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Revolving doors and the optimal tolerance for agency collusion

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In this article, I study how the presence of a revolving door and potential collusion between a regulator and a regulated firm affect the regulator's performance incentives. Contrary to the conventional wisdom, these seemingly undesirable features of the regulatory system may serve the interests of the government because (i) the regulator's efforts to enhance her industry qualifications may have a complementary effect on her regulatory performance and (ii) the regulator may become more aggressive in regulation so as to signal her industry qualifications to the firm. Collusion between a regulator and a firm also can be beneficial because a regulator may increase her monitoring effort in order to increase the chance of achieving a profitable side contract with the firm, and side-contracting may not always succeed.

1. Introduction

■ It is commonly recognized that there is a revolving door connecting government regulatory agencies with the firms that they regulate. Stories of government employees passing through this revolving door are numerous and cover a wide range of agencies and firms. For example, procurement officials at the Department of Defense (DoD) often obtain highly profitable postretirement positions at defense contracting firms.[1] Regulators from federal commissions who supervise antitrust actions often retire to counsel regulated firms on how to fight the antitrust actions. Private accounting firms offer high salaries to lure IRS officers who have inside knowledge of government auditing procedures. Some cases are more subtle than these. Rather than becoming employed by a regulated firm, a federal retiree may form a consulting firm or join a law partnership that contracts with the regulated firm.[2] Despite public concern over the

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[1] Of the 1,406 former DoD officials and retired officers known to have transferred during FY1969–1973, 379 (27%) passed through revolving doors (Reed, 1975). An extensive study conducted by Adams (1982) shows that of 487 total civilian transfers between DoD and NASA and the eight major defense contractors during 1970–1979, 119 employees fall into the same category.

[2] In a typical usage, the revolving door refers to a two-sided personnel movement; here, I focus on the more problematic side, in which a regulatory agent transfers from public service to private industry.

potential conflicts of interest created by this situation, revolving doors largely remain open.[3]

This revolving door appears to be an inescapable consequence of the regulatory agency's need for specialized knowledge and industry-specific expertise. These forms of human capital are valuable to the firms as well as to the agencies. Regulators need the human capital for good regulatory performance. Regulated firms need regulators' unique expertise to minimize the cost of complying with regulations. The existence of revolving doors can affect the performance of a regulator in two different ways. *Ex ante,* it changes her incentives to acquire regulatory expertise. *Ex post,* i.e., after expertise has been acquired, it alters her willingness to pursue the objectives of the government against those of the firm.

So far, most atttention has been focused on the *ex post* performance incentives of regulators. Public concern is phrased in terms of conflict of interest issues. One major hypothesis is that the anticipation of future job opportunities in regulated firms will make regulators less aggressive in administering regulatory policy. In other words, revolving doors make it more likely that regulators will collude with firms. Fox (1974, p. 461) observes a situation which leads to unconscious favoritism:

> The availability of jobs in industry can have a subtle, but debilitating effect on an officer's performance during his tour of duty . . . If he takes too strong a hand, . . . he might be damaging his opportunity for a second career following retirement. Positions are offered to officers who have demonstrated their appreciation for industry's particular problems and commitments.

Favoritism in a procurement situation can mean that procurement officers accede too readily to cost overruns, production delays, and performance downgrading. In a regulatory setting, favoritism could entail a food inspector overlooking a violation of law by a food company, which could endanger public health.

Notably absent in this standard argument, however, is any consideration of the regulator's *ex ante* performance incentives. How might revolving doors affect a regulator's incentive for acquiring monitoring skills, learning industry-specific knowledge, and mastering existing regulatory rules? These kinds of investments are often unobservable, unverifiable, and therefore difficult to motivate through explicit contractual arrangements. Nor can career markets be relied upon to provide the necessary incentives. Because of its specific nature, regulatory human capital is in general not transferable outside the specific industries with which regulators have experience. In fact, the only practical source of the incentives to build such capital may be the industries regulators oversee: not only do these industries value the regulator's expertise, but they are often in the best position to evaluate it. When this is the case, restricting revolving doors may have the undesirable effect of discouraging regulators from collecting the human capital needed for effective regulation.

The objective of this article is to formally analyze the effect of revolving doors on the regulator's *ex ante* as well as *ex post* incentives. To this end, I develop a three-tier principal-agent model similar to Tirole (1986), in which the government (top tier) assigns a regulator (middle tier) to monitor the privately realized cost parameter of a firm (bottom tier). To examine *ex ante* incentives, I additionally assume that the monitoring requires a costly investment in human capital on the part of the regulator.

Using the framework of a three-tier hierarchy, I consider three different circumstances in which revolving doors may have interesting effects. The first two cases rule out the possibility of collusion, which allows us to focus on the way the regulator's

[3] Several federal statutes (18 U.S.C. 203, 205, 207, 209, and 281 and 37 U.S.C. 801 (c)) prohibit federal employees and military officials from representing any other party before agencies of the federal government. Also, a reporting requirement can serve as a check if enforced properly. As Reed (1975) notes, however, these statutes have not been firmly enforced.

concern over industry qualifications affects her monitoring performance. When the revolving door is open, the regulator has a greater incentive to acquire human capital that can enhance her qualifications for a postagency job at the firm. Such human capital could be intimate knowledge of regulatory procedures or simply accumulated influences over the agencies.

In the first case considered, the firm observes the regulator's qualifications. In this case, depending on the nature of the qualifications, an effort to enhance them may promote or retard the regulator's monitoring performance. If the regulator contemplates selling technical or regulatory expertise, opening the revolving doors will have a positive effect on the regulator's performance. If, on the other hand, the regulator is hired by the firm for her ability to influence the agency, the revolving door will simply divert the regulator's effort away from monitoring, so in this case barring revolving doors will be optimal.

The second case concerns a signalling effect. When the regulator's industry qualifications are not observable to the industry, aggressive monitoring may become an effective way to signal her qualifications for the industry job. The government benefits from the added monitoring incentives that result from the signalling effect. Opening revolving doors allows us to fully exploit the beneficial signalling effect.

For the last scenario, I introduce the possibility of collusion between the regulator and the firm. Tirole (1986) claims that agency collusion is essentially detrimental to the principal and that organizations are designed in such a way that the likelihood of agency collusion is minimized.[4] In contrast to his approach, I look for circumstances where agency collusion is beneficial and optimally tolerated by the principal. By looking at a class of side contracts with limited commitment, I find that agency collusion may provide valuable incentives for noncontractable monitoring effort by the regulator.

This approach has some advantages. Using the approach, we can, for instance, explain why seemingly undesirable cliques, or colluding groups, are sometimes optimally tolerated; why some organizations are more lenient than others toward corruption by agents; and what determines the optimal degree of tolerance for agency collusion. In fact, I show the possibility that collusion is desirable even when it is costless to deter. This result conforms to some stylized facts. For example, organizations often appear to protect cliques by punishing whistleblowers, although rewarding them, one would think, could lead to a better outcome by destroying agency collusion.[5]

This article is not the first to consider the possibility that the principal tolerates agents' side contracting. Itoh (1993) and Holmström and Milgrom (1990) show that side contracting between risk-averse agents results in an efficient risk allocation and thus allows the principal to save on risk compensation. Kofman and Lawarree (1991) study the optimality of allowing collusion in a model similar to that in this article, but they do not explore agents' investment incentives. Salant (1995) shows how the revolving door can promote a regulated firm's unverifiable investment. His conclusion is similar to that in this article, but his model does not consider the possibility of collusion between the regulator and the firm.

I organize the rest of this article as follows. In Section 2, I describe the model. In Section 3, I use the model to study the effects of revolving doors. Section 4 analyzes the effect of agency collusion. Section 5 concludes.

[4] More precisely, it is the threat of collusion, rather than actual collusion, that is detrimental. Due to the equivalence principle, the principal, without loss of generality, offers collusion-proof contracts.

[5] Glazer and Glazer (1989) document the episodes of blacklisting, dismissal, transfer, and personal harassment as ways to punish whistleblowers.

