incentives to invest under competition are weaker than those under regulation: this preserves all the model's results.

*A positive shadow cost of public funds.*—For  $\lambda > 0$  the rule giving the type dependent price as a function of the marginal cost will be of the Ramsey type and will be implicitly defined by  $p_i = \Psi(c_i)$  with  $\Psi \equiv \varphi^{-1}$  and  $\varphi(\lambda, p_i) \equiv p_i + \lambda(1 + \lambda)^{-1} q(p_i) [q'(p_i)]^{-1} = c_i$  so that  $\partial p_i / \partial c_i > 0$ . Also, it turns out that the level of investment continues to be higher under regulation and that the effect of a change in  $\alpha$  and  $\gamma$  on the level of welfare under regulation is multiplied by  $\partial p_i / \partial c_i$ . Yet, provided that conditions slightly stricter than those imposed by assumptions A1 and A2 hold, it also follows that the model's message is unaffected.

*Regulatory commitment.*—Provided that an ex post participation constraint is imposed, the level of investment under regulation, when contractible, is still inefficient and higher than the one under competition. Besides, the rule giving price as a function of marginal cost is unaffected (see Laffont and Tirole, [1993]); as a result, proposition 1, 2 and 3 still hold.<sup>20</sup> When investment is not contractible, instead, the allocation of the high cost firm is distorted even more in order to account for the moral hazard in investment constraint. Yet, it can be shown that regulation retains its dynamic advantage and, under condition similar to those listed in assumption A1 and A2, the model's message survives.<sup>21</sup>

## 5 Empirical Implications

The basic idea of the theory is that, under reasonable conditions, while competition delivers more limited allocative distortions, regulation assures higher expected profits and,

<sup>20</sup>Without ex post participation constraint the first best is achieved with a fixed contract.

<sup>21</sup>When the planner auctions an incentive contract as in Laffont and Tirole (1993), the low cost firm interim expected rent is  $(1/2) (1 - \hat{I}^R) x^1(c_H, c_H) \Delta q(\hat{c}_H)$  where  $x^j(c^1, c^2)$  for  $j = 1, 2$  is the probability that firm  $j$  is chosen when firm 1 has type  $c^1$  and 2 type  $c^2$ . Under symmetric auctions, this rent becomes  $(1/4) (1 - \hat{I}^R) \Delta q(\hat{c}_H)$  and regulation would lose its dynamic advantage; yet, proposition 2 would survive.

consequently, produces stronger incentives to invest. As a result, competitive pressures will be more likely when regulation leaves more limited informational rents and the reformer's concerns with stimulating cost-reducing investments are weaker. This was embodied in proposition 1, 2 and 3 above and leads to the first testable prediction, which read as:

**Prediction 1:** *The likelihood of a reform toward more competitive settings will be higher when regulators are elected, and will fall with society's cost-reducing investment concerns and with the reformer hold on power. Also, it will be lower when the reformer is pro-shareholder.*

My second test is motivated by the observation that while regulation yields a better distribution of firms' types due to the stronger incentives to invest, competition induces a higher conditional—on the types distribution—probability that the firm with the lowest cost serves the market. Hence, the relation between market institutions and expected average costs is undecided. Indeed, competition will assure a lower expected average cost when

$$\left[2\frac{1-(\hat{I}^C)^2}{4} + \frac{(1+\hat{I}^C)^2}{4}\right]c_L + \frac{(1-\hat{I}^C)^2}{4}c_H < \frac{1+\hat{I}^R}{2}c_L + \frac{1-\hat{I}^R}{2}c_H \leftrightarrow \frac{1-2(\hat{I}^R-\hat{I}^C)-(\hat{I}^C)^2}{4}(c_L - c_H) < 0,$$

which could fail under the mild restrictions imposed by assumptions A1, A2 and A3. On top of this, the second prediction deals with regulatory outcomes and reads as:

**Prediction 2:** *The average cost could be either greater or lower under competition.*

Regulation will guarantee lower expected average costs when  $\hat{I}^R - \hat{I}^C$  is sufficiently big or  $\hat{I}^R > (1/2) \left[1 + 2\hat{I}^C - (\hat{I}^C)^2\right]$ . As a glance to problems (1) and (2) suggests, whether or not the last inequality is true depends on the relative sizes of the first derivatives of the functions  $q(\cdot)$  and  $\psi(\cdot)$  and on the investment concern  $\alpha$ . Yet, provided that  $\psi'$  is not too small, competition would yield lower expected costs when  $\alpha$  is sufficiently small and, thus, the investment level under regulation cannot be enough higher than the one under competition. This is very likely to be the case for the market that I use in the empirical

exercise discussed below. Indeed, two historical features of the U.S. power market are: 1. a suboptimal technological speed (see the evidence on R&D patents in Margolis and Kammen [1999])—i.e. a not too small  $\psi'$ ; 2. that “the primary concern of regulatory commissions has been to keep nominal prices from increasing” (Joskow, 1974, page 298)—i.e. a very small  $\alpha$ .

## 6 Evidence

While between 1993 and 1998 all states held hearings on possible restructuring, just under half the jurisdictions—23 states and the District of Columbia—enacted restructuring legislations between 1996 and 2000.<sup>22</sup> Yet, as widely documented by Fabrizio, Rose and Wolfram (2007), utilities often acted before final legislations altering in advance their behaviors. In order to capture at best the role of expectations and have a wide enough comparison period, I take into consideration productivity of all the large fossil-fuel steam and combined cycle gas turbine generating plants for which data were reported to the FERC between 1981 and 1999. I restrict the sample to states for which data on the quality of the information gathering technology and political competition are available—see the appendix. As a result, the dataset gathers 8,059 observations on 503 plant-epochs—i.e. years over which the plant capacity did not change more than 40 MW or the 15 percent of the capacity—operating in 43 U.S. states. I consider two dependent variables: 1. *Deregulation* which equals one for IOU plants in states that restructured beginning in the year of the first formal hearing and zero otherwise (see also Fabrizio, Rose and Wolfram, [2007]);<sup>23</sup> 2. *Der\_Ord* which equals three

---

<sup>22</sup>Between 1982 and 2002, twenty-three U.S. states adopted some forms of broadly defined incentive regulation (see Guerriero, [2011b]). Once considered, performance based regulation does not show complementarities with restructuring and its presence does not change the gist of the results discussed below.

<sup>23</sup>Should I use, instead of *Deregulation*, either the dummy *Law*, which equals one for IOU plants in states that restructured beginning in the year that legislation was enacted, or the dummy *Retail*, which equals one for

for states that restructured beginning in the year that legislation was enacted, two for states that restructured beginning in the year of the first formal hearing, one otherwise. I will use the latter to explain the choice of the power of the adopted competitive pressures and the former to compare competition and regulation; also, I will first identify the determinants of market institutions and then examine their impact on the input use and the plant efficiency.

### 6.1 *Non Random Market Institution Selection*

*The empirical strategy.*—In order to exploit the three-dimensional variation—over time and across states and power levels—of competitive pressures, I use a an ordered logit with dependent *Der\_Ord* and a logit with dependent *Deregulation* both ran on state level data.

