

# Privatization and the Effectiveness of Monitoring Agencies\*

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## Abstract

The privatization literature depicts the choice whether to contract out as a tradeoff between excessive private investment in quality-reducing cost saving and inadequate public investment in cost-increasing quality improvement, under circumstances where neither the amount of investment nor the cost or quality outcomes are contractible. This paper shows that a monitoring regime, which can verify the benefit of the service at a cost, can bring the investment levels of the private contractor closer to the optimum, while it may not be able to improve the performance of the public sector. Monitors can be captured, and the possibility of capture may decrease social welfare. Social welfare losses due to the possibility of capture may be greater in the case of public provision: The agencies that decide whether to privatize and the agencies that monitor service providers are often identical to, or closely related with, the agencies that actually provide the service if it is kept in-house. Therefore, privatization decisionmakers and monitoring agencies may be more prone to capture when the service is public. Therefore, efficiency may counsel in favor of a purchaser-provider split and a monitor-provider split.

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## 1 Introduction

This paper formalizes various features of privatization, in the context of the model developed by Hart, Shleifer, and Vishny [hereinafter HSV] (1997). In particular, it explores the effects of monitoring, collusion between providers and monitoring agencies, and the identity of the privatization decisionmaker and the monitor.

The conventional wisdom on privatization is that it saves money by reducing quality. This result emerges from a model where investment in cost-cutting, and the benefit of the service itself,

are non-contractible. Monitoring improves the quality of both sectors, though—because monitoring is costly—it does not achieve first-best quality levels.

The conventional wisdom is no longer correct once, as HSV posit, we introduce a second kind of investment—in quality-enhancing innovations—and allow for ex-post contract renegotiation. Then there is an asymmetry between the two types of investment, and between the two types of provider. HSV show that private contractors for government services invest too much in quality-reducing cost saving and too little in cost-increasing quality improvement, while public contractors invest too little in cost saving and *far* too little in quality improvement.

This paper shows that monitoring likewise has different effects depending on who is providing the service. Provided the setup costs of the monitor are not too high, monitoring can always improve the quality of the private sector, but it is not guaranteed to be able to improve the quality of the public sector. There is underdeterrence not only because monitoring is costly but also because of the interaction of the two different kinds of non-contractible investment.

The presence of a monitoring agency opens up the possibility of collusion (regulatory capture). A proper incentive scheme for the monitor can prevent collusion, but at a cost, so social welfare may decrease once we allow for the possibility of capture. However, when the monitoring agency (as is common) benefits from public provision, it is willing to collude on more favorable terms with the public contractor than with the private contractor, which decreases social welfare still further. Therefore, efficiency may counsel in favor of both a purchaser-provider split (where the decision whether to privatize is made by someone who doesn't benefit from public or private provision) and a monitor-provider split (where the agency doesn't benefit from public provision).

## 2 Motivation

### 2.1 The public-private distinction in the law

The distinction between public and private agencies matters in the law.

On the one hand, the public sector is subject to certain due process protections, like the civil

service system, and certain accountability-forcing laws like the Freedom of Information Act, which do not apply to the private sector.

But in other ways, courts sometimes hold private agencies—in particular in the prison context—to a higher standard than their public counterparts. For instance, under *Harlow v. Fitzgerald*, 457 U.S. 800 (1982), and *Procunier v. Navarette*, 434 U.S. 555 (1978), state government officials (including prison guards) performing discretionary functions are shielded from federal liability for civil damages under 42 U.S.C. §1983, the Civil War-era civil rights statute, if their conduct does not violate “clearly established statutory or constitutional rights of which a reasonable person would have known.” In *Richardson v. McKnight*, 521 U.S. 399 (1997), however, the Supreme Court held that private prison guards working for the state do not enjoy this qualified immunity.

More generally, courts are less deferential when reviewing challenges to private agency action. Courts have traditionally deferred to the government in prison suits because of the common judicial unwillingness to second-guess the political branches. As the Supreme Court wrote in *Procunier v. Martinez*, 416 U.S. 396 (1974): “[T]he problems of prisons in America are complex . . . they are not readily susceptible of resolution by decree . . . [C]ourts are ill equipped to deal with the increasingly urgent problems of prison administration.” Yet courts have often been hostile to private, for-profit delegations, and this judicial hostility manifests itself through more vigorous due process scrutiny (see Wecht 1987). For instance, the Supreme Court, in *Fuentes v. Shevin*, 407 U.S. 67 (1972), struck down state laws authorizing a private party to obtain a summary writ to seize goods in another person’s possession in debt disputes. The Court wrote that the summary nature of the writ, which did not allow for a hearing before seizure, amounted to an effective “abdication of] control over state power.”

The preceding doctrines rest on generalizations about how public and private agencies act:

- In *Fuentes*, the Court invoked the specter of “[p]rivate parties, serving their own private advantage . . . unilaterally invok[ing] state power to replevy goods from another,” without any oversight by a “state official.”
- The lower court in *McKnight* (in *McKnight v. Rees*, 88 F.3d 417 (6th Cir. 1996)), denying

qualified immunity in a §1983 case against state private prison guards, argued that private guards “are not principally motivated by a desire to further the interests of the public at large” and stated that “[t]he balance struck by qualified immunity, at least implicitly, contemplates a government actor acting for the good of the state, not a private actor acting for the good of the pocketbook.”

The preceding cases merge an idealistic view of public provision with an essentially negative view of private provision. But other cases take a more nuanced view of both:

- The Supreme Court majority in *McKnight* argued that qualified immunity is necessary for public guards, who seek to minimize their exposure to suit and who, protected by civil service rules and largely insulated from democratic accountability, face strong incentives to act timidly. At the same time, the *McKnight* majority argued that the same immunity is unnecessary for private guards because “marketplace pressures” are sufficient to keep guards in line: Private providers that want to be rehired will minimize expensive prisoner lawsuits by preventing guards from being too aggressive, but if they are not aggressive enough, they will lose out to a competing provider who can offer a better discipline level. The *McKnight* dissent, on the other hand, characterized as “fanciful” the suggestion that “marketplace pressures” are relevant “where public officials are the only purchaser, and other people’s money the medium of payment,” and argued that the private contractor’s willingness to keep costs low by minimizing expensive prisoner lawsuits would make private prison guards overly cautious if they could not benefit from the same qualified immunity available to the public sector. (See Gillette and Stephan (2000) for a critique of both sides’ reasoning in *McKnight*.)
- The Supreme Court revisited qualified immunity in *Correctional Services Corp. v. Malesko*, 534 U.S. 61 (2001), in the context of federal civil rights suits against employees of private agencies working for *federal*, not state, governments, and reached the opposite result. (Federal civil rights suits against federal officials are governed not by §1983 but by *Bivens v. Six Unknown Federal Narcotics Agents*, 403 U.S. 388 (1971).) The majority questioned “[w]hether it makes sense to impose asymmetrical liability costs on private prison facilities alone,” while the dissent

restated the *McKnight* majority’s argument that marketplace pressures are sufficient to keep private actors (here, employees of a privately operated halfway house) in line.

In short, arguments for and against different aspects of the public-private distinction implicitly embody a theory of what motivates public and private actors, though this theory is often not fully thought out (see Laffont and Tirole [1993] for a critique of the “conventional wisdom” for and against privatization on contract-theory grounds). Indeed, modern contract theory teaches that if the government could write a complete contingent contract telling its contractor what actions to take in every state of the world, much of the difference between public and private provision would vanish. A convincing theory of the public-private distinction should explore the incompleteness of contracts, which makes the allocation of residual control rights significant.

## 2.2 The privatization literature

HSV use an incomplete-contracting perspective to discuss the differences between in-house provision of a government service and the contracting out of that service. (For specificity, I will occasionally use the example of a prison.) Their model builds on the Grossman and Hart (1986) and Hart and Moore (1990) property rights model, which describes property rights as a means of allocating residual control rights. If two parties have assets and can make non-verifiable relationship-specific investments, then the party who owns the assets has “better” incentives to make the investments while the party who doesn’t own the assets has “worse incentives.” The optimum involves a tradeoff between the two parties’ investments. In HSV, only one party, the (public or private) contractor who provides the service, makes all the investments, but now there are two kinds of investments: cost-cutting (and quality-cutting) effort  $e$ , and quality-improving (and cost-increasing) investment  $i$ . Whether the service is public or private changes the residual control rights and thus differently affects the contractor’s incentives to engage in  $e$  and  $i$ . (See also Hart [2003] for a general discussion of these models and an extension to public-private partnerships, and see Besley and Ghattak [2001] for an application of the model in the NGO context, where potential contracting parties can reap the benefits of a project even if they are excluded from it. See Schmidt [1996] for a different approach,

still grounded in incomplete contracts, based on the allocation of inside information about the firm.)

The conclusion of HSV is that, left to their own devices, private contractors do too much  $e$  and not enough  $i$ , while public contractors do too little of both: too little  $e$  and *even less*  $i$ . HSV assume that the effort levels themselves (the thought and research that goes into finding cost-cutting or quality-improving opportunities) are unverifiable, so one cannot write a contract contingent on particular values of  $e$  and  $i$ . Likewise, the ultimate cost and benefit of the project are assumed to be unverifiable.

In short, HSV assume that whatever is verifiable can be verified at no cost, and that whatever is unverifiable cannot be verified at any cost. This seems too simple in a couple of ways.

### **2.3 Accountability and monitoring**

The assumption of non-verifiability runs into the existence and widespread use of monitoring agencies. Commentators on the prison industry, for instance, stress the importance of monitoring in ensuring that contractors, whether public or private, do the right thing. Penologist Richard Harding (1997:29–30) speaks of “[i]ndependent research and evaluation” and “financial accountability,” including sanctions for low quality. Other accountability mechanisms include Freedom of Information laws, laws authorizing private lawsuits against (public or private) contractors, and the like.

This concern for not just the level of quality but also what sorts of institutions will assure that the government’s values and contractual demands are actually followed appears in the non-economic literature under the rubric of “accountability.” Minow (2003:1260; see also 2002) notes “the vital role of public oversight and checks and balances,” and defines “public accountability” as “being answerable to authority that can mandate desirable conduct and sanction conduct that breaches identified obligations” (see also Moore 2003).

Moreover, verifiability cannot be simply purchased. Verification is not guaranteed to be equally effective for public and private provision—and in fact is not guaranteed to be effective at all—so the cost of achieving a given welfare improvement using monitoring will in general differ between sectors. Many commentators (such as Minow, above) assume that divergences between contractors’ goals and “public values” is especially likely in the case of private provision, but this is not obvious.

On the one hand, public contractors are subject to various requirements that do not apply to private contractors, like civil service rules and freedom of information laws (see, for example, Cásarez 1995). On the other hand, Freeman (2003) sees privatization as a method that, far from necessarily *diluting* public values, can *extend* public values to private actors, to the extent that the government uses its contracting power to “insist on detailed contractual terms and on supervising compliance with them, conceivably requiring information disclosure, public consultation, mandatory auditing, and the like.” Moreover, private contractors are already subject to various other accountability mechanisms that are absent from the public sector. For instance, in the prison context (see generally *Harvard Law Review* 2002):

- As noted above, federal courts, suspicious of private contractors’ cost-cutting incentives, have denied state private prison guards qualified immunity, and courts also scrutinize delegations to for-profit entities more searchingly than they scrutinize delegations to public agencies.
- Juries are more likely to award large verdicts against corporations than against governments. Jury hostility also affects settlements, which are made in the shadow of expected recovery amounts at trial. Consider, for example, the case of the Northeast Ohio Correctional Center, a federal prison in Youngstown, Ohio, run by CCA under a contract with the District of Columbia. As part of a recent settlement of a lawsuit alleging inadequate security and medical treatment as well as excessive force, CCA paid \$1,650,000 in damages to the 2000 members of the inmate class—an extraordinarily high settlement amount for class actions involving prisoners. This huge settlement amount may reflect the well-known tendency of juries, rightly or wrongly, to be less sympathetic to large corporate defendants. Moreover, monetary awards against public prisons are more limited.
- A private prison may have its contract rescinded. This possibility is not always as easy as it sounds—the private prison industry is a somewhat concentrated oligopoly, though that may change with increased privatization. But as long as more than one firm is operating and the government continues to run part of the prison system, someone will be available to take over a dysfunctional prison, making the government’s threat to rescind a contract somewhat

credible.<sup>1</sup> At any rate, even such imperfect discipline is more difficult to impose on public prisons—the government cannot take over its own prison except by firing civil servants, and it cannot have a private firm take it over except by opening a new bidding process, which is more difficult than finding someone to take over an existing contract.