2. Model

■ The model is structured as a three-tier hierarchy consisting of a principal, a regulator, and a firm. The principal could represent Congress or a regulatory commission issuing regulations regarding the firm's production project.[6] Alternatively, the principal is a government agency interested in procuring a good from the firm. The objective of the principal is to maximize net benefit from the procurement, or consumers' surplus in the regulatory setting.[7] The firm has a simple zero-one production decision: it produces one unit of output or nothing. I assume throughout this article that, at the optimum, the principal prefers that the firm produce one unit. The regulator is an agent in charge of carrying out the regulations. The lack of expertise and time on the part of the principal explains the need for delegation of the regulatory authority by the principal. The principal exercises control by designing a wage scheme for the regulator and a procurement contract for the firm. The principal is assumed to be able to commit to a contract in his best interests. Given that cancelling the project is not optimal, the principal minimizes his expected payments to the agents.

The need for oversight arises because of the inherent informational disadvantage the principal has with respect to the firm. The firm privately observes the realized cost of the project, whereas the principal knows only the distribution of costs. This informational asymmetry allows the firm to command informational rents. The rents can be interpreted as managerial slack or, in the procurement setting, avoidable cost overruns. The role of the regulator is to monitor the realized cost of the project, which would otherwise be known only to the firm, and to report to the principal. One could imagine a cost analyst employed by DoD to detect, and thereby help prevent, unnecessary cost overruns of a defense project. The enhanced informational position of the principal resulting from the regulator's report can mitigate the firm's strategic motive to pad costs. Thus, when properly motivated to report truthfully, the regulator can help reduce the informational rents accruing to the firm. Effective monitoring, however, is costly for the regulator, requiring her to expend time and effort needed in gaining industry-specific knowledge and learning the legal and economic details of existing regulatory rules.

The central concern for the principal is how to provide monitoring incentives to the regulator and at the same time induce truthful reporting from both the regulator and the firm. As demonstrated by Tirole (1986), the *ex post* incentive problem of inducing truthful reporting from both agents can be especially acute when the regulator colludes with the firm. The implication of agency collusion is studied in Section 4. In Section 3 I rule out the possibility of collusion to focus on the *ex ante* incentive problem.

The model uses the following notation:

w = wage payment to the regulator;

t = transfer to the firm;

x = production assignment to the firm, $x \in \{0, 1\}$;

[6] In practice, Congress passes enabling legislation, and regulatory commissions issue regulations. The Congress would be close to the description of the principal in this article if the legislation were specific, whereas the commission would be more appropriate if the legislation left a lot of room for regulatory rulemaking to the commission.

[7] While this assumption is most suitable for many proconsumer regulatory agencies, it is consistent with any approach that discounts the producer's surplus relative to the consumer's surplus. One classical argument for such discounting is the distortionary taxation required for raising public money (see Laffont and Tirole, 1986).

k = the extent to which the revolving door is open, measured by the probability of postagency employment ($k \in [0, 1]$);[8]

p = monitoring performance, measured by the probability that the regulator observes the firm's cost realization ($p \in [0, 1]$);

q = the regulator's qualifications for postagency employment at the firm, measured by the probability that the regulator is hired by the firm, provided that the revolving door is open ($q \in [0, 1]$);

v = value of the postagency employment; and

$\psi(p, q)$ = disutility of effort.

The sequence of events, depicted in Figure 1, is as follows. First, the principal picks k, or the extent to which the revolving door is open, by altering various organizational instruments such as employment arrangement, allocation of authority, and ethics legislation. Presumably, various ethics laws (summarized in footnote 3) against government retirees working for regulated firms are only partially effective. As noted in Section 1, a government employee can indirectly revolve by joining a law/consulting firm servicing the firm she used to regulate or even a new subsidiary of the regulated firm. The government varies the size of k by changing the scope of ethics laws with respect to these gray areas.

Simultaneously, the principal offers a contract specifying a wage payment, w, to the regulator and a production contract specifying production assignment, x, and a transfer payment, t, to the firm. These contracts can be made contingent on the information (including reports from both agents) that becomes available to the principal.

Second, the regulator picks the level of monitoring performance, p, and collects her industry qualifications, q. The industry qualifications are specific in the sense that they can be collected only through employment at the agency. I consider two cases. In the first case considered in the first subsection of Section 3, the industry qualifications are skills that regulators can acquire through development of relevant human capital. In the second subsection of Section 3, I consider the opposite case, in which the collected qualifications are related to regulators' innate abilities.

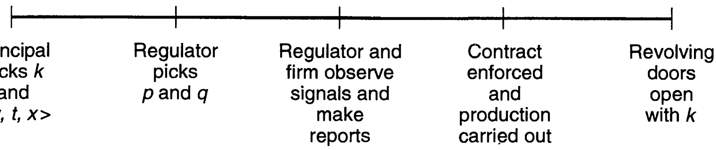
It is assumed that, after her term, the regulator is hired by the firm with probability q, if the revolving door is open (i.e., $k > 0$). The expected value of postagency employment for the regulator is kqv, where v represents expected rents earned from the industry job. The efforts cause disutility of $\psi(p, q)$ to the regulator. I assume that ψ is twice continuously differentiable, increasing in both arguments, and convex. Furthermore, to ensure an interior solution, I assume $\psi_1(0, \cdot) = \psi_2(\cdot, 0) = \psi(0, 0) = 0$, $\lim_{p\to1}\psi_1(p, \cdot) = \infty$, and $\lim_{q\to1}\psi_2(\cdot, q) = \infty$.

Third, both the firm and the regulator observe signals (s_F, s_R) about the firm's cost of carrying out the project and make reports (r_F, r_R) to the principal. The firm's signal is completely informative. It draws a correct cost realization $s_F = c \in [\underline{c}, \bar{c}]$ according to a well-defined distribution function $F(\cdot)$, where $0 < \underline{c} < \bar{c}$. The information content of the regulator's signal depends on the level of monitoring effort p that she previously picked. With probability p the regulator observes correct information about the firm's cost (i.e., $s_R = s_F$), and with probability of $1 - p$ she observes nothing, an event denoted by n.

Finally, the contract is executed; the firm receives a transfer and carries out the project, and the regulator receives a wage payment. Later, the revolving door is opened with probability k.

[8] Later, k is used to describe the extent to which collusion between the regulator and the firm is allowed.

FIGURE 1



The following assumptions are made.

Assumption 1. The regulator and the firm have limited liability (denoted by zero reservation payoff).

Assumption 2. The regulator's observation is common knowledge between the regulator and the firm but unknown to the principal.

Assumption 3. The regulator's information is hard in the sense that the regulator's informative signal (except for the null signal) is verifiable to the principal.

Assumption 1 implies that the principal cannot impose an unlimited penalty on the regulator and the firm; therefore, he must reward the agents to provide incentives. Without this assumption, the principal's incentive problem would be trivial, because he could induce truthful reporting at zero expenditure by imposing a severe enough penalty for any report indicating that one of the agents is lying. Assumption 2 states that both the regulator and the firm learn, as common knowledge, whether the regulator has observed the correct signal. It implies that when one agent makes a report he knows whether his report will be substantiated by the truthful report of the other agent. The main implication of Assumption 3 is that the regulator cannot fabricate a false signal: the only way she can lie is to conceal the information she has observed.[9]

The model will be modified in several ways to focus on different aspects of the revolving door, but the basic framework will remain unchanged throughout this article.