For what concerns the ordered logit model, if  $y_{s,t}^*$  is the latent variable driving a reformer in state  $s$  at time  $t$  to choose the competitive pressure  $y_{s,t}$ , we will observe the choice  $k$  only and only if the unobserved variable  $y_{s,t}^*$  lies in between the two cut-points  $\vartheta_{k-1}$  and  $\vartheta_k$  to be estimated or  $y_{s,t} = k \Leftrightarrow \vartheta_{k-1} \leq y_{s,t}^* \leq \vartheta_k$  for  $k = 1, 2, 3$ . The related structural model is  $y_{s,t}^* = \theta' \mathbf{z}_{s,t} + \nu_{s,t}$ , where  $\mathbf{z}_{s,t}$  is the vector of market institutions determinants and  $\nu_{s,t}$  the error term with c.d.f.  $\Lambda$ , which I assume to be Logistic.<sup>24</sup> The odds ratio  $\Delta_{s,t}(y_{s,t} > k)$  of a reformer adopting, in state  $s$  at time  $t$ , a competitive pressure more powerful than  $k$  is:

$$\Delta_{s,t}(y_{s,t} > k) = P[y_{s,t} > k]/P[y_{s,t} \leq k] = [1 - \Lambda(\vartheta_k - y_{s,t}^*)] [\Lambda(\vartheta_k - y_{s,t}^*)]^{-1} \forall k. \quad (6)$$

The linear log-odds obtained taking the logarithm of both sides of (6) characterize the

---

IOU plants in states that restructured beginning in the year that retail access was introduced, the estimates will be qualitatively similar—results available from the Author.

<sup>24</sup>Inequality (5) does not exclude a role for interaction terms: when introduced in the logit, they are usually not significant for the groups whose probability of reforming is either 0 or 0.5 (Ai and Norton, 2003).

ordered logit model, which is easily estimated by maximum likelihood. I will focus on the exponentiated coefficients because for a one unit change in the control the odds that the reformer selects a competitive pressure more powerful than  $k$  versus one at most as powerful as  $k$  are the exponentiated coefficient times larger. For the logit, I will report the marginal effects which give the percentage variation in the likelihood of the *Deregulation* when the control rises by one percentage point. Next, I will introduce the proxies gathered in  $\mathbf{z}_{s,t}$ .

*Measuring investment concerns and the politicians' and regulator's incentives.*—Creating meaningful proxies for society's cost-reducing investment concerns is a challenging task. My strategy is to assume that stimulating such investments is more salient in a state where marginal costs or the inefficiency of input usages are higher than the mean level of the same variables calculated for the group of the other states in the sample or for the group of bordering states. This approach directly captures the pressure put on the reformers by a society faced with a relatively inefficient production technology.

Following Fabrizio, Rose and Wolfram (2007), the two key inputs for electricity generation variable in the medium-term, which is the horizon of the present study, are labor and fossil fuels. Hence, I use as proxy for more pressing society's cost-reducing investment concerns one of the following six variables lagged three years: 1. the average marginal labor cost in the state expressed in cents of dollar per Kwh and obtained, at the plant level, dividing the product of the number of employees and the annual wage bill by the total generation—*Mc\_Labor*; 2. the average marginal fuel cost in the state expressed in cents of dollar per Kwh and obtained, at the plant level, dividing the product of total British Thermal Units (BTUs) and the composite fossil fuels price index by the total generation—*Mc\_Fuel*; 3. the average heat rate calculated at the state level—*Heat\_Rate*; 4. the ratio of the average marginal labor

cost in a state over those of bordering states—*Ratio\_Mlc*; 5. the ratio of the average marginal fuel cost in a state over those of bordering states—*Ratio\_Mfc*; 6. the ratio of the average heat rate in a state over those of bordering states—*Ratio\_Hr*.<sup>25</sup> The heat rate gives the amount of fuel input, expressed in BTUs, necessary to produce one MWh of power and captures both inefficiencies due to inappropriate fossil fuels usage and those driven by incorrect equipments handling: in this perspective, it should be linked to both labor and fuel inputs. The choice of lagging these proxies assures an orthogonality condition when testing prediction two. Making use of different proxies, like the marginal costs calculated as in the state there was a single monopoly, will not change the message of the present section. Finally, it is worth to notice that the idea that, due to the cost-based nature of regulation, higher costs could coincide with over-investment is inaccurate in describing the post Oil-crisis period. Indeed, looking at R&D spending and patents, Margolis and Kammen (1999) conclude that the 80s and the 90s have been characterized by a significant and sustained pattern of under-investment in the US energy sector both in absolute terms and compared to similar industries.

Implicit incentives are summarized by *Reg\_Elec* which is equal to one where the PUC commissioners are elected and zero otherwise. Because this variable lacks enough within variation, its introduction prohibits the use of state fixed effects; excluding *Reg\_Elec* and switching to a fixed effects logit will leave the evidence on the other variables pretty similar.<sup>26</sup>

---

<sup>25</sup>In order to maximize the sample size 46 IOU operating data points have been inputed using the year foregoing the missing observation. This choice does not affect the qualitative idea of the evidence. The latter is also true when I control in Table 2 and 3 also for: the population, the proportion aged over 65, the one aged 5-17, the income per capita, the number of employees and the budget of the PUC, the commissioner term of office, a consumer advocate dummy, the other controls used in section 6.2, the share of generation from hydroelectric sources and the lagged residential price. The latter increases the likelihood of deregulating which squares with the observation made above that competition curbs allocative distortions (see also White, [1996]).

<sup>26</sup>Guerriero (2011a) shows that regulatory appointment rules are driven by the same battery of forces that drives deregulation. When I instrument *Reg\_Elec* with the share of bordering states electing PUC commissioners, which is an exogenous instrument as explained below, I obtain very similar estimates.

Furthermore, the results do not change very much when the errors, which are “robust” to generic heteroskedasticity and serial correlation, are instead clustered at the state level.

Turning to political competition, Hanssen (2004) proposes the share of seats held by the majority party averaged across upper and lower houses—*Majority*—as a proxy of the strength of the incumbent hold on power. Switching to other available measures—e.g. the Ranney index—will not affect the essence of the evidence. For what concerns the identity of the reformer’s constituency, even if several political scientists claim that Republicans have been nearer to the utility shareholders’ interests (see Teske, [2004]), it is also true that there are more shareholders of companies buying electricity than there are of companies selling it. With this pitfall in mind, I consider as proxy for a more pro-shareholder attitude of the reformer a binary equal to one if both houses were under the Republicans’ control—*Republican*. If, as Besley and Coate (2003) suggest, regulation is not salient for the majority of voters at politicians’ elections, the two proxies will be orthogonal to unobserved policy-driven determinants of investment concerns. Finally, scholars of policy innovation (Teske, 2004) claim that the diffusion of a new institution displays peculiar learning features: the deregulation in one state could shift support for the same reform in bordering states without affecting their market performances until the reform is implemented (Steiner, 2004). In order to capture this exogenous imitation process, I will introduce the share of bordering states for which *Deregulation* equals one. Using as reference group the one identified by the NERC or census region to which the state belongs will not change the gist of the results. While data sources are illustrated in the appendix, each variable is described in all details in Table 1.

*Empirical results.*—While the estimates of the ordered logit are reported in Table 2, those of the logit are listed in Table 3. For the most part, the results are consistent with prediction 1,

and the implied effects are large. Starting with society's investment concerns, the likelihood of deregulation (see Table 3) falls by: 1. 11.4-percentage-points as a result of a one-standard-deviation rise in the lagged average marginal fuel cost; 2. 3.3-percentage-points as a result of a one-standard-deviation rise in the lagged average heat rate; 3. 7.6-percentage-points as a consequence of a one-standard-deviation rise in the lagged ratio of the average marginal fuel cost in a state over those of bordering states; 4. 6.1-percentage-points as a consequence of a one-standard-deviation rise in the lagged ratio of the average heat rate in a state over those of bordering states. All these coefficients are significant at 1 percent. The coefficients attached to *Mc\_Labor* and *Ratio\_Mlc* are, instead, statistically insignificant: this evidence squares with the paramount relevance of fossil fuel inputs. Also, the estimated odds ratios deliver a message very similar to the just discussed estimated marginal effects (see Table 2).

