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ABSTRACT

Consumer Standards as a Strategic Device to Mitigate Ratchet Effects in Dynamic Regulation*

Strategic delegation to an independent regulator with a pure consumer standard improves dynamic regulation by mitigating ratchet effects associated with short term contracting. A pure consumer standard alleviates the regulator's myopic temptation to raise output after learning the firm is inefficient. Anticipating this tougher regulatory behavior, efficient firms find it less attractive to exaggerate costs. This reduces the need for long term rents and mitigates ratchet effects. A welfare standard biased towards consumers entails, however, allocative costs arising from partial separation of the firms' cost types. A trade-off results which favors strategic delegation when efficient firms are relatively likely.

JEL Classification: D82 and L51
Keywords: consumer standard, dynamic regulation, limited commitment, ratchet effects and strategic delegation

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1 Introduction

Ratchet effects associated with short term contracting due to limited regulatory commitment represent one of the major practical problems in dynamic regulation.[1] Intuitively, the ratchet problem follows from the regulator's inability to commit not to use against the firm in the future any cost information inferred from the firm's actions in earlier periods. In the absence of commitment, the regulator succumbs to the temptation to expropriate the firm's rents after learning such new information. Anticipating that it jeopardizes future rents, the firm is less inclined to disclose its information. This reluctance to reveal information reduces social welfare.

This paper investigates the scope for strategic delegation to an independent regulatory agency in a dynamic regulatory framework with ratchet effects. We show that establishing a regulator with a mandate that assigns a lower weight on firm profits than the legislators' preferences acts as a strategic device that mitigates ratchet effects. This mandate places more emphasis on rent extraction and induces the regulator to be tougher towards the firm. The optimal regulatory objective exhibits a zero weight on profits, and therefore the regulator is assigned a pure consumer standard. Hence, a pure consumer standard improves the dynamic efficiency of short term regulatory contracts. In contrast, we do not find any beneficial strategic delegation effect of a more lenient regulator.

Prima facie, the result that a tougher regulator mitigates ratchet effects seems counterintuitive. Since the ratchet problem implies that the regulator is unable to hand out long term rents, standard intuition would suggest that, if strategic delegation is to mitigate ratchet effects, then only via a regulator that is less eager to extract rents. This reasoning would lead to the opposite conclusion that the regulator should be more lenient with the firm.

Our analysis shows that this intuition is misleading, because it neglects a crucial driver of the ratchet problem: the regulator's temptation to raise the firm's output after learning it is inefficient. To illustrate our results, we consider a two-period version of the seminal Baron and Myerson (1982) monopoly regulation model, where a firm has private information about its time invariant marginal costs. A fundamental insight of the Baron and Myerson model is that the firm's private information leads the regulator to trade off allocative efficiency against rent extraction. The reason why tougher regulation helps to mitigate ratchet effects is directly related to this fundamental trade-off. A regulator with full commitment powers can optimally refrain from using the pertinent information and commit to an ex post inefficiently low output of the inefficient firm in order to reduce the socially costly informational rents to the efficient firm. However, a regulator who can only use short term contracts succumbs to the temptation to raise the output of the inefficient firm after learning its private information. This myopic regulatory behavior triggers the ratchet problem, because the efficient firm anticipates a higher output for the inefficient firm and therefore it expects to receive higher rents in the second period if it claims to be inefficient in the first. A regulatory objective with a lower profit weight reduces the regulator's temptation to raise the inefficient firm's output, since the lower profit weight induces the regulator to place more emphasis on rent extraction via a downward output distortion. This limits the need for long term rents to the efficient firm and mitigates ratchet effects. Hence, rather than restoring the regulator's ability to hand out long term rents, it is preferable to mitigate the ratchet problem by assigning the regulator a pure consumer standard which reduces the need for long term rents. This explains our result that tougher regulators improve the dynamics of regulation in the presence of ratchet effects.

Strategic delegation with a pure consumer standard entails, however, allocative costs since it induces partial separation contracts that create a partial "mismatch" between the firm's cost types and contracts. Hence, a trade-off results, which shifts in favor of strategic delegation with the likelihood of the efficient firm. Strategic delegation is therefore optimal when the efficient firm is relatively likely. Otherwise, a regulator with an unbiased welfare perspective is preferable.

Our results are consistent with the mandate of modern independent regulatory agencies that focus their attention on consumers, while downplaying the role of profits. For example, Section 2A of the UK Water Industry Act 1991 states that the Water Services Regulation Authority "shall exercise and perform the powers [...] to further the consumer objective", while mentioning with regard to firm profits that the Authority's duty is "to secure that companies [...] are able [...] to finance the proper carrying out of those functions". Consequently, profits are viewed only as an indirect mean for regulators to achieve their primary goal of serving consumers. Similarly, Ofgem, the UK Office of the Gas and Electricity Markets, states that "protecting consumers is our first priority", clarifying further that the "Authority's *principal* objective is to protect the interests of existing and future consumers".[2] Likewise, the Federal Energy Regulatory Commission in the US bluntly states on its website: "Mission: Reliable, Efficient and Sustainable Energy for Customers".[3]

A second, more technical, contribution of our paper is to show that a repeated version of the Baron and Myerson (1982) model allows a full characterization of the optimal dynamic regulatory contract in the presence of limited commitment. Laffont and Tirole (1993) emphasize the difficulties in obtaining explicit results within their framework even with two cost types. As a result, they have to resort to simulations when investigating ratchet effects. Although the analytical tractability within the Baron and Myerson framework is higher, it still limits us to demonstrate our results with only two cost types.[4] Despite this restriction, the intuition gleaned from the two-type model identifies the general principles underlying our results. Hence, our stylized formulation puts sufficient structure on the problem to derive analytical results, while still being rich enough to describe the relevant effects of short term contracting.

Economic literature has recognized the relevance of strategic delegation for a long time. The seminal papers of Vickers (1985), Fershtman (1985), Fershtman and Judd (1987), and Sklivas (1987) show that a firm's profit-maximizing owner may prefer to distort managerial incentives via a remuneration which is proportional to a (linear) combination of profits and output. More recently, Jansen et al. (2007) find similar results with managerial rewards based on a weighted sum of profits and market share.

Strategic delegation is particularly important in the presence of time inconsistency problems. Rogoff (1985) demonstrates that policy makers can benefit from a central banker whose mandate departs from social welfare and places a greater weight on controlling inflation than on fighting unemployment. In an environmental regulation framework, Spulber and Besanko (1992) find that a regulatory mandate which assigns a different profit weight from the policy makers' preferences is optimal when the agency cannot make a credible commitment to enforce a particular regulatory standard. Similarly, Besanko and Spulber (1993) examine a model of merger policy where the antitrust authority cannot commit to a challenge rule before a merger is proposed. They find that a greater weight on consumer surplus in the welfare standard increases the probability of challenging the merger and improves social welfare.[5]

In line with this strand of literature, we investigate strategic delegation as a commitment device to cope with time inconsistency problems. Differently from previous work, our focus is, however, on the benefits of strategic delegation to mitigate ratchet effects, which the regulation literature considers as one of the major practical problems in dynamic regulation. Evans et al. (2011) also address the question of strategic delegation in a regulatory setting with ratchet effects. In a two-period version of the Laffont and Tirole (1986) model, they are however unable to obtain analytical results and therefore have to resort to simulations. Moreover, contrary to our analysis, they do not establish the insight that tougher regulators can mitigate ratchet effects.

The ratchet problem in the presence of limited commitment has been extensively investigated by Laffont and Tirole (1988, 1993). In a two-period version of the Laffont and Tirole (1986) model with time invariant private information, they show that a regulator with full commitment powers finds it optimal to commit not to exploit the information revealed by the firm in earlier periods. If however only short term contracting is feasible, the regulator succumbs to this temptation and therefore the ratchet problem arises. This makes a separating contract more costly, and even unfeasible with a continuum of firm's types.[6]

The rest of the paper is organized as follows. Section 2 sets out the model which allows us to demonstrate our results analytically. Section 3 investigates the regulator's behavior for a given regulatory mandate. Section 4 explores the scope for strategic delegation and shows that a pure consumer standard is optimal when the efficient firm is relatively likely, otherwise there is no room for strategic delegation. Section 5 concludes. All relevant proofs are relegated to the Appendix.[7]

2 The model

We consider a regulated monopolistic firm that can provide a public service with consumer value $S > 0$ in each of two periods $\tau = 1, 2$. We weight the first period with 1 and the second period with $\rho > 0$. The different weighting reflects differences in the length of periods or the number of consumers. We mainly focus on the case $\rho > 1$, because it limits the number of case distinctions. As we show in Section 4, our results also extend to the case $\rho \leq 1$.

The firm incurs time invariant unit costs $c_i > 0$ for each period it provides the service. With probability $\nu \in (0, 1)$ costs are c_l and with probability $1 - \nu$ costs are c_h, where $\Delta c \equiv c_h - c_l > 0$. The cost realization is the firm's private information. Fixed costs are normalized to zero. We assume $S > c_h$ so that production is also efficient with high costs.

Given a transfer $t_\tau \in \mathbb{R}$ and (a probability of) production $q_\tau \in [0, 1]$ in period τ, consumer surplus is $\Psi_\tau = Sq_\tau - t_\tau$, while the firm with costs c_i receives a profit $\Pi_{\tau i} = t_\tau - c_i q_\tau$. We consider a Congress with a social welfare function consisting of a weighted sum of consumer surplus and firm's profits. Congress' objective in period τ when facing a firm with costs c_i is

$$W_{\tau i} = \Psi_\tau + \alpha_c \Pi_{\tau i} = Sq_\tau - t_\tau + \alpha_c(t_\tau - c_i q_\tau),$$

where $\alpha_c \in [0, 1]$ is the relative weight on the firm's profits. Congress' greater concern with consumer surplus than shareholders' rents typically reflects distributional issues or partial foreign ownership of the firm. Congress' aggregate welfare is the sum over the first and second period:

$$W_i = W_{1i} + \rho W_{2i}. \tag{1}$$

Congress cannot engage directly in regulation and thus assigns a regulator the mandate to regulate the firm. The regulator lacks the commitment power to offer the firm a long term regulatory contract that covers both periods. Instead, only short term contracting is feasible. The regulatory mandate is to maximize each period τ a weighted sum of consumer surplus and firm's profits, which may diverge from Congress' preferences:

$$V_{\tau i} = \Psi_\tau + \alpha_r \Pi_{\tau i} = Sq_\tau - t_\tau + \alpha_r(t_\tau - c_i q_\tau),$$

where $\alpha_r \in [0, 1]$ is the weight the regulator assigns to profits. The regulator's aggregate payoff is the sum over the first and second period:

$$V_i = V_{1i} + \rho V_{2i}. \tag{2}$$

Our main question is whether Congress finds it optimal to appoint a regulator with different preferences, namely, with a profit weight α_r which differs from α_c.[8]

In summary, we consider the following sequence of events. First, Congress sets the regulatory mandate $\alpha_r \in [0, 1]$. Second, the firm privately learns its cost type $c_i \in \{c_l, c_h\}$. Third, the regulator regulates the firm for two periods. In order to distinguish between the three players, we refer to Congress as "she", the regulator as "he", and the firm as "it".

3 The regulation game

Proceeding backward, we start our analysis by considering the regulation game between the regulator and firm for some given weight α_r.

3.1 Two relevant benchmarks

Before solving the dynamic regulatory problem, it is helpful to consider first the optimal regulatory schedule for the one-period static problem. By the revelation principle (e.g., Myerson 1979), the regulator can restrict attention to a direct incentive compatible contract menu $\{\gamma_l, \gamma_h\} = \{(q_l, t_l), (q_h, t_h)\}$, which induces the firm to truthfully reveal its type. Defining a cutoff value $\overline{\nu}$ as

$$\overline{\nu} \equiv \frac{S - c_h}{S - c_h + (1 - \alpha_r)\Delta c}, \tag{3}$$

we fully characterize the optimal static mechanism in the following lemma.