3. Incentive effects of the revolving door

■ **Effect of qualifications enhancing effort.** The principal designs a contract (w, t, x) contingent on both agents' reports (r_F, r_R). By the revelation principal (Myerson, 1982), there is no loss of generality in restricting attention to direct revelation mechanisms by which both agents report truthfully about their types. The principal faces the following problem:

$$\min_{w(\cdot,\cdot),t(\cdot,\cdot),k,p,q} \quad C \equiv pE\big[t(c,\, c) + w(c,\, c)\big] + (1 - p)E\big[t(c,\, n) + w(c,\, n)\big] \qquad \text{(P1)}$$

subject to

$$\pi(c,\, s_R) \equiv t(c,\, s_R) - cx(c,\, s_R) \geq t(\tilde{c},\, s_R) - cx(\tilde{c},\, s_R) \qquad \text{(EP-IC)}$$

$$\text{where } s_R = c,\, n,\ \forall c,\, \tilde{c} \in [\underline{c},\, \overline{c}]$$

$$w(c,\, c) \geq w(c,\, n) \qquad \text{for } \forall c \in [\underline{c},\, \overline{c}]$$

[9] If the regulator's information is unverifiable, the outcomes of Section 3 are still sustained as an equilibrium, but there is another equilibrium in which both agents lie and report the maximum feasible cost.

$$(p, q) \in \operatorname{argmax} pE\left[w(c, c)\right] + (1 - p)E\left[w(c, n)\right] - \psi(p, q) + kvq \tag{EA-IC}$$

$$w(\cdot, \cdot) \geq 0,\ t(\cdot, \cdot) - cx(\cdot, \cdot) \geq 0\ \forall c \in [\underline{c}, \overline{c}] \tag{LL}$$

$$x(c, c) = 1\ \forall c \in [\underline{c}, \overline{c}]. \tag{NC}$$

In (P1), the principal minimizes expected expenditures subject to the constraints that both agents tell the truth *ex post* (EP-IC), that the regulator picks p and q in her best interest (EA-IC), that neither agent can sustain a loss (LL), and that cancelling the project is not optimal (NC). (EP-IC) ensures that truthful reporting is induced as a Nash equilibrium. Due to the hardness of the signal, the constraint for the regulator requires that concealing information be unprofitable (because fabricating false information is automatically prevented). (EA-IC) recognizes the regulator's concern over postagency employment. As will be clear, it is through this constraint that the revolving door affects the regulator's performance. The next lemma characterizes an optimal mechanism.

Lemma 1. (P1) has a solution, and the following are its characteristics.

(i) $t(c, c) = c$, $t(c, n) = \overline{c}$ for $c \in [\underline{c}, \overline{c}]$; and $t(\cdot, \cdot) = 0$ otherwise;

(ii) $w(\cdot, c) = w^*$, $w(\cdot, n) = 0$ for $c \in [\underline{c}, \overline{c}]$; and

(iii) $0 < w^* < R \equiv E[R(c)]$, where $R(c) \equiv \overline{c} - c$.

The proof of Lemma 1, along with most of the remaining proofs, is contained in the Appendix.

According to (i), the firm commands informational rents if and only if monitoring fails. The regulator's wage consists of a simple incentive fee scheme; she gets a positive bonus when monitoring is successful, but nothing when it fails. In fact, the following simple mechanism implements the optimal mechanism.[10] First, the regulator is asked to report her signal in a verifiable manner. If she does, she gets a fixed bonus, w^*, and the firm is reimbursed the cost the regulator reported. If the regulator does not report, she earns zero payoff, and the firm is reimbursed the maximum cost, $\overline{c}$.

Now, I am in a position to discuss the effect of the revolving door. When the revolving door is open, the regulator is concerned about her industry qualifications and tries to improve them during her agency term. Her acquiring the qualifications for the postagency job may have a positive or negative spillover effect on her monitoring effort, depending on the cross-partial derivative of the disutility function.

If $\psi_{12} < 0$, improving industry qualifications makes it less costly for the regulator to exert monitoring effort. This is likely the case when the skills that the regulator acquires to improve her chance of getting a job at the firm also enhance her monitoring performance. For example, a regulator may try to learn more about the details of the regulated industry and the regulatory rules if the firm values this kind of knowledge. On the other hand, if $\psi_{12} > 0$, acquiring industry qualifications has a negative spillover effect on the monitoring effort. This happens, for instance, when successful revolving requires developing human capital that has nothing to do with, or hinders, her monitoring performance. For example, if a regulator could be hired by a firm for her abilities to influence her colleagues in the regulatory agency, she will try to accumulate her influence contacts, which will divert her time or resources away from monitoring.

The following proposition characterizes the optimal regulatory policy under alternative assumptions about the interaction of two efforts. I first treat k as a parameter.

[10] I thank a referee for this intuitive interpretation of the mechanism.

Proposition 1. The principal's minimized expected payment C^* is weakly decreasing (increasing) in k if $\psi_{12} < 0$ ($\psi_{12} > 0$).

Proof. Suppose first $\psi_{12} < 0$. Using Lemma 1, we can rewrite the utility of the regulator, given a fixed bonus w, as $u(p, q; w, k) \equiv pw - \psi(p, q) + kvq$. This utility function is supermodular in (p, q). In addition, it exhibits increasing differences in $(p, q; w, k)$. Because the (p, q) that satisfies (EA-IC) is unique, it follows from Topkis (1978) that (p, q) is nondecreasing in (w, k). Then, when k increases, the principal can (weakly) lower w and still induce the same level of p from the regulator. This operation will not affect the principal's expected payment to the firm but will (weakly) decrease his expected payment to the regulator. Because an optimal adjustment in w further reduces the principal's expected payment, the latter must decrease when k increases. Finally, the case with $\psi_{12} > 0$ follows analogously upon confirming that the regulator's utility is supermodular in $(p, -q)$ and exhibits increasing differences in $(p, -q; w, -k)$. *Q.E.D.*

When the qualification-enhancing effort is complementary to the monitoring effort, opening the revolving door increases the incentives for monitoring effort at the given level of incentive bonus. This means that, by raising k, the principal can induce the same level of monitoring effort at a lower incentive payment. Thus, an optimal policy is to fully open the revolving door ($k^* = 1$).

On the contrary, if $\psi_{12} > 0$, opening the revolving door diverts the regulator's attention away from investing in human capital that improves her monitoring and toward capital that enhances her industry qualifications. Now a given level of monitoring bonus carries less incentive power, and to maintain the same level of monitoring performance, the incentive bonus must increase. Therefore, the principal is worse off by opening the revolving door.

If the principal has at his disposal organizational arrangements that influence the feasibility of the revolving doors, then the following corollary immediately follows from Proposition 1.

Corollary. $k^* = 1$ if $\psi_{12} < 0$; and $k^* = 0$ if $\psi_{12} > 0$.

A simple implication from this result is that regulators should be encouraged to revolve when the marketable human asset consists mainly of technical/regulatory expertise, whereas revolving doors should be shut when the marketability of the regulator depends on her influence contacts.[11] This finding is consistent with the 1989 Federal Ethics Commission's report, which supports the restriction of the transfer of influence-bearing information but emphasizes the importance of free employment flows (U.S. Government, 1989).

□ **The signalling effect.** Now I extend the analysis to a case in which the regulator's industry qualifications q are a fixed parameter rather than a choice variable. This is a reasonable assumption when the regulator's industry productivity depends on her innate abilities in the relevant area or on personal traits that are not easily changed. When q is fixed, the presence of the revolving door has no direct impact on the regulator's monitoring incentive, as in the previous subsection. However, as I show in what follows, the revolving door nonetheless affects the regulator's monitoring performance, through her motive to signal her qualifications for the industry job.

To explore this possibility, I postulate that the firm cannot directly observe the regulator's qualifications level, q, but can indirectly infer q through its observation of

[11] This finding is based solely on incentive consideration. In general, allowing revolving doors may cause additional social costs in diminishing the credibility of government employees and leading to tolerance of corruption in the private sector.

the regulator's monitoring effort (the choice of p). It is not unrealistic that a firm can estimate a regulator's monitoring effort by looking at how many hours the regulator spends on inspection and how prepared she is at the negotiation table, etc.[12] I assume that the regulator is exogenously endowed with $q \in \{q_L, q_H\}$ with probability $1 - \phi$ and ϕ, respectively, where $0 < q_L < q_H < 1$. Here, q represents the level of the regulator's inherent productivity at the private sector job. I call q_L a low-type and q_H a high-type regulator. Upon revolving, the regulator is paid according to her (revealed) industry productivity; that is, the firm pays the high-type regulator $q_H v$ and the low-type regulator $q_L v$.