- Private corporations are sensitive to drops in their stock prices. Contract rescission, as well as the possibility of lawsuits with high damage awards, affects profitability, and perceptions of a company’s profitability are reflected in the price of its stock. Thus, a private corporation is punished financially for bad news, and possibly for mismanagement that may impose costs in the future. For example, the INS detention center in Elizabeth, New Jersey, run by Esmor Corrections, erupted in a massive riot in 1994 because the company had continuously cut corners on food and facility upkeep. Esmor’s stock price dropped from \$20 a share to \$7 after news of the riot became known, and the company has since reformed its practices (see also Harding 1997:108).

Moreover, public monitoring agencies, like any other government agency, are peopled by self-interested actors and are subject to regulatory capture (see Trebilcock and Iacobucci 2003; Harding 1997:ch. 3 & 4).

Thus, I make monitoring, and its failures, endogenous in the following sections on monitoring and collusion, and discuss how monitoring, even without collusion, can improve the performance of private contractors while it may not be able to improve the performance of public contractors. I also discuss how the danger of collusion may be greater when the privatization decisionmaker or the monitor has a stake in public provision, which is often the case today.

## **2.4 The design of governance structures**

The HSV model discusses when privatization would be optimal, and the assumption is that a government that believes the model can implement these recommendations, though HSV do informally raise the possibility that these decisions will be skewed through corruption or patronage. What are the appropriate mechanisms for minimizing the danger of corruption or patronage?

Much ink has been spilled on the exact design of governance structures for public agencies and for private contractors. For instance, Harding (ch. 12) explains how this is done in some prison privatization governance regimes:

- As mentioned above, in most U.S. and Australian states, the public contractor is related to the privatization decisionmaker. The privatization decisionmaker is, say, the state Department of Corrections, which also runs public prisons.
- In the UK, the monitor is an independent “chief inspector of prisons,” which can make recommendations for prison reform.
- In Florida, private and public prisons are monitored by separate monitors: the Florida Correctional Privatization Commission monitors private prisons, while the Florida Department of Corrections monitors public prisons.
- Harding himself recommends an alternative system, where an overarching Prisons Authority should put all new prison projects out to bid to both the public and private sectors. The Prisons Authority would monitor all prisons, whether private or public. When the contract period is up, these prisons should be put out to bid again, so prison management may “churn” not only within the private sector but also between the private and public sectors.

These systems raise questions such as where in the government monitoring agencies should be located (within or outside the agency that runs public prisons?), and whether the same agency should monitor all projects or whether the public and private sectors should each have their own monitor. I discuss these questions in the context of the purchaser-provider split and the monitor-provider split. These issues are also relevant in the design of private governance structures, like the state or federal civil-rights suits that were at issue in the *McKnight* and *Malesko* cases.

### 3 A model with cost-cutting investment

#### 3.1 Setup

The model in this paper is inspired by HSV.

Perhaps the simplest interesting model of privatization would involve the following: At time 0, the government chooses a contractor to manage a government service. The contract can be given to a private contractor  $M$  (for “market”) or to a private contractor  $G$  (for “government”), which have identical technology. The contract specifies that the contractor gets a contract price ( $P_0$  for a private provider,  $W_0$  for a public provider), contingent on providing a service  $S$ . The nature of the service is taken as given, so the question whether to “bundle” or “unbundle” different components of the service (see Hart 2003) doesn’t arise.

At time 1, the contractor can invest effort after the contracting stage in figuring out how to perform the service differently.

The contractor can invest effort  $e$  in “cost innovation,” ideas for a cost-cutting measure that is consistent with the contract and that reduces cost by  $c(e)$ . I assume that  $c(0) = 0, c'(0) = \infty, c' > 0, c'' < 0, c'(\infty) = 0$ . This cost innovation also reduces quality by  $b(e)$ . I assume that  $b(0) = 0, b' > 0, b'' > 0$ .<sup>2</sup>

The social benefit and social cost of the project are, respectively:

$$\begin{cases} B(e) \equiv B_0 - b(e) \\ C(e) \equiv C_0 - c(e) \end{cases} . \quad (1)$$

(Note that  $B' \equiv -b' < 0, B'' \equiv -b'' < 0, C' \equiv -c' < 0$ , and  $C'' \equiv -c'' > 0$ .)

The total social welfare of the project is the net implementation-stage benefit of the project,

minus the cost of the investment itself:

$$\begin{aligned}
\Pi^*(e) &\equiv \pi^*(e) - e \\
&\equiv B(e) - C(e) - e \\
&\equiv B_0 - C_0 - b(e) + c(e) - e.
\end{aligned} \tag{2}$$

At time 2, the service is delivered.

Differentiating equation (2), it is clear (see HSV 1997:1136) that the first-best solution  $e^*$  satisfies:

$$-b'(e^*) + c'(e^*) = 1. \tag{3}$$

(The solution is interior because  $\frac{\partial \pi^*}{\partial e}$  is infinite at  $e = 0$ , negative at  $e = \infty$ , and monotonically decreasing.)

### 3.2 Different assumptions on verifiability

First, suppose  $e$  is verifiable. Then the first-best solution is easy to implement for either mode of provision: The government can, by contract, make the price  $P_0$  or wage  $W_0$  contingent on delivering a service  $S$  defined by investing effort  $e^*$ .

Second, suppose  $e$  is not verifiable, but  $B$  is. The first-best solution is again easy to implement for either mode: The government can, by contract, make the price  $P_0$  or wage  $W_0$  contingent on achieving a benefit  $B^* \equiv B_0 - b(e^*)$ . It is clear that we get the same result if  $C$  is verifiable—the target cost will be  $C^* \equiv C_0 - c(e^*)$ .

Third, and more interestingly, suppose neither effort  $e$  nor the outcomes  $B$  or  $C$  are verifiable. Then we are in the realm of incomplete contracting. The service  $S$  is not a single action but a “basic service” that can be satisfied by a set of possible actions, all of which are identical from the point of view of a court if the government sues under the contract. Then the choice of  $e$  depends on the allocation of residual control rights—that is, on who has the right to choose what actions  $s(e) \in S$  are taken. (Residual control rights existed under the first two assumptions as well, but

they were irrelevant because the contract implemented the first best under any allocation.)

We solve this model backwards. First, we assume the contractor has already made an investment  $e$  at time 1, and see how he can benefit from it in period 2.

After making the investment, a private contractor is free to implement his cost-cutting measure and deliver service  $s(e)$ , because this is consistent with the basic service  $S$  specified in the contract. Thus, his payoff is:

$$\Pi_M(e) \equiv \pi_M(e) - e \tag{4}$$

$$\equiv P_0 - C_0 + c(e) - e. \tag{5}$$

Because the public contractor has no residual control rights, he cannot implement any changes on his own, but must get government approval. The public contractor's income,  $W_0$ , does not depend on any action he takes, so it is not clear how he would benefit from any cost savings; even if he told the government about his  $e$  ideas, far from compensating him, the government could simply steal the ideas and implement them on its own. But this situation—where the public contractor may have thought of some ideas but then has no reason to implement them—is ex post inefficient. One may expect that ex post inefficiencies will be eliminated through a round of contract renegotiation just before service delivery, so we now have renegotiation in period 2 and service delivery in period 3.

What leverage does the public contractor have in these renegotiations? HSV assume that if his measures are implemented, a fraction  $\lambda$  of the net social welfare from these changes is embodied in him as part of his human capital. (For instance, since he thought up the ideas, he may be a better project manager than a replacement contractor.) He could either offer that proportion  $\lambda$  to the government as an inducement not to fire him, or threaten to quit and take the proportion  $\lambda$  with him. So the public contractor will now stay on the job and, through Nash bargaining, split  $\lambda$  of the social benefit with the government. Since he can anticipate such an ex post renegotiation, the

payoffs from the renegotiation affect his incentives ex ante. The public contractor's payoff is thus:

$$\Pi_G(e) \equiv \pi_G(e) - e \equiv W_0 + \frac{\lambda}{2}(-b(e) + c(e)) - e. \quad (6)$$

Now we solve for the contractor's choice in period 1. Differentiating equations (5) and (6) with respect to  $e$ , it is clear that (see HSV 1997:1137–38) the private solution  $e_{M0}$  and the public solution  $e_{G0}$  satisfy:

$$\begin{cases} c'(e_{M0}) = 1 \\ \frac{\lambda}{2}(-b'(e_{G0}) + c'(e_{G0})) = 1 \end{cases}. \quad (7)$$

(The private solution is interior because  $\frac{\partial \pi_M}{\partial e}$  is infinite at  $e = 0$ , zero at  $e = \infty$ , and monotonically decreasing. The public solution is interior because  $\frac{\partial \pi_G}{\partial e}$  is infinite at  $e = 0$ , negative at  $e = \infty$ , and monotonically decreasing.)

The public sector's incentives are diluted not only by the fractional incentive effect of Nash bargaining but also by the “irreplaceability” effect of the parameter  $\lambda$ , and so it does too little cost-cutting investment: Because  $f(e) = -b'(e) + c'(e)$  is strictly decreasing,  $f(e^*) = 1$ , and  $f(e_G) = \frac{2}{\lambda} > 2$ , it follows that  $e_G < e^*$ . Similarly, the private sector doesn't take the reduction in social benefit into account when it sets  $e$ , so it does too much cost-cutting investment:  $f(e) < c'(e)$  for all  $e$ ,  $c'(e)$  is strictly decreasing,  $f(e^*) = 1$ , and  $c'(e_M) = 1$ ; this all implies that  $c'(e^*) > 1$  and therefore that  $e^* < e_M$ . The result that:

$$e_{G0} < e^* < e_{M0} \quad (8)$$

(see HSV 1997:1139) implies:

$$\begin{cases} B(e_{M0}) < B(e^*) < B(e_{G0}) \\ C(e_{M0}) < C(e^*) < C(e_{G0}) \end{cases} \quad (9)$$

because both  $B$  and  $C$  are decreasing in  $e$ . Private contractors produce a lower-cost service that also comes at a lower quality than in the first best, while public contractors produce a higher-cost service that also has a higher quality than in the first best. Social welfare under private provision

could be either higher or lower than under public provision:

$$\Pi^*(e_{G0}) - \Pi^*(e_{M0}) = (-b(e_{G0}) + b(e_{M0})) + (c(e_{G0}) - c(e_{M0})) - (e_{G0} - e_{M0}) \quad (10)$$

$$= (-b'(\zeta) + c'(\zeta) - 1)(e_{G0} - e_{M0}) \text{ for some } \zeta \in (e_{G0}, e_{M0}), \quad (11)$$

and this is of ambiguous sign. The efficient choice between public and private provision thus depends on weighing the importance of cost-cutting and quality-cutting in the two cases.

The result of this simple model—a single type of investment in cost-cutting that is also harmful to quality, with the private sector “saving costs by cutting corners” and the private sector “gold-plating”—corresponds to certain views of privatization in the popular literature.

### 3.3 Monitoring in the simple model

The assumption that  $e$  is verifiable seems unreasonable, and the assumption that  $B$  or  $C$  is verifiable (at least, costlessly verifiable) seems too optimistic. More realistic, though, is an assumption that  $B$  or  $C$  (or perhaps both) could be verified with some probability and at some cost.

Suppose the government can verify true quality  $B$  (to the satisfaction of a court) with probability  $p$  by paying a cost  $a(p)$ , with  $a(0) = 0$ ,  $a' > 0$ ,  $a'' > 0$ , and  $\lim_{p \rightarrow 0} a(p) = A > 0$ . (It makes no difference whether we choose  $B$  or  $C$  to monitor. Which assumption is more reasonable depends on the context: for public utilities, cost monitoring may be more plausible, while for prisons, it may be easier to imagine a prison monitor investigating quality issues like conditions of confinement. The results in this section do not fundamentally depend on whether the agency observes  $B$  or  $C$ , or even both together.)

If the government can verify true quality, it has the right to impose a fine of  $g(B)$ .<sup>3</sup> To be credible, monetary fines cannot exceed a certain level, for instance the level required to push the company into bankruptcy:<sup>4</sup>

$$g(B) \leq M, \forall B. \quad (12)$$

The contractor, assumed risk-neutral, chooses  $e$  to maximize:

$$\Pi(e; p, g) \equiv \Pi(e) - pg(B(e)). \quad (13)$$

Denote this choice  $e(p, g)$  ( $e_M(p, g)$  for a private contractor and  $e_G(p, g)$  for a public contractor).

The government, a social-welfare maximizer, chooses  $p$  and the penalty scheme  $g$  to maximize:

$$\begin{aligned} SW_0(p, g) &\equiv \Pi^*(e(p, g); p, g) - a(p) \\ &\equiv \pi^*(e(p, g)) - e(p, g) - a(p), \end{aligned} \quad (14)$$

In principle, there's no need to make  $g$  the same for both public and private contractors. Each type of contractor, public or private, can have its own fine function  $g_M$  and  $g_G$ , with associated probabilities  $p_M$  and  $p_G$ .

