A Re-examination of Collusion under Hard and Soft Information

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Abstract

This study takes a closer look into the equivalence result of Baliga (1999) namely, that a principal obtains the same optimal collusion-proof payoff for both hard and soft information. In the procurement model of Baliga (1999), we consider the sensitivity of equivalence to monitoring technologies, the agent's type-dependent reservation utility, and the supervisor's career concerns. We also show that career concerns may exacerbate the collusion problem. In response, the principal refrains from fully revealing the supervisor's performance to the future employer, hence generating informational frictions in the labor market.

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1. Introduction

Modern economic theories of organizations devote great efforts to understanding information flows and various incentive problems they trigger.[1] By the celebrated Revelation Principle, the analyst can limit the content of information transmission to the private information held by a party (the agent), while permitting the agent full freedom of information manipulations. The agent only communicates his “type,” but can report any possible type regardless of the true state of nature.[2] The primary task of the analyst is to identify binding incentive compatibility constraints, i.e., those information manipulations that benefit the agent, and then to design a proper mechanism to deter manipulations and ensure truthful information revelation.

When the analysis is extended to a more complex organization, freedom of information manipulations sometimes is curtailed. The literature of collusion in organizations introduces to the standard principal-agent model a supervisor who, equipped with a monitoring technology, can (imperfectly) detect the agent’s private information, but may collude with the agent against the principal (Tirole, 1986). A common assumption, namely, hard information, restricts the supervisor to either truthfully report his discovery or hide it with the claim that nothing has learned. The possibility of faking discovery, or, more generally, full freedom of manipulations as in the standard Revelation Principle, is only permitted when the information is “soft.”

While hard information certainly applies to some situations,[3] its

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1 Laffont and Martimort (2002): “When economists began to look more carefully at the firm, either in agricultural or managerial economics, incentives became the central focus of their analysis. Indeed, for various reasons, the owner of the firm must delegate several tasks to the members of the firm. This necessity raises the problem of managing information flows within the firm. The problem of managing information flows was the first research topic for economists, once they mastered behavior under uncertainty, thanks to von Neumann and Morgenstern (1944).”

2 A notable exception is Green and Laffont (1986), which considers type-dependent restrictions on the message space of the agent.

3 A piece of evidence with scientific foundations, e.g., experiment results, could be thought of as hard information; and subjective assessment, or belief, is a typical example of soft information.

popularity as a modeling device (e.g., Tirole (1986, 1992) and Kofman and Lawarrée (1993)) and departure from the Revelation Principle naturally raise a question: How restrictive is this assumption, and how sensitive is the optimal allocation to hard vs. soft information?[4] Since hard information precludes some information manipulations and reduces the principal's coalition incentive compatibility constraints, the question becomes: To what extent is hard information a harmless assumption? Or, when will the principal do equally well under soft and hard information?

To our best knowledge, Baliga (1999) first addresses this question. In a procurement model with adverse selection, Baliga (1999) shows that the principal can obtain the same optimal payoff for both hard and soft information. Intuitively, the standard adverse selection