Again, the impact of differing q's on a regulator's monitoring efficiency is captured by the cross-partial derivative of ψ. Here, I consider two cases: $\psi_{12} < 0$ and $\psi_{12} = 0$.[13] In the first case, a regulator's industry qualifications are positively related to her monitoring efficiency. This is likely the case when the postagency employment is based on the regulator's innate abilities, her technical expertise of the related area, or her expertise in the regulatory procedures. For example, a highly skilled government prosecutor is likely also to be a good defense attorney for the firm fighting against a government regulatory action. When $\psi_{12} = 0$, a regulator's industry qualifications have no bearing on her monitoring efficiency. This would describe the situation in which firms hire regulators for qualities, such as their influence contacts, that have little to do with their innate abilities or expertise on regulatory rules.

For simplicity, the principal is assumed to know the regulator's type and base his contracts on that type, and these contracts are observable to the firm.[14] Because the problem facing the principal is essentially the same as (P1), we can use Lemma 1 to limit attention to a simpler problem in which the principal offers two bonus levels, w_H and w_L, to the high- and low-type regulators, respectively.

In analyzing the regulator's effort choice, I focus on a sequential equilibrium that satisfies the intuitive criterion.[15] The intuitive criterion typically eliminates all sequential equilibria except for the most plausible separating equilibrium that involves a minimal signalling distortion. When $\psi_{12}(\cdot, \cdot) = 0$, the two types face exactly the same monitoring cost. For this case, I additionally assume that the regulator's out-of-equilibrium monitoring performance is signal free; i.e., the firm does not update its beliefs off the equilibrium path. Without this additional restriction on the beliefs, multiple equilibria arise, all but one of which are based on the firm's implausible out-of-equilibrium belief. In what follows, a sequential equilibrium satisfying the above restrictions will be called simply an "equilibrium."

The new program facing the principal can be expressed as

$$\min_{k, w_H, w_L, p_H, p_L} \quad C = c_e + \phi[p_H w_H + (1 - p_H)R] + (1 - \phi)[p_L w_L + (1 - p_L)R] \qquad \text{(P2)}$$

subject to

[12] Here, I rule out the possibility that the principal uses a more sophisticated scheme, in which he makes the firm report on p and bases the regulator's wage on the report. Such a scheme is not only unrealistic, it admits an undesirable equilibrium in which the firm reports $q = 0$ and the regulator picks $p = 0$.

[13] The case in which $\psi_{12} > 0$ is symmetric to that of $\psi_{12} < 0$, except for the possible nonexistence of a symmetric equilibrium. See footnote 18.

[14] Whether the principal observes the regulator's type and whether the contracts are observable to the firm do not affect the nature of the results that are obtained. Regardless of the principal's information, opening revolving doors expands the feasible set of contracts from which the principal can choose.

[15] The restriction prescribes that a zero belief should be assigned to a strategic move involving an equilibrium-dominated choice. See Cho and Kreps (1987) for details.

$$(p_H, p_L) \text{ is an equilibrium for given } (w_H, w_L, k),$$

where $c_e \equiv E[c]$.

I first characterize the constraints of the program. Let γ denote the belief held by the firm that the regulator is of the high type, where $\gamma \in [0, 1]$. Then, type-i regulator's ($i = H, L$) utility function when she picks p is given by

$$U_i(p \mid w_i, \gamma) \equiv pw_i - \psi(p, q_i) + q(\gamma)kv,$$

where $q(\gamma) \equiv \gamma q_H + (1 - \gamma)q_L$. Clearly, the utility is strictly increasing in γ. Regardless of type, the regulator is better off if the future employer believes that she has the high ability. Because different types of regulators have different marginal costs of increasing monitoring effort, the regulator's monitoring effort can have a signalling value.

Clearly, when $w_H \neq w_L$, the firm can trivially separate the types of regulators, so if the revolving door is open ($k > 0$), each type of regulator will be rewarded accordingly by the firm upon hiring. Thus, regardless of k, the type-i regulator picks $p_i^*(w_i)$, where $p_i^*(w_i) \equiv \text{argmax } pw_i - \psi(p, q_i)$. Note that $p_i^*(\cdot)$ is well defined and unique, due to the convexity of $\psi(\cdot, q_i)$. I call this a full-information choice for the type-i regulator.

Now, suppose $w_H = w_L = w$. In this case, the wage contract does not reveal the regulator's type. The firm then indirectly infers the regulator's type from her monitoring performance. This means that, if the revolving door is open, the regulator will try to send a good signal about her industry qualifications by appropriately choosing her monitoring effort. The specific way in which signalling alters the regulator's monitoring effort depends on the cross-partial derivative of ψ.

If $\psi_{12} = 0$, clearly, there cannot be any equilibrium in which the type of the regulator is revealed (separating equilibrium). Both types of regulator face the same monitoring cost, so the low-type regulator will mimic any choice that the high-type regulator may want to pick to reveal her type. Moreover, the only possible pooling equilibrium is one in which both types pick the full-information choice $p_H^*(w) = p_L^*(w)$. All other pooling choices are subject to profitable deviation toward the full-information choice, given our restriction on the beliefs of the firm.

If $\psi_{12} < 0$, a separating equilibrium may exist, because the high-type regulator faces a lower marginal cost of monitoring than the low-type regulator. In any separating equilibrium, the low-type regulator picks her full-information monitoring effort ($p_L^*(w)$); or else, there will be a profitable deviation toward the full-information level. Now consider the best monitoring choice for the high type, $\tilde{p}_H(w)$, that the low-type regulator does not wish to mimic. Formally,

$$\tilde{p}_H(w) \equiv \text{argmax}_{p_L^*(w) \leq p_H \leq 1} U_H(p_H \mid w, 1)$$

subject to

$$U_L(p_L^*(w) \mid w, 0) \geq U_L(p_H \mid w, 1). \tag{S}$$

Note that $\tilde{p}_H(w)$ is well defined and unique for all $w \geq 0$.[16]

[16] The constraint set is nonempty and compact. It is nonempty because $p_L^*(w) < 1$ and

$$U_L(p_L^*(w) \mid w, 0) > U_L(1 \mid w, 1)$$

by the Inada assumption. That the objective function is continuous and concave then ensures the existence and uniqueness of the solution.

The next lemma characterizes the equilibrium.

Lemma 2. If $w_H \neq w_L$ or $\psi_{12} = 0$ or $k = 0$, the unique equilibrium is $(p_H^*(w_H), p_L^*(w_L))$. If $w_H = w_L = w \geq 0$, $\psi_{12} < 0$, and $k > 0$, there exists a unique equilibrium in which the regulator picks $(\tilde{p}_H(w), p_L^*(w_L))$.

The proof of the lemma, which follows the line of arguments by Milgrom and Roberts (1986), is standard and thus omitted, but it is available upon request. Two remarks are made. First, a unique separating equilibrium exists when $\psi_{12} < 0$. Second, in this separating equilibrium, the low type's monitoring choice is the full-information choice, regardless of whether the revolving door is open. However, the high type may deviate from her full-information choice to signal her type, when the revolving door is open. The following proposition further characterizes the direction of possible deviation.

Proposition 2. If $\psi_{12} < 0$, $w_H = w_L = w \geq 0$ and $k > 0$, $\tilde{p}_H(w) \geq p_H^*(w)$ and $\tilde{p}_H(w)$ is monotone increasing in k. When v is sufficiently large, $\tilde{p}_H(w) > p_H^*(w)$ and $\tilde{p}_H(w)$ is strictly increasing in k.

Opening the revolving door provides the regulator with a motive to signal good qualifications for the industry job. This means that for a given incentive bonus, opening the revolving door makes the regulator exert more monitoring effort. The larger the stake of postagency employment v becomes, the more effort the regulator will provide. Therefore, the principal is (at least weakly) better off by opening the revolving door, when he offers a pooling wage to the regulator. Conceivably, the principal may not offer a pooling contract to the regulator. Even in this case, opening the revolving door does not worsen the principal. An interesting possibility, however, is that the revolving door makes the principal strictly better off. A pooling contract can be beneficial because it creates a signalling motive for the high-type regulator.[17] In particular, if ψ_{12} (< 0) is very close to 0 and v is very large, then the full-information wages for the two types of regulator are almost the same. In this case, offering the same wage will not affect the plaintiff's welfare much in terms of a flexibility loss, whereas the gain from the signalling effect will be significant. Thus, the pooling wage will be optimal, and the revolving door makes the principal strictly better off.