Turning to the regulators' incentives, the odds that in a state electing its regulators a more powerful competitive pressure is selected are about 1.2 times those in an appointing state; yet, the coefficient is never statistically significant. More mixed, instead, is the evidence on the political competition. On one hand, a one-percentage-point increase in the reformer's hold on power implies a decrease of the likelihood of deregulation of about 7 percentage points and this coefficient is always significant at 10 percent. On the other hand, the coefficient attached to *Republican* has a sign suggesting that industrial users were more politically powerful than consumers but it is never statistically significant. This last piece of evidence deserves more attention in future research. Finally, the data confirm the idea that regulatory reforms could be produced by shocks to preferences due to the decisions of bordering markets.

All in all, it is fair to conclude that the distribution of deregulation across American states is not random but reflects efficiency-enhancing and strategic political forces. Also,

this non random assignment implies that the variation in deregulation used to explain input choices could be related to shocks shaping also the firm’s cost minimization decisions: this correlation would make OLS biased. Even more crucially, this bias could go either way. It could be positive because deregulation could correlate with low cost-reducing effort by a low investment concerned state; yet, it could also be negative because deregulation could correlate with forces increasing the efficiency of the information gathering technology and, in turn, lowering the firm’s cost-reducing investments. Which sign the bias takes is ultimately an empirical question: the following subsection provides an answer.

## 6.2 *Input Uses, Plant Efficiency and Endogenous Market Institutions*

To test prediction 2, first of all, I follow Fabrizio, Rose and Wolfram (2007) and I examine whether deregulation pushes the firm to use a better mix of inputs given their prices. The inputs I consider are the natural log of the number of employees—*Ln\_Emp*—and the natural log of the total BTUs of fuel consumption—*Ln\_Btu*—in the plants  $p$  in year  $t$ . I estimate first by OLS and then by GMM the following input N use equations:

$$\ln(N_{p,t}) = \beta_1^N \ln(Q_{p,t}^N) + \beta_2^N \ln(P_{p,t}^N) + \mathbf{j}'\mathbf{x}_{p,t}^N + \gamma_{p,t}^N + \alpha_p^N + \delta_t^N + \varepsilon_{p,t}^N$$

where  $Q_{p,t}^N$  is the annual net MWh generation for plant  $p$  in year  $t$ .<sup>27</sup>  $P_{p,t}^N$  is the price of the input  $N_{p,t}$  and it used only for *Ln\_Emp*.<sup>28</sup> In this case,  $P_{p,t}^N$  represents the BLS annual wage bill in dollars divided by total employment. The matrix  $\mathbf{x}_{p,t}^N$  gathers the determinants of deregulation which cannot be excluded by the input use equation—*Elec\_Reg*, *Republican* and

<sup>27</sup>The equations are obtained taking the logs of both sides of the binding first order conditions coming from a canonical and well behaved cost minimization problem (see for details Fabrizio, Rose and Wolfram, [2007]).

<sup>28</sup>The choice reflects the fact that, while decisions concerning labor inputs are made in advance of production, those regarding fuel inputs are made in real time; using the composite index as a price for fuel will lead to similar results. The latter is also true when I substitute the log of the non fossil fuels expenses for *Ln\_Emp*.

*Majority* (see also Guerriero, [2011b])—and a dummy for the presence of a FGD scrubber.<sup>29</sup>  $\gamma_{p,t}^N$  is the dummy *Deregulation*. Finally, while base differences in input uses are embedded in the plant fixed effects  $\alpha_p^N$ , common annual changes are measured by the time effects  $\delta_t^N$ .

Table 4 lists the OLS and GMM estimates. Columns (1) and (2) refers to the equation with dependent *Ln\_Emp*, columns (3) and (4) to those with dependent *Ln\_Btu*. While columns (1) and (3) gather the OLS estimates, columns (2) and (4) report the GMM estimates. In the GMM specification I treat as endogenous *Deregulation*, and I use a two-step procedure.<sup>30</sup> Here, the challenge is to avoid too many instruments because their count tends to explode with the number of years and too many moment conditions can fail to expunge the endogenous component of the endogenous variables, weakening also the power of the over-identification restrictions test (see Roodman, [2009]). To accomplish the task, I use as exogenous instruments *Mc\_Fuel* lagged three periods and *Der\_Nei* and I collapse each instrument set into a single column.<sup>31</sup> This strategy assures the strongest first stage. While the exogeneity of *Der\_Nei* has been motivated above, the one of the other instrument is explained as follows: because the residuals of the input use equations show first-order serial correlation, variables correlated to the dependent variable and lagged two periods or less would be not orthogonal to the error term which is lagged in the difference specification.<sup>32</sup>

---

<sup>29</sup>There may be variation within plant-epochs when “scrubbers”—fuel-gas desulfurization systems, or FGDs—are installed to reduce sulfur-dioxide emissions by some coal plants (Fabrizio, Rose and Wolfram, 2007).

<sup>30</sup>Differently from the GLS-IV estimator employed by Fabrizio, Rose and Wolfram (2007), the difference GMM estimator: 1. allows the use of a kernel-based estimator for the standard errors handling arbitrary patterns of covariance within individuals; 2. sustains a feasible two-step estimator which can be corrected in small samples (Windmeijer, 2005); 3. minimizes the loss of observations due to gaps in the panel. The latter amounts to 127 observations in Table 4. Switching to a forward orthogonal deviations GMM estimator will assure that the OLS sample size is preserved but will make the first stage much weaker and, thus, the partition of exogenous and endogenous variation essentially arbitrary.

<sup>31</sup>Should the instruments be not collapsed, the results will be comparable to those discussed below except for the fact that deregulation will have, in general, no statistically significant effect on fuel inputs.

<sup>32</sup>In this way, the instrument count is well below the number of cross sections: this assures that “too many instruments” are not considered (Roodman, 2009).

The key observations are that: 1. in accordance with the second testable prediction applied to the U.S. electricity market, competition leads to lower average marginal costs; 2. OLS tend to overestimate the cost reduction incentives brought by deregulation; 3. considering the endogeneity of market institutions brings dramatic differences in the estimates. Indeed, the implied percentage reduction in the input use rise from 6.7 to 12 percentage points in the case of labor inputs and from 2.1 to 14.2 percentage points in the case of fuel inputs.<sup>33</sup> All these coefficients are significant at ten percent or better and suggest that the bias introduced by not taking into account the endogeneity of deregulation to the strength of society’s investment concerns outweighs the one of neglecting the role played by the efficiency of the information gathering technology.<sup>34</sup> Two more features of the estimated model confirm the exogeneity of the employed instruments and, consequently, the consistency of the estimates: 1. the Hansen test, which is the consistent one with robust standard errors, does not reject the over-identifying restrictions at a level nowhere lower than 34 percent; 2. the residuals in the differenced specification do not show third order autocorrelation.<sup>35</sup>

In order to interpret the results, it is key to highlight two related pieces of evidence. First, using state level data, Guerriero (2011a) show that, during the Oil-crisis pre-reform period, the pass-through of cost shocks into prices was fiercely opposed by regulators. Second, in the same sample used in Table 4, deregulation has a statistically insignificant endogenous

---

<sup>33</sup>I use  $100 [\exp(\gamma_{p,t}^N) - 1]$  to approximate the implied percentage effect of *Deregulation* on input use.

<sup>34</sup>This evidence squares with the fact that, in the data (see Table 2 and 3), the first force is a more important determinant of market institutions. This pattern, in turn, nicely matches a key feature of the model discussed above: information has only a second order effect on market design.