**Proposition 1** *The optimal monitoring regime will include a fine schedule  $\hat{g}$  of the form:*

$$\hat{g}(B) = \begin{cases} 0 & \text{for } B = \hat{B} \\ M, & \forall B \neq \hat{B} \end{cases} \quad (15)$$

and a detection probability:

$$p = \frac{\Pi(e_0) - \Pi(\hat{e})}{M}, \quad (16)$$

where  $e_0$  is the contractor's no-monitoring choice and  $\hat{e} \equiv B^{-1}(\hat{B})$ .

**Proof.** See Appendix A. ■

Because  $g$  can be uniquely described with the target benefit level  $\hat{B}$ , and because the choice of  $\hat{B}$  implies a unique  $\hat{e}$ , which in turn implies a particular detection probability  $\hat{p}$ , the choice of  $p$  and

$g$  is actually a choice of  $\hat{e}$ . The government thus chooses  $\hat{e}$  to maximize:

$$\begin{aligned}
SW_1(\hat{e}) &\equiv \Pi^*(\hat{e}) - a(\hat{p}(\hat{e})) \\
&\equiv \pi^*(\hat{e}) - \hat{e} - a(\hat{p}(\hat{e})) \\
&\equiv B(\hat{e}) - C(\hat{e}) - \hat{e} - a\left(\frac{\Pi(e_0) - \Pi(\hat{e})}{M}\right)
\end{aligned} \tag{17}$$

Not every quality level will be implementable—such a monitoring regime can only implement those  $\hat{e}$  for which  $\Pi(e_0) - \Pi(\hat{e}) \leq M$ —nor will every implementable quality level be optimal. (The optimal monitoring regime may be a trivial regime, i.e. a corner solution: the government could set  $\hat{B}$  equal to the contractor’s no-monitoring choice,  $B(e_0)$ , and set  $p = 0$ .)

It is clear that, if monitoring is costless—that is, if  $a \equiv 0$ , then this maximization is the same as maximizing equation (2), so provided  $\hat{e}$  is implementable by a fine of at most  $M$ , the government will find it optimal to set  $\hat{e} = e^*$  and implement the first best. (It is worth considering the effect of different values of  $M$ . One may suspect that  $M$  is lower for the public sector—both the level of possible rewards and the level of possible penalties tends to be limited in the case of government employees. If this is the case, then the range of implementable values of  $B$  is lower for the public sector, and the value that is optimal to implement for the private sector may not even be achievable for the public sector.)

**Proposition 2** *Suppose the monitoring regime may differ between public and private contractors. Then:*

- (1) *If  $A = 0$ , it is always optimal to monitor contractors.*
- (2) *There exists  $\bar{A}$  such that,  $\forall A \leq \bar{A}$ , the optimal monitoring regime is the same as the optimal contracting regime for  $A = 0$ , and  $\forall A > \bar{A}$ , the optimal monitoring regime is the trivial regime.*
- (3) *Under nontrivial monitoring, the performance of both public and private contractors moves closer to the first best, but optimal monitoring never achieves the first best.*

**Proof.** See Appendix B. ■

The simple model thus gives us an unsurprising result: Unless monitoring is too expensive,

some amount of monitoring is optimal, and monitoring improves the performance of each sector by moving its choice of  $e$  closer to the first-best level. This result does not hold in a more complicated model where there are two types of investment (see Proposition 5).

### 3.4 Interpreting this model in a two-period context

One may object that the government will not really levy a fine on a public contractor, or perhaps that the contractor (say, a public prison warden) may not have the cash available. The agency may even be unwilling to fine a private contractor if the fine could drive the firm into bankruptcy and endanger the service. It may perhaps be more realistic to interpret the penalty for low quality as a reduced probability of contract renewal for the next period.

A two-period model has an added benefit: It allows us to talk later (in the section on the monitor-provider split) about the endogenous benefits of public provision to a monitoring agency. In a dynamic model, as I explain later, monitors (if they are not the government itself but agents of the government) can be more willing to suppress bad information if they benefit from a particular mode of provision (public or private).

There are two periods. The contractor chooses (and pays for)  $e$  in each period— $e_1$  and  $e_2$ . Monitoring happens in period 1, and the monitor observes true quality with probability  $p$ . The probability that the contractor is fired next period is  $\eta(B)$ . In period 2, the monitoring agency can't affect the contractor's behavior, so we revert to no-monitoring behavior:  $e_2 = e_0$ .

Under the model so far, it will not be time-consistent for the government to honor the contract in period 2, since the government will want to hire the contractor who performs best in a no-monitoring setting regardless of how the period-1 contractor behaved. So our current assumptions rule out using non-renewal as a credible threat.

Therefore, assume that there is some variation in contractors' technology. Each contractor has a different constant  $B_0$  in the benefit function  $B(e) = B_0 - b(e)$ , say either a low value  $B_{0L}$  or a high value  $B_{0H}$ , drawn from a known distribution  $p(B_0 = B_{0L}) = p_L \in (0, 1)$ . The public contractor has  $B_0^G$  and the private contractor has  $B_0^M$ . Given some observation of  $B_0$ , denote the resulting benefit function  $B(e|B_0)$ .

Either the agency will separate the two types by choosing two levels ( $\hat{B}_L, \hat{B}_H$ ) such that high types will achieve  $\hat{B}_H$  and low types will achieve  $\hat{B}_L$ , or will pool by choosing a single level  $\hat{B}$  that both high types and low types will achieve.

- If the agency pools, then in period 2 it picks the type of contractor (public or private) that, on average (averaging over high and low types), is optimal in the no-monitoring, one-period setting. It chooses the private contractor if:

$$E_{p_L} \Pi^*(e_{M0}) > E_{p_L} \Pi^*(e_{G0}), \quad (18)$$

and chooses the public contractor otherwise.

- But at least for certain parameter values, it will be optimal to separate high types from low types. If the agency separates, then in period 2, it knows for certain whether its period-1 contractor was high-type or low-type. Suppose the high types are “good enough” and the low types are “bad enough” that:

$$\begin{cases} \max\{\Pi^*(e_{M0}|B_{0L}), \Pi^*(e_{G0}|B_{0L})\} < \min\{E_{p_L} \Pi^*(e_{M0}), E_{p_L} \Pi^*(e_{G0})\} \\ \min\{\Pi^*(e_{M0}|B_{0H}), \Pi^*(e_{G0}|B_{0H})\} > \max\{E_{p_L} \Pi^*(e_{M0}), E_{p_L} \Pi^*(e_{G0})\} \end{cases} . \quad (19)$$

That is, the worst-sector high-type is better than the best-sector average contractor, and the best-sector low-type is worse than the worst-sector average contractor. Then it will be optimal for the agency to rehire a high type or fire a low type in period 2. Moreover, for low enough low types, pooling would require choosing a very low benefit level, which would not be optimal; and if the high types are high enough, pooling would prevent the agency from identifying and rehiring a highly efficient period-1 contractor.

In a separating equilibrium, a high-type period-1 contractor will be motivated by the fear of losing  $p\Pi(e_2)$ , the expected cost of being fired for certain for some observation of  $B$ . Thus, the fear of being fired in period 2 works like a monetary penalty for high types. So the previous model of monetary fines works as an intuition even if monetary fines as such are infeasible.

## 4 A model with two kinds of investment

### 4.1 Setup

In the HSV model, there are two types of investment: effort invested in finding “cost innovations” (the same  $e$  as above), and effort invested in finding “quality innovations” (which HSV dub  $i$ ). While  $e$  decreases cost and thus decreases quality,  $i$  increases quality and thus increases cost. This is more realistic than the model with only cost-cutting investment: For instance, in the case of prisons, contractors may seek to innovate not only by, for instance, cutting corners on medical care for inmates or corrections officer training, but also by developing vocational, psychological, and other rehabilitative programs.<sup>5</sup>

We assume that an investment of  $i$  increases quality by  $\beta(i)$ ,  $\beta(0) = 0$ ,  $\beta'(0) = \infty$ ,  $\beta' > 0$ ,  $\beta'' < 0$ ,  $\beta'(\infty) = 0$ , and increases cost by  $\gamma(i)$ ,  $\gamma(0) = 0$ ,  $\gamma' > 0$ ,  $\gamma'' > 0$ . (HSV use  $\beta$  to represent net benefits, but in this model I separate the components of quality innovation, so net benefits here are  $\beta - \gamma$ .)

The social benefit and social cost of the project are thus:

$$\begin{cases} B(e, i) \equiv B_0 - b(e) + \beta(i) \\ C(e, i) \equiv C_0 - c(e) + \gamma(i) \end{cases} \quad (20)$$

(Note that  $B_e = -b' < 0$ ,  $B_i = \beta' > 0$ ,  $B_{ee} = -b'' < 0$ ,  $B_{ii} = \beta'' < 0$ ,  $C_e = -c' < 0$ ,  $C_i = \gamma' > 0$ ,  $C_{ee} = -c'' > 0$ ,  $C_{ii} = \gamma'' > 0$ .) The total social welfare of the project, then, is:

$$\begin{aligned} \Pi^*(e, i) &\equiv \pi^*(e, i) - e - i \\ &\equiv B(e, i) - C(e, i) - e - i \\ &\equiv B_0 - C_0 - b(e) + c(e) + \beta(i) - \gamma(i) - e - i. \end{aligned} \quad (21)$$

Differentiating equation (21) with respect to  $e$  and  $i$ , it is clear that (as HSV show, with somewhat

different notation) the first-best solution  $(e^*, i^*)$  satisfies:

$$\begin{cases} -b'(e^*) + c'(e^*) = 1 \\ \beta'(i^*) - \gamma'(i^*) = 1 \end{cases} . \quad (22)$$

(The  $e$  condition is the same as in equation (3), and the solution for  $i$  is interior for the same reasons.)

Suppose  $e$  and  $i$  are verifiable. Then, as before, a contract can be made contingent on  $e^*$  and  $i^*$ .

Similarly, suppose both  $B$  and  $C$  are verifiable. Then a contract can be made contingent on  $B^*$  and  $C^*$ . The government can back out the values of  $e$  and  $i$  by solving the system:

$$\begin{cases} B(e, i) \equiv B_0 - b(e) + \beta(i) = B^* \\ C(e, i) \equiv C_0 - c(e) + \gamma(i) = C^* \end{cases} . \quad (23)$$

Any solution  $\tilde{e}$  to this system implies a corresponding solution  $\tilde{i} = \gamma^{-1}(C^* - C_0 + c(\tilde{e}))$ , so the first equation of system (23) can be rewritten:

$$f(e) \equiv -b(e) + \beta(\gamma^{-1}(C^* - C_0 + c(e))) = B^* - B_0. \quad (24)$$

It is clear that equation (24) has at least one solution,  $e^*$  (which implies  $i^*$ ), but it may have a second solution, since  $f(e)$  is not necessarily monotonic:

$$f'(e) \equiv -b'(e) + \frac{\beta'(\gamma^{-1}(C^* - C_0 + c(e))) \cdot c'(e)}{\gamma'(\gamma^{-1}(C^* - C_0 + c(e)))}, \quad (25)$$

which has an ambiguous sign because  $-b'(e)$  is negative while the  $\frac{\beta' c'}{\gamma'}$  term is positive. However, it is easy to check that  $f$  is concave, so equation (24) has no more than two solutions. In any event, for some range of parameters,  $f$  will have a single solution, so a contract contingent on  $B^*$  and  $C^*$  will elicit the first-best effort levels  $e^*$  and  $i^*$ .

If none of  $e$ ,  $i$ ,  $B$ , or  $C$  are verifiable, then we are in the HSV model of incomplete contracting. The “basic service”—the set  $S$ —can be conceptualized as two subservices  $S_1$  and  $S_2$ , so the action

$s \in S$  is actually a pair of actions  $(s_1(e), s_2(i)) \in S_1 \times S_2$ . Thus, the allocation of control rights—that is, who can choose the action—matters. The next subsection discusses this case.

## 4.2 Results under incomplete contracting

The incentives for the different types of contractor depend on the allocation of residual control rights.

As before, we solve the model backwards: First, we assume that the contractor has already made the investments  $e$  and  $i$  at time 1, and see how they can benefit from them in period 2. The incentives for  $e$  are as before—the private contractor ignores the detrimental effect of  $e$  on benefits, while the public contractor renegotiates over a proportion  $\lambda$  of net social benefits—but now we must also look at incentives for  $i$ .