Combining these arguments leads to the optimal value of k for (P2).

Proposition 3. A solution to (P2) exists if either $\psi_{12} < 0$ or $\psi_{12} = 0$. In that solution, it is optimal to open the revolving door if $\psi_{12} < 0$, whereas it has no merit if $\psi_{12} = 0$.

This finding complements the conclusion drawn in the previous subsection. If the regulator is hired by the firm for expertise that is also valuable for the efficient administration of regulatory policies, the revolving door has a positive spillover effect on the regulatory performance. If the regulator is demanded for her assets that have little to do with her regulatory performance, opening the revolving door has no such merit.[18]

4. The role of agency collusion

■ The revolving door can serve as a mechanism for exchanging favors between regulators and firms. For instance, a regulator may choose to be extra lenient toward

[17] The revelation principle does not apply here because revelation of private information affects the behavior of the outside party. The principal chooses not to reveal the regulator's type so as to foster the latter's signalling motive toward the firm.

[18] In the case in which $\psi_{12} > 0$, intuition suggests that the revolving door will encourage the high-type regulator to signal by exerting less effort than otherwise. This intuition is correct when a separating equilibrium exists. For w close to zero, the separating equilibrium fails to exist.

a firm, anticipating a postagency job as a reward. Collusion of this kind between a regulator and a firm, if perfectly enforceable, would be undesirable.[19] What makes the matter less obvious, however, is that such a collusion is never perfectly enforceable. This is because the firm cannot give a contractual assurance to the regulator that her favor will be rewarded. Without a binding assurance, it may not be certain that the firm will, *ex post,* prefer the regulator who exerted the most favor rather than the one most qualified for a particular job. Given this imperfect enforceability, it is not clear how regulators and firms will react to the possibility of mutually beneficial collusion. In this section, I explore how the possibility of collusion affects the regulator's *ex ante* performance incentive, when the latter cannot be provided through contractual means.

To capture its imperfect nature, I assume that successful collusion occurs between the regulator and the firm only with probability k.[20] As before, I assume that the principal has various organizational arrangements (including ethics laws against revolving doors) at his disposal to influence the feasibility of the collusion, k. One way to influence k would be through the policy toward whistleblowers. Presumably, punishment of whistleblowers can increase the feasibility of collusion, whereas rewarding them through bounty would discourage collusion.[21] In practice, the government would have only limited ability to influence k, and when the government can lower k, it can do so only at substantial costs. Even in this case, treating k as a choice variable helps us to answer a normative question: Will the principal ever prefer $k > 0$? To concentrate on the collusion issue, I ignore the problem associated with the regulator's industry qualifications. I assume $q = 0$ and redefine $\psi(\cdot) = \psi(\cdot, 0)$, where $\psi' > 0$, $\psi'' > 0$, and $\psi''' \geq 0$. (The assumption on the third derivative is a technical condition used in the proof of Proposition 5.)

Collusion between the regulator and the firm is introduced in this model as follows. After the principal signs contracts with the regulator and the firm, a state of the side-contracting environment is realized. With probability k, the state is collusive, in which case the two agents can get together and sign a side contract to coordinate their reports in a mutually beneficial way.[22] If the state is noncollusive (which arises with probability $1 - k$), the two agents report independently, much in the same way as in Section 3. The new time line is presented in Figure 2.

As for the information of the state, I assume the following:

Assumption 4. Whether a state is collusive is common knowledge between the two agents but unknown to the principal.

A coordination in reports can be mutually profitable for both the regulator and the firm when the regulator observes the firm's cost. To see this, suppose the contracts described in Lemma 1 are offered to the agents. If the regulator observes the firm's

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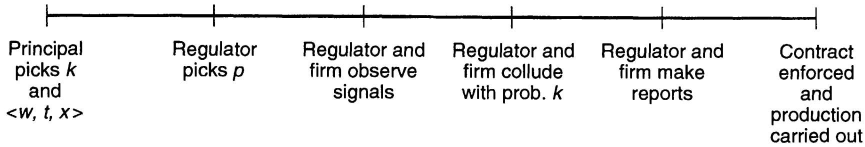
[19] As will be shown subsequently, collusion between the regulator and the firm may provide incentives for noncontractable investments by either party. Collusion is still undesirable to the principal, if it is perfectly enforceable, because the benefits from the enhanced investment incentives do not accrue to the principal.

[20] Implicit in this setup is the notion that enforceability of collusion is correlated with the extent to which the revolving door is open. In this section, I focus only on the effect of collusion between the regulator and the firm. Thus, I shall not make any explicit reference to the revolving door as a possible cause of collusion.

[21] In 1986, Congress increased the availability and attractiveness of so-called *qui tam* lawsuits by which citizens can enforce the False Claims Act on behalf of the government. This move allowed employees of government agencies and private companies to become bounty hunters for the False Claims Act. See Kovacic (1994).

[22] Here, I do not consider a side contract that directly coordinates on the regulator's monitoring effort. Such side contracting can be beneficial to both parties but is harder to enforce than the type considered here. For example, the firm may renege on its payment after the regulator poses little threat.

FIGURE 2



cost, say c, she can earn the bonus w^* by reporting the cost truthfully. On the other hand, if she withholds the information, she forgoes the bonus, but she can let the firm pad its cost fully and thereby earn the information rents of $R(c)$. Therefore, when $R(c)$ is greater than w^*, the two parties can write a profitable side contract that requires the regulator to withhold her observation. If such side contracting occurs, the regulator and the firm are assumed to split the net gain from collusion, $R(c) - w^*$, at θ to $1 - \theta$, where θ parameterizes the bargaining power of the regulator.

Notice that such profitable side contracting is possible only when the regulator can observe the firm's cost. When she cannot, the regulator poses no threat to the firm's cost padding and thus has no profitable side contract to offer to the firm. In this situation, the regulator can achieve side contracting only as a result of her successful monitoring. This implies that the possibility of collusion provides incentive for the regulator to exert monitoring effort. If the regulator enjoys some bargaining power relative to the firm, i.e., if $\theta > 0$, her return to monitoring effort under collusion exceeds the incentive bonus she receives without collusion. The ensuing added monitoring incentive does not, of course, benefit the principal in the collusive state, because the information obtained from it is not reported to the principal. However, it has a beneficial spillover effect on the monitoring performance in the noncollusive state. Therefore, when setting policies affecting k, the extent to which collusion is feasible, the principal must weigh this beneficial incentive effect against the negative information-concealment effect in the collusive state.

The problem facing the principal is formalized as follows. The principal offers a contract $\langle x, t, w \rangle$ contingent on both agents' reports about the firm's costs.[23] Then, the problem facing the principal is represented as follows:

$$\min_{w(\cdot,\cdot),t(\cdot,\cdot),k,p} \quad C \equiv (1 - p)E\big[t(c, n) + w(c, n)\big] + (1 - k)pE\big[t(c, c) + w(c, c)\big]$$

$$+ kpE\big[\max\{t(c, c) + w(c, c), t(c, n) + w(c, n)\}\big] \qquad \text{(P3)}$$

subject to (EP-IC), (LL), and (NC)

$$p \in \operatorname{argmax}\ (1 - p)E\big[w(c, n)\big] + p\big\{(1 - k)E\big[w(c, c)\big]$$

$$+ kpE\big[w(c, c) + \theta z(c)\big]\big\} - \psi(p), \qquad \text{(EA-IC)}$$

where

$$z(c) \equiv \max\{t(c, c) + w(c, c), t(c, n) + w(c, n)\} - \big[t(c, c) + w(c, c)\big]$$

$$0 \le w(\cdot, \cdot) \le \overline{w}. \qquad \text{(WL)}$$

[23] One may consider a more sophisticated scheme that requires the agents to report whether a given state is collusive. This more complicated scheme would yield the same outcome as the simple scheme studied here, except that, at the optimum, the principal would offer collusion-proof contracts.