<sup>35</sup>The differenced residuals tend to show first and second order autocorrelation but no fourth order one. I obtain qualitatively similar results when: 1. I consider the time-varying controls discussed in footnote 25; 2. I switch to the one-step estimator or I estimate the model in levels; 3. I include among the instruments one more lag of the endogenous variable; 4. I use as extra external instrument the state sales and treat as endogenous variable also *Ln\_Mwhs* (see Fabrizio, Rose and Wolfram, [2007]); 5. I employ as instruments the other proxies for society’s cost-reducing investment concerns discussed in section 6.1.

impact on both the heat rate—see columns (5) and (6) of Table 4, and the mark up of the residential price over the marginal labor and fuel costs—results available from the Author. All in all, two key conclusions can be drawn. First, regulation was retained whenever the needs of accommodating dynamic efficiency concerns after an era of rising input costs and excessively pro-consumer attitudes by regulators were sufficiently pressing. Second, even if competition seems to make possible that the firm with the most efficient technology serves the market for a given cost distribution, such distribution does not become more favorable in the medium run. More than that, the perverse mix of tougher incentives to undercut a competitor and the softer incentives to reduce costs could deteriorate the firms' profitability to the point of inducing heavy dynamic inefficiencies. This last remark makes a long way in clarifying the slowdown of the deregulation wave that has interested the U.S. electricity markets in the years following the end of the sample used in my analysis (EIA, 2003).<sup>36</sup>

## 7 Concluding Comments

The relevance of regulatory institutions to economic development is key especially in a period of deregulation and liberalization. Yet, the determinants of these settings are still poorly understood: here, I developed and tested a property rights—on sunk investments—theory of “endogenous market institutions” (see also Guerriero [2011a, b]), focusing on the choice between competition and regulation when the demand is inelastic.

I close by highlighting several avenues for further research. The first one is to gain more

---

<sup>36</sup>Indeed, estimates available from the Author reveal that the likelihood that in 2003 a state was delaying its restructuring decisions significantly increases by 8 percentage points as a result of a one-standard-deviation rise in the ratio of its average heat rate in 1999 over its average heat rate in 1993.

insights on the single elements of liberalization: reimbursement of stranded costs, regional planning, rate and functional unbundling, creation of independent system operators and setting up of transition mechanisms (EIA, 2003). Second, a key issue is to assess the effect of deregulation on service quality. Indeed, even if a lively literature (see Ajodhia and Hakvoort, [2005]) has provided evidence according to which competitive pressures might induce firms to reduce quality in order to minimize costs, regulatory reforms have been always considered as exogenous. Third, an important extension to the model is to endogenize the probability of re-election after a reform. Even if it is hard to envision elections in which regulation is salient for voters, there are examples of political failures originated by reckless regulatory reforms: the defeat of the governor Gray Davis in the aftermath of the post-deregulation crisis in California is a case in point. Finally, an extremely topical issue is to look at the determinants and economic consequences of the competitive pressures enhanced in other markets like the commercial banking ones (see Benmelech and Moskowitz, [2010]).

# Appendix

## *Underinvestment: Regulation Versus Competition*

The socially optimal investment level  $I^*$  solves the following strictly concave problem

$$\hat{I}^* = \arg \max_{I \geq 0} (1/2) [(1 + I) S(c_L) + (1 - I) S(c_H)] - \psi(I). \quad (\text{A1})$$

whose unique interior solution is implicitly defined by  $\psi'(I^*) = (1/2) [S(c_L) - S(c_H)]$ . Clearly enough  $I^* < 1$  because  $\lim_{I \rightarrow 1} 2\psi'(I) \geq S(c_L) - S(c_H)$ . The unique and interior solutions to

problem (1) and (2) are implicitly defined respectively by  $\psi'(\hat{I}^R) = (\Delta/2) q(\hat{c}_H)$  and  $\psi'(\hat{I}^C) = (1 - \hat{I}^C) (\Delta/4) q(c_H)$ . Being  $(1/2) [S(c_L) - S(c_H)] > \max \left\{ (\Delta/2) q(\hat{c}_H), (1 - \hat{I}^C) (\Delta/4) q(c_H) \right\}$ ,

both institutions lead to underinvestment. Also,  $I^R > I^C$  whenever  $2q(\hat{c}_H) > q(c_H)$ , which is true

under assumption A1 because, with inelastic demand, a fall in price from  $\hat{c}_H$  to  $c_H$  implies that:

$$\left| \frac{q(\hat{c}_H) - q(c_H)}{(1 + \hat{I}^R)(1 - \hat{I}^R)^{-1}(1 - \alpha)\Delta} \frac{c_H + (1 + \hat{I}^R)(1 - \hat{I}^R)^{-1}(1 - \alpha)\Delta}{q(\hat{c}_H)} \right| < 1 \leftrightarrow q(\hat{c}_H) \frac{c_H + 2(1 + \hat{I}^R)(1 - \hat{I}^R)^{-1}(1 - \alpha)\Delta}{c_H + (1 + \hat{I}^R)(1 - \hat{I}^R)^{-1}(1 - \alpha)\Delta} > q(c_H).$$

A fortiori it must be the case that  $2q(\hat{c}_H) > q(c_H)$ . Clearly the argument remains true for all  $p > \hat{c}_H$

and consequently also when  $\hat{c}_H$  becomes so high to be equal to  $\bar{p}$ .  $\square$

### *Inequality (3) in Details*

In order to obtain the inequality in (3) notice that  $W^C - W^R$  can be written as  $\frac{\hat{I}^R - 2\hat{I}^C - (\hat{I}^C)^2}{4} S(c_L) + \frac{1 + \hat{I}^R}{4} [S(c_L) - S(c_H)] < \frac{1 - \hat{I}^R}{2} [S(c_H) - S(\hat{c}_H)] + \frac{\hat{I}^R - 2\hat{I}^C - (\hat{I}^C)^2}{4} S(c_H) + \frac{1 - (\hat{I}^C)^2}{2} \alpha \Delta q(c_H)$ .  $\square$

### *Proof of Proposition 1*

The impact of  $\alpha$  on the probability of choosing competition has the sign of  $\partial(W^C - W^R)/\partial\alpha =$

$$-2 \frac{\partial \hat{I}^R}{\partial \alpha} \left[ S(c_L) - S(\hat{c}_H) - 2 \frac{1 - \alpha}{1 - \hat{I}^R} \Delta q(\hat{c}_H) \right] + 2 \left[ 1 - (\hat{I}^C)^2 \right] \Delta q(c_H) - 2 \left( 1 - \hat{I}^R \right) \frac{1 + \hat{I}^R}{1 - \hat{I}^R} \Delta q(\hat{c}_H).$$

By totally differentiating the first order condition to problem (1) I obtain that:

$$\left[ \frac{2(1 - \alpha)\Delta^2 q'(\hat{c}_H)}{2(1 - \hat{I}^R)^2} - \psi''(\hat{I}^R) \right] d\hat{I}^R - \frac{(1 + \hat{I}^R)\Delta^2 q'(\hat{c}_H)}{2(1 - \hat{I}^R)} d\alpha = 0 \rightarrow \frac{\partial \hat{I}^R}{\partial \alpha} > 0.$$

After noticing that  $S(c_L) - S(\hat{c}_H) - 2 \frac{1 - \alpha}{1 - \hat{I}^R} \Delta q(\hat{c}_H) > \alpha \Delta q(\hat{c}_H)$ , it is clear that a sufficient condi-

tion to have  $\partial(W^C - W^R)/\partial\alpha < 0$  is that  $\left[1 - (\hat{I}^C)^2\right] q(c_H) < (1 + \hat{I}^R) q(\hat{c}_H)$  which is true if  $2(\hat{I}^C)^2 + \hat{I}^R - 1 > 0$ —where I used the above-shown fact that  $2q(\hat{c}_H) > q(c_H)$ —and *a fortiori* if  $2(\hat{I}^C)^2 + \hat{I}^C - 1 > 0$ . Under assumption A2,  $\hat{I}^C > 1/2$  and thus  $2(\hat{I}^C)^2 + \hat{I}^C - 1 > 0$ .  $\square$