After the investments have been made, a private contractor is free to implement the cost-cutting measure  $(s_1(e))$ , because this is consistent with the basic service specified in the contract. He will not make the quality-increasing measures by himself because these increase cost, but at the time of renegotiation at time 2, he can suggest  $s_2(i)$  to the government and split the surplus through Nash bargaining. Thus, the private contractor's payoff is:

$$\Pi_M(e, i) \equiv \pi_M(e, i) - e - i \tag{26}$$

$$\equiv P_0 - C_0 + c(e) + \frac{1}{2}(\beta(i) - \gamma(i)) - e - i. \tag{27}$$

Because the public contractor has no residual control rights, he will not implement any changes on his own. As before, we assume renegotiation with Nash bargaining over a fraction  $\lambda$  of the net social welfare from these changes. The public contractor's payoff is thus:

$$\Pi_G(e, i) \equiv \pi_G(e, i) - e - i \tag{28}$$

$$\equiv W_0 + \frac{\lambda}{2}(-b(e) + c(e) + \beta(i) - \gamma(i)) - e - i. \tag{29}$$

Differentiating equations (27) and (29) with respect to  $e$  and  $i$ , it is clear that the private solution

$(e_M, i_M)$  satisfies:

$$\begin{cases} c'(e_M) = 1 \\ \frac{1}{2}(\beta'(i_M) - \gamma'(i_M)) = 1 \end{cases} . \quad (30)$$

and the public solution  $(e_G, i_G)$  satisfies:

$$\begin{cases} \frac{\lambda}{2}(-b'(e_G) + c'(e_G)) = 1 \\ \frac{\lambda}{2}(\beta'(i_G) - \gamma'(i_G)) = 1 \end{cases} . \quad (31)$$

(The first-order conditions with respect to  $e$  are the same as in equation (7). The  $i$  solutions are interior because both  $\frac{\partial \pi_M}{\partial i}$  and  $\frac{\partial \pi_G}{\partial i}$  are infinite at  $i = 0$ , negative at  $i = \infty$ , and monotonically decreasing.<sup>6</sup>)

Because  $g(i) = \beta'(i) - \gamma'(i)$  is strictly decreasing,  $g(i^*) = 1$ ,  $g(i_M) = 2$ , and  $g(i_G) = \frac{2}{\lambda} > 2$ , it follows that (see HSV 1997:1139):

$$i_G < i_M < i^* . \quad (32)$$

In other words, private contractors only take a fractional part of social benefits into account when setting  $i$  because of the structure of Nash bargaining; thus, they do too little  $i$  relative to the first best, and as we have already seen, they do too much  $e$  because they don't take into account the negative effect that  $e$  has on social benefit. Public contractors' incentives on  $i$  (like their incentives on  $e$ ) are diluted not only by the fractional incentive effect of Nash bargaining but also by the "irreplaceability" effect of the parameter  $\lambda$ ; thus, they do too little of each kind of investment, relative to the first-best.

The private sector dominates the public sector on the  $i$  dimension, and it is unclear who dominates on the  $e$  dimension. (Note that these results depend on the additive separability of  $e$  and  $i$  in the functions  $B$  and  $C$ .)

- Proposition 3** (1) *Costs and benefits are lower under private provision than in the first-best.*  
(2) *Costs and benefits under public provision may be either higher or lower than in the first-best.*  
(3) *Costs and benefits under public provision may be either higher or lower than under private provision.*

(4) *Social welfare under public provision may be either higher or lower than under private provision.*

**Proof.** See Appendix C. ■

This result—or rather the absence of a result—that public could either be higher or lower quality and higher or lower cost than private prisons is (1) at odds with the “popular wisdom” about private prisons that emerges from the model without  $i$ , which is that we generally expect lower cost and lower benefit, and (2) consistent with the handful of empirical studies of private versus public prisons, which generally finds somewhat lower costs at private prisons and roughly comparable quality (see Segal and Moore (2002), *Harvard Law Review* (2002)).

### 4.3 The effects of quality monitoring

As before, suppose the monitor can observe true quality  $B$ . (Also as before, the agency could also observe some other variable, such as  $C$ .<sup>7</sup> All that is necessary here is that the agency not be able to observe both  $B$  and  $C$  together.)

The contractor, assumed risk-neutral, chooses  $e$  and  $i$  to maximize:

$$\begin{aligned}\Pi(e, i; p, g) &\equiv \Pi(e, i) - pg(B(e, i)) \\ &\equiv \pi(e, i) - e - i - pg(B(e, i)),\end{aligned}\tag{33}$$

where  $\pi(e, i)$  is his profit function. Denote these choices  $e(p, g)$  and  $i(p, g)$ . The government, a social-welfare maximizer, chooses  $p$  and the penalty scheme  $g$  to maximize:

$$\begin{aligned}SW_0(p, g) &\equiv \Pi^*(e, i; p, g) - a(p) \\ &\equiv \pi^*(e, i) - e - i - a(p),\end{aligned}\tag{34}$$

where  $e \equiv e(p, g)$  and  $i \equiv i(p, g)$ . (In principle, there’s no need to make  $g$  the same for both public and private contractors: we can have different functions  $g_M$  and  $g_G$ .)

#### 4.4 Results under optimal monitoring

**Proposition 4** *The optimal monitoring regime will include a fine schedule  $\hat{g}$  of the form:*

$$\hat{g}(B) = \begin{cases} 0 & \text{for } B = \hat{B} \\ M, & \forall B \neq \hat{B} \end{cases}, \quad (35)$$

and a detection probability:

$$p = \frac{\Pi(e_0, i_0) - \Pi(\hat{e}, \hat{i})}{M}, \quad (36)$$

where  $\hat{e}$  and  $\hat{i}$  maximize  $\Pi(e, i)$  subject to  $B(e, i) = \hat{B}$ .

**Proof.** See Appendix D. ■

Because  $g$  can be uniquely described with the target benefit level  $\hat{B}$ , and because the choice of  $\hat{B}$  implies a particular detection probability  $\hat{p} = \hat{p}(\hat{B})$ , the choice of  $p$  and  $g$  is actually a choice of  $p$  and  $\hat{B}$ . The government chooses  $\hat{B}$  to maximize:

$$\begin{aligned} SW_1(\hat{p}(\hat{B}), \hat{B}) &\equiv \pi^*(e, i) - e - i - a(\hat{p}(\hat{B})) \\ &= B(e, i) - C(e, i) - e - i - a(\hat{p}(\hat{B})), \end{aligned} \quad (37)$$

where  $e$  and  $i$  are chosen by the contractor to maximize:

$$\Pi(e, i) \equiv \pi(e, i) - e - i \quad (38)$$

subject to:

$$B(e, i) = \hat{B}. \quad (39)$$

(To correspond to our change of notation from  $SW_0$  to  $SW_1$ , we may denote the contractor's choices  $e(\hat{B})$  and  $i(\hat{B})$ .) The first-order conditions of the contractor's problem are:

$$\frac{\Pi_e}{\Pi_i} \equiv \frac{\pi_e - 1}{\pi_i - 1} = \frac{B_e}{B_i}, \text{ and} \quad (40)$$

$$B(e, i) = \hat{B}. \quad (41)$$

(The contractor's solution is interior because  $c'(0) = \infty$  and  $\beta'(0) = \infty$ , so it will never be cost-minimizing to choose  $e = 0$ , and it will always be advantageous to decrease quality with some amount of  $e$  and then choose  $i > 0$  to increase quality.) To simplify matters, we may combine the contractor's and government's problems, and choose  $e$ ,  $i$ , and  $\hat{B}$  to solve the following problem:

$$\max_{e, i, \hat{B}} B(e, i) - C(e, i) - e - i - a \left( \frac{\Pi(e_0, i_0) - \Pi(e, i)}{M} \right), \quad (42)$$

subject to:

$$\begin{cases} (\pi_e - 1)B_i = (\pi_i - 1)B_e \\ B(e, i) = \hat{B} \end{cases}. \quad (43)$$

**Proposition 5** *Suppose the monitoring regime may differ between public and private contractors.*

*Then:*

(1) *For either type of contractor, if monitoring changes its choices at all (i.e., if there is no corner solution), it moves cost-saving effort  $e$  and quality-improving effort  $i$  in opposite directions. That is, in a monitoring optimum  $(e^A, i^A)$ , either we have  $(e^A, i^A) = (e_0, i_0)$ , or we have one of the following:  $e^A > e_0$  and  $i^A < i_0$ , or  $e^A < e_0$  and  $i^A > i_0$ .*

(2) *For private contractors, optimal monitoring improves social welfare by reducing cost-saving effort and increasing quality-improving effort:  $e_M^A < e_M$ ,  $i_M^A > i_M$ . Both types of effort move in the direction of first-best effort levels.*

(3) *For public contractors, both types of effort do not simultaneously move in the direction of first-best effort levels, and social welfare may not increase.*

(4) *Optimal monitoring does not achieve the no-monitoring first best. That is,  $(e^A, i^A) \neq (e^*, i^*)$ .*

**Proof.** See Appendix E. ■

For some intuition on this proposition, recall, first, that in the private no-monitoring equilibrium,  $e$  is too high and  $i$  is too low relative to the first best, and second, that  $e$  and  $i$  move  $B(e, i)$  in opposite directions. Thus, optimal benefit-based fines, by implementing a particular benefit level, will decrease  $e$  and increase  $i$  for the private contractor, moving both variables in the direction of the first-best. But for the public contractor,  $e$  and  $i$  are both too low, so benefit-based fines will either increase  $e$  while decreasing  $i$ , or decrease  $e$  while increasing  $i$ ; social welfare may not increase.

In Proposition 2, the only reason we had underdeterrence was the standard Polinsky-Shavell (1992) reason: Monitoring costs money. However, here, there is underdeterrence even if monitoring is free (and public-sector quality may not increase even if monitoring is free): Any quality level  $\hat{B}$  or cost level  $\hat{C}$  can be achieved with many different combinations  $(e, i)$ . Because we can only monitor one outcome (here, by assumption,  $B$ , though this also works with  $C$ ) but can't monitor the choices of  $e$  and  $i$ , we cannot guarantee that first-best quality  $B^*$  will be achieved with first-best investment levels  $e^*$  and  $i^*$ , and indeed, we know that it will not be.

By replacing  $B$  with  $C$  in the proof of Proposition 5, one can see that the same results hold if, instead of observing  $B$ , the agency can only observe  $C$ . Like  $B$ ,  $C$  has oppositely-signed first derivatives with respect to  $e$  and  $i$ , and negative second derivatives. The same results hold with any function  $F$  that is additively separable in  $e$  and  $i$  and that has oppositely-signed first derivatives and negative second derivatives  $\frac{\partial^2 F}{\partial e^2}$  and  $\frac{\partial^2 F}{\partial i^2}$ . The intuition is clear: as long as  $\frac{\partial F}{\partial e}$  and  $\frac{\partial F}{\partial i}$  have opposite signs, a monitoring regime based on  $F$  will tend to push  $e$  and  $i$  in opposite directions. This definitely increases social welfare in the private case, where  $e$  and  $i$  are on opposite sides of the first-best—instead of implementing a higher level of  $B$ , one could implement a higher level of  $C$ —but it may not increase social welfare in the public case, where both types of effort are too low and thus at least one of the types of effort moves away from the first-best level. (Real-world considerations (not modeled here) suggest that rewarding high cost may not be as feasible as rewarding high benefit: It is just too easy to inflate costs. In other words, either the cost technology isn't perfectly known to the monitor, or there are other investments than  $e$  and  $i$  (perhaps a hard-to-observe form of investment, “throwing money away,” that increases cost while not affecting benefit).)<sup>8</sup>

The moral of Proposition 5 is the following: Without monitoring, either the public sector or

the private sector may be optimal. But there remains the problem of “accountability”: How do we achieve what the model assumes, which is that the contractors do what the principal (the government) tells them to do? A widespread method of control is the use of monitoring agencies. At first glance, monitoring may not seem to change the balance between the public and private sectors—the assumption is that monitoring improves both sectors. Indeed, some lay commentators seem to assume that, if anything, government agents, as employees of the same organization that does the monitoring, are easier to control than are private agents; and, focusing on the harmful cost-cutting motive, they argue that monitoring of private contractors should overcome this natural bias by being stricter than monitoring of public contractors (see *Fuentes* and *McKnight v. Rees*). The preceding proposition suggests that these assumptions may be misplaced: In this model, monitoring improves the social welfare from private contracting (even when variable monitoring cost is taken into account), but it is not guaranteed to improve the social welfare from public contracting at all. Moreover, this result does not depend on the assumption that monitors observe  $B$ ; it applies even if monitors observe  $C$  or any other function with similar properties.