Several remarks are in order. First, the optimal collusion decision for the regulator-firm coalition is embedded in the objective function. When the state is collusive and the regulator observes the firm's cost (this event occurs with probability pk), the two parties will collude if and only if concealing the information leads to a higher joint payoff. Thus, the principal pays (and the two parties receive) either $t(c, c) + w(c, c)$ or $t(c, n) + w(c, n)$, whichever is greater. Second, the *ex ante* incentive constraint for the regulator is modified by the fact that the regulator receives θ of the net gains from collusion, $z(c)$, when collusion occurs. As explained before, collusion occurs only when the regulator observes the firm's cost. Finally, (WL) is introduced to capture the possible restriction on the incentive wage scheme that the principal implements. Such a constraint is not unrealistic, because incentive wage schemes are rarely used in the public sector. This may be because, in practice, the regulator's information may not be costlessly verifiable. When verifying the regulator's information is costly, the incentive scheme is likely to be low powered, and in this case, $\overline{w}$ can be interpreted as a reduced-form solution.

Lemma 3. The following describes a solution to (P3).

(i) $t(c, c) = c$, $t(c, n) = \overline{c}$ for $c \in [\underline{c}, \overline{c}]$, and $t(\cdot, \cdot) = 0$ otherwise;

(ii) $w(\cdot, n) = 0$ for $c \in [\underline{c}, \overline{c}]$; and

(iii) for $k \in (0, 1)$, collusion occurs with positive probability for all $\overline{w} \geq 0$.

The results and interpretation of (i) and (ii) are the same as in Lemma 1, except that the simple fixed bonus scheme may not be optimal here. Now the structure of the incentive bonus, $w(c, c)$ (and not just its expected value), matters because it affects the probability of collusion. The principal may set the wage to increase with the information rent in order to prevent collusion for some cost realizations. (It will be shown later that this does not occur.)

Because in most cases it is unreasonable to believe that the principal can actually enforce policies that drive k completely to zero, the world is typically one in which $k > 0$. An important question then becomes whether the principal's optimal contract in such circumstances will prevent or tolerate collusion. Interestingly, (iii) implies that collusion-proof contracts (which discourage agents from colluding) are not optimal. This result contrasts with Tirole's (1986) equivalence principle, according to which any feasible mechanism can be implemented by a collusion-proof contract. The equivalence principle is violated in this model because collusion is only partially feasible ($0 < k < 1$). To be collusion proof, a contract must pay the two parties at least the equivalent of what they can obtain through collusion, i.e., $\max\{t(c, c) + w(c, c), t(c, n) + w(c, n)\}$. This collusion-proof payment, however, is strictly more than is necessary to induce truthful reporting in the noncollusive state, in which truthful reporting requires only that $w(c, c) \geq w(c, n)$. Suppose the principal lowers his payment to the agents slightly below the collusion-proof level. Then collusion will occur with some positive probability. This does not increase the principal's payment in the collusive state because the collusion-proof constraint is binding. This, however, strictly reduces the principal's payment in the noncollusive state because the incentive constraint is not binding. Therefore, collusion-proof contracts can never be optimal. Note that this argument does not depend on the restriction on the regulator's bonus. Even when there is no restriction on the bonus, the principal does not offer collusion-proof contracts if collusion is partially feasible.[24]

[24] This shows that the equivalence principle depends on collusion being perfectly enforceable. One can verify that equivalence is restored when collusion is perfectly enforceable ($k = 1$), confirming the result of Tirole (1986).

Without loss of generality, one can eliminate the possibility of inconsistent reporting. Thus, let $w(c) \equiv w(c, c)$. Using this simplified notation and the results in Lemma 3, we can substitute part of (EP-IC) and (LL) into the objective function. (P3) can now be rewritten as (P3a).

$$\min_{w(\cdot),k,p} C = c_e + (1-p)E\big[R(c)\big] + pE\big[w(c)\big] + pkE\big[\max\{R(c) - w(c), 0\}\big] \quad \text{(P3a)}$$

subject to

$$p \in \operatorname{argmax} pE\big[w(c)\big] + pk\theta E\big[\max\{R(c) - w(c), 0\}\big] - \psi(p)$$

$$0 \leq w(\cdot) \leq \overline{w}.$$

Now, I am in a position to analyze the principal's optimal choice of k.

Proposition 4. If the size of the incentive bonus is unrestricted and the regulator has less than full bargaining power, a solution to (P3) exists. In the solution, (i) collusion is disallowed and (ii) a fixed bonus w^* is adopted.

The proposition establishes the notion that collusion is an inferior substitute to incentive bonus as a source of the regulator's monitoring incentive. The intuition behind this result is that, although the full amount of the bonus is used as an incentive to the regulator, of all the expenses incurred due to the existence of collusion, only a portion θ acts as an incentive because the firm gets the rest.

An important question is how robust the result is. The above result is based on a rather extreme assumption that the principal is unrestricted in his use of the incentive wage scheme for the regulator. If this assumption is relaxed, allowing collusion can be optimal. To illustrate the point, suppose, for instance, that the principal cannot use an incentive wage scheme at all (i.e., $\overline{w} = 0$). Then, if collusion is not allowed ($k = 0$), the regulator will have no incentive to monitor ($p = 0$). Therefore, the firm will pad its cost fully and will extract the maximum payment ($\overline{c}$) from the principal. If the principal allows collusion with some probability, however, the regulator will expend some monitoring effort in order to have a successful side-contracting opportunity. To the extent that $k < 1$, this added monitoring effort helps the principal save his expenditure in the noncollusive state, resulting in a less-than-maximal payment by the principal. Hence, allowing collusion is optimal.

Proposition 5. A solution to (P3) exists for all $\overline{w} \geq 0$. In that solution, (i) it is optimal to allow collusion partially ($0 < k^* < 1$) if and only if $\theta = 1$ or $\overline{w} < \hat{w}$ for some $\hat{w} \in (0, w^*)$, (ii) a fixed bonus scheme with $w(\cdot) = \min\{\overline{w}, w^*\}$ is optimal, and (iii) p^* is nondecreasing in $\overline{w}$.

Because it is never optimal for the principal to contractually discourage collusion (Lemma 3 (iii)), $k^* > 0$ means that collusion will actually occur with positive probability. Although the restriction on the size of the bonus plays a critical role in the above argument, the idea of optimally tolerating collusion seems more general. For instance, a similar conclusion can be reached if there are costs associated with lowering k.[25] The properties of the optimal mechanism are characterized in (ii) and (iii). Just like the case without collusion, a fixed bonus scheme is optimal for the regulator. The optimality of

[25] Making the regulatory environment less collusive means placing more restrictions on employment/influence flows and firmer enforcement of ethics laws, both of which require resources. Likewise, awarding bounties to whistleblowers is also costly.

a fixed bonus scheme may be surprising, given that the principal may potentially benefit from partially discouraging collusion through wage contracts. One may think that, for some c, the principal may want to set the wage just high enough so that collusion is prevented (i.e., $w(c) = R(c)$), in which case the bonus will vary negatively with c. This conjecture is not correct, however. If collusion is undesirable, it is less costly for the principal to prevent it by setting $k^* = 0$. When $k^* > 0$, collusion is desirable, and the principal does not want to discourage collusion through wage contracts. The intuition for (iii) is clear. When $\overline{w}$ decreases, a less efficient monitoring incentive (= collusion) replaces a more efficient one (= bonus). Thus, the optimal monitoring incentive becomes weaker.

5. Concluding remarks

■ In this article, I have examined the effect of revolving doors and agency collusion on the monitoring incentives of regulators. The following remarks draw some further implications from the analysis I have presented in this article.