### *Proof of Proposition 2*

The unique solution to problem (4) is defined by  $\psi'(\hat{I}^{R,S}) = (1 - \gamma)(\Delta/2)q(\hat{c}_H^S)$  so that:

$$\left[ \frac{(1-\gamma)^2(1-\alpha)\Delta^2 q'(\hat{c}_H^S)}{(1-\hat{I}^{R,S})^2} - \psi''(\hat{I}^{R,S}) \right] d\hat{I}^{R,S} + \left[ -\frac{\Delta q(\hat{c}_H^S)}{2} - \frac{(1+\hat{I}^{R,S})(1-\gamma)(1-\alpha)\Delta^2 q'(\hat{c}_H^S)}{2(1-\hat{I}^{R,S})} \right] d\gamma = 0,$$

which implies  $\frac{\partial \hat{I}^i}{\partial \gamma} < 0$  because the expression in the second square bracket is negative being

$$-\frac{q'(\hat{c}_H^S)(1+\hat{I}^{R,S})(1-\hat{I}^{R,S})^{-1}(1-\gamma)(1-\alpha)\Delta}{q(\hat{c}_H^S)} < -\frac{q'(\hat{c}_H^S)\hat{c}_H^S}{q(\hat{c}_H^S)} < 1$$

under assumption A1. The probability of competition being chosen increases with  $\gamma$  whenever

$$\frac{\partial(W^C - W^R, S)}{\partial \gamma} = -2 \frac{\partial \hat{I}^{R,S}}{\partial \gamma} \left[ S(c_L) - S(\hat{c}_H^S) - 2 \frac{1-\alpha}{1-\hat{I}^R} (1-\gamma) \Delta q(\hat{c}_H) \right] - 2(1 + \hat{I}^{R,S})(1-\alpha) \Delta q(\hat{c}_H^S)$$

is positive. The latter is indeed the case whenever  $2(1 + \hat{I}^{R,S})(1-\alpha) \Delta q(\hat{c}_H^S) <$

$$\frac{\Delta q(\hat{c}_H^S) + (1+\hat{I}^{R,S})(1-\hat{I}^{R,S})^{-1}(1-\gamma)(1-\alpha)\Delta^2 q'(\hat{c}_H^S)}{\psi''(\hat{I}^{R,S}) - (1-\hat{I}^{R,S})^{-2}(1-\gamma)^2(1-\alpha)\Delta^2 q'(\hat{c}_H^S)} (\alpha + \gamma - \alpha\gamma) \Delta q(\hat{c}_H^S) \leftrightarrow$$

$$-\frac{(1+\hat{I}^{R,S})(1-\gamma)(1-\alpha)\Delta^2 \left[ 2(1-\gamma)(1-\alpha) + (1-\hat{I}^{R,S})(\alpha + \gamma - \alpha\gamma) \right] q'(\hat{c}_H^S)}{1-\hat{I}^{R,S}} <$$

$$(1-\hat{I}^{R,S})(\alpha + \gamma - \alpha\gamma) \Delta q(\hat{c}_H^S) - 2 \left[ 1 - (\hat{I}^{R,S})^2 \right] (1-\alpha) \psi''(\hat{I}^{R,S}) \leftrightarrow$$

$$\varepsilon_{p,q} = -\frac{q'(\hat{c}_H^S)\hat{c}_H^S}{q(\hat{c}_H^S)} < \bar{\varepsilon}_{p,q} \equiv \frac{\hat{c}_H^S(1-\hat{I}^{R,S})(\alpha+\gamma-\alpha\gamma)\Delta - 2\hat{c}_H^S \left[ 1 - (\hat{I}^{R,S})^2 \right] (1-\alpha) \psi''(\hat{I}^{R,S}) [q(\hat{c}_H^S)]^{-1}}{\frac{1+\hat{I}^{R,S}}{1-\hat{I}^{R,S}}(1-\gamma)(1-\alpha)\Delta^2 [2(1-\gamma)(1-\alpha) + (1-\hat{I}^{R,S})(\alpha+\gamma-\alpha\gamma)]}. \quad \square$$

### *Proof of Proposition 3*

The probability of adopting competition falls with  $\left\{ (1 + \hat{I}^{R,S}) q(\hat{c}_H) - \left[ 1 - (\hat{I}^C)^2 \right] q(c_H) \right\}$  which

is positive as seen in the proof of proposition 1; hence, it will decrease with both  $\chi_{\tilde{m}}$  and  $\tilde{x}(\chi_{\tilde{m}} - \lambda)$

and party *Re* will choose competition less often. The following derivatives conclude the proof:

$$\frac{\partial \tilde{x}(\chi_{Re} - \lambda)}{\partial x_{Re}} = (\chi_{Re} - \lambda)(\rho_{Re} - \rho_{De}) > 0; \quad \frac{\partial \tilde{x}(\chi_{De} - \lambda)}{\partial x_{De}} = (\chi_{De} - \lambda)(\rho_{De} - \rho_{Re}) > 0. \quad \square$$

### *Sample Construction*

This study analyzes productivity for large fossil-fueled steam turbine or combined cycle plants owned by IOUs only. The core data source is the Utility Data Institute (UDI) O&M Production Cost Database, which is based on the FERC Form 1 filings. Following Fabrizio, Rose and Wolfram

(2007), I have eliminated the plants with mean capacity in gross megawatts below 100 MW or with three years of operations at a scale not greater than 100 MW, the plants with missing or nonpositive output data and the outliers spotted using the Stata's *dfbeta* regression diagnostic. Moreover, I did not consider the plants for which data on regulatory institutions and political competition were not available: thus, there are no observations for Alaska, the District of Columbia, Nebraska, Rhode Island, Tennessee and Vermont. Also, there are no IOUs serving Hawaii and Idaho in the UDI Database. As a result, after imputing 46 data points using the year foregoing the missing observation, I obtain a dataset with 8,059 observations on 503 plant-epochs—i.e., years over which the plant capacity did not change more than 40 MW or the 15 percent of the capacity—operating in 43 U.S. states. Aggregating the plant-epochs data at the state level produces the strongly balanced panel of 817 observations—i.e., 19 yearly data points for 43 states—used to obtain Table 2 and 3.

#### *Data Sources*

*Deregulation.*—Data on restructuring come from: 1. EIA (2003); 2. EIA. 2000. “The Changing Structure of the Electric Power Industry: 2000 An Update.” EIA; 3. EIA. 2002. “Status of State Electric Industry Restructuring Activity.” EIA; 4. Edison Electric Institute. 2001. “Electric Competition in the States.” EEI; 5. National Association of Regulatory Utility Commissioners (NARUC). 1995 and 1996. “Utility Regulatory Policy in the United States and Canada, Compilation.” NARUC; 6. Council of State Governments (CGS). 1999. “Restructuring the Electricity Industry.” CSG; 7. State Public Utility Commission websites, relevant legislation, and reports.

*IOU operating data.*—The number of employees, the total annual BTUs of fuel consumption and net MWh generation are collected from the UDI O&M Production Cost Database.

*Wages.*—US Department of Labor, BLS. Electric Utility Wages: SIC Industries 4911.

*composite fossil fuels price index.*—Data on prices of fossil fuels reported in kilowatt hours come from the Energy Information Administration, Annual Energy Review, 1999, Table 3.1 and are de-

noted in dollars per BTUs.