## 5 The effects of collusion

### 5.1 The basic form of regulatory capture

So far, all monitoring has been done directly by the government, which we have assumed to be unitary. This is of course unrealistic. In the real world, monitoring is done by monitoring agencies, and whenever one talks about agencies, one must consider that the agency may have objectives of its own and may possibly be captured by (or otherwise collude with) the regulated entity. Any model that would take this into account must therefore have three tiers (see Tirole 1986). The government (here assumed social-welfare-maximizing) may empower an agency to observe the contractor’s operations and assess fines based on its observation.

Now the contractor and the agency can collude. (In the prison context, some degree of collusion has been observed in most systems. Harding finds the British monitoring system “vigorously

independent, with no danger of capture to date,” but attributes this to the monitor’s toothlessness (1997:159–60).) Given an observation of benefit  $B$ , they can collectively save  $g(B)$  if the agency falsely tells the government that it hasn’t found any quality problems. The fine  $g$  goes to the government, not to the agency—if the agency were entitled to collect the entire amount of the fine from the contractor, then the contractor would maximize the same  $\pi - e - i - g$  as under direct government monitoring, so the results under collusion would be the same as the results without collusion. By assumption, the agency cannot extract money from the contractor by threatening to report a false value of  $B$ . (This has the flavor of the model of agency monitoring in Laffont and Tirole [1993:ch. 10].)

Under the setup from the previous section, if the contractor and the agency split the gains from collusion through Nash bargaining, the contractor only has to give up  $\frac{g}{2}$ . Thus, the contractor chooses  $e$  and  $i$  to maximize:

$$\pi(e, i) - e - i - \frac{1}{2}pg(e, i). \quad (44)$$

In a monitoring equilibrium with collusion, social welfare is either the same as in the no-collusion equilibrium, or it is lower. Formally, collusion is identical to a worsening of detection technology whereby  $p$  becomes  $\frac{p}{2}$ , so the new agency budget required for a “real” detection probability of  $p$  is:

$$A(p) \equiv a(2p) \geq a(p). \quad (45)$$

The new social welfare function,

$$SW_1(p, g) \equiv \pi^*(e(p, g), i(p, g)) - e(p, g) - i(p, g) - A(p), \quad (46)$$

is everywhere (for all  $(p, g)$  combinations) lower than the old objective function (equation (37), which had  $a(p)$  instead of  $A(p)$ ) except at  $p = 0$ , therefore its maximized value is strictly lower as long as  $\hat{p} > 0$ . If the optimal detection probability was  $\hat{p} = 0$  in the no-collusion equilibrium—that is, if there were a corner solution in monitoring—then there is no effective monitoring, and so collusion changes neither outcomes nor social welfare. Note that the government cannot undo the effects of

capture by doubling penalties, because of the maximum penalty  $M$ : The optimal penalty is  $M$  for  $B \neq \hat{B}$ , and penalties above  $M$  are infeasible (thus, some benefit levels that had been implementable are no longer implementable). Nor will it generally be optimal to undo the effects of capture by doubling the detection probability, because this is costly.

When we allow for collusion, the government must set the contractor's fine structure and the monitor's compensation knowing that regulatory capture will occur, and we can limit our attention to collusion-proof compensation schemes (see Tirole 1986; Laffont and Tirole 1993). The monitor's flat compensation scheme ( $a(p)$ ) will always lead to collusion. Collusion can only be avoided if the monitor, instead of the government, keeps the entire fine  $g$ —since if the monitor kept less than  $g$ , it could gain from collusion, and paying the monitor anything extra is not optimal because of the social losses associated with raising money through distortionary taxation. Then the solution becomes the same as in the previous section, because the agency problem between the government and the agency is essentially eliminated, and we are left with a two-actor problem, which is immune to collusion. Since in equilibrium, no problems are found, there is not even any actual transfer of wealth between the government and the monitor.

But note that even in this model, if money fines are infeasible, as in the two-period model where the fine is the foregone opportunity to earn  $\pi(e_2, i_2)$ , the government must pay the monitor  $\pi(e_2, i_2)$  for finding problems to prevent him from colluding with the contractor. Since the two-period model relies on revealed heterogeneity between period-1 contractors, monitoring does in fact find problems for all low-type contractors, so this payment actually takes place, which gives rise to a social welfare loss of  $p_L \theta \pi(e_2, i_2)$ , where  $p_L$ , as above, is the probability that a period-1 contractor is low-type, and  $\theta$  is the social cost of raising a dollar of revenue through distortionary taxation. (Also, in a more realistic model, where there is randomness either on the contractor's or on the monitor's side, an all-or-nothing contract based on the exact realization of a benefit level will not be optimal in general, and some problems will be found in equilibrium, so preventing collusion will involve a real loss of government revenue and therefore a real social welfare loss.)

## 5.2 The purchaser-provider split

So far we haven't been explicit about who makes the choice whether or not to privatize. In many cases, the agency that chooses whether to privatize is the same as the public contractor that provides the service if the service is kept in-house (e.g., the Department of Corrections). For instance, in most U.S. and Australian states, the privatization decision is made by the "public sector correctional agency" (Harding 1997:159), which also makes many of the decisions regarding how to run the prisons. Suppose, for instance, that the privatization decisionmaker is the same actor who would make the  $e$  and  $i$  decisions if the service were provided in-house. This would skew the decision whether to privatize, since the decisionmaker would benefit from providing services in-house:  $\Pi_G(e_G^A, i_G^A) > 0$  for each potential project, the decisionmaker will choose to keep all possible projects in-house, instead of only those projects where  $\Pi^*(e_G^A, i_G^A) > \Pi^*(e_M^A, i_M^A)$ . (Essentially, the decisionmaker is capturing the policy advice process about privatization; this has the flavor of Romer and Rosenthal [1979].)

To see this more formally, assume there is a continuum of projects (with volume normalized to 1). Let the technology of each project be characterized by a parameter:

$$\delta = \Pi^*(e_G^A, i_G^A) - \Pi^*(e_M^A, i_M^A), \quad (47)$$

that is, the relative benefit of having public over private provision. Thus, each project  $k$  has benefit:

$$B(e, i; \delta_k) = B_0 - b(e; \delta_k) + \beta(i; \delta_k), \quad (48)$$

and similarly with cost, so a project's  $\delta$  affects the choices that contractors make. As we saw earlier, public provision is preferred to private provision if there are plentiful opportunities for harmful cost-cutting and quality innovation is relatively unimportant. The variation in  $\delta$  can be interpreted as variation in these underlying factors. Projects with high  $\delta$  may involve, say, maximum-security prisons or prisons with a high proportion of mentally ill inmates, where opportunities for harmful cost-cutting are high and where the government may be less willing to experiment, and more

willing to fall back on traditional, possibly inefficient practice. Projects with low  $\delta$  may involve, say, juvenile halfway houses and minimum-security prisons, where cost-cutting is less harmful and quality innovation more beneficial. (This is only a conjecture; arguably, the failures of the prison management status quo are most pronounced where inmates are highly dangerous or mentally ill.) Given such variation, it is optimal to contract out some projects and keep others in-house; the question is how to distinguish the good candidates from the bad ones.

For a project with a parameter  $\delta$ , denote the public sector's choice  $(e_G^A(\delta), i_G^A(\delta))$  and the private sector's choice  $(e_M^A(\delta), i_M^A(\delta))$ . Let  $\delta$  be distributed with a density function  $\phi_\delta$ .

**Proposition 6** (1) *The first best is to privatize a proportion  $\rho^* = \Phi(0)$  of projects, that is, all the projects where  $\delta < 0$ . Then total social welfare is:*

$$W^* = \int_{-\infty}^0 \pi^*(e_M^A(\delta), i_M^A(\delta))\phi_\delta d\delta + \int_0^\infty \pi^*(e_G^A(\delta), i_G^A(\delta))\phi_\delta d\delta. \quad (49)$$

(2) *Without government oversight, the public provider in charge of privatization will choose to privatize  $\rho = 0$ , so social welfare is:*

$$W_0 = \int_{-\infty}^\infty \pi^*(e_G^A(\delta), i_G^A(\delta))\phi_\delta d\delta < W^*. \quad (50)$$

(3) *If the public provider chooses to privatize  $\rho_A < \rho^*$ , then all projects such that  $\delta \in (\Phi^{-1}(\rho_A), 0]$  will wrongly stay in-house, for a social welfare loss of:*

$$\begin{aligned} L(\rho_A) &= \int_{\Phi^{-1}(\rho_A)}^0 [\pi^*(e_M^A(\delta), i_M^A(\delta)) - \pi^*(e_G^A(\delta), i_G^A(\delta))]\phi_\delta d\delta \\ &= - \int_{\Phi^{-1}(\rho_A)}^0 \delta\phi_\delta d\delta. \end{aligned} \quad (51)$$

(4) If the government can override the agency's decision at a cost  $K$ , the agency will choose:

$$\hat{\rho}_A = \min_{\rho_A \geq 0} \{L(\rho_A) \leq K\} < \rho^*. \quad (52)$$

**Proof.** See Appendix F. ■

Thus, if government oversight is costless, the agency will choose the first-best,  $\rho^* = \Phi(0)$ , because otherwise the government will override the agency's decision. In reality, the cost of government oversight ( $K$ ) includes the cost of organizing legislators to vote and drafting legislation, and also the substantial cost of determining which projects merit privatization and which don't. The government doesn't have as much expertise as the decisionmaking agency to develop the  $\delta$ -ranking of agencies, so  $K$  can be quite large. (McNollGast discuss costly legislative ex-post correction of administrative decisions in McCubbins, Noll, and Weingast [1987]. They stress that ex-post correction has its limits and also explore [1987, 1989] how Congress can affect bureaucratic outcomes by designing procedural rules, but this discussion focuses on ex-post correction.)

Thus, the purchaser-provider split is necessary to remove the decisionmaker's incentive to keep services in-house: An agency that benefits from keeping services in-house should not choose which projects to privatize (see also Harding [1997] on how to establish a "Chinese wall" between the public provider and the privatization decisionmaker).

### 5.3 The monitor-provider split

In most monitoring systems, for prisons and for other services, the monitoring agency is the same as, or closely related to, the agency that will provide the service if the service is kept in-house. For example, prison systems are often monitored by the state Department of Corrections, which also runs public prisons. We can talk about the monitor-provider split in the context of a two-period model where monitoring in period 1 affects whether the contract is renewed for period 2.

- Recall the two-period model discussed earlier. There is variation in contractors'  $B_0$ , which is unobservable, but the fact that a contractor achieves  $\hat{B}$  makes the government willing to

hire him in the next period. If the public provider monitors itself, because  $\Pi_G(e_G, i_G) > 0$ , it never finds any problems (reports  $B = \hat{B}$ ), and its contract is always renewed for period 2. Since there is no second party with which to Nash bargain, this is obviously equivalent to having no monitor.

- More realistically, public contractors can be monitored by another government agency, but this agency is in the same general division, which benefits from public provision in a more general way. For instance, say that all prisons are monitored through the Department of Corrections; the Department of Corrections doesn't make the  $e$  and  $i$  decisions in individual prisons, but it generally benefits from public provision, because under public provision it hires more people and has larger budgets to administer the public prison apparatus. A fraction  $1 - \phi$  of cost is paid to outside providers, but  $\phi$  of cost is retained as benefits to the agency, for instance, as payments for overhead, support staff, legal services, health insurance, and so on. (This is similar to the "patronage" issue discussed in HSV.) On the other hand, if provision is private, then the Department of Corrections only does contract monitoring and doesn't have to provide the same sort of support staff. (One could say that the monitoring agency gets 0 in this case, or suppose that they get  $\phi_M \ll \phi_G$ .) Then, through Nash bargaining, the colluding contractor and the monitor split (conditional on the monitor's finding a problem)  $\Pi_G(e_2, i_2) + \phi C(e_2, i_2)$  if the contractor is public, or  $\Pi_M(e_2, i_2) - \phi C(e_2, i_2)$  if the contractor is private (instead of, as before in the two-period context, just  $\Pi_G(e_2, i_2)$ ). A collusion-proof arrangement would require the government to pay the monitor this amount if any problems were found. In equilibrium in this two-period model, no problems are found in period 1 for the high-type contractors, but they are found for low-type contractors, so conditional on the period-1 contractor being low-type, actual collusion-proofness incentive payments to the monitor are  $2\phi C(e_2, i_2)$  higher for public than for private provision, for a social welfare loss of  $2\theta\phi C(e_2, i_2)$ , where  $\theta$ , as before, is the social cost of raising a dollar of tax revenue through distortionary taxation.