Lemma 1 (optimal static regulation) *The optimal static regulatory policy depends on the likelihood of the efficient firm,* $\nu \in (0,1)$*, as follows:*
i) For $\nu < \bar{\nu}$ *it exhibits* $(q_l, t_l) = (q_h, t_h) = (1, c_h)$.
ii) For $\nu \geq \bar{\nu}$ *it exhibits* $(q_l, t_l) = (1, c_l)$ *and* $(q_h, t_h) = (0, 0)$.

Underlying the regulation problem is the familiar trade-off between allocative efficiency and rent extraction, which induces the regulator to choose either a pooling or a separating contract. A pooling contract entails efficient production at the cost of informational rents to the efficient firm. In contrast, a separating contract extracts all informational rents but shuts down the production of the inefficient firm. Consequently, the pooling contract is optimal for the *pessimistic case*, $\nu < \bar{\nu}$, where the efficient firm is relatively unlikely, while the separating contract is optimal for the *optimistic case*, $\nu \geq \bar{\nu}$.

A second important benchmark is the analysis of the two-period regulation problem when the regulator is endowed with full commitment powers. In this case, the revelation principle still applies so that the regulator optimally offers the firm a direct incentive compatible menu of two long term contracts $\gamma_l = \{(q_{1l}, t_{1l}), (q_{2l}, t_{2l})\}$ and $\gamma_h = \{(q_{1h}, t_{1h}), (q_{2h}, t_{2h})\}$. In principle, each contract might specify different allocations over the two periods. Baron and Besanko (1984) and Laffont and Tirole (1993), however, show that the regulator optimally commits not to use any information inferred from the firm's behavior. Hence, the regulator's optimal long term contract is, in the presence of time invariant costs, a straightforward repetition of the optimal static contract.

Lemma 2 (optimal regulation with long term contracting) *The optimal two-period regulatory policy with long term contracting depends on the likelihood of the efficient firm,* $\nu \in (0,1)$*, as follows:*
i) For $\nu < \bar{\nu}$ *it exhibits* $(q_{1l}, t_{1l}) = (q_{1h}, t_{1h}) = (q_{2l}, t_{2l}) = (q_{2h}, t_{2h}) = (1, c_h)$.
ii) For $\nu \geq \bar{\nu}$ *it exhibits* $(q_{1l}, t_{1l}) = (q_{2l}, t_{2l}) = (1, c_l)$ *and* $(q_{1h}, t_{1h}) = (q_{2h}, t_{2h}) = (0, 0)$.

3.2 Dynamic regulation with short term contracting

We now address the regulation problem when the regulator cannot commit to long term contracts and only short term contracting is feasible. Laffont and Tirole (1988, 1993) emphasize that, in dynamic regulatory settings with short term contracts, the standard revelation principle does not apply any longer. Bester and Strausz (2001) provide an appropriate adaptation of the revelation principle.

They show that, despite a lack of commitment, the mechanism designer still optimally uses a *direct* mechanism under which truthful revelation is an optimal strategy for the agent but the agent does not necessarily report truthfully with probability 1.

For our setup, this means that, in line with the standard revelation principle, we can restrict attention to a first period menu of two contracts $\{\gamma_{1l}, \gamma_{1h}\} = \{(q_{1l}, t_{1l}), (q_{1h}, t_{1h})\}$. However, going beyond the standard revelation principle, we also have to consider explicitly the possibility that the firm randomizes between the two contracts. Of course, in equilibrium, any active randomization must be an optimal behavioral strategy of the firm. Let β_i be the probability that a firm of type c_i picks the contract γ_{1i}. By labeling contracts appropriately, we can always ensure that $\beta_l + \beta_h \geq 1$. With this labeling convention, the firm of type c_i is more likely to select the contract γ_{1i} than the other type c_j so that we can interpret γ_{1i} as the contract targeted at c_i rather than at c_j. Moreover, we can focus on pairs (β_l, β_h) with $\beta_l > 0$ and $\beta_h > 0$.[9]

Given a first period menu $\{\gamma_{1l}, \gamma_{1h}\}$, let $\nu_{2i} \equiv Pr\{c_l|\gamma_{1i}\}$ denote the regulator's updated beliefs that the firm's type is c_l after the contract γ_{1i} has been chosen in the first period. With these posterior beliefs, the regulator offers the firm a new contract in the second period. This is the final period, and therefore the standard revelation principle applies, which ensures that we can restrict attention to direct incentive compatible mechanisms. Since they may depend on the firm's contract choice in the first period, let $\{\gamma_{2il}, \gamma_{2ih}\} = \{(q_{2il}, t_{2il}), (q_{2ih}, t_{2ih})\}$ represent the second period menu which the regulator offers when the firm picked the contract γ_{1i} in the first period. Therefore, for a given choice of the first period contract γ_{1i}, the second period contract induces the firm of type c_l to select the contract γ_{2il} and the firm of type c_h to select the contract γ_{2ih}.

The *outcome* of the regulation game with short term contracting is a first period menu $\{\gamma_{1l}, \gamma_{1h}\}$ and a subsequent tuple

$$\Gamma = \{(\beta_l, \beta_h), (\nu_{2l}, \nu_{2h}), \{\gamma_{2ll}, \gamma_{2lh}\}, \{\gamma_{2hl}, \gamma_{2hh}\}\},$$

which describes the firm's reporting strategies (β_l, β_h), the regulator's updated beliefs (ν_{2l}, ν_{2h}), and the second period menus $\{\gamma_{2ll}, \gamma_{2lh}\}$ and $\{\gamma_{2hl}, \gamma_{2hh}\}$.

Given a first period menu $\{\gamma_{1l}, \gamma_{1h}\}$, the outcome Γ constitutes a *perfect Bayesian equilibrium (PBE)* if

1. (*Bayes' consistency*) the regulator's updated beliefs (ν_{2l}, ν_{2h}) are Bayes' consistent with the firm's reporting strategies (β_l, β_h);

2. (*sequential rationality*) the regulator's second period menus $\{\gamma_{2ll}, \gamma_{2lh}\}$ and $\{\gamma_{2hl}, \gamma_{2hh}\}$ are optimal given his respective beliefs ν_{2l} and ν_{2h};

3. (*optimal reporting*) the reporting strategies (β_l, β_h) are optimal given the first period menu $\{\gamma_{1l}, \gamma_{1h}\}$ and the regulator's second period offers $\{\gamma_{2ll}, \gamma_{2lh}\}$ and $\{\gamma_{2hl}, \gamma_{2hh}\}$.

A *solution* to the regulation game with short term contracting is a first period menu $\{\gamma_{1l}, \gamma_{1h}\}$ along with a PBE outcome Γ that maximizes the regulator's objective in (2) under the condition that the firm receives non-negative profits. We next discuss the restrictions that these equilibrium requirements put on the outcome Γ.

Bayes' consistency

Since we can restrict attention to $\beta_l > 0$ and $\beta_h > 0$, out-of-equilibrium considerations are irrelevant, and Bayes' consistency implies that the firm's reporting strategies (β_l, β_h) fully determine the regulator's updated beliefs (ν_{2l}, ν_{2h}) as follows

$$\nu_{2l} = \nu_l(\beta_l, \beta_h) \equiv \frac{\nu\beta_l}{(1-\nu)(1-\beta_h) + \nu\beta_l};$$

$$\nu_{2h} = \nu_h(\beta_l, \beta_h) \equiv \frac{\nu(1-\beta_l)}{(1-\nu)\beta_h + \nu(1-\beta_l)}. \tag{4}$$

It follows from $\beta_l + \beta_h \geq 1$ that $\nu_h(\beta_l, \beta_h) \leq \nu \leq \nu_l(\beta_l, \beta_h)$. Hence, Bayes' consistency implies that, if the firm selects the contract γ_{1i} in the first period, this raises the regulator's beliefs that the firm is of type c_i.

Sequential rationality

The requirement that the second period offer is sequentially rational implies that the menu $\{\gamma_{2il}, \gamma_{2ih}\}$ is optimal given the regulator's updated beliefs ν_{2i}. Consequently, the second period menu coincides with the optimal static mechanism of Lemma 1 with the probability ν_{2i} that the firm is efficient. We know from Lemma 2 that, in the pessimistic case $\nu < \overline{\nu}$, a regulator with full commitment powers finds it optimal to offer a pooling contract for both periods. Since this contract does not affect the regulator's updated beliefs, we obtain the following result.

Lemma 3 (pessimistic case) *Suppose $\nu < \overline{\nu}$. Then, a first period full pooling menu $\gamma_{1l} = \gamma_{1h} = (1, c_h)$ with reporting strategies $\beta_l + \beta_h = 1$, and a PBE outcome Γ with second period full pooling menus $\gamma_{2ll} = \gamma_{2lh} = \gamma_{2hl} = \gamma_{2hh} = (1, c_h)$ yields the regulator the same payoff as the optimal long term contract and is optimal.*

Conversely, it seems that, in the optimistic case $\nu \geq \overline{\nu}$, short term contracts cannot achieve the optimal outcome under long term contracting. In this case the regulator with full commitment powers offers a separating contract for both periods which shuts down the production of the inefficient firm. This contracting structure, however, is *not* sequentially rational, because the firm's private information is fully revealed in the first period and therefore the regulator has an incentive to propose a new second period contract which induces the inefficient firm to produce with a transfer that exactly covers its costs.

Hence, for the optimistic case $\nu \geq \bar{\nu}$, the equilibrium requirements imposed by short term contracting put non-trivial restrictions on the dynamic regulation game. In particular, Bayes' consistency and sequential rationality imply that, in any perfect Bayesian equilibrium, the firm's reporting strategies fully determine the second period contract menus $\{\gamma_{2ll}, \gamma_{2lh}\}$ and $\{\gamma_{2hl}, \gamma_{2hh}\}$.

Lemma 4 (second period contracts) *Suppose $\nu \geq \bar{\nu}$. Then, a PBE outcome Γ exhibits $\nu_{2l} = \nu_l(\beta_l, \beta_h)$, $\nu_{2h} = \nu_h(\beta_l, \beta_h)$, and $\{\gamma_{2ll}, \gamma_{2lh}\} = \{(1, c_l), (0, 0)\}$. Moreover,*
i) for $\nu_{2h} < \bar{\nu}$ the tuple Γ exhibits $\gamma_{2hl} = \gamma_{2hh} = (1, c_h)$;
ii) for $\nu_{2h} \geq \bar{\nu}$ the tuple Γ exhibits $\{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$.

Optimal reporting

We now turn to the implications of the final equilibrium requirement that the firm's reporting strategies (β_l, β_h) must be optimal given the first period menu and the second period offers. In the light of Lemma 3, we focus on the non-trivial case $\nu \geq \bar{\nu}$. As Lemma 4 reveals, we have $\gamma_{2ll} = (1, c_l)$ in any PBE outcome Γ. Hence, an efficient firm which picks γ_{1l} in the first period exactly breaks even in the second period, and its associated overall payoff is simply $t_{1l} - c_l q_{1l}$. Conversely, after choosing γ_{1h}, an efficient firm receives from γ_{2hl} a second period profit $t_{2hl} - c_l q_{2hl}$, yielding an overall payoff $t_{1h} - c_l q_{1h} + \rho (t_{2hl} - c_l q_{2hl})$. For any PBE outcome Γ, the reporting strategy β_l is therefore optimal if and only if

$$\beta_l = \arg \max_{\beta \in (0,1]} \beta (t_{1l} - c_l q_{1l}) + (1 - \beta) [t_{1h} - c_l q_{1h} + \rho (t_{2hl} - c_l q_{2hl})] . \tag{5}$$

Lemma 4 also shows that, in any PBE outcome Γ, the inefficient firm does not receive any rent in the second period with either γ_{2lh} or γ_{2hh}. Consequently, the reporting strategy β_h is optimal if and only if

$$\beta_h = \arg \max_{\beta \in (0,1]} \beta(t_{1h} - c_h q_{1h}) + (1 - \beta)(t_{1l} - c_h q_{1l}). \tag{6}$$

Conditions (5) and (6) summarize the equilibrium requirements concerning the firm's reporting strategies.