*Appointment rules.*—NARUC (1981-1999).

*Political competition.*—CSG. 1981-1999. *The Book of the States*. CSG.

## References

Aghion, Philippe, Nick Bloom, Richard Blundell and Rachel Griffith. 2005. “Competition and Innovation: an Inverted-U Relationship.” *Quarterly Journal of Economics*, 120: 701-728.

Aghion, Philippe, Yann Algan, Pierre Cahuc, and Andrei Shleifer. 2010. “Regulation and Distrust.” *Quarterly Journal of Economics*, 125: 1015-1049.

Ai, Chunrong, and Edward C. Norton. 2003. “Interaction Terms in Logit and Probit Models.” *Economics Letters*, 80: 123-129.

Alesina, Alberto, and Guido Tabellini. 1990. “A Positive Theory of Fiscal Deficits and Government Debt.” *Review of Economic Studies*, 57: 403-414.

Alesina, Alberto, Silvia Ardagna, Giuseppe Nicoletti, and Fabio Schiantarelli. 2005. “Regulation and Investment.” *Journal of the European Economic Association*, 3: 791-825.

Alesina, Alberto, and Guido Tabellini. 2007. “Bureaucrats or Politicians? Part I: A Single Policy Task.” *American Economic Review*, 97: 169-179.

Alesina, Alberto, and Richard Holden. 2008. “Extremism and Ambiguities in Two-Candidate Elections.” NBER working paper no. 14143.

Armstrong, Mark, and David E. M. Sappington. 2006. “Regulation, Competition, and Liberalization.” *Journal of Economics Literature*, 44: 325-366.

Armstrong, Mark, and David E. M. Sappington. 2007. “Recent Developments in the Theory of Regulation.” in *Handbook of Industrial Organization*, Vol. III. Mark Armstrong and Robert Porter, eds. Amsterdam: North-Holland.

Ajodhia, Virendra, and Rudi Hakvoort. 2005. “Economic Regulation of Quality in Electricity Distribution Networks.” *Utilities Policy*, 13: 211-221.

Baggs, Jen, and Jean-Etienne de Bettignies. 2007. “Product Market Competition and Agency Costs.” *Journal of Industrial Economics*, 55: 289-323.

Baumol, William J., and Alvin K. Klevorick. 1970. “Input Choices and Rate-of-Return Regulation: An overview of the Discussion.” *Bell Journal of Economics*, 1: 289-323.

Belloc, Filippo, and Antonio Nicita. 2010. "Privatization-Liberalization Paths. Does Government Ideology Matter?" Unpublished.

Benmelech, Efraim and Tobias J. Moskowitz. 2010. "The Political Economy of Financial Regulation: Evidence from U.S. State Usury Laws in the 19th Century." *Journal of Finance*, 65: 1029-1073.

Besley, Timothy, and Stephen Coate. 2003. "Elected versus Appointed Regulators: Theory and Evidence." *Journal of the European Economic Association*, 1: 1176-1206.

Boyer, Marcel, and Jean-Jacques Laffont. 2003. "Competition and the Reform of Incentive Schemes in the Regulated Sector." *Journal of Public Economics*, 87: 1353-1381.

Bushnell, James B., and Catherine Wolfram. 2005. "Ownership Change, Incentives and Plant Efficiency: The Divestiture of U.S. Generation Plants." University of California Energy Institute, Working Paper, 140.

Bushnell, James B., Erin T. Mansur, and Celeste Saravia. 2008. "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured US Electricity Markets." *American Economic Review*, 98: 237-266.

Craig, J. D. and Scott J. Savage. 2010. "Market Restructuring and Productive Efficiency: Plant-level Evidence from U.S. electricity Generation." Unpublished.

Duso, Tomaso, and Lars-Hendrik Röller. 2003. "Endogenous Deregulation: Evidence from OECD Countries." *Economic Letters*, 81: 67-71.

EIA. 2003. "Status of State Electric Industry Restructuring Activity – as of February 2003." EIA: Washington, DC.

Espey, James A., and Molly Espey. 2004. "Turning on the Lights: A Meta-analysis of Residential Electricity Demand Elasticities." *Journal of Agricultural and Applied Economics*, 36: 65-81.

Fabrizio, Kira, Nancy Rose, and Catherine Wolfram. 2007. "Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency." *American Economic Review*, 97: 1250-1277.

Faure-Grimaud, Antoine, and David Martimort. 2003. "Regulatory Inertia." *Rand Journal of Economics*, 34: 413-437.

Fremeth, Adam, and Guy L. F. Holburn. 2010. "Information Asymmetries and Regulatory Decision Costs: Evidence from Electric Utility Rate Reviews 1980-2000." forthcoming, *Journal of Law, Economics, and Organization*.

Friedman, Lee S. 1991. "Energy Utility Pricing and Customer Response." In *Regulatory Choices: A Perspective on Developments in Energy Policy*, ed. Gilber, Richard J. University of California Press: Berkeley, U.S.A.

- Glaeser, Edward L., and Andrei Shleifer. 2003. "The Rise of the Regulatory State." *Journal of Economic Literature*, 41: 401-425.
- Glaeser, Edward L., Giacomo A. M. Ponzetto, and Jesse M. Shapiro. 2005. "Strategic Extremism: Why Republicans and Democrats Divide on Religious Values?" *Quarterly Journal of Economics*, 120: 1283-1330.
- Gormley, William T. 1983. *The Politics of Public Utility Regulation*. University of Pittsburgh Press: Pittsburgh, PA.
- Guerriero, Carmine. 2011a. "Accountability in Government and Regulatory Policies: Theory and Evidence." Forthcoming, *Journal of Comparative Economics*.
- Guerriero, Carmine. 2011b. "The Political Economy of Incentive Regulation: Theory and Evidence from the U.S. States." Unpublished.
- Hanssen, Andrew F. 2004. "Is There a Politically Optimal Level of Judicial Independence?" *American Economic Review*, 94: 712-729.
- Joskow, Paul. 1974. "Inflation and Environmental Concern: Structural Change in the Process of Public Utility Regulation." *Journal of Law and Economics*, 17: 291-327.
- Joskow, Paul, and Richard Schmalensee. 1986. "Incentive Regulation for Electric Utilities." *Yale Journal of Regulation*, 4: 1-49.
- Joskow, Paul. 2008. "Lessons Learned From Electricity Market Liberalization." *Energy Journal*, 29: 9-42.
- Knittel, Christopher R. 2006. "The Adoption of State Electricity Regulation: the Role of Interest Groups." *Journal of Industrial Economics*, 54: 201-222.
- Laffont, Jean-Jacques, and Jean Tirole. 1993. *A Theory of Incentives in Procurement and Regulation*. MIT Press: Cambridge MA.
- Leaver, Clare. 2009. "Bureaucratic Minimal Squawk Behavior: Theory and Evidence from Regulatory Policy." *American Economic Review*, 99: 572-607.
- Margolis, Robert M., and Daniel M. Kammen. 1999. "Evidence of Under-investment in Energy R&D in the United States and the Impact of Federal Policy." *Energy Policy*, 27: 575-584.
- Metcalf, Gilbert E. 2008. "Using Tax Expenditures to Achieve Energy Policy Goals." *American Economic Review*, 98: 90-94.
- Myerson, Roger B. 1979. "Incentive Compatibility and the Bargaining Problem." *Econometrica*, 47: 61-73.
- NARUC. 1981-1999. *Yearbook of Regulatory Agencies*. NARUC Press: Washington, DC.