Saying that the monitor “has an interest” in continued public provision means more than just saying that the monitor and the provider are in the same department. The example of the Florida system is instructive (see Harding 1997:161). The standard monitoring system builds in a bias in favor of public prisons when the prison monitor benefits from public provision, as when public prisons and the monitor are in the same department: In the model here, both public and private prisons always get their contracts renewed (through collusion), but monitoring is more efficient for private prisons. The Florida system, which separates monitoring of the public and private systems and makes each monitor organizationally separate from the prisons it monitors, seems to solve this problem. But it raises another one of its own.

In Florida, the asymmetry disappears: The public monitor only monitors public prisons, and the private monitor only monitors private prisons, so there is no bias in the system. But each monitor agency benefits from provision in its own sector: The public monitor benefits from public provision, while the private monitor benefits from private provision. So *each* monitor will collude with its contractor on favorable terms, and so each contractor will choose an  $e_1$  and  $i_1$  too close to the no-monitoring case. Harding (1997:161–65) suggests an alternative system that seems to mitigate the chances of capture: Not only should the monitors be separated from the prisons they monitor, but there should also be a single monitoring agency for both public and private sectors.

While a monitor-provider split mitigates the problem of monitors’ being captured by public contractors (akin to what HSV call “patronage”), it does not address the parallel problem of privatization decisionmakers’ or monitors’ being captured by private contractors (HSV’s “corruption”; see also Glaeser (2001)). The privatization decision can be partly depoliticized by removing the discretionary issue of whether to privatize projects: putting all projects all out to bid and letting both the private and public sectors bid on them. Auctions do not need to be low-cost, and in fact in many U.S. states current practice looks more like “high-social-welfare” auctions, where the government can accept a higher bid if it offers “value for services” (Harding 1997:75–78). But this is beyond the scope of this paper.

Finally, some monitoring is already done by private parties, and more could be done—in the prison context, this is done either by the prisoners themselves (through civil rights suits) or by

the residents of the surrounding communities (by giving them the right to sue under privatization contracts as “third-party beneficiaries”). Capture is probably less likely, while the administrative costs are probably higher. Another major factor in the choice among governance mechanisms concerns the possibility of cross-fertilization. Some commentators, for instance Sturm (1990), focus on the “dynamics of organizational stasis” and argue that in institutions such as prisons, innovations are slow to spread because actors at all different levels resist change. Harding (1997) argues that governance mechanisms that put projects out to bid repeatedly may improve the total quality of the system by helping to spread innovations. But these considerations are beyond the scope of this paper.

## 6 Conclusion

The model presented in this paper presents various considerations relevant to choosing between public and private provision. The main point of HSV remains valid: If contractual incompleteness is too pervasive and harmful, public provision is still optimal. For instance, this model probably counsels against contracting out national defense to Boeing, since the social costs of excessive  $e$  are probably too great and, while the foreign policy apparatus (including the military) is probably more expensive than it needs to be, these excessive costs are not as great an issue. (For a recent discussion of this issue, see Carter (2004).) Private provision will tend to dominate when cost innovations are not so harmful and when quality innovations are important.

But this paper shows that an effective monitoring regime can increase social welfare in the case of private-sector provision, while it may not be able to do so in the case of public-sector provision. The reason is that the private sector’s incentives are *skewed*: It does too much cost-cutting and too little quality-enhancing innovation. Conveniently, benefit tends to be decreased by cost-cutting and increased by quality innovation, so fines based on benefit will tend to decrease cost-cutting and increase quality innovation, which unambiguously increases social welfare. By contrast, the public sector’s incentives are not so much *skewed* as *weak*. It does too little of everything, so basing fines on benefit will increase one type of innovation and decrease another, which on balance is not guaranteed

to increase social welfare.

Regulatory capture, or collusion with the monitor, tends to decrease social welfare. Both public and private contractors collude with the monitor, but there is reason to believe that, given the current institutional structure of monitors, monitors collude with public contractors on too-favorable terms because they benefit from public provision.

This model abstracts from many real-world considerations; in particular, it does not model corruption by private parties, so it would be inappropriate to conclude from this paper that we should adopt an anti-*McKnight* regime, where private actors have qualified immunity while public actors do not, or where public delegations are scrutinized *more* heavily than private delegations. But in light of the opportunities for regulatory capture and current institutional arrangements under which monitors benefit indirectly from public provision, it may be inappropriate for courts to defer to public agencies to the extent they currently do. More generally, it may be prudent to split the roles of purchaser, monitor, and provider. In the prison regime, the question whether the public or private sectors deliver greater quality at lower cost, and the extent to which total social welfare may be improved by monitoring, takes on added significance, since prison conditions are often a constitutional matter. Increased quality can mean fewer cases of unconstitutional treatment, and decreased cost allows the government to remedy overcrowding, which in some circumstances can be unconstitutional, at both public and private prisons.

## Notes

<sup>1</sup>In 1995, for example, an investigative reporter and a surprise inspection revealed appallingly crowded, unsanitary, and abusive conditions at the Bowie County Correctional Facility, a private “warehouse turned prison facility” in Texarkana, Texas, housing 500 inmates from Colorado. After a federal lawsuit and a riot, the state of Colorado terminated Bowie County’s contract and relocated its inmates.

At the Seal Beach City Jail, operated by the private Correctional Systems, Inc. since 1994, two private prison guards were indicted in August 2001 for allegedly “arranging and concealing an attack on a drunken inmate who was singing boisterously in the jail’s detoxification cell.” Within ten weeks of the attack, both guards had been fired; one guard was charged with federal civil rights violations and the other with being an accessory after the fact for trying to conceal the attack. The first guard was sentenced to over four years in prison. This incident prompted the city to review its contract with CSI and to consider other options.

Similarly, in Santa Fe County, New Mexico, CCA brought in prisoners convicted of murder and rape from Oregon to fill its private jail cells but reportedly failed to notify the Sheriff’s Department that it was housing inmates who posed a danger to the public. The Oregon prisoners were removed from the jail only after county officials threatened to cancel the county’s contract with the company.

<sup>2</sup>HSV use  $\geq$ , but this model uses  $>$  to get sharper results. I have dropped the HSV assumption that  $c' - b' \geq 0$  (presumably  $\forall e$ ): If this were true, then combined with the assumptions that  $c'$  decreases to 0 and that  $b'$  is nonnegative and nondecreasing ( $b' \geq 0$  and  $b'' \geq 0$ ) in HSV), this would (absurdly) imply that  $b' \equiv 0$ .

<sup>3</sup>I assume all sanctions are monetary in this corporate context. The fine is paid directly by the manager, whether public or private (i.e., by the private prison firm, or by the public warden or agency head—whoever makes the  $e$  decisions). Note that in the public case, it may be hard to make the public contractor to “personally” pay the full fine  $g$ , and this fine may in fact come from a different fund (this is quite common; for instance, when governments are made to pay for violations of constitutional rights or takings of property, the money that compensates the victims comes from

a different fund). If this is the case, then the decisionmaker who chooses  $e$  doesn't pay any fine, and this is equivalent to having no monitor. Or, if, in effect, the public contractor only pays a portion (say a proportion  $\alpha$ ) of the fine, while other government accounts pay the remaining  $1 - \alpha$ , then this is formally similar to a less effective monitor, where the detection probability becomes  $\alpha p$  instead of  $p$ . This is equivalent to a change in detection technology whereby the agency budget necessary to achieve a "real" level of becomes  $A(p) = a(\frac{p}{\alpha})$ .

<sup>4</sup> $M$  may be different for the public and private sectors. For the private sector, it may be the amount required to push the company into bankruptcy. For the public sector, it may have to do with a cash constraint of the department responsible for setting  $e$ . This model does not rule out monetary rewards in addition to monetary penalties as long as there is an upper bound on rewards—we can normalize the highest reward level to 0, so  $M$  represents the highest reward level plus the highest possible penalty. In practice, rewards are used quite rarely. And clearly the level of rewards is subject to some government budget constraint, so the point about maximal penalties still applies. Finally,  $M$  may include restitution of the contract price  $P_0$  or  $W_0$ . (See Laffont and Martimort 2002:122–23 on exogenous vs. endogenous punishments.)

<sup>5</sup>One may object that the basic model assumes that both the government and a private contractor are operating on the Pareto frontier, that is, that any cost reduction comes at the expense of quality and that any quality improvement must increase cost.

Since all of these ideas require effort to find, there is no reason to believe that we are on the Pareto frontier. Moreover, much of the benefit of privatization has been in the discovery of previously unknown methods to both *decrease* cost and *increase* quality. (See Segal and Moore 2002; *Harvard Law Review* 2002). For example, a Virginia private contractor stopped the expensive practice keeping one month's worth of provisions on hand at the prison at all times. The previous management's best guess at why they did that was that it was a holdover from older days when it took weeks to supply the prison by mule. Also, private prisons reduce labor costs in part by better management of overtime and sick days, which may not have any adverse effect on quality. Some of the reduction in labor costs comes from lower wages, which some commentators claim results in less motivated employees and higher turnover, which decreases quality; but some survey data suggests

that motivation is actually better in private prisons (see evidence cited in Harding 1997:117–19).

We could easily add a third type of innovation—call it  $j$ —that both decreases cost and increases quality. Denote the cost reduction by  $k(j)$  and the benefit increase by  $d(j)$ , where  $k(j)$  behaves like  $c(e)$  and  $d(j)$  behaves like  $\beta(i)$ . Then social benefit becomes  $B(e, i, j) = B_0 - b(e) + \beta(i) + d(j)$  and social cost becomes  $C(e, i, j) = C_0 - c(e) + \gamma(i) - k(j)$ .

It is then easy to show that in the first-best,  $d'(j^*) + k'(j^*) = 1$ ; in the private solution,  $k'(j_M) = 1$ ; and in the public solution,  $\frac{\lambda}{2}(d'(j_G) + k'(j_G)) = 1$ . Thus,  $j_G < j^*$  and  $j_M < j^*$ ;  $j_G > j_M$  if  $d'(j_M) > (\frac{2}{\lambda} - 1)k'(j_M)$ , and  $j_G < j_M$  for sufficiently low  $\lambda$ .

All the basic results of this paper go through with the addition of  $j$ . Moreover, even if one disputes the relevance of Nash bargaining on the grounds that such ex-post renegotiation is rarely seen in the real world, a model with  $e$  and  $j$  and without renegotiation produces the same basic results as here.

<sup>6</sup>Note, for future reference, that  $\pi_{Me} = c' > 0$ ,  $\pi_{Mi} = \frac{1}{2}(\beta' - \gamma')$  (which is of ambiguous sign),  $\pi_{Mee} = c'' < 0$ , and  $\pi_{Mii} = \frac{1}{2}(\beta'' - \gamma'') < 0$ . Note also that  $\pi_{Ge} = \frac{\lambda}{2}(-b' + c')$  (which is of ambiguous sign),  $\pi_{Gi} = \frac{\lambda}{2}(\beta' - \gamma')$  (which is of ambiguous sign),  $\pi_{Gee} = \frac{\lambda}{2}(-b'' + c'') < 0$ , and  $\pi_{Gii} = \frac{\lambda}{2}(\beta'' - \gamma'') < 0$ .

<sup>7</sup>Why must the agency only observe total quality, and not its  $e$  and  $i$  components,  $b(e)$  and  $\beta(i)$ ? Observing total quality is plausible because the individual components may be hard to untangle. Total benefit is the result of many actions, some of which are quality innovations and some of which are cost innovations, which may affect the same outcome. For instance, prison guards might be trained less effectively but prison discipline is nonetheless maintained by better use of prisoner rewards and punishments. The only way an agency can see whether this is worthwhile is by looking at overall prison discipline or some such global variable. Also, contracts and statutes in the real world do in fact treat quality as a single variable. See, e.g., Ariz. Rev. Stat. §41-1609.01(G) (2001) (requiring the contractor to offer cost savings); id. §41-1609.01(H) (requiring the contractor to offer services of “at least equal” quality); Fla. Stat. Ann. §957.07 (West 2002) (requiring 7% cost savings, where a private entity’s corporate income and sales tax payments count as an offset to costs, and where the cost of services provided to the public entity at no direct cost by other

government agencies is allocated to the public entity); id. §957.11 (requiring evaluation of “costs and benefits” of contracts); Ohio Rev. Code Ann. §9.06(A)(4) (West 2001 Supp.) (requiring that the contractor “convincingly demonstrate” that it can operate the facility and provide required services with at least a 5% savings over the projected cost to the public entity); Tenn. Code Ann. §41-24-104(c)(2)(A) (1997) (requiring quality to be at least equal to that provided at state prisons); id. §41-24-104(c)(2)(B) (requiring cost to be at least 5% less than the state’s cost); id. §41-24-1-105(c) (requiring evaluation of performance, with the contract to be renewed only if the contractor provides “essentially the same quality” as the state at 5% lower cost, or superior services at “essentially the same cost” as the state, where “superior” is defined as 5% better and “essentially the same” is defined as within 5%).