Since the objective in (5) is linear in β, it follows that, if $\beta_l = 1$ is optimal, we must have

$$t_{1l} - c_l q_{1l} \geq t_{1h} - c_l q_{1h} + \rho \left(t_{2hl} - c_l q_{2hl} \right). \tag{7}$$

This condition characterizes the usual incentive compatibility constraint for the efficient firm, which induces truthful information revelation. If $\beta_l \in (0,1)$ is optimal, then (5) implies that (7) must hold with equality.

Similarly, it follows from (6) that, if $\beta_h = 1$ is optimal, we must have

$$t_{1h} - c_h q_{1h} \geq t_{1l} - c_h q_{1l}, \tag{8}$$

which represents the standard incentive compatibility condition for the inefficient firm. If $\beta_h \in (0,1)$ is optimal, then (6) implies that (8) must be satisfied with equality.

The next lemma shows how optimal reporting and sequential rationality place limits on any PBE outcome Γ.

Lemma 5 (information revelation) *Suppose $\nu \geq \bar{\nu}$ and $\rho > 1$. Then, in any PBE outcome Γ, it holds $\nu_{2h} \geq \bar{\nu}$. Equivalently, in any PBE outcome Γ, the reporting strategies (β_l, β_h) are such that $\beta_l \leq \bar{\beta}_l(\beta_h)$, where*

$$\bar{\beta}_l(\beta_h) \equiv 1 - \frac{(1-\nu)(S-c_h)}{(1-\alpha_r)\nu\Delta c}\beta_h \in (0,1).$$

Lemma 5 shows that, in the optimistic case $\nu \geq \overline{\nu}$, the regulator cannot induce too much information revelation. In particular, it is not feasible to achieve full revelation, i.e., $\beta_l = \beta_h = 1$, because $\bar{\beta}_l(1) < 1$. This result is a consequence of the well-known "take-the-money-and-run" strategy (Laffont and Tirole 1993). The intuition is that an efficient firm anticipating the ratchet problem requires a large upfront payment in order to induce it to reveal itself in the first period. This payment makes it however attractive for the inefficient firm to claim it is efficient. When the second period is sufficiently valuable ($\rho > 1$) so that the upfront payment is relatively large, a regulator that wants to induce full information revelation cannot resolve the conflict between the two incentive problems; the two incentive constraints (7) and (8) are mutually inconsistent.[10]

Since full information revelation cannot be achieved, only partial separation is feasible and a partial *mismatch* between the firm's cost types and contracts occurs in the first period. This is because even when the inefficient firm picks "its" contract γ_{1h} with probability 1, i.e., $\beta_h = 1$, the efficient firm must also choose the contract γ_{1h} at least with probability $1 - \bar{\beta}_l(1) > 0$. The mismatch between the firm's cost types and contracts results in some allocative inefficiency. This suggests that short term contracting increases the cutoff level above which the regulator no longer pools the firm's types in the first period. Moreover, when partial separation is implemented, it seems natural to induce the highest degree of information revelation, i.e., $\beta_l = \overline{\beta}_l(1)$ and $\beta_h = 1$, since this increases allocative efficiency at no cost in terms of informational rents. Defining the cutoff level

$$\tilde{\nu} \equiv \frac{(S - c_h)\left[S - c_l + (1 - \alpha_r)\Delta c\right]}{(S - c_h)\left[S - c_l + (1 - \alpha_r)\Delta c\right] + (1 - \alpha_r)^2 (\Delta c)^2} \in (\overline{\nu}, 1), \tag{9}$$

where $\overline{\nu}$ is specified in (3), the following lemma corroborates the two aforementioned insights formally.[11]

Lemma 6 (optimistic case) *Suppose $\nu \geq \bar{\nu}$ and $\rho > 1$. Then, a solution to the regulation problem with short term contracting depends on the likelihood of the efficient firm, $\nu \in (0,1)$, as follows:*

(i) For $\nu < \tilde{\nu}$ it consists of a first period full pooling menu $\gamma_{1l} = \gamma_{1h} = (1, c_h)$ with reporting strategies $\beta_l + \beta_h = 1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll}, \gamma_{2lh}\} = \{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$.

(ii) For $\nu \geq \tilde{\nu}$ it consists of a first period partial separation menu $\{\gamma_{1l}, \gamma_{1h}\} = \{(1, c_l), (0, 0)\}$ with reporting strategies $\beta_l = \bar{\beta}_l(1)$ and $\beta_h = 1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll}, \gamma_{2lh}\} = \{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$.

Equipped with the results of Lemma 3 and Lemma 6, we are able to fully characterize the solution to the regulation problem with short term contracting.

Proposition 1 (optimal regulation with short term contracting) *Suppose $\rho > 1$. Then, the optimal two-period regulatory policy with short term contracting depends on the likelihood of the efficient firm, $\nu \in (0,1)$, as follows:*

(i) For $\nu < \overline{\nu}$ it coincides with the solution under long term contracting and consists of a first period full pooling menu $\gamma_{1l} = \gamma_{1h} = (1, c_h)$ with reporting strategies $\beta_l + \beta_h = 1$, and a PBE outcome Γ with second period full pooling menus $\gamma_{2ll} = \gamma_{2lh} = \gamma_{2hl} = \gamma_{2hh} = (1, c_h)$.

(ii) For $\nu \in [\overline{\nu}, \tilde{\nu})$ it consists of a first period full pooling menu $\gamma_{1l} = \gamma_{1h} = (1, c_h)$ with reporting strategies $\beta_l + \beta_h = 1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll}, \gamma_{2lh}\} = \{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$.

(iii) For $\nu \geq \tilde{\nu}$ it consists of a first period partial separation menu $\{\gamma_{1l}, \gamma_{1h}\} = \{(1, c_l), (0, 0)\}$ with reporting strategies $\beta_l = \bar{\beta}_l(1)$ and $\beta_h = 1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll}, \gamma_{2lh}\} = \{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$.

Proposition 1 shows that under short term contracting the regulator implements a first period pooling contract for a larger range of probability values ν than under long term contracting. To understand the rationale behind this result, recall from Lemma 5 that the ratchet effects prevent the regulator from achieving full information revelation in the first period. The regulator has two options to cope with this problem. Either he refrains from offering a revelation contract in the first period altogether, or he designs a partial separation contract that still induces some information revelation. A partial separation contract entails, however, some allocative costs because it yields a partial mismatch between the firm's types and contracts. This makes a pooling contract more attractive under short term contracting. Since partial separation allows the regulator to save on informational rents, this contract becomes desirable when the probability of an efficient firm is sufficiently high.

4 Optimal strategic delegation

After characterizing the regulator's behavior for any weight α_r, we are now in a position to investigate whether Congress benefits from strategic delegation by assigning the regulator a mandate with a profit weight α_r that differs from her own weight α_c. The following lemma shows that there is no gain from strategic delegation as long as the regulator can commit to long term contracts. This intuitive result emphasizes that any benefit of strategic delegation in the regulation problem with short term contracting is indeed due to a lack of commitment to long term contracts.

Lemma 7 (optimal delegation with long term contracting) *Under long term contracting there is no value from strategic delegation and Congress finds it optimal to set a regulatory weight on profits $\alpha_r = \alpha_c$.*

Next, we examine the scope for strategic delegation under short term contracting. Since we know from Lemma 3 that for $\nu < \overline{\nu}$ short term contracts achieve the same outcome as under long term contracting, a direct implication of Lemma 7 is that strategic delegation can only be potentially valuable for the optimistic case $\nu \geq \overline{\nu}$.

Note from Proposition 1 that the regulatory outcome - and thereby Congress' payoff - crucially depends on the weight α_r via the two cutoff values $\bar{\nu}$ in (3) and $\tilde{\nu}$ in (9) that determine how the regulator optimally trades off allocative efficiency against rent extraction. In addition, the weight α_r affects the reporting probability $\overline{\beta}_l(1)$ under partial separation. In order to express this dependence more explicitly, we write $\bar{\nu}(\alpha_r)$, $\tilde{\nu}(\alpha_r)$, and $\hat{\beta}_l(\alpha_r)$, where

$$\hat{\beta}_l(\alpha_r) \equiv \overline{\beta}_l(1) = 1 - \frac{(1-\nu)(S-c_h)}{(1-\alpha_r)\nu\Delta c}.$$

Using the results in Proposition 1, Congress' aggregate (expected) payoff in (1) can be represented as a function of the regulatory weight α_r in the following way:

$$W(\alpha_r) = \begin{cases} W^{fc} \equiv (1+\rho)\left(S - c_h + \nu\alpha_c\Delta c\right) & \text{if } \nu < \overline{\nu}(\alpha_r) \\ W^{p} \equiv S - c_h + \nu\alpha_c\Delta c + \nu\rho(S-c_l) & \text{if } \nu \in [\overline{\nu}(\alpha_r), \tilde{\nu}(\alpha_r)) \\ W^{ps}(\alpha_r) \equiv \nu(S-c_l)\left(\hat{\beta}_l(\alpha_r) + \rho\right) & \text{if } \nu \geq \tilde{\nu}(\alpha_r), \end{cases} \tag{10}$$

where W^{fc} is social welfare when the solution under full commitment (long term contracting) is implementable, W^p is social welfare when first period pooling contracts are optimal, and W^{ps} is social welfare when first period partial separation contracts are optimal.

Defining

$$\nu^*\left(\alpha_c\right) \equiv \frac{\left(S-c_h\right)\left(S-c_l+\Delta c\right)}{\left(S-c_h\right)\left(S-c_l+\Delta c\right) + \left(1-\alpha_c\right)\left(\Delta c\right)^2} \in \left(\overline{\nu}\left(\alpha_c\right), 1\right)$$

enables us to present our main results.[12]

Proposition 2 (optimal strategic delegation) *Suppose $\rho > 1$. Then, for $\nu > \nu^*(\alpha_c)$, Congress strictly benefits from strategic delegation. Optimal delegation assigns the regulator a profit weight $\alpha_r = 0$, i.e., a pure consumer standard. For $\nu \leq \nu^*(\alpha_c)$, Congress does not benefit from strategic delegation and finds it optimal to set a weight $\alpha_r = \alpha_c$, implying a regulator with an unbiased welfare perspective.*

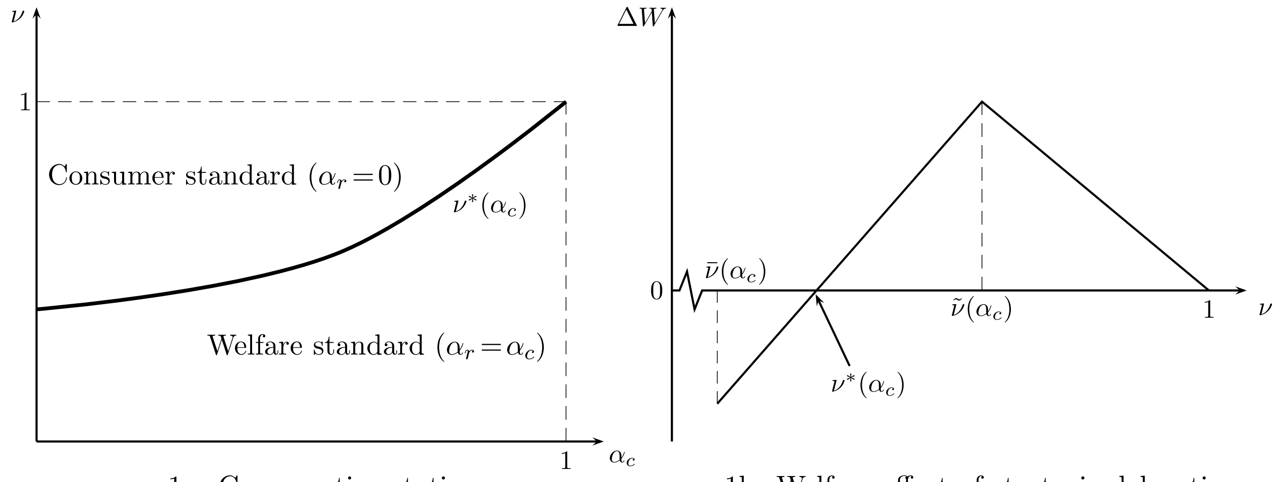
Proposition 2 shows that, if strategic delegation is beneficial, then it induces the regulator to be tougher towards the firm. In order to substantiate the intuition behind this result as provided in the introduction, it is helpful to reconsider the logic why ratchet effects are actually problematic. We know from Lemma 2 that for $\nu \geq \overline{\nu}$ a regulator with full commitment powers optimally commits to an ex post inefficiently low output of the inefficient firm in order to reduce the (relatively costly) rents to the efficient firm. This regulatory behavior, however, is not feasible with short term contracting.