- Parker, David, Colin Kirkpatrick, and Yin-Fang Zhang. 2008. "Electricity Sector Reform in Developing Countries: an Econometric Assessment of the Effects of Privatization, Competition and Regulation." *Journal of Regulatory Economics*, 33: 159-178.
- Persson, Torsten, and Lars E. O. Svensson. 1989. "Why a Stubborn Conservative Would Run a Deficit: Policy with Time-Inconsistent Preferences." *Quarterly Journal of Economics*, 104: 325-345.
- Pinotti, Paolo. 2010. "Trust, Regulations and Market Failures." Unpublished.
- Potrafke, Niklas. 2010. "Does Government Ideology Influence Deregulation of Product Markets? Empirical Evidence from OECD Countries." *Public Choice*, 143: 135-155.
- Raith, Michael. 2003. "Competition, Risk, and Managerial Incentives." *American Economic Review*, 93: 1425-1436.
- Roodman, David M. 2009. "How to do Xtabond2: an Introduction to "Difference" and "System" GMM in Stata." *Stata Journal*, 9: 86-136.
- Sappington, David E. M. 1986. "Commitment to Regulatory Bureaucracy." *Information Economics and Policy*, 2: 243-258.
- Shumilkina, Evgenia. 2009. "Industry Restructuring, Regulatory Reform, and the Quality of Service in U.S. Electric Markets: An Interim Assessment." Unpublished.
- Steiner, Faye. 2004. "The Market Response to Restructuring: a Behavioural Model." *Journal of Regulatory Economics*, 25: 59-80.
- Stigler, George. 1971. "The Theory of Economic Regulation." *Bell Journal of Economics*, 2: 3-21.
- Stiglitz, Joseph. 1989. *Wither Socialism?* Cambridge and London: MIT Press.
- Teske, Paul. 2004. *Regulation in the States*. Brookings Institution: Washington, DC.
- Vives, Xavier. 2008. "Innovation and Competitive Pressure." *Journal of Industrial Economics*, 56: 419-469.
- White, Matthew W. 1996. "Power Struggles: Explaining Deregulatory Reforms in Electricity Markets." *Brooking Papers on Economic Activity, Microeconomics*, 67: 201-267.
- Windmeijer, Frank. 2005. "A Finite Sample Correction for the Variance of Linear Efficient Two-step GMM Estimators." *Journal of Econometrics*, 126: 25-51.
- Zhang, Yin Fang. 2007. "Does Electricity Restructuring Work? Evidence from the U.S. Nuclear Energy Industry." *Journal of Industrial Economics*, 55: 397-418.

# Tables

Table 1: Variables Names and Descriptions

|   | Variables Name        | Variable Description   | Mean (Standard deviation) |
|---|-----------------------|--|---------------------------|
| Market institutions:                                  | <i>Deregulation</i> : | 1 for states that restructured or for IOU plants in states that restructured, beginning in the year of the first formal hearing; 0 otherwise.  | 0.137 (0.344)             |
|   | <i>Law</i> :          | 1 for states that restructured or for IOU plants in states that restructured, beginning in the year in which legislation was enacted; 0 otherwise.   | 0.055 (0.228)             |
|   | <i>Der_Ord</i> :      | Indicator equal to: 3 when both <i>Deregulation</i> and <i>Law</i> are equal to 1; 2 when only <i>Deregulation</i> equals 1; 1 otherwise.  | 1.192 (0.515)             |
| Marginal costs, inefficiency measures and input uses: | <i>Mc_Labor</i> :     | Average marginal labor cost in cents of dollar per Kwh calculated at the state level. At the plant level, it is obtained dividing the product of the number of employees and their annual wage bill by the total generation.   | 0.570 (1.688)             |
|   | <i>Mc_Fuel</i> :      | Average marginal fuel cost in cents of dollar per Kwh calculated at the state level. At the plant level, it is obtained dividing the product of total BTUs and the composite fossil fuels price index by the total generation. | 1.889 (1.407)             |
|   | <i>Heat_Rate</i> :    | Average heat rate calculated at the state level. At the plant level, the heat rate measures the BTUs necessary to produce 1 MWh of power.  | 9.523 (2.550)             |
|   | <i>Ratio_Mlc</i> :    | Ratio of the average marginal labor cost in a state over those of bordering states.  | 1.530 (4.640)             |
|   | <i>Ratio_Mfc</i> :    | Ratio of the average marginal fuel cost in a state over those of bordering states.   | 1.051 (0.722)             |
|   | <i>Ratio_Hr</i> :     | Ratio of the average heat rate in a state over those of bordering states.  | 1.037 (0.476)             |
|   | <i>Ln_Emp</i> :       | ln (annual average number of employees).   | 4.745 (0.804)             |
|   | <i>Ln_Btu</i> :       | ln (total BTUs of fuel consumption). Total BTUs are calculated as: (tons of coal*2000 lbs/ton*BTU/lb) + (barrels of oil*42 gal/barrel*BTU/gal) + (Mcf gas*1000 cf/mcf*BTU/cf).   | 30.577 (1.282)            |
|   | <i>Ln_Hr</i> :        | ln (heat rate in BTUs per MW).   | 2.388 (0.223)             |
| Supervision technology:                               | <i>Elec_Reg</i> :     | 1 for states or for IOU plants in a state where the public utility commissioners are elected; 0 otherwise.   | 0.215 (0.411)             |
| Political competition:                                | <i>Republican</i> :   | 1 for states or for IOU plants in a state where both houses are controlled with the relative majority of seats by the Republican party; 0 otherwise.   | 0.258 (0.438)             |
|   | <i>Majority</i> :     | Share of seats held by the majority party averaged across both houses. The variable equals 0 when no party holds the relative majority in both houses.   | 0.542 (0.283)             |
| Other controls:                                       | <i>Ln_Mwhs</i> :      | ln (annual net MWh generation).  | 14.374 (1.369)            |
|   | <i>Ln_Wage</i> :      | ln (Bureau of Labor Statistics annual wage bill in dollars divided by total employment calculated at the state-year level for IOU plants).   | 10.576 (0.277)            |
|   | <i>Scrubber</i> :     | 1 for IOU plants having a FGD scrubber; 0 otherwise.   | 0.096 (0.295)             |
|   | <i>Der_Nei</i> :      | Share of bordering states for which <i>Deregulation</i> equals 1.  | 0.141 (0.278)             |

Note : 1. All the statistics are computed for the full sample 1981-1999 and across states except in the cases of *Ln\_Emp*, *Ln\_Btu*, *Ln\_Hr*, *Ln\_Mwhs*, *Ln\_Wage* and *Scrubber*, which are computed across plants.