□ **Intersectoral wage difference, and the incentives to enter the public sector.** It is documented that regulators with five years' public service can triple their salaries just by stepping out the revolving door (*Newsweek,* February 6, 1989, pp. 16–18). This phenomenon can be explained based on the findings in this article. If a regulated private sector values the regulatory expertise acquired by government employees, then the wage that the private sector pays for revolvers will include payments for their human capital. If, in addition, the personnel transfer is preceded by collusion in the workplace, the private sector salary might additionally include a deferred payment of the surplus from the collusion. For regulators, then, it is worthwhile to stay in the less profitable public sector for several years before accepting a private sector job, because it gives them a chance to accumulate government contacts and demonstrate their intimate knowledge about the regulatory procedure and the industry. This idea can explain why individuals may be attracted to the relatively lower paying public sector in the beginning. If, in fact, the revolving doors are closed, those who have skills and competency that can only be used fully through postagency employment in the private sector may find the public sector less attractive and decide not to enter. This concern is shared by the U.S. Government (1989): "[Restrictive limitations] will necessarily reduce the number of qualified persons who would be otherwise willing to enter into federal employment."

□ **Noncontractable investment by regulated firms.** In this article, I have studied the possibility that collusion between regulators and firms may encourage the regulators to undertake a desirable effort. A similar point can be made about the noncontractable effort the firms may undertake. In many government procurement situations, firms often undertake R&D investment prior to entering into the contracting relationship. Although such R&D investment is important in determining the overall performance of procurement, the government cannot easily control this investment because it usually cannot be contracted upon. Sometimes competition at the precontracting stage provides some incentives; however, they are often insufficient. To make matters worse, the presence of regulatory monitoring can destroy the firms' investment incentives because it reduces the appropriable returns to the investment. In this regard, Riordan (1987) and Sappington (1986) noted the desirability of the government's committing not to engage in excessive monitoring. One way to achieve such commitment may be to tolerate some degree of collusion between regulators and firms. Such collusion increases the appropriable returns to the investment and may thereby encourage the firm's R&D investment.

Appendix

■ Proof of Lemmas 1 and 3 and Propositions 2–5 follow.

Proof of Lemma 1. I first obtain conditions characterizing the solution to (P1), and then use these conditions to show the existence of the solution.

Because the regulator can be asked to verify her report, the regulator's *ex post* incentive-compatibility constraint is satisfied if and only if $w(\cdot, c) \geq w(\cdot, n)$ for any verified $c \in [\underline{c}, \bar{c}]$. Meanwhile, the firm's incentive constraint requires $t(c, s_R) - cx(c, s_R) \geq t(\tilde{c}, s_R) - cx(\tilde{c}, s_R)$, where $s_R = c, n, \forall c, \tilde{c} \in [\underline{c}, \bar{c}]$. Without loss of generality, set $x(\tilde{c}, c) = t(\tilde{c}, c) = 0$ for any $\tilde{c} \neq c$. Then, $t(c, c) = c$ is the optimal choice satisfying the incentive constraint because $x(c, c) = 1$ for all $c \in [\underline{c}, \bar{c}]$. For $s_R = n$, the incentive constraint implies, via the envelope theorem, that $[\partial \pi(c, n)]/\partial c = x(c, n)$. Integrating both sides and using (NC), I obtain $\pi(c, n) = \pi(\bar{c}, n) + \int_c^{\bar{c}} x(t, n)\, dt = \pi(\bar{c}, n) + (\bar{c} - c)$. Clearly, this condition is also sufficient for incentive compatibility for the firm.

Now, optimality requires $\pi(\bar{c}, n) = 0$. Hence, $t(c, n) = \bar{c}$. This also satisfies the incentive constraint and the firm's (LL) constraint.

Proof of (ii) and (iii) involves several steps:

(1) $E\big[t(c, c) + w(c, c)\big] < E\big[t(c, n) + w(c, n)\big]$.

Suppose otherwise. Then, the minimized cost $C^* \geq E[t(c, n) + w(c, n)] \geq \bar{c}$. But this can be strictly improved upon by setting $w(c, n) = 0$ and $w(c, c) = w$ at sufficiently small positive levels for all c. This is because $E[t(c, c) + w(c, c)] = E[c + w] < \bar{c}$ for sufficiently small w.

(2) $E\big[w(c, n)\big] = 0$.

Suppose, to the contrary, $E[w(c, n)] > 0$. From (1), the optimal monitoring effort p is positive. Also, by the incentive constraint, $E[w(c, c)] > 0$. Now, reducing both $E[w(c, n)]$ and $E[w(c, c)]$ at the same rate will keep the choice of (p, q) unchanged but will reduce the expected cost of the principal, thus showing the contradiction.

From (2), setting $w(\cdot, n) = 0$ is optimal.

(3) A fixed incentive bonus ($w(c, c) = w^*$) is optimal.

Suppose ($w(c, c)$ is the optimal incentive bonus. Then, set $w^* \equiv E\,[(w(c, c)]$. The principal is not worse off.

Since $p^* > 0$, $w^* > 0$. Finally, (1) and (3) imply $w^* < R$.

Next, I show that a solution to (P1) exists. Using (i), (ii), and (iii), we can rewrite (P1) as follows:

$$\max_{w \geq 0, k \in [0,1]} \quad p^*(w, k)\big\{E[c] + w\big\} + \Big(1 - p^*(w, k)\Big)\bar{c}, \tag{P1a}$$

where $p^*(w, k)$ is the unique solution to (EA-IC), given (w, k). (The solution to (EA-IC) is unique because ψ is convex.) By the theorem of maximum (Debreu, 1959), $p^*(\cdot, \cdot)$ is continuous. Then, because $w^* \leq R$ by Lemma 1 and k^* lies in a compact set, a solution to (P1) exists. *Q.E.D.*

Proof of Proposition 2. I first show that $\tilde{p}_H \geq p_H^*$. Suppose, to the contrary, that $p_L^* < \tilde{p}_H < p_H^*$. Then, raising p from $\tilde{p}_H$ to p_H^* increases the high-type's payoff and still satisfies (S), which is a contradiction to the definition of $\tilde{p}_H$. To show the monotonicity of $\tilde{p}_H$ in k, it suffices to show that $\tilde{p}_H$ is increasing in k whenever (S) is binding. (When (S) is not binding, $\tilde{p}_H = p_H^*$.) The binding (S) can be written as

$$w\tilde{p}_H - \psi(\tilde{p}_H, q_L) = wp_L^* - \psi(p_L^*, q_L) - k(q_H - q_L)v.$$

As k increases, the right-hand side of the equation decreases. To restore equality, $\tilde{p}_H$ must increase, because $\tilde{p}_H > p_L^*$. From the equation, it is also obvious that, as v increases, the marginal impact of an increase in k increases, implying that $\tilde{p}_H$ will increase more. Furthermore, as v increases without bounds, $\tilde{p}_H$ must approach one. This proves that, for sufficiently high v, $\tilde{p}_H > p_H^*$. *Q.E.D.*

Proof of Proposition 3. The characterization of the optimal value of k follows directly from Proposition 2. Here, I show that a solution to (P2) exists. Since there exists a unique equilibrium choice for each type for all w_i and k, one can simply substitute the equilibrium monitoring efforts of both types into the objective function of (P2). Call the resulting program (P2a). The theorem of maxima (Debreu, 1959) implies that p_i^* and $\tilde{p}_H$ are continuous in w_H, w_L, and k. From Lemma 2, it then follows that the objective function of (P2a) is continuous in w_H, w_L, and k except possibly when $w_H = w_L$ and $k > 0$. Because $\tilde{p}_H \geq p_H^*$, the value of the objective function is less than or equal to its limiting value at $w_H = w_L$ and $k > 0$. This shows that the objective function of (P2a) is lower-semicontinuous. Because w_H, $w_L \leq R$ and k lies in a compact set, a minimum of (P2a) exists. *Q.E.D.*

Proof of Lemma 3. I first demonstrate (iii). For this, it is sufficient to show that, for any $k > 0$,

$$E\big[t(c, c) + w(c, c)\big] < E\big[t(c, n) + w(c, n)\big],$$

because this will imply that, with positive probability, the agents will decide to collude (i.e., conceal the regulator's information). Suppose, to the contrary, $E[t(c, c) + w(c, c)] \geq E[t(c, n) + w(c, n)]$. Then, because the noncollusive incentive constraint requires $t(c, n) \geq \bar{c}$ (see the proof of Lemma 1), the optimized expected cost of the principal will be greater than or equal to $\bar{c}$. Consider the following contract:

$$t(c, c) = c,\ t(\tilde{c}, c) = x(\tilde{c}, c) = 0;\ w(c, n) = 0; \qquad \text{and} \qquad w(c, c) = \min\{½(\bar{c} - c), \bar{w}\}$$

for all $c \neq \tilde{c} \in [\underline{c}, \bar{c}]$. This contract satisfies all the constraints and will be favored by the principal over the original contract, because the value of the objective function is now

$$p(1 - k)E\big[c + w(c, c)\big] + (1 - p + pk)\bar{c},$$

which is strictly less than $\bar{c}$. Therefore, the original contract could not have been optimal.