Once a myopic regulator has learned that the firm is inefficient, he finds it no longer optimal to distort its production downward. It is exactly this myopic reaction that triggers the ratchet problem, because the efficient firm anticipates that it would receive a higher rent in the second period if it claims to be inefficient in the first. If the regulator did not succumb to the temptation to raise the inefficient firm's output, then the efficient firm would not require a higher rent for revealing its information.

This reasoning clarifies that a crucial driver of the ratchet problem is the regulator's temptation to raise the firm's output after learning it is inefficient. A pure consumer standard, which implies a lower profit weight than Congress' preferences, places more emphasis on rent extraction via a downward output distortion and therefore alleviates the regulator's temptation. It reduces the need for long term rents to the efficient firm and mitigates ratchet effects.

To better appreciate the beneficial impact of strategic delegation with a consumer standard, note from Proposition 1 that a lower regulatory profit weight α_r decreases the cutoff probability $\widetilde{\nu}(\alpha_r)$ above which the regulator induces first period partial separation with an output reduction in the contract γ_{1h} targeted at the inefficient firm. This reflects the idea that a tougher regulator towards the firm is more inclined to distort the output of the inefficient firm downward. Moreover, a lower α_r increases the probability $\hat{\beta}_l(\alpha_r)$ with which the efficient firm truthfully reveals itself in the first period under partial separation. As a consequence, a pure consumer standard, which places a weight $\alpha_r = 0$ on the firm's profits, has the benefit of allowing a larger degree of separation, while keeping the efficient firm's rents at zero.

However, the imposition of a pure consumer standard does not remove ratchet effects completely. Partial separation induced by a consumer standard mandate yields a mismatch between the firm's types and contracts, which involves some allocative inefficiency in comparison to the optimal long term regulatory outcome. As a result, Congress faces a cost-benefit trade-off when delegating regulation strategically. In particular, a consumer standard facilitates separation between the firm's types at the cost that the efficient firm picks the first period contract γ_{1h} targeted at the inefficient firm with a positive probability $1-\hat{\beta}_l(0)$ which decreases with the likelihood of the efficient firm ν, as $\partial\hat{\beta}_l(0)/\partial\nu > 0$. Since the cost-benefit trade-off shifts in favor of strategic delegation with the likelihood of the efficient firm, strategic delegation is optimal when the efficient firm is relatively likely. Conversely, when the efficient firm is relatively unlikely, the cost of the mismatch between the firm's types and contracts is too high so that Congress prefers a regulator with an unbiased welfare perspective, who implements a pooling contract that ensures production at the cost of some informational rents.[13]



1a: Comparative statics

1b: Welfare effect of strategic delegation

Figure 1: Comparative statics and welfare effects of strategic delegation

Proposition 2 further shows that strategic delegation with a more lenient mandate, which places a greater weight on profits than Congress' preferences, is never optimal. In the light of the usual intuition that the problem behind the ratchet effects is driven by the regulator's inability to resist expropriating rents after learning new information, this conclusion seems surprising because a more lenient regulator is indeed less eager to extract rents. Yet, a more lenient regulator is less inclined to distort the output of the inefficient firm. We find from Lemma 2 that for $\nu \geq \overline{\nu}(\alpha_c)$, where strategic delegation is potentially helpful, this is exactly the opposite of what a regulator with full commitment powers would do. A more lenient mandate therefore aggravates rather than mitigates the ratchet problem.

Figure 1a illustrates the comparative statics behind our results with respect to the weight α_c that Congress assigns to profits and the likelihood of the efficient firm ν. A lower α_c relaxes the condition $\nu > \nu^*(\alpha_c)$ and thereby increases the scope for strategic delegation. This is because a regulator with a pure consumer standard better reflects the preferences of a Congress with a greater interest in consumer surplus. These implications may lend themselves for an empirical validation of our results. In particular, our model predicts that strategic delegation with a consumer standard should be more prevalent in countries where firms are expected to be relatively efficient and legislators are, a priori, already more concerned with consumers' well-being.

Using expression (10), we can quantify the welfare impact of strategic delegation as

$$\Delta W \equiv W(0) - W(\alpha_c),$$

which measures the difference between social welfare with a consumer standard ($\alpha_r = 0$) and social welfare with an unbiased regulatory mandate ($\alpha_r = \alpha_c$). Focusing on the optimistic case $\nu \geq \overline{\nu}(\alpha_c)$, Figure 1b provides a graphical representation of the welfare impact of strategic delegation for a given Congress' weight α_c. If $\nu \leq \nu^*(\alpha_c)$, strategic delegation lowers social welfare ($\Delta W \leq 0$) because the induced partial separation, with its mismatch between the firm's types and contracts, performs worse than the pooling outcome achievable in the absence of strategic delegation. As a consequence, an unbiased regulatory mandate is preferable. Conversely, if $\nu > \nu^*(\alpha_c)$, a consumer standard enhances social welfare ($\Delta W > 0$). Note that the benefit of strategic delegation increases in the range $[\bar{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$ since the mismatch between the firm's types and contracts decreases with ν. For larger values of ν, where partial separation is implemented with both a consumer standard and an unbiased regulatory mandate, the benefit of strategic delegation declines, since the regulator is already relatively well informed about the efficiency of the firm so that the ratchet effects associated with limited commitment under asymmetric information are less relevant.

We have focused so far our attention on a dynamic framework in which the second period is more relevant than the first, i.e., $\rho > 1$. Importantly, our results are not limited to this setting but also apply when $\rho \leq 1$. The analysis becomes more involved because for $\rho \leq 1$ first period full separation contracts are feasible.[14] Partial separation contracts induced by a consumer standard mandate are optimal when, as in Proposition 2, the efficient firm is relatively likely, i.e., $\nu > \nu^*(\alpha_c)$. In addition, the discount factor must be sufficiently large, $\rho > \rho^*(\alpha_c)$, where

$$\rho^*(\alpha_c) \equiv \frac{(1-\nu)(S-c_h)(S-c_l)}{\Delta c\left[\nu(1-\alpha_c)\Delta c - (1-\nu)(S-c_h)\right]},$$

so that the ratchet problem is severe enough.[15] For $\rho \leq \rho^*(\alpha_c)$, first period full separation contracts achievable with an unbiased regulator perform better, so that strategic delegation is not optimal.

We can therefore extend the results in Proposition 2 to the case where $\rho \leq 1$.

Proposition 3 (optimal strategic delegation) *Suppose* $0 < \rho \leq 1$. *Then, for* $\nu > \nu^*(\alpha_c)$ *and* $\rho > \rho^*(\alpha_c) \in (0,1)$, *Congress strictly benefits from strategic delegation. Optimal delegation assigns the regulator a profit weight* $\alpha_r = 0$, *i.e., a pure consumer standard. Otherwise, Congress does not benefit from strategic delegation and finds it optimal to set a weight* $\alpha_r = \alpha_c$, *implying a regulator with an unbiased welfare perspective.*

Our results can be also generalized in other directions. For instance, they carry over when the downward output distortion for the inefficient firm does not entail a complete shutdown of production. In this scenario, for $\nu \geq \overline{\nu}$ a regulator with full commitment powers still optimally commits to an ex post inefficiently low output for the inefficient firm, but now he must hand out some positive informational rents since the activity of the inefficient firm in both periods increases the efficient firm's incentive to manipulate its costs. Even in the absence of full shutdown, a myopic regulator remains tempted to raise the firm's output after learning it is inefficient. This leads to a regulatory behavior in line with the results of Proposition 1. The only difference is that, as in the full commitment benchmark, the regulator must now deliver larger informational rents to the efficient firm, because the inefficient firm operates in both periods. Strategic delegation with a pure consumer standard still allows a larger degree of separation while minimizing the informational rents. Consequently, the results derived in Propositions 2 and 3 also hold without complete shutdown of the inefficient firm.

5 Conclusions

In this paper we show that strategic delegation to an independent regulator with a pure consumer standard improves dynamic regulation by mitigating ratchet effects associated with short term contracting. These results are derived analytically in a repeated version of the Baron and Myerson (1982) model, which allows a full characterization of the optimal regulatory contract. Despite its stylized formulation, the formal analysis suggests that the principles underlying our results are general. A crucial driver of the dynamic incentive problem with ratchet effects is that the regulator cannot refrain from raising the firm's output after learning it is inefficient. A pure consumer standard, which places more emphasis on firm's rent extraction via a downward output distortion, alleviates the regulator's myopic temptation, and therefore limits the need for rents to the efficient firm. An allocative cost of strategic delegation, however, follows from the induced partial separation contracts that entail a partial mismatch between the firm's types and contracts. Since the cost-benefit trade-off shifts in favor of strategic delegation with the probability of the efficient firm, strategic delegation is optimal when the efficient firm is relatively likely. Otherwise, a regulator with an unbiased welfare perspective is preferable.

Appendix

This Appendix collects the proofs.

Proof of Lemma 1: The regulator's objective is

$$\begin{aligned}\max_{q_l,t_l,q_h,t_h} \quad & \nu[Sq_l - t_l + \alpha_r(t_l - c_l q_l)] + (1-\nu)[Sq_h - t_h + \alpha_r(t_h - c_h q_h)] \\ \text{s.t.} \quad & t_l - c_l q_l \geq 0; \quad t_h - c_h q_h \geq 0 \\ & t_l - c_l q_l \geq t_h - c_l q_h; \quad t_h - c_h q_h \geq t_l - c_h q_l,\end{aligned}$$

where the first two constraints are the firm's participation constraints and the other two constraints represent the incentive constraints. Standard arguments show that the participation constraint of the inefficient firm and the incentive constraint of the efficient firm are binding at the optimal contract. Substituting them out, the problem simplifies to

$$\max_{q_l,q_h} \nu[(S-c_l)q_l - (1-\alpha_r)\Delta c q_h] + (1-\nu)(S-c_h)q_h.$$

Maximizing for q_l yields $q_l = 1$, while $q_h = 1$ is optimal for $\nu < \bar{\nu}$ and $q_h = 0$ is optimal for $\nu \geq \bar{\nu}$.[16] The values for t_l and t_h obtain from the participation constraint of the inefficient firm, $t_h = c_h q_h$, and the incentive constraint of the efficient firm, $t_l = c_l q_l + \Delta c q_h$. Q.E.D.

Proof of Lemma 2: The proof follows from the argument in Laffont and Tirole (1993, p. 104) that if some different, possibly time variant, contract is optimal, then one can construct an appropriate possibly random contract for the static problem that leads to a higher payoff. This would contradict the optimality of the optimal static contract in Lemma 1.[17] Q.E.D.

Proof of Lemma 3: Consider the first period contract menu $\gamma_{1l} = \gamma_{1h} = (1, c_h)$. It follows that for $\nu < \overline{\nu}$ an outcome Γ with $\beta_l + \beta_h = 1$, $\nu_{2l} = \nu_{2h} = \nu$, and $\gamma_{2ll} = \gamma_{2lh} = \gamma_{2hl} = \gamma_{2hh} = (1, c_h)$ constitutes a perfect Bayesian equilibrium, because it satisfies Bayes' consistency, sequential rationality, and optimal reporting. It yields the regulator $W_l^{fc} = (1+\rho)\left[S - c_l - (1-\alpha_r)\Delta c\right]$ when facing a cost type c_l and $W_h^{fc} = (1+\rho)(S - c_h)$ when facing a cost type c_h. The contract menus and associated payoffs coincide with those under the optimal long term contracting in Lemma 2. Because the regulator cannot improve on long term contracting, the contract described in the lemma is also optimal. Q.E.D.

Proof of Lemma 4: Given the reporting strategies (β_l, β_h), Bayes' consistency implies $\nu_{2l} = \nu_l(\beta_l, \beta_h)$ and $\nu_{2h} = \nu_h(\beta_l, \beta_h)$. Since $\nu_{2l} = \nu_l(\beta_l, \beta_h) \geq \nu$, the lemma's supposition $\nu \geq \bar{\nu}$ implies $\nu_{2l} \geq \bar{\nu}$. By

Lemma 1, sequential rationality entails $\{\gamma_{2ll}, \gamma_{2lh}\} = \{(1, c_l), (0, 0)\}$, while $\gamma_{2hl} = \gamma_{2hh} = (1, c_h)$ if $\nu_{2h} < \overline{\nu}$, and $\{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$ if $\nu_{2h} \geq \overline{\nu}$. Q.E.D.

Proof of Lemma 5: Suppose to the contrary that a PBE outcome with $\nu_{2h} < \bar{\nu}$ exists. Lemma 4 implies that in any such PBE the efficient firm receives a rent $t_{2hl} - c_l q_{2hl} = \Delta c$ after reporting type c_h in the first period. Hence, the incentive condition (7) reduces to $t_{1l} - t_{1h} - c_l(q_{1l} - q_{1h}) \geq \rho \Delta c$, whereas the incentive condition (8) implies $t_{1h} - t_{1l} + c_h(q_{1l} - q_{1h}) \geq 0$. Adding both inequalities and dividing by Δc yields $q_{1l} - q_{1h} \geq \rho$, which contradicts $q_{1l}, q_{1h} \in [0, 1]$ and $\rho > 1$. Hence, we must have $\nu_{2h} \geq \bar{\nu}$ in any PBE outcome. Using (4), this is equivalent to $\beta_l \leq \bar{\beta}_l(\beta_h)$. Q.E.D.

Proof of Lemma 6: For the optimistic case $\nu \geq \overline{\nu}$, Lemma 5 ensures that we can restrict attention to $\nu_{2h} \geq \overline{\nu}$. Because $\nu_{2l} \geq \nu \geq \overline{\nu}$, Lemma 4 and the discussion following Lemma 1 imply that the regulator's aggregate (expected) payoff in (2) for a first period menu $\{\gamma_{1l}, \gamma_{1h}\}$ and a PBE outcome Γ can be written as

$$\begin{aligned} V \;=\; & \nu \{\beta_l[Sq_{1l} - t_{1l} + \alpha_r(t_{1l} - c_l q_{1l})] + (1 - \beta_l)[Sq_{1h} - t_{1h} + \alpha_r(t_{1h} - c_l q_{1h})] + \rho(S - c_l)\} \\ & + (1 - \nu)\{\beta_h[Sq_{1h} - t_{1h} + \alpha_r(t_{1h} - c_h q_{1h})] + (1 - \beta_h)[Sq_{1l} - t_{1l} + \alpha_r(t_{1l} - c_h q_{1l})]\}. \end{aligned} \tag{11}$$

In order to induce the firm's participation, overall profits from the regulatory relationship must be non-negative. We know from Lemma 4 that for $\nu_{2l} \geq \overline{\nu}$ and $\nu_{2h} \geq \bar{\nu}$ the efficient firm does not get any rent in the second period, so that its participation constraint reduces to

$$\beta_l (t_{1l} - c_l q_{1l}) + (1 - \beta_l)(t_{1h} - c_l q_{1h}) \geq 0. \tag{12}$$

Likewise, the participation constraint of the inefficient firm is

$$\beta_h (t_{1h} - c_h q_{1h}) + (1 - \beta_h)(t_{1l} - c_h q_{1l}) \geq 0. \tag{13}$$

Hence, for the optimistic case $\nu \geq \overline{\nu}$, the regulator solves

$$P^o : \max_{\beta_l, \beta_h, q_{1l}, q_{1h}, t_{1l}, t_{1h}} V \text{ s.t. } (5), (6), (12), (13),$$

under the domain restriction $\beta_l \leq \bar{\beta}_l(\beta_h)$.

It follows from Lemma 5 that we must have $\beta_l \in (0, 1)$, which implies that the incentive constraint (5) is equivalent to the constraint (7) satisfied with equality. Moreover, at least one of the participation constraints (12) or (13) in P^o is binding at the optimum, because if they were both slack, one could raise the regulatory objective V in P^o by reducing t_{1l} and t_{1h} by the same degree, as this affects neither

(5) nor (6). Moreover, this binding constraint must be (13), since, as usual, the incentive conditions (7) and (8) and the participation constraint of the inefficient firm (13) imply the participation constraint of the efficient firm (12): $\beta_l(t_{1l} - c_l q_{1l}) + (1 - \beta_l)(t_{1h} - c_l q_{1h}) \geq t_{1h} - c_l q_{1h} = \beta_h (t_{1h} - c_h q_{1h}) + (1 - \beta_h)(t_{1h} - c_h q_{1h}) + \Delta c q_{1h} \geq \beta_h (t_{1h} - c_h q_{1h}) + (1 - \beta_h)(t_{1l} - c_h q_{1l}) + \Delta c q_{1h} \geq \Delta c q_{1h} \geq 0$.

Consequently, a solution to P^o coincides with a solution to a transformed problem, where constraint (5) is replaced by the binding constraint (7) together with $t_{2hl} = c_l$ and $q_{2hl} = 1$ (by the combination of Lemma 4 and Lemma 5), the constraint (13) is satisfied with equality, and the constraint (12) is disregarded.

We solve this transformed problem in two steps. First, we check whether $\beta_h \in (0, 1)$ is optimal. If this is the case, then (6) is equivalent to (8) satisfied with equality and the transformed problem becomes

$$
\begin{aligned}
P' : \max_{\beta_l, \beta_h, q_{1l}, q_{1h}, t_{1l}, t_{1h}} \quad & V \\
\text{s.t.} \quad & t_{1l} - c_l q_{1l} = t_{1h} - c_l q_{1h} && (14) \\
& t_{1h} - c_h q_{1h} = t_{1l} - c_h q_{1l} && (15) \\
& \beta_h (t_{1h} - c_h q_{1h}) + (1 - \beta_h)(t_{1l} - c_h q_{1l}) = 0 && (16) \\
& \beta_l \leq \bar{\beta}_l(\beta_h), && (17)
\end{aligned}
$$

where V is given by (11). Constraints (15) and (16) imply $t_{1h} = c_h q_{1h}$ and $t_{1l} = c_h q_{1l}$. Using in addition (14), it follows $q_{1l} = q_{1h}$. Substituting out these three variables, the objective function V in P' simplifies to

$$\nu[(S - c_h + \alpha_r \Delta c) q_{1l} + \rho(S - c_l)] + (1 - \nu)(S - c_h) q_{1l},$$

which must be maximized with respect to q_{1l} under (17). The expression is independent of β_l and β_h and maximized for $q_{1l} = 1$. This implies $q_{1h} = 1$, $t_{1l} = t_{1h} = c_h$ with $\beta_l + \beta_h = 1$,[18] and yields the regulator the payoff

$$V^p \equiv S - c_h + \nu \alpha_r \Delta c + \nu \rho (S - c_l).$$

We next check whether $\beta_h = 1$ is optimal, while not being a solution to P'.[19] If this is the case, then, at any solution, (15) is satisfied with a *strict* inequality rather than equality. Using $\beta_h = 1$, (16) simplifies to $t_{1h} = c_h q_{1h}$, so that (14) implies $t_{1l} = c_l q_{1l} + \Delta c q_{1h}$. Consequently, (15) with a strict inequality implies $q_{1h} < q_{1l}$ and, moreover, the objective V simplifies to

$$\nu \beta_l (S - c_l)(q_{1l} + \rho) + \nu(1 - \beta_l)(S - c_l)(q_{1h} + \rho) - \nu(1 - \alpha_r) \Delta c q_{1h} + (1 - \nu)(S - c_h) q_{1h}.$$

The expression is increasing in q_{1l} so that $q_{1l} = 1$ is optimal. This implies that (15) is only satisfied with a strict inequality if $q_{1h} < q_{1l} = 1$. Since the expression is linear in q_{1h}, then $\beta_h = 1$ is optimal, while not being a solution to P', when the expression is decreasing in q_{1h} so that $q_{1h} = 0$ must be optimal.[20] Therefore, the expression is increasing in β_l so that (17) must bind at the optimum. If $\beta_h = 1$ is optimal while not being a solution to P', then we get $\beta_l = \bar{\beta}_l(1) \equiv \widehat{\beta}_l(\alpha_r)$ and the regulator's payoff becomes

$$V^{ps} \equiv \nu(S - c_l)(\widehat{\beta}_l(\alpha_r) + \rho) = \nu(S - c_l)\left[1 + \rho - \frac{(1-\nu)(S - c_h)}{(1-\alpha_r)\nu\Delta c}\right].$$

Straightforward computations reveal that $V^{ps} \geq V^p$ if and only if $\nu \geq \tilde{\nu}$.

The second period contract menus $\{\gamma_{2ll}, \gamma_{2lh}\} = \{\gamma_{2hl}, \gamma_{2hh}\} = \{(1, c_l), (0, 0)\}$ follow from the combination of Lemma 4 and Lemma 5. Q.E.D.

Proof of Proposition 1: The proof follows directly from Lemma 3 and Lemma 6. Q.E.D.

Proof of Lemma 7 : With $\alpha_r = \alpha_c$ the regulator implements Congress' optimal long term contract in Lemma 2. Hence, for some $\alpha_r \neq \alpha_c$ Congress cannot obtain a strictly larger payoff, as this would violate the optimality of the long term contract in Lemma 2. Q.E.D.

Proof of Proposition 2: The proof goes through the following four steps.

Step 1: Suppose $\nu < \bar{\nu}(\alpha_c)$. Then, $\alpha_r = \alpha_c$ is optimal, because $\alpha_r = \alpha_c$ induces the regulator to implement the contract in Lemma 3, which coincides with Congress' optimal long term contract.