Table 2: Determinants of Deregulation — Ordered Logit

|  | (1)  | (2)                    | (3)                     | (4)                  | (5)                     | (6)                     |
|--|--|------------------------|-------------------------|----------------------|-------------------------|-------------------------|
| The dependent variable is <i>Der_Ord</i> |  |                        |                         |                      |                         |                         |
| <i>Mc_Labor</i> (-3)                     | 0.881<br>(0.200)   |                        |                         |                      |                         |                         |
| <i>Mc_Fuel</i> (-3)                      |  | 0.256<br>(0.078)***    |                         |                      |                         |                         |
| <i>Heat_Rate</i> (-3)                    |  |                        | 0.931<br>(0.052)        |                      |                         |                         |
| <i>Ratio_Mlc</i> (-3)                    |  |                        |                         | 0.931<br>(0.083)     |                         |                         |
| <i>Ratio_Mfc</i> (-3)                    |  |                        |                         |                      | 0.338<br>(0.174)**      |                         |
| <i>Ratio_Hr</i> (-3)                     |  |                        |                         |                      |                         | 0.702<br>(0.320)        |
| <i>Elec_Reg</i>                          | 1.324<br>(0.496)   | 1.155<br>(0.445)       | 1.362<br>(0.505)        | 1.317<br>(0.489)     | 1.300<br>(0.482)        | 1.360<br>(0.503)        |
| <i>Republican</i>                        | 1.313<br>(0.407)   | 1.201<br>(0.378)       | 1.282<br>(0.404)        | 1.307<br>(0.402)     | 1.255<br>(0.396)        | 1.275<br>(0.399)        |
| <i>Majority</i>                          | 0.461<br>(0.212)*  | 0.538<br>(0.240)       | 0.466<br>(0.207)*       | 0.476<br>(0.224)     | 0.450<br>(0.198)*       | 0.441<br>(0.198)*       |
| <i>Der_Nei</i>                           | 322.495<br>(146.318)***  | 201.726<br>(91.439)*** | 300.483<br>(134.476)*** | 322.2<br>(146.14)*** | 340.210<br>(155.599)*** | 311.076<br>(136.760)*** |
| Pseudo $R^2$                             | 0.37   | 0.39                   | 0.38                    | 0.37                 | 0.38                    | 0.37                    |
| Log Pseudo-likelihood                    | - 238.44   | - 231.02               | - 237.73                | - 238.24             | - 236.38                | - 238.38                |
| Number of Observations                   | 688  | 688                    | 688                     | 688                  | 688                     | 688                     |
| Notes:                                   | <ol style="list-style-type: none"> <li>1. The unit of observation is state per year;</li> <li>2. The entries are odds ratios;</li> <li>3. In parentheses are reported the robust standard errors;</li> <li>4. *** denotes significant at the 1% confidence level; **, 5%; *, 10%.</li> </ol> |                        |                         |                      |                         |                         |

Table 3: Determinants of Deregulation — Logit

|   | (1)   | (2)                   | (3)                   | (4)                  | (5)                   | (6)                   |
|---|---|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|
| The dependent variable is the likelihood of <i>Deregulation</i> |   |                       |                       |                      |                       |                       |
| <i>Elec_Reg</i>   | 0.015<br>(0.028)  | - 0.001<br>(0.017)    | 0.011<br>(0.026)      | 0.015<br>(0.027)     | 0.009<br>(0.024)      | 0.008<br>(0.023)      |
| <i>Mc_Labor</i> (-3)  | - 0.007<br>(0.016)  |                       |                       |                      |                       |                       |
| <i>Mc_Fuel</i> (-3)   |   | - 0.082<br>(0.013)*** |                       |                      |                       |                       |
| <i>Heat_Rate</i> (-3)   |   |                       | - 0.013<br>(0.004)*** |                      |                       |                       |
| <i>Ratio_Mlc</i> (-3)   |   |                       |                       | - 0.004<br>(0.007)   |                       |                       |
| <i>Ratio_Mfc</i> (-3)   |   |                       |                       |                      | - 0.105<br>(0.034)*** |                       |
| <i>Ratio_Hr</i> (-3)  |   |                       |                       |                      |                       | - 0.130<br>(0.031)*** |
| <i>Republican</i>   | 0.035<br>(0.029)  | 0.018<br>(0.020)      | 0.030<br>(0.028)      | 0.034<br>(0.029)     | 0.027<br>(0.027)      | 0.024<br>(0.025)      |
| <i>Majority</i>   | - 0.077<br>(0.037)**  | - 0.038<br>(0.027)    | - 0.065<br>(0.037)*   | - 0.075<br>(0.038)** | - 0.069<br>(0.035)**  | - 0.066<br>(0.033)**  |
| <i>Der_Nei</i>  | 0.414<br>(0.051)***   | 0.256<br>(0.047)***   | 0.401<br>(0.052)***   | 0.411<br>(0.052)***  | 0.392<br>(0.051)***   | 0.372<br>(0.053)***   |
| Pseudo $R^2$  | 0.45  | 0.48                  | 0.46                  | 0.45                 | 0.46                  | 0.47                  |
| Log Pseudo-likelihood   | - 169.29  | - 159.60              | - 165.56              | - 169.18             | - 165.58              | - 163.42              |
| Number of Observations  | 688   | 688                   | 688                   | 688                  | 688                   | 688                   |
| Notes:  | <ol style="list-style-type: none"> <li>1. The unit of observation is state per year;</li> <li>2. The entries are marginal effects;</li> <li>3. In parentheses are reported the robust standard errors;</li> <li>4. *** denotes significant at the 1% confidence level; **, 5%; *, 10%.</li> </ol> |                       |                       |                      |                       |                       |

Table 4: Input Uses and Plant Efficiency – OLS Versus Two-Step Difference GMM

|                                     | (1)                        | (2)                   | (3)                   | (4)                 | (5)               | (6)                |
|-------------------------------------|----------------------------|-----------------------|-----------------------|---------------------|-------------------|--------------------|
|                                     | The dependent variable is: |                       |                       |                     |                   |                    |
|                                     | <i>Ln_Emp</i>              | <i>Ln_Emp</i>         | <i>Ln_Btu</i>         | <i>Ln_Btu</i>       | <i>Ln_Hr</i>      | <i>Ln_Hr</i>       |
| <i>Deregulation</i>                 | - 0.069<br>(0.010)***      | - 0.127<br>(0.032)*** | - 0.021<br>(0.007)*** | - 0.153<br>(0.081)* | 0.005<br>(0.008)  | - 0.122<br>(0.080) |
| <i>Elec_Reg</i>                     | 0.139<br>(0.030)***        | - 0.001<br>(0.004)    | 0.012<br>(0.019)      | - 0.005<br>(0.006)  | 0.012<br>(0.019)  | - 0.003<br>(0.007) |
| <i>Republican</i>                   | - 0.046<br>(0.012)***      | - 0.0004<br>(0.004)   | 0.004<br>(0.008)      | 0.005<br>(0.007)    | 0.001<br>(0.008)  | 0.003<br>(0.007)   |
| <i>Majority</i>                     | 0.031<br>(0.014)**         | - 0.007<br>(0.008)    | 0.001<br>(0.014)      | 0.009<br>(0.014)    | 0.023<br>(0.013)* | 0.014<br>(0.015)   |
| <i>Wage</i>                         | - 0.122<br>(0.106)         | - 0.061<br>(0.048)    |                       |                     |                   |                    |
| <i>Ln_Mwhs</i>                      | 0.121<br>(0.008)***        | 0.024<br>(0.007)***   | 0.883<br>(0.009)***   | 0.850<br>(0.021)*** |                   |                    |
| Estimation Procedure                | OLS                        | Two-Step Dif. GMM     | OLS                   | Two-Step Dif. GMM   | OLS               | Two-Step Dif. GMM  |
| Instrument count                    |                            | 25                    |                       | 24                  |                   | 23                 |
| Hansen Test of over-identification  |                            | 0.51                  |                       | 0.34                |                   | 0.25               |
| Test for AR(3) in first differences |                            | 0.36                  |                       | 0.10                |                   | 0.25               |
| Number of observations              | 8059                       | 7429                  | 8059                  | 7429                | 8059              | 7429               |

Notes: 1. The unit of observation is plant per year;  
2. All specifications consider also *Scrubber* and fixed plant and time effects;  
3. In parentheses are reported the robust standard errors, which are corrected following Windmeijer (2005) in column (2), (4), (6);  
4. \*\*\* denotes significant at the 1% confidence level; \*\*, 5%; \*, 10%;  
5. In the GMM models of column (2), (4) and (6), the endogenous variable is *Deregulation* and the excluded instruments are *Der\_Nei* and *Mc\_Fuel* lagged three years. Each instrument set is collapsed into a single column.