<sup>8</sup>What if we could monitor both  $B$  and  $C$ ? For instance, an agency could observe the true level of  $B$  with probability  $p_B$  for a cost of  $a_B(p_B)$  and observe the true level of  $C$  with probability  $p_C$  for a cost of  $a_C(p_C)$ . (This separability seems reasonable, since monitoring benefit and monitoring cost are two different activities and require monitors with different sorts of skills.) If this were so, the agency could implement particular levels  $\hat{B}$  and  $\hat{C}$  and thus could implement particular levels  $\hat{e}$  and  $\hat{i}$ . Then it is no longer clear that  $e$  and  $i$  move in different directions under monitoring, and monitoring can definitely improve social welfare under either mode of provision.

The case discussed in this paper, where the agency can only observe one function, is still relevant. Generalizing from Proposition 2, monitoring some outcome is only optimal if the fixed cost of setting up that monitoring regime is not too high. If each type of monitoring has a setup cost  $A_B$  and  $A_C$ , the government now chooses both which sector to employ and which functions to monitor. For some parameter values, it may be better to only monitor one function and only pay a single setup cost than to monitor both functions and have to pay both setup costs.

# Appendices

## A Proof of Proposition 1

Assume  $(p, g)$  is an optimal combination of detection probability and fine schedule. The contractor chooses  $e(p, g)$ ; denote  $B_g \equiv B(e(p, g))$ .

(1) Now consider a fine schedule  $\hat{g}$  such that:

$$\hat{g}(B) = \begin{cases} 0 & \text{for } B = B_g \\ M, & \forall B \neq B_g \end{cases}. \quad (\text{A1})$$

The contractor's choice of  $e$  is identical under the two fine schedules:

$$e(p, g) = e(p, \hat{g}). \quad (\text{A2})$$

To see this, suppose the contractor chooses an  $e$  such that  $B(e) \neq B_g$ . Under the original fine schedule  $g$ , we had:

$$\begin{aligned} \Pi(e(p, g); p, g) &\equiv \Pi(e(p, g)) - pg(B_g) \\ &\geq \Pi(e; p, g) \equiv \Pi(e) - pg(B(e)), \forall e \neq e(p, g). \end{aligned} \quad (\text{A3})$$

Under the new fine schedule  $\hat{g}$ , the inequality still holds because the left-hand side becomes weakly larger and the right-hand side becomes weakly smaller:

$$\begin{aligned} \Pi(e(p, g); p, \hat{g}) &\equiv \Pi(e(p, g)) - p\hat{g}(B_g) = \Pi(e(p, g)) \\ &\geq \Pi(e; p, \hat{g}) \equiv \Pi(e) - p\hat{g}(B(e)) = \Pi(e) - pM, \forall e \neq e(p, g). \end{aligned} \quad (\text{A4})$$

Since the contractor's choice of  $e$  is unchanged, there is no change to the project itself. Therefore,

monitoring regime  $(p, \hat{g})$  is as good as the (by hypothesis) optimal monitoring regime  $(p, g)$ :

$$SW_0(p, \hat{g}) \equiv \pi^*(e(p, \hat{g})) - e(p, \hat{g}) - a(p) = SW_0(p, g). \quad (\text{A5})$$

(2) So, if  $(p, g)$  is optimal,  $(p, \hat{g})$  must also be optimal. Given a fine schedule  $\hat{g}$ , a benefit level  $\hat{B} = B(e_0)$  can obviously be implemented with  $p = 0$ . Any other benefit level  $\hat{B} \neq B(e_0)$  can be implemented as long as:

$$p \geq \frac{\Pi(e_0) - \Pi(\hat{e})}{M}. \quad (\text{A6})$$

Then  $pM \geq \Pi(e_0) - \Pi(\hat{e})$ , so:

$$\begin{aligned} \Pi(e_0; p, \hat{g}) &\equiv \Pi(e_0) - p\hat{g}(B(e_0)) = \Pi(e_0) - pM \\ &\leq \Pi(e_0) - \Pi(e_0) + \Pi(\hat{e}) = \Pi(\hat{e}). \end{aligned} \quad (\text{A7})$$

(If  $\Pi(e_0) - \Pi(\hat{e}) > M$ ,  $\hat{B}$  cannot be implemented.) For optimality, equation (A6) must hold with equality:

$$\hat{p} = \frac{\Pi(e_0, i_0) - \Pi(\hat{e}, \hat{i})}{M}, \quad (\text{A8})$$

because any higher probability would still implement the same  $\hat{B}$  but would incur higher monitoring costs  $a(p)$ . Thus, the monitoring regime  $(\hat{p}, \hat{g})$  is the optimal monitoring regime.

Note that this last proposition differs from certain results in the law enforcement literature (see Polinsky & Shavell 1992): The optimal regime does not involve the maximal fine over one range and a zero fine over *another range*. If higher  $B$  were always better, then we would not mind implementing a benefit level above  $\hat{B}$ . But here, a contractor may suboptimally choose a benefit level that is too high (because it is too expensive). Thus, once we choose the optimal  $\hat{B}$  to implement, we want to be sure to implement exactly that level.

It is possible that the optimal regime would nonetheless be of the “threshold” type:  $g(B) = M$  for  $B < \hat{B}$ , and  $g(B) = 0$  for  $B \geq \hat{B}$ . But if so, then the “optimal point” regime described in the proof would also be optimal: suppose  $g$  implements a level  $\tilde{B}$ ; then define  $\hat{g}(B) = M$  for  $B \neq \tilde{B}$  and

$$\hat{g}(\tilde{B}) = 0.$$

## B Proof of Proposition 2

(1) Social welfare, as a function of  $\hat{e}$ , is given by equation (17). Differentiating with respect to  $e$ , we obtain:

$$SW_1'(\hat{e}) \equiv B'(\hat{e}) - C'(\hat{e}) - 1 - \frac{\Pi'(\hat{e})}{M} \cdot a' = 0, \quad (\text{B1})$$

where  $\Pi$  is the payoff of the relevant contractor. This gives us the optimum as long as  $SW_1(\hat{e})$  is continuous, that is, if  $A = 0$ . If it were optimal to have no monitoring for a particular type of contractor, then we would have  $\Pi'(\hat{e}) = 0$  at the optimal point. But that would imply that  $B'(\hat{e}) - C'(\hat{e}) - 1 = 0$ , which is only true at the first-best point  $e^*$ . Since, by equation (8), the no-monitoring optimum is not the first-best for either mode of provision, some monitoring is optimal for each type of contractor as long as  $A = 0$ .

(2) Because, for  $A = 0$ , some monitoring is optimal,  $SW_1(\hat{e}) > \Pi^*(e_0)$ . For  $A \geq SW_1(\hat{e}) - \Pi^*(e_0)$ , monitoring ceases to be optimal. However, for  $A \in (0, SW_1(\hat{e}) - \Pi^*(e_0))$ , the first-order condition in equation (B1) is unchanged, and so the optimal monitoring regime is the same as that when  $A = 0$ .

(3) By section (1), it is optimal to monitor either type of contractor. It is clear that this requires each contractor's choice of  $e$  to move toward the first best, or else (given that monitoring is costly) there could be no increase in social welfare. However, if monitoring achieved the first best, we would have  $B'(\hat{e}) - C'(\hat{e}) - 1 = 0$ . But this would imply  $\Pi'(\hat{e}) = 0$ , which would imply that the first best is also the no-monitoring optimum for some type of contractor. As noted above, we know this to be false, by equation (8).

Intuitively, suppose optimal monitoring achieved the first best. Then one could reduce the probability of detection  $p$  slightly so as to induce a slight departure from the first-best. Any decrease in social welfare is second-order, while there is a first-order decrease in the monitoring cost  $a(p)$ . Thus, there will be some efficient “underdeterrence” under any monitoring regime. (This idea is similar to the underdeterrence idea in Polinsky and Shavell [1992].)

### C Proof of Proposition 3

$$(1a) C(e_M, i_M) - C(e^*, i^*) = [c(e^*) - c(e_M)] - [\gamma(i^*) - \gamma(i_M)] = c'(\zeta_1)[e^* - e_M] - \gamma'(\xi_1)[i^* - i_M] < 0$$

(where  $\zeta_1 \in [e^*, e_M]$  and  $\xi_1 \in [i_M, i^*]$ ).

$$(1b) B(e_M, i_M) - B(e^*, i^*) = [b(e^*) - b(e_M)] - [\beta(i^*) - \beta(i_M)] = b'(\zeta_2)[e^* - e_M] - \beta'(\xi_2)[i^* - i_M] < 0$$

(where  $\zeta_2 \in [e^*, e_M]$  and  $\xi_2 \in [i_M, i^*]$ ).

$$(2a) C(e_G, i_G) - C(e^*, i^*) = [c(e^*) - c(e_G)] - [\gamma(i^*) - \gamma(i_G)] = c'(\zeta_3)[e^* - e_G] - \gamma'(\xi_3)[i^* - i_G]$$

(where  $\zeta_3 \in [e_G, e^*]$  and  $\xi_3 \in [i_G, i^*]$ ), and this is of ambiguous sign because  $c'(\zeta)[e^* - e_G]$  and  $\gamma'(\xi)[i^* - i_G]$  are both positive.

$$(2b) B(e_G, i_G) - B(e^*, i^*) = [b(e^*) - b(e_G)] - [\beta(i^*) - \beta(i_G)] = b'(\zeta_4)[e^* - e_G] - \beta'(\xi_4)[i^* - i_G]$$

(where  $\zeta_4 \in [e_G, e^*]$  and  $\xi_4 \in [i_G, i^*]$ ), and this is of ambiguous sign because  $b'(\zeta)[e^* - e_G]$  and  $\beta'(\xi)[i^* - i_G]$  are both positive.

$$(3a) C(e_G, i_G) - C(e_M, i_M) = [c(e_M) - c(e_G)] - [\gamma(i_M) - \gamma(i_G)] = c'(\zeta_5)[e_M - e_G] - \gamma'(\xi_5)[i_M - i_G]$$

(where  $\zeta_5 \in [e_G, e_M]$  and  $\xi_5 \in [i_G, i_M]$ ), and this is of ambiguous sign because  $c'(\zeta)[e_M - e_G]$  and  $\gamma'(\xi)[i_M - i_G]$  are both positive.

$$(3b) B(e_G, i_G) - B(e_M, i_M) = [b(e_M) - b(e_G)] - [\beta(i_M) - \beta(i_G)] = b'(\zeta_6)[e_M - e_G] - \beta'(\xi_6)[i_M - i_G]$$

(where  $\zeta_6 \in [e_G, e_M]$  and  $\xi_6 \in [i_G, i_M]$ ), and this is of ambiguous sign because  $b'(\zeta)[e_M - e_G]$  and  $\beta'(\xi)[i_M - i_G]$  are both positive.

Note that this last part of the proposition contradicts Proposition 5 in HSV. The convention in HSV was to call  $\beta$  the net benefit of investment in quality innovations (what this model calls  $\beta - \gamma$ ), so the quantity  $B_0 - b(e) + \beta(i)$  (which in this model equals  $B_0 - b(e) + \beta(i) - \gamma(i)$ ) was labeled “benefit” and the quantity  $C_0 - c(e)$  was labeled “cost.” Under these definitions, public contractors’ cost is indeed unambiguously lower than first-best cost, and public contractors’ cost is higher than first-best. But when, as here, we include expenditure on quality innovations in cost, cost may be higher under private provision than under public provision because  $i$  is higher.

(4) This follows clearly from the previous:

$$\Pi^*(e_G, i_G) - \Pi^*(e_M, i_M) = [b'(\zeta_7) - c'(\zeta_7)][e_M - e_G] - [\beta'(\xi_7) - \gamma'(\xi_7)][i_M - i_G] + (e_M - e_G) + (i_M - i_G). \quad (\text{C1})$$

(where  $\zeta_7 \in [e_G, e_M]$  and  $\xi_7 \in [i_G, i_M]$ ). The terms  $(e_M - e_G)$  and  $(i_M - i_G)$  are positive. The private sector will tend to dominate (that is, the expression will be negative) (1) if cost innovations ( $e$ -type investments) have important cost-cutting properties and are not highly harmful, (2) if quality innovations ( $i$ -type investments) have important quality benefits and are not too costly, and (3) if the investments themselves are not too costly.