Step 2: Suppose $\nu \geq \bar{\nu}(\alpha_c)$. We show that Congress prefers $\alpha_r = \alpha_c$ to any $\alpha_r > \alpha_c$. To see this, note first that $\overline{\nu}$ and $\widetilde{\nu}$ are strictly increasing in α_r, so that $\alpha_c < \alpha_r$ implies $\bar{\nu}(\alpha_c) < \bar{\nu}(\alpha_r)$ and $\tilde{\nu}(\alpha_c) < \tilde{\nu}(\alpha_r)$. Moreover, $\bar{\nu}(\alpha_r) < \tilde{\nu}(\alpha_r)$ and $\bar{\nu}(\alpha_c) < \tilde{\nu}(\alpha_c)$. Hence, we have either the ordering $\bar{\nu}(\alpha_c) < \bar{\nu}(\alpha_r) < \tilde{\nu}(\alpha_c) < \tilde{\nu}(\alpha_r)$ or the ordering $\bar{\nu}(\alpha_c) < \tilde{\nu}(\alpha_c) \leq \bar{\nu}(\alpha_r) < \tilde{\nu}(\alpha_r)$.

Depending on $\nu \in (0, 1)$, we distinguish the following four cases under the first ordering:

(i) For $\nu \in [\bar{\nu}(\alpha_c), \bar{\nu}(\alpha_r))$ it follows from (10) that $W(\alpha_c) - W(\alpha_r) = W^p - W^{fc} = S - c_h + \nu\alpha_c\Delta c + \nu\rho(S - c_l) - (1 + \rho)(S - c_h + \nu\alpha_c\Delta c) \geq 0$, where the inequality holds since $\nu \geq \bar{\nu}(\alpha_c)$.

(ii) For $\nu \in [\bar{\nu}(\alpha_r), \tilde{\nu}(\alpha_c))$ it follows from (10) that $W(\alpha_c) - W(\alpha_r) = W^p - W^p = 0$.

(iii) For $\nu \in [\tilde{\nu}(\alpha_c), \tilde{\nu}(\alpha_r))$ it follows from (10) that $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^p = \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c) + \rho\right) - [S - c_h + \nu\alpha_c\Delta c + \nu\rho(S - c_l)] \geq 0$, where the inequality holds since $\nu \geq \tilde{\nu}(\alpha_c)$.

(iv) For $\nu \geq \tilde{\nu}(\alpha_r)$ it follows from (10) that $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{ps}(\alpha_r) = \nu(S -$

$c_l)\left(\hat{\beta}_l(\alpha_c)+\rho\right) - \nu(S-c_l)\left(\hat{\beta}_l(\alpha_r)+\rho\right) > 0$, where the inequality holds since $\hat{\beta}_l(.)$ is strictly decreasing.

Under the second ordering we obtain the following four cases:

(v) For $\nu \in [\bar{\nu}(\alpha_c), \tilde{\nu}(\alpha_c))$ it follows from case (i) that $W(\alpha_c) - W(\alpha_r) = W^p - W^{fc} \geq 0$.

(vi) For $\nu \in [\tilde{\nu}(\alpha_c), \bar{\nu}(\alpha_r))$ it follows from (10) that $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{fc} = \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c)+\rho\right) - (1+\rho)(S - c_h + \nu\alpha_c\Delta c) > 0$, where the inequality holds since $\nu \geq \tilde{\nu}(\alpha_c)$.

(vii) For $\nu \in [\bar{\nu}(\alpha_r), \tilde{\nu}(\alpha_r))$ it follows from case (iii) that $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^p \geq 0$.

(viii) For $\nu \geq \tilde{\nu}(\alpha_r)$ it follows from case (iv) that $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{ps}(\alpha_r) > 0$.

Step 3: If $\nu > \nu^*(\alpha_c)$, Congress strictly prefers $\alpha_r = 0$ to $\alpha_r = \alpha_c$. Otherwise, Congress prefers $\alpha_r = \alpha_c$ to $\alpha_r = 0$. To see this, note first that we have either the ordering $\bar{\nu}(0) < \bar{\nu}(\alpha_c) < \tilde{\nu}(0) < \tilde{\nu}(\alpha_c)$ or the ordering $\bar{\nu}(0) < \tilde{\nu}(0) \leq \bar{\nu}(\alpha_c) < \tilde{\nu}(\alpha_c)$. The first ordering reduces to $\bar{\nu}(\alpha_c) < \tilde{\nu}(0) < \tilde{\nu}(\alpha_c)$ and the second ordering reduces to $\bar{\nu}(\alpha_c) < \tilde{\nu}(\alpha_c)$, since Step 1 implies that Congress finds it optimal to set $\alpha_r = \alpha_c$ for $\nu < \bar{\nu}(\alpha_c)$. Depending on $\nu \in (0,1)$, we distinguish the following three cases under the first ordering:

(ix) For $\nu \in [\bar{\nu}(\alpha_c), \widetilde{\nu}(0))$ it follows from (10) that $W(0) - W(\alpha_c) = W^p - W^p = 0$.

(x) For $\nu \in [\widetilde{\nu}(0), \widetilde{\nu}(\alpha_c))$ it follows from (10) that $W(0) - W(\alpha_c) = W^{ps}(0) - W^p = \nu(S - c_l)\left(\hat{\beta}_l(0)+\rho\right) - [S - c_h + \nu\alpha_c\Delta c + \nu\rho(S-c_l)] > 0$ if and only if $\nu > \nu^*(\alpha_c) \in (\widetilde{\nu}(0), \widetilde{\nu}(\alpha_c))$.

(xi) For $\nu \geq \widetilde{\nu}(\alpha_c)$ it follows from (10) that $W(0) - W(\alpha_c) = W^{ps}(0) - W^{ps}(\alpha_c) = \nu(S - c_l)\left(\hat{\beta}_l(0)+\rho\right) - \nu(S-c_l)\left(\hat{\beta}_l(\alpha_c)+\rho\right) > 0$, where the inequality holds since $\hat{\beta}_l(.)$ is strictly decreasing.

The second ordering yields the following two cases:

(xii) For $\nu \in [\bar{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$ it follows from case (x) that $W(0) - W(\alpha_c) = W^{ps}(0) - W^p > 0$ if and only if $\nu > \nu^*(\alpha_c) \in (\bar{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$.

(xiii) For $\nu \geq \widetilde{\nu}(\alpha_c)$ it follows from case (xi) that $W(0) - W(\alpha_c) = W^{ps}(0) - W^{ps}(\alpha_c) > 0$.

Step 4: Congress prefers either $\alpha_r = 0$ or $\alpha_r = \alpha_c$ to any $\alpha_r \in (0, \alpha_c)$. To see this, substitute $\alpha_r = 0$ with $\alpha_r \in (0, \alpha_c)$ in Step 3. This does not affect welfare in case (ix) but reduces welfare in cases (x) and (xi) or in cases (xii) and (xiii), since W^{ps} decreases in α_r.

Proposition 2 follows from combining Steps 1, 2, 3, 4. Q.E.D.

Technical Appendix

This Appendix provides the proof of Proposition 3.

Defining

$$\overline{\rho} \equiv \frac{(1-\nu)(S-c_l)(S-c_h)}{(1-\alpha_r)\,\Delta c\left[\nu(1-\alpha_r)\,\Delta c-(1-\nu)(S-c_h)\right]},$$

we first characterize the optimal regulatory policy for $0<\rho\leq 1$ in the following lemma.

Lemma 8 (optimal regulation with short term contracting) *Suppose $0<\rho\leq 1$. Then, the optimal two-period regulatory policy with short term contracting depends on the likelihood of the efficient firm, $\nu\in(0,1)$, as follows:*

(i) For $\nu<\overline{\nu}$ it coincides with the solution under long term contracting and consists of a first period full pooling menu $\gamma_{1l}=\gamma_{1h}=(1,c_h)$ with reporting strategies $\beta_l+\beta_h=1$, and a PBE outcome Γ with second period full pooling menus $\gamma_{2ll}=\gamma_{2lh}=\gamma_{2hl}=\gamma_{2hh}=(1,c_h)$.

(ii) For $\nu\in[\overline{\nu},\tilde{\nu})$, and for $\nu\geq\tilde{\nu}$ together with $\rho<\overline{\rho}\in(0,1]$, it consists of a first period full separation menu $\{\gamma_{1l},\gamma_{1h}\}=\{(1,c_l+\rho\Delta c),(0,0)\}$ with reporting strategies $\beta_l=\beta_h=1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll},\gamma_{2lh}\}=\{\gamma_{2hl},\gamma_{2hh}\}=\{(1,c_l),(1,c_h)\}$.

(iii) For $\nu\geq\tilde{\nu}$ and $\rho\geq\overline{\rho}\in(0,1]$ it consists of a first period partial separation menu $\{\gamma_{1l},\gamma_{1h}\}=\{(1,c_l),(0,0)\}$ with reporting strategies $\beta_l=\bar{\beta}_l(1)$ and $\beta_h=1$, and a PBE outcome Γ with second period full separation menus $\{\gamma_{2ll},\gamma_{2lh}\}=\{\gamma_{2hl},\gamma_{2hh}\}=\{(1,c_l),(0,0)\}$.

Proof of Lemma 8: Following the same approach as in the proof of Lemma 6, it is straightforward to show that the participation constraint of the efficient firm is slack, while the participation constraint of the inefficient firm is binding in equilibrium. We know from Lemma 3 that for $\nu\leq\overline{\nu}$ the solution to the regulatory problem coincides with the solution under long term contracting, and thus we can restrict attention to $\nu\geq\overline{\nu}$. The regulator's problem becomes

$$
\begin{aligned}
P'': \max_{\beta_l,\beta_h,q_{1l},q_{1h},t_{1l},t_{1h}} \quad & \nu\left\{\beta_l\left[Sq_{1l}-t_{1l}+\alpha_r\left(t_{1l}-c_lq_{1l}\right)+\rho W_l\left(\nu_{2l}\right)\right]\right. && (18)\\
& \left.+\left(1-\beta_l\right)\left[Sq_{1h}-t_{1h}+\alpha_r\left(t_{1h}-c_lq_{1h}\right)+\rho W_l\left(\nu_{2h}\right)\right]\right\}\\
& +\left(1-\nu\right)\left\{\beta_h\left[Sq_{1h}-t_{1h}+\alpha_r\left(t_{1h}-c_hq_{1h}\right)+\rho W_h\left(\nu_{2h}\right)\right]\right.\\
& \left.+\left(1-\beta_h\right)\left[Sq_{1l}-t_{1l}+\alpha_r\left(t_{1l}-c_hq_{1l}\right)+\rho W_h\left(\nu_{2l}\right)\right]\right\}\\
\text{s.t.} \quad & t_{1l}-c_lq_{1l}\geq t_{1h}-c_lq_{1h}+\rho\left(t_{2hl}-c_lq_{2hl}\right) && (19)\\
& t_{1h}-c_hq_{1h}\geq t_{1l}-c_hq_{1l} && (20)\\
& \beta_h\left(t_{1h}-c_hq_{1h}\right)+\left(1-\beta_h\right)\left(t_{1l}-c_hq_{1l}\right)=0, && (21)
\end{aligned}
$$

where the incentive constraints (19) and (20), which coincide with (7) and (8), hold with equality if $\beta_l \in (0,1)$ and $\beta_h \in (0,1)$, respectively. The binding condition (21) is equal to (13) with equality. We have to consider the following four cases: (I) $\beta_l = \beta_h = 1$; (II) $\beta_l \in (0,1)$, $\beta_h \in (0,1)$; (III) $\beta_l = 1$, $\beta_h \in (0,1)$; (IV) $\beta_l \in (0,1)$, $\beta_h = 1$.

Case I ($\beta_l = \beta_h = 1$). Standard arguments imply that (19) is binding, while (20) can be neglected. Substituting $t_{1h} = c_h q_{1h}$ from (21) and $t_{1l} = c_l q_{1l} + \Delta c q_{1h} + \rho \Delta c$ from (19) into (18), the regulator's objective becomes

$$
\nu\left\{Sq_{1l}-c_lq_{1l}-\left(1-\alpha_r\right)\Delta cq_{1h}+\rho\left[S-c_l-\left(1-\alpha_r\right)\Delta c\right]\right\}+\left(1-\nu\right)\left[Sq_{1h}-c_hq_{1h}+\rho\left(S-c_l\right)\right],
$$

which is maximized for $q_{1l} = 1$ and $q_{1h} = 0$. The regulator's payoff is

$$
V^{fs}\equiv\nu\left(1+\rho\right)\left(S-c_l\right)+\rho\left(1-\nu\right)\left(S-c_h\right)-\nu\rho\left(1-\alpha_r\right)\Delta c.
$$

Case II ($\beta_l \in (0,1), \beta_h \in (0,1)$). Note that both (19) and (20) are binding, which implies after some manipulation $q_{1l} - q_{1h} = \frac{\rho}{\Delta c}\left(t_{2hl} - c_l q_{2hl}\right)$. Moreover, from (21) we obtain $t_{1h} = c_h q_{1h}$ and $t_{1l} = c_h q_{1l}$. Two subcases arise.

(*i*) $\nu_{2h} < \overline{\nu}$. As $t_{2hl} - c_l q_{2hl} = \Delta c$ by Lemma 4, we have $q_{1l} = q_{1h} + \rho$, with $q_{1h} \in [0, 1-\rho]$ since $q_{1l}, q_{1h} \in [0,1]$. Substituting these conditions into (18) the regulator's payoff becomes

$$
\begin{aligned}
& \nu\left\{\beta_l\left[\left(S-c_h\right)\left(q_{1h}+\rho\right)+\alpha_r\left(q_{1h}+\rho\right)\Delta c+\rho\left(S-c_l\right)\right]\right.\\
& \left.+\left(1-\beta_l\right)\left[Sq_{1h}-c_hq_{1h}+\alpha_r\Delta cq_{1h}+\rho\left(S-c_l-\left(1-\alpha_r\right)\Delta c\right)\right]\right\}\\
& +\left(1-\nu\right)\left\{\beta_h\left[Sq_{1h}-c_hq_{1h}+\rho\left(S-c_h\right)\right]+\left(1-\beta_h\right)\left(S-c_h\right)\left(q_{1h}+\rho\right)\right\},
\end{aligned}
$$

which is maximized for $q_{1h} = 1 - \rho$ and $q_{1l} = 1$. Hence, the regulator's payoff is $\nu (S - c_h + \alpha_r \Delta c) + \nu \beta_l \rho (S - c_l) + (1 - \nu)(S - c_h) < V^{fs}$, so that subcase (i) is irrelevant.

(ii) $\nu_{2h} \geq \overline{\nu}$. As $t_{2hl} - c_l q_{2hl} = 0$ by Lemma 4, we have $q_{1l} = q_{1h}$, and the regulator's payoff becomes $Sq_{1l} - c_h q_{1l} + \nu \alpha_r \Delta c q_{1l} + \nu \rho (S - c_l)$, which is maximized for $q_{1l} = q_{1h} = 1$. The regulator's payoff is $S - c_h + \nu \alpha_r \Delta c + \nu \rho (S - c_l) \leq V^{fs}$, which implies that subcase (ii) is also irrelevant. Therefore, case II is irrelevant.

Case III ($\beta_l = 1, \beta_h \in (0,1)$). From the binding conditions (20) and (21), we have $t_{1h} = c_h q_{1h}$ and $t_{1l} = c_h q_{1l}$. Substituting these conditions into (18) yields after some manipulation

$$\nu \left[Sq_{1l} - c_h q_{1l} + \alpha_r \Delta c q_{1l} + \rho (S - c_l)\right] + (1 - \nu) \left\{\beta_h \left[Sq_{1h} - c_h q_{1h} + \rho (S - c_h) + (1 - \beta_h)(Sq_{1l} - c_h q_{1l})\right]\right\},$$

which is maximized for $q_{1l} = 1$. Since (19) implies $q_{1l} > q_{1h}$ and the regulator's objective is linear in q_{1h}, we must have $q_{1h} = 0$ in equilibrium. The regulator's payoff is $S - c_h + \nu \alpha_r \Delta c + \nu \rho (S - c_l) - (1 - \nu) \beta_h (1 - \rho)(S - c_h) < V^{ps}$, so that case III is irrelevant.

Case IV ($\beta_l \in (0,1), \beta_h = 1$). Note that the binding conditions (19) and (21) imply $t_{1h} = c_h q_{1h}$ and $t_{1l} = c_l q_{1l} + \Delta c q_{1h} + \rho (t_{2hl} - c_l q_{2hl})$. Two subcases arise.

(i) $\nu_{2h} < \overline{\nu}$. As $t_{2hl} - c_l q_{2hl} = \Delta c$ by Lemma 4, (18) becomes

$$\begin{aligned}
&\nu \left\{\beta_l \left[Sq_{1l} - c_l q_{1l} - \Delta c q_{1h} - \rho \Delta c + \alpha_r \Delta c (q_{1h} + \rho) + \rho (S - c_l)\right]\right. \\
&\left. + (1 - \beta_l)\left[Sq_{1h} - c_h q_{1h} + \alpha_r \Delta c q_{1h} + \rho (S - c_l - (1 - \alpha_r) \Delta c)\right]\right\} \\
&+ (1 - \nu)\left[Sq_{1h} - c_h q_{1h} + \rho (S - c_h)\right],
\end{aligned}$$

which is maximized for $q_{1l} = 1$. Summing (19) and (20) implies $q_{1l} > q_{1h}$. Since the regulator's objective is linear in q_{1h}, we must have $q_{1h} = 0$ in equilibrium. The regulator's payoff becomes $\nu \rho (S - c_h + \alpha_r \Delta c) + \nu \beta_l (S - c_l) + \rho (1 - \nu)(S - c_h) < V^{fs}$ so that subcase (i) is irrelevant.

(ii) $\nu_{2h} \geq \overline{\nu}$. As $t_{2hl} - c_l q_{2hl} = 0$ by Lemma 4, (18) becomes

$$\begin{aligned}
&\nu \left\{\beta_l \left[Sq_{1l} - c_l q_{1l} - \Delta c q_{1h} + \alpha_r \Delta c q_{1h} + \rho (S - c_l)\right]\right. \\
&\left. + (1 - \beta_l)\left[Sq_{1h} - c_h q_{1h} + \alpha_r \Delta c q_{1h} + \rho (S - c_l)\right]\right\} + (1 - \nu)(Sq_{1h} - c_h q_{1h}) \\
\text{s.t.} \quad &\beta_l \leq \overline{\beta}_l(1) \equiv \widehat{\beta}_l(\alpha_r),
\end{aligned}$$

which is maximized for $q_{1l} = 1$. Summing (19) and (20) implies $q_{1l} \geq q_{1h}$. For $q_{1l} = q_{1h}$, (20) also holds with equality, and the solution is derived in case II. If (20) is slack at the optimum, i.e., $q_{1l} > q_{1h}$, then the linearity of the regulator's objective in q_{1h} implies $q_{1h} = 0$.[21] The regulator's payoff becomes after some manipulation $\nu(\beta_l + \rho)(S - c_l)$, which increases with β_l, so that $\beta_l = \overline{\beta}_l(1) \equiv \widehat{\beta}_l(\alpha_r)$ is optimal. The payoff of the regulator is

$$V^{ps} \equiv \nu(S - c_l)(\widehat{\beta}_l(\alpha_r) + \rho) = \nu(S - c_l)\left[1 + \rho - \frac{(1-\nu)(S - c_h)}{(1-\alpha_r)\nu\Delta c}\right].$$

Standard computations yield $V^{ps} \geq V^{fs}$ if and only if $\nu \geq \widetilde{\nu}$ and $\rho \geq \overline{\rho} \in (0, 1]$.

The second period contract menus $\{\gamma_{2ll}, \gamma_{2lh}\}$ and $\{\gamma_{2hl}, \gamma_{2hh}\}$ follow from Lemma 4. Q.E.D.

Defining

$$\rho^*(\alpha_c) \equiv \frac{(1-\nu)(S - c_h)(S - c_l)}{\Delta c[\nu(1-\alpha_c)\Delta c - (1-\nu)(S - c_h)]},$$

we are now in a position to show the proof of Proposition 3, which goes through the following steps.

Step 1: Suppose $\nu < \bar{\nu}(\alpha_c)$. Then, $\alpha_r = \alpha_c$ is optimal, because $\alpha_r = \alpha_c$ induces the regulator to implement the contract in Lemma 3, which coincides with Congress' optimal long term contract.

Step 2: Suppose $\nu \geq \bar{\nu}(\alpha_c)$. We show that Congress prefers $\alpha_r = \alpha_c$ to any $\alpha_r > \alpha_c$. To see this, note first that $\overline{\rho}(.)$ is strictly increasing in α_r. Moreover, $\overline{\nu}$ and $\widetilde{\nu}$ are also strictly increasing in α_r. Hence, we have either the ordering $\bar{\nu}(\alpha_c) < \overline{\nu}(\alpha_r) < \widetilde{\nu}(\alpha_c) < \widetilde{\nu}(\alpha_r)$ or the ordering $\bar{\nu}(\alpha_c) < \widetilde{\nu}(\alpha_c) \leq \overline{\nu}(\alpha_r) < \widetilde{\nu}(\alpha_r)$. Depending on $\nu \in (0, 1)$, we distinguish the following four cases under the first ordering:

(i) For $\nu \in [\overline{\nu}(\alpha_c), \overline{\nu}(\alpha_r))$ it follows from Lemma 8 that $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fc} = \nu(1+\rho)(S - c_l) + \rho(1-\nu)(S - c_h) - \nu\rho(1-\alpha_r)\Delta c - (1+\rho)(S - c_h + \nu\alpha_c\Delta c) \geq 0$, where the inequality holds since $\nu \geq \overline{\nu}(\alpha_c)$.

(ii) For $\nu \in [\overline{\nu}(\alpha_r), \widetilde{\nu}(\alpha_c))$ it follows from Lemma 8 that $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fs} = 0$.

(iii) For $\nu \in [\widetilde{\nu}(\alpha_c), \widetilde{\nu}(\alpha_r))$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fs} = 0$; (b) if $\rho \geq \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{fs} = \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c) + \rho\right) - [\nu(1+\rho)(S - c_l) + \rho(1-\nu)(S - c_h) - \nu\rho(1-\alpha_r)\Delta c] \geq 0$, where the inequality holds since $\rho \geq \overline{\rho}(\alpha_c)$.

(iv) For $\nu \geq \widetilde{\nu}(\alpha_r)$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fs} = 0$; (b) if $\rho \in [\overline{\rho}(\alpha_c), \overline{\rho}(\alpha_r))$, then $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{fs} \geq 0$, where the inequality stems from case (iii(b)); (c) if $\rho \geq \overline{\rho}(\alpha_r)$, then $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{ps}(\alpha_r) = \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c) + \rho\right) - \nu(S - c_l)\left(\hat{\beta}_l(\alpha_r) + \rho\right) > 0$, where the inequality holds since $\hat{\beta}_l(.)$ is strictly decreasing.

The second ordering yields the following four cases:

(v) For $\nu \in [\bar{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$ it follows from case (i) that $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fc} \geq 0$.

(vi) For $\nu \in [\widetilde{\nu}(\alpha_c), \overline{\nu}(\alpha_r))$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fc} \geq 0$, where the inequality stems from case (i); (b) if $\rho \geq \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{fc} = \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c) + \rho\right) - (1+\rho)(S - c_h + \nu\alpha_c\Delta c) > 0$, where the inequality holds since $\nu \geq \tilde{\nu}(\alpha_c)$.

(vii) For $\nu \in [\overline{\nu}(\alpha_r), \widetilde{\nu}(\alpha_r))$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{fs} - W^{fs} = 0$; (b) if $\rho \geq \overline{\rho}(\alpha_c)$, then $W(\alpha_c) - W(\alpha_r) = W^{ps}(\alpha_c) - W^{fs} \geq 0$, where the inequality stems from case (iii(b)).

(viii) For $\nu \geq \widetilde{\nu}(\alpha_r)$ it follows from case (iv) that $W(\alpha_c) - W(\alpha_r) \geq 0$.

Step 3: If $\nu > \nu^*(\alpha_c)$ and $\rho > \rho^*(\alpha_c)$, Congress strictly prefers $\alpha_r = 0$ to $\alpha_r = \alpha_c$. Otherwise, Congress prefers $\alpha_r = \alpha_c$ to $\alpha_r = 0$. To see this, note first that we have either the ordering $\bar{\nu}(0) < \bar{\nu}(\alpha_c) < \widetilde{\nu}(0) < \widetilde{\nu}(\alpha_c)$ or the ordering $\bar{\nu}(0) < \widetilde{\nu}(0) \leq \overline{\nu}(\alpha_c) < \widetilde{\nu}(\alpha_c)$. The first ordering reduces to $\bar{\nu}(\alpha_c) < \widetilde{\nu}(0) < \widetilde{\nu}(\alpha_c)$ and the second ordering reduces to $\overline{\nu}(\alpha_c) < \widetilde{\nu}(\alpha_c)$ since Step 1 implies that Congress finds it optimal to set $\alpha_r = \alpha_c$ for $\nu < \bar{\nu}(\alpha_c)$. Depending on $\nu \in (0, 1)$, we distinguish the following three cases under the first ordering:

(ix) For $\nu \in [\bar{\nu}(\alpha_c), \widetilde{\nu}(0))$ it follows from Lemma 8 that $W(0) - W(\alpha_c) = W^{fs} - W^{fs} = 0$.

(x) For $\nu \in [\widetilde{\nu}(0), \widetilde{\nu}(\alpha_c))$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(0)$, then $W(0) - W(\alpha_c) = W^{fs} - W^{fs} = 0$; (b) if $\rho \geq \overline{\rho}(0)$, then $W(0) - W(\alpha_c) = W^{ps}(0) - W^{fs} = \nu(S - c_l)\left(\hat{\beta}_l(0) + \rho\right) - [\nu(1+\rho)(S - c_l) + \rho(1-\nu)(S - c_h) - \nu\rho(1-\alpha_r)\Delta c] > 0$ if and only if $\rho > \rho^*(\alpha_c)$ with $\rho^*(\alpha_c) \in [\overline{\rho}(0), 1)$ for $\nu > \nu^*(\alpha_c) \in (\widetilde{\nu}(0), \widetilde{\nu}(\alpha_c))$.

(xi) For $\nu \geq \widetilde{\nu}(\alpha_c)$ it follows from Lemma 8 that (a) if $\rho < \overline{\rho}(0)$, then $W(0) - W(\alpha_c) = W^{fs} - W^{fs} = 0$; (b) if $\rho \in [\overline{\rho}(0), \overline{\rho}(\alpha_c))$, then $W(0) - W(\alpha_c) = W^{ps}(0) - W^{fs} > 0$ if and only if $\rho > \rho^*(\alpha_c)$ with $\rho^*(\alpha_c) \in [\overline{\rho}(0), \overline{\rho}(\alpha_c))$, where the inequality stems from case (x(b)); (c) if $\rho \geq \overline{\rho}(\alpha_c)$, then $W(0) - W(\alpha_c) = W^{ps}(0) - W^{ps}(\alpha_c) = \nu(S - c_l)\left(\hat{\beta}_l(0) + \rho\right) - \nu(S - c_l)\left(\hat{\beta}_l(\alpha_c) + \rho\right) > 0$, where the inequality holds since $\hat{\beta}_l(.)$ is strictly decreasing.

The second ordering yields the following two cases:

(xii) For $\nu \in [\overline{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$ it follows from case (x) that $W(0) - W(\alpha_c) > 0$ if and only if $\rho > \rho^*(\alpha_c)$ with $\rho^*(\alpha_c) \in [\overline{\rho}(0), 1)$ for $\nu > \nu^*(\alpha_c) \in (\overline{\nu}(\alpha_c), \widetilde{\nu}(\alpha_c))$.

(xiii) For $\nu \geq \widetilde{\nu}(\alpha_c)$ it follows from case (xi) that $W(0) - W(\alpha_c) > 0$ if and only if $\rho > \rho^*(\alpha_c)$.

Step 4: Congress prefers either $\alpha_r = 0$ or $\alpha_r = \alpha_c$ to any $\alpha_r \in (0, \alpha_c)$. To see this, substitute $\alpha_r = 0$

with $\alpha_r \in (0, \alpha_c)$ in the Step 3. This reduces welfare in cases (x(b)), (xi(b)) and (xi(c)), or (xii) and (xiii), since W^{ps} decreases in α_r, while it does not affect welfare in all other cases.

The result in Proposition 3 follows from combining Steps 1, 2, 3, 4. Q.E.D.

Footnotes

[1]For a deeper discussion on diverse regulatory commitment problems, we refer to Levy and Spiller (1996) and Newbery (1999).

[2]Quotes with emphasis added are taken directly from Ofgem's website http://www.ofgem.gov.uk.

[3]See http://www.ferc.gov/about/about.asp.

[4]In a Baron and Myerson framework with two types and no commitment, Drugov (2010) also obtains analytical results. Since in his model production takes place at most once, the commitment problem however does not lead to ratchet effects. He also points out that analytical tractability is lost in his model with a continuum of types (p. 600).

[5]Baron (1988) shows that, if there is a strong electoral connection between the benefits delivered to constituents and their electoral support, the legislature will choose a welfare standard which assigns a greater weight to consumer surplus than firm profits. However, the paper does not address any commitment problem, and therefore the legislature does not have any incentive to distort the regulatory mandate from the voting outcome.

[6]Short term contracting is not the only form of limited commitment explored in the literature on optimal regulation (for a review on this topic, we refer to Armstrong and Sappington 2007). Laffont and Tirole (1990) assume that the regulator can offer the firm a long term contract but both parties may renegotiate the original contract if they agree to do so. Renegotiation presumes that the regulator can credibly promise to deliver future rents to the firm but cannot commit to a specific policy that induces ex post inefficiencies. Baron and Besanko (1987) introduce a different form of limited commitment, labeled as "fairness", which requires the firm to fulfill the terms of future policies if they are "fair" in the light of the information disclosed in earlier periods.

[7]We refer to a Technical Appendix available online for the proof of Proposition 3.

[8]In modern regulatory practices, the (possibly long term) tenure of an independent regulator is usually specified by statutory or legal provisions, and therefore we assume that the weight α_r is time invariant.

[9]This result follows because if $\beta_i = 0$ then $\beta_l + \beta_h \geq 1$ implies $\beta_j = 1$, so that the contract γ_{1j} is picked with probability 1 while γ_{1i} is never picked. This is, however, equivalent to a contract menu with $\gamma_{1j} = \gamma_{1i}$ which allows the firm to randomize such that $\beta_l + \beta_h = 1$ with $\beta_l > 0$ and $\beta_h > 0$.

[10]Figuring prominently in Laffont and Tirole (1993), this mutual inconsistence of incentive constraints results in analytical intractabilities in dynamic extensions of the Laffont and Tirole (1986) regulation model so that only numerical simulations are available even if one restricts attention to simple settings with only two cost types. As it turns out, our dynamic extension of the Baron and Myerson (1982) regulation model puts enough structure on the problem to obtain analytical solutions, while still being rich enough to illustrate the relevant effects of short term contracting.

[11]To see $\tilde{\nu} > \bar{\nu}$, note that $\tilde{\nu} \equiv \frac{(S-c_h)[S-c_l+(1-\alpha_r)\Delta c]}{(S-c_h)[S-c_l+(1-\alpha_r)\Delta c]+(1-\alpha_r)^2(\Delta c)^2} = \frac{(S-c_h)[S-c_l+(1-\alpha_r)\Delta c]}{(S-c_h)(S-c_l)+[S-c_h+(1-\alpha_r)\Delta c](1-\alpha_r)\Delta c} > \frac{(S-c_h)[S-c_l+(1-\alpha_r)\Delta c]}{[S-c_h+(1-\alpha_r)\Delta c](S-c_l)+[S-c_h+(1-\alpha_r)\Delta c](1-\alpha_r)\Delta c} = \frac{(S-c_h)[S-c_l+(1-\alpha_r)\Delta c]}{[S-c_h+(1-\alpha_r)\Delta c][S-c_l+(1-\alpha_r)\Delta c]} = \frac{(S-c_h)}{S-c_h+(1-\alpha_r)\Delta c} \equiv \bar{\nu}$.

[12]To see $\nu^*(\alpha_c) > \overline{\nu}(\alpha_c)$, note that $\nu^*(\alpha_c) \equiv \frac{(S-c_h)(S-c_l+\Delta c)}{(S-c_h)(S-c_l+\Delta c)+(1-\alpha_c)(\Delta c)^2} = \frac{(S-c_h)(S-c_l+\Delta c)}{(S-c_h)(S-c_l)+[S-c_h+(1-\alpha_c)\Delta c]\Delta c} > \frac{(S-c_h)(S-c_l+\Delta c)}{[S-c_h+(1-\alpha_c)\Delta c](S-c_l)+[S-c_h+(1-\alpha_c)\Delta c]\Delta c} = \frac{(S-c_h)(S-c_l+\Delta c)}{[S-c_h+(1-\alpha_c)\Delta c](S-c_l+\Delta c)} = \frac{(S-c_h)}{S-c_h+(1-\alpha_c)\Delta c} = \bar{\nu}(\alpha_c)$.

[13]For reasons of plausibility, we assume that a regulatory mandate with a negative weight on profits is unfeasible. We note that such a mandate would reduce the mismatch problem even further. Yet, also with a negative weight, Congress cannot fully mitigate ratchet effects so that she always faces a cost-benefit trade-off concerning strategic delegation and only in the extreme, when the weight goes to minus infinity, the ratchet problem disappears.

[14]This is consistent with the results of Laffont and Tirole (1993).

[15]Note that $\rho^*(\alpha_c) \in (0,1)$ for $\nu > \nu^*(\alpha_c)$.

[16]Note that for $\nu = \overline{\nu}$ the solution is not unique and any $q_h \in [0,1]$ is optimal. We pick the solution $q_h = 0$, because only this choice ensures the existence of an optimal contract in the dynamic regulatory game.

[17]That a non-degenerate random contract is suboptimal follows directly from Strausz (2006).

[18]Notice that (17) is satisfied at the optimum.

[19]If $\beta_h = 1$ is optimal and at the same time a solution to P', then the regulator's optimal payoff is actually V^p.

[20]From the first-order condition for q_{1h} this is the case if and only if $\beta_l \geq \widetilde{\beta}_l$, where $\widetilde{\beta}_l \equiv 1 - \frac{\nu(1-\alpha_r)\Delta c-(1-\nu)(S-c_h)}{\nu(S-c_l)}$. Note that $\widetilde{\beta}_l \leq \bar{\beta}_l(1)$ for $\nu \geq \widetilde{\nu}$, so that the interval $\left[\widetilde{\beta}_l, \bar{\beta}_l(1)\right]$ is non-empty.

[21]From the first-order condition for q_{1h} we find that $q_{1h} = 0$ is optimal if and only if $\beta_l \geq \widetilde{\beta}_l^{'} \equiv \frac{S-c_h+\nu\alpha_r\Delta c}{\nu(S-c_l)}$. Note that $\widetilde{\beta}_l^{'} \leq \widehat{\beta}_l\left(\alpha_r\right)$ for $\nu \geq \widetilde{\nu}$, so that the interval $\left[\widetilde{\beta}_l^{'}, \widehat{\beta}_l\left(\alpha_r\right)\right]$ is non-empty.

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