Next, I demonstrate (i) and (ii). Arguments in the proof of Lemma 1 can be used for the most part. All that remains, therefore, is to show that $w(c, n) = 0$; $t(c, c) = c$; and $t(c, n) = \bar{c}$. Here, I only show $t(c, n) = \bar{c}$. The other results can be obtained by an argument similar to the one that will follow.

Suppose, to the contrary, that $t(c, n) > \bar{c}$. First, rewrite the objective function of (P3) as

$$C \equiv (1 - p)E\big[t(c, n) + w(c, n)\big] + pE\big[t(c, c) + w(c, c)\big] + kpE\big[z(c)\big],$$

where $z(c) \equiv \max\{t(c, c) + w(c, c), t(c, n) + w(c, n)\} - [t(c, c) + w(c, c)]$. Next, consider a relaxed program in which $0 \leq k \leq 1$ is replaced by a more relaxed constraint $k \geq 0$. This does not change the solution, because it can be shown, using the argument as above, that $k^* < 1$. Now, lower $t(c, n)$ by ϵ for all c where ϵ is a small positive number. This will reduce the first term of the objective function by $(1 - p)\epsilon$. The second term remains unchanged. $z(c)$ in the third term can be reduced. This will affect (EA-IC). However, k could be raised to keep $kE[z(c)]$ unchanged. (This is possible because k is not restricted from above.) Therefore, the principal is better off overall with a lower $t(c, n)$. The optimized expected cost of the principal is further reduced through the optimal adjustment of k. Therefore, $t(c, n) > \bar{c}$ cannot be optimal. *Q.E.D.*

Proof of Proposition 4. Here, the critical step is to show $k^* = 0$ whenever (P3) is well defined. If $k^* = 0$, (P3) is essentially the same as (P1), so a fixed bonus scheme is optimal for the regulator. Furthermore, a solution to (P3) exists by the existence of the proof of Lemma 1.

Let $E[R(c) - w(c)]^+ \equiv E[\max\{R(c) - w(c), 0\}]$. Using this notation and $\bar{w} = \infty$, rewrite (P3a) as follows.

$$\min_{w(\cdot),k,p,I} C = c_e + (1 - p)E\big[R(c)\big] + p\big[I + k(1 - \theta)E\big[R(c) - w(c)\big]^+\big\} \tag{P3b}$$

subject to

$$p \in \text{argmax } pI - \psi(p)$$

$$I = E\big[w(c)\big] + k\theta E\big[R(c) - w(c)\big]^+$$

$$w(\cdot) \geq 0.$$

To prove the claim, suppose, to the contrary, $k^* > 0$. Let I^* be the corresponding optimal choice. Now, lower k from k^* to zero while raising the incentive bonus $w(c)$ to maintain the same level of I^*. Then, the choice of monitoring by the regulator remains unchanged, but the expected cost of the principal is lower, contradicting the optimality of $k^* > 0$. *Q.E.D.*

Proof of Proposition 5. Again, the existence of a solution to (P3) is shown last. I first establish (i), (ii), and (iii) assuming the existence of a solution.

Suppose first that $\theta = 1$. Then, the extra term in the objective function (P3b) drops out. Therefore, in this case, collusion becomes a perfect substitute for the bonus. Specifically, starting from an optimal policy, reducing $w(\cdot)$ and raising k while maintaining the value of I does not affect the incentive of the regulator. Furthermore, the value of the objective function remains unaffected. Thus, allowing collusion is optimal.

Next, I examine the case in which $\overline{w}$ is sufficiently small. To this end, I first replace (EA-IC) with its first-order representation. (This is possible because the problem has an interior solution and because the third derivative of ψ is nonnegative.) The corresponding Lagrangian function is

$$L = pE\big[w(c)\big] + (1 - p)R + pkE\big[R - w(c)\big]^{+} + \lambda\big\{\psi' - (w + \theta kE\big[R - w(c)\big]^{+})\big\}.$$

Now, let $k = 0$ and evaluate the first-order condition.

$$L_{k|k=0} = E\big[R(c) - w(c)\big]^{+}\left\{p - \frac{\theta E\big[R(c) - w(c)\big]}{\psi''(p)}\right\}. \tag{A1}$$

For sufficiently small $\overline{w} < w^*$, (A1) is negative, thus implying that $k^* > 0$. Clearly, $k^* < 1$, because otherwise, the principal's expected payment would be $\overline{c}$, which the principal could easily better by setting $k^* < 1$.

Next, I prove (ii)—that a fixed bonus is optimal. This is trivially true when $k^* = 0$. In this case, the problem facing the principal is the same as in (P1), and the optimality of a fixed bonus scheme is established in Lemma 1. Clearly then, the optimal bonus must be $\min\{\overline{w}, w^*\}$. (Recall that w^* denotes the optimal bonus level at which $\overline{w} = \infty$ and $k = 0$.) Assume now that $k^* > 0$. I prove that $w(\cdot) = \overline{w}$ is optimal. To see this, suppose, to the contrary, that $E[w(c)] < \overline{w}$. First notice that $\overline{w} < I^*$, where I^* is an optimal choice in (P3b), because otherwise, $k^* = 0$ (apply the argument used in Proposition 4 to see this). Now, raise the incentive bonus so that $E[w(c)] = \overline{w}$, and at the same time, lower k while maintaining the level of I^*. This operation will keep the level of p unchanged because the monitoring incentive remains unchanged, but it will reduce the principal's expected payment. Therefore, $E[w(c)] = \overline{w}$ is optimal. Combining the two cases, I conclude that a fixed bonus of $\min\{\overline{w}, w^*\}$ is optimal.

Now, I prove (iii)—that p^* is nondecreasing in $\overline{w}$. Define $\Delta \equiv kE[R - w(c)]^{+}$. Then, from (P3b), $I = E[w(c)] + \theta\Delta$. Because from the first part of (ii), $E[w(c)] = \overline{w}$ when $k^* > 0$, an increase in $\overline{w}$ decreases Δ if I is held constant. Now, consider a first-order expression of the Lagrangian equation corresponding to (P3b):

$$L_I = p + \big[I + (1 - \theta)\Delta - R\big]\frac{1}{\psi''}.$$

Observe that this expression decreases at every I as $\overline{w}$ increases. Therefore, an increase in $\overline{w}$ increases I. From (P3b), this implies that p^* also increases.

Using (ii) and (iii), it is clear that the braced term in (A1) is nonincreasing in $\overline{w}$. This implies that, if (A1) is negative at $\overline{w}$, it is also negative at $\overline{w}' < \overline{w}$. Furthermore, (A1) is positive when $\overline{w} = w^*$. It follows that there exists $\hat{w} \in (0, w^*)$ such that $k^* > 0$ if $w < \hat{w}$ and $k^* = 0$ if $w \geq \hat{w}$.

Having established (i), (ii), and (iii), the existence of a solution to (P3) follows easily. Because a fixed bonus is optimal, one can describe the monitoring effort that satisfies (EA-IC) as a function of (w, k), where w is a fixed bonus for the regulator. This is possible because (EA-IC) has a unique maximum (due to the convexity of $\psi(\cdot)$). Moreover, the theorem of maxima (Debreu, 1959) implies that this function is continuous. Now, I can substitute this function into (P3a) and rewrite the program as an unconstrained minimization problem, in which the principal chooses a fixed bonus, w, and k. The objective function of this new program is clearly continuous in (w, k), and (w, k) lies in a compact set. Therefore, a solution to this program exists. *Q.E.D.*

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