## D Proof of Proposition 4

(1) The proof of this section is analogous to the proof of Proposition 1. To show why the fine schedule  $\hat{g}$  implements the same choice of  $e$  and  $i$  as any other purportedly optimal fine schedule  $g$ , we first consider combinations  $(e, i)$  such that  $B(e, i) \neq B_g$ . By a reasoning analogous to that of Proposition 1, one can see why, if such a combination is not chosen under  $g$ , it will not be chosen under  $\hat{g}$ . Now consider combinations  $(e, i)$  such that  $B(e, i) = B_g$ . Under the original fine schedule  $g$ , we had:

$$\begin{aligned} \Pi(e(p, g), i(p, g); p, g) &\equiv \Pi(e(p, g), i(p, g)) - pg(B_g) \\ &\geq \Pi(e, i; p, g) \equiv \Pi(e, i) - pg(B_g). \end{aligned} \quad (\text{D1})$$

Canceling the  $pg(B_g)$  term, we obtain:

$$\Pi(e(p, g), i(p, g)) \geq \Pi(e, i). \quad (\text{D2})$$

Under the new fine schedule  $\hat{g}$ , we get the same inequality:

$$\begin{aligned}\Pi(e(p, g), i(p, g); p, \hat{g}) &\equiv \Pi(e(p, g), i(p, g)) - p\hat{g}(B_g) = \Pi(e(p, g), i(p, g)) \\ &\geq \Pi(e, i; p, \hat{g}) \equiv \Pi(e, i) - p\hat{g}(B(e, i)) = \Pi(e, i).\end{aligned}\tag{D3}$$

Thus, as before, the fine schedule  $\hat{g}$  does not change the contractor's choices of  $e$  and  $i$  relative to fine schedule  $g$ , so monitoring regime  $(p, \hat{g})$  is as good as the (by hypothesis) optimal monitoring regime  $(p, g)$ .

(2) The proof that the optimal probability is  $p = \frac{\Pi(e_0, i_0) - \Pi(\hat{e}, \hat{i})}{M}$  is analogous to that in Proposition 1.

## E Proof of Proposition 5

The first-order conditions of the Lagrangean are:

$$B_e - C_e - 1 + \frac{\Pi_e}{M}a' = \lambda(\pi_{ee}B_i - B_{ee}(\pi_i - 1)) + \mu B_e,\tag{E1}$$

$$B_i - C_i - 1 + \frac{\Pi_i}{M}a' = \lambda((\pi_e - 1)B_{ii} - B_e\pi_{ii}) + \mu B_i,\tag{E2}$$

$$0 = -\mu,\tag{E3}$$

$$(\pi_e - 1)B_i = (\pi_i - 1)B_e, \text{ and}\tag{E4}$$

$$B(e, i) = \hat{B}.\tag{E5}$$

Equations (E1), (E2), and (E3) reduce to:

$$\frac{B_e - C_e - 1 + \frac{\pi_e - 1}{M}a'}{B_i - C_i - 1 + \frac{\pi_i - 1}{M}a'} = \frac{\pi_{ee}B_i - B_{ee}(\pi_i - 1)}{(\pi_e - 1)B_{ii} - B_e\pi_{ii}}.\tag{E6}$$

(1) Consider equation (E4), where the functions are evaluated at the monitoring optimum,  $(e^A, i^A)$ . Since  $B_e < 0$  and  $B_i > 0$  for all  $e$  and  $i$ , either  $\pi_e - 1$  and  $\pi_i - 1$  are both zero at  $(e^A, i^A)$  or they must have opposite signs. If they are both zero, we are in the no-monitoring optimum, which means that the optimum is no effective monitoring:  $(e^A, i^A) = (e_0, i_0)$ . If they have

opposite signs, then either  $e$  increases and  $i$  decreases ( $e^A > e_0$  and  $i^A > i_0$ ), or  $e$  decreases and  $i$  increases.

(2a) If the optimum did not change the private contractor's choice of  $e$  and  $i$ , then he would have  $\pi_{Me} - 1 = 0$  and  $\pi_{Mi} - 1 = 0$  (evaluated at  $(e_M^A, i_M^A) = (e_M, i_M)$ ). So equation (E6) would reduce to:

$$\frac{B_e - C_e - 1}{B_i - C_i - 1} = \frac{\pi_{Me} B_i}{-B_e \pi_{Mi}}. \quad (\text{E7})$$

But this is impossible, since the left-hand side is negative while the right-hand side is positive. So the monitoring optimum does involve some positive amount of monitoring, with  $p > 0$  and  $\hat{B} \neq B(e_M, i_M)$  (even taking into account the cost of monitoring).

(2b) Clearly, since  $e_M > e^*$  and  $i_M < i^*$ , decreasing  $e$  and increasing  $i$  improves social welfare. So at the monitoring optimum, the government will choose to implement a benefit level  $\hat{B} > B(e_M, i_M)$ , which (given that under monitoring,  $e$  and  $i$  move in opposite directions) can only be achieved with lower  $e$  and higher  $i$ .

(3) We already know that optimal monitoring (if it changes anything) either decreases  $e$  and increases  $i$ , or increases  $e$  and decreases  $i$ . Suppose it decreases  $e$  and increases  $i$ , like in the private case. But here,  $e$  is already too low. So  $e$  falls below its level  $e_G < e^*$ , while  $i$  moves in the direction of the first-best level  $i^*$ . This may or may not increase social welfare. If it does not, the government could increase  $e$  and decrease  $i$ , in which case  $i$  would fall even further below its already-too-low level  $i_G < i_M < i^*$ , while  $e$  would increase toward the first-best level  $e^*$ . In neither case is social welfare guaranteed to increase: the losses from one variable's moving in the "wrong" direction may entirely cancel out the gains from another variable's moving in the "right" direction.

Here is an example to illustrate that the monitoring optimum may involve no change in the public contractor's choices. If the optimum did not change the public contractor's choice of  $e$  and  $i$ , then he would have  $\pi_{Ge} - 1 = 0$  and  $\pi_{Gi} - 1 = 0$  (evaluated at  $(e_G^A, i_G^A) = (e_G, i_G)$ ). So equation

(E6) would reduce to

$$\begin{aligned} \frac{B_e - C_e - 1}{B_i - C_i - 1} &= \frac{\pi_{Gee} B_i}{-B_e \pi_{Gii}} \\ \Leftrightarrow \frac{[-b' + c - 1]b'}{-b'' + c''} &= \frac{[\beta' - \gamma' - 1]\beta'}{\beta'' - \gamma''}. \end{aligned} \quad (\text{E8})$$

Equation (E8) holds at  $(e_G, i_G)$  provided that (as is possible)  $b(x) = \gamma(x)$  and  $c(x) = \beta(x)$  for all  $x$ , and  $b'(e_G) = \beta'(e_G)$ .

(4a) Public contractors have  $e_G < e^*$  and  $i_G < i^*$ . If monitoring achieved the first best, both  $e$  and  $i$  would have to increase, which contradicts the point above that if monitoring changes the contractor's choices, it must move them in opposite directions.

(4b) Private contractors have  $e_M > e^*$  and  $i_M < i^*$ , which has the following implications for the two partial derivatives of the contractor's profit function:

$$\begin{cases} \Pi_{Me}(e^*, i^*) = \pi_{Me}(e^*, i^*) - 1 > 0 \\ \Pi_{Mi}(e^*, i^*) = \pi_{Mi}(e^*, i^*) - 1 < 0 \end{cases}. \quad (\text{E9})$$

If monitoring achieved the first-best, we would have:

$$B_e - C_e - 1 = B_i - C_i - 1 = 0, \quad (\text{E10})$$

so equation (E6) would reduce to:

$$\frac{\pi_{Me} - 1}{\pi_{Mi} - 1} = \frac{\pi_{ee} B_i - B_{ee}(\pi_{Mi} - 1)}{(\pi_{Me} - 1)B_{ii} - B_e \pi_{ii}} \quad (\text{E11})$$

(evaluated at  $(e^*, i^*)$ ). But this is impossible, since the left-hand side is negative while the right-hand side is positive.

## F Proof of Proposition 6

(1) The problem is to choose a partition of the real line into sets  $\Omega_1$  and  $\Omega_2 = \Omega_1^C$  to maximize:

$$W(\Omega_1) = \int_{\Omega_1} \pi^*(e_M^A(\delta), i_M^A(\delta))\phi_\delta d\delta + \int_{\Omega_2} \pi^*(e_G^A(\delta), i_G^A(\delta))\phi_\delta d\delta. \quad (\text{F1})$$

By definition, projects with  $\delta > 0$  produce greater social welfare in the public sector and projects with  $\delta < 0$  produce greater social welfare in the private sector:

$$\pi^*(e_G^A(\delta), i_G^A(\delta)) > \pi^*(e_M^A(\delta), i_M^A(\delta)) \text{ iff } \delta > 0. \quad (\text{F2})$$

(Because  $\phi_\delta$  is continuous,  $P(\delta = 0) = 0$ .) Therefore, the solution is  $\Omega_1 = (-\infty, 0)$  and  $\Omega_2 = (0, \infty)$ .

(2) If the public provider is the same as the privatization decisionmaker, the benefit to the public provider of public provision is  $\pi_G(e_G^A, i_G^A) > 0$ , while the benefit to the public provider of private provision is 0. Therefore, the public provider's problem is to choose a partition of the real line into sets  $\Omega_1$  and  $\Omega_2$  to maximize:

$$W_A(\Omega_1) = \int_{\Omega_1} 0\phi_\delta d\delta + \int_{\Omega_2} \pi^*(e_G^A(\delta), i_G^A(\delta))\phi_\delta d\delta. \quad (\text{F3})$$

The solution is  $\Omega_1 = \emptyset$  and  $\Omega_2 = \mathbb{R}$ .

(3) If the public provider chooses to privatize a proportion of projects  $\rho_A < \rho^*$ , then privatization proceeds over  $\delta \in (-\infty, \Phi^{-1}(\rho_A))$  instead of over the optimal range,  $(-\infty, 0)$ , so the range  $(\Phi^{-1}(\rho_A), 0)$  wrongly stays in the public sector. The social welfare from privatization of  $\rho_A$  is:

$$W((-\infty, \Phi^{-1}(\rho_A))) = \int_{-\infty}^{\Phi^{-1}(\rho_A)} \pi^*(e_M^A(\delta), i_M^A(\delta))\phi_\delta d\delta + \int_{\Phi^{-1}(\rho_A)}^{\infty} \pi^*(e_G^A(\delta), i_G^A(\delta))\phi_\delta d\delta, \quad (\text{F4})$$

and the difference between this and optimal social welfare is the social loss (expressed as a positive

number):

$$\begin{aligned}
L(\rho_A) &= W^* - W((-\infty, \Phi^{-1}(\rho_A))) \\
&= \int_{\Phi^{-1}(\rho_A)}^0 [\pi^*(e_M^A(\delta), i_M^A(\delta)) - \pi^*(e_G^A(\delta), i_G^A(\delta))] \phi_\delta d\delta \\
&= - \int_{\Phi^{-1}(\rho_A)}^0 \delta \phi_\delta d\delta.
\end{aligned} \tag{F5}$$

(4) The government will override the agency's decision at a cost  $K$  (and set  $\rho_A = \rho^*$  for a social welfare of  $W^*$ ) if  $L(\rho_A) > K$ . If the government does so, the benefit to the public provider is:

$$\int_0^\infty \pi^*(e_G^A(\delta), i_G^A(\delta)) \phi_\delta d\delta. \tag{F6}$$

Thus, the agency's problem is to choose a set  $\Omega_1$  to privatize (this will be an interval of the form  $(-\infty, \Phi^{-1}(\rho_A))$  for some  $\rho_A$ ) so as to maximize:

$$\hat{W}_A((-\infty, \Phi^{-1}(\rho_A))) = \begin{cases} \int_{\Phi^{-1}(\rho_A)}^\infty \pi^*(e_G^A(\delta), i_G^A(\delta)) \phi_\delta d\delta & \text{if } L(\rho_A) \leq K \\ \int_0^\infty \pi^*(e_G^A(\delta), i_G^A(\delta)) \phi_\delta d\delta & \text{if } L(\rho_A) > K \end{cases}. \tag{F7}$$

$\hat{W}_A$  is positive and decreasing in  $\rho_A$  over the set  $\{\rho_A | L(\rho_A) \leq K\}$ , so it is maximized for  $\hat{\rho}_A = \min_{\rho_A \geq 0} \{L(\rho_A) \leq K\}$ . The set  $\{\rho_A | L(\rho_A) \leq K\}$  contains  $\rho^*$  (because  $L(\rho^*) = 0$ ), so  $\hat{\rho}_A < \rho^*$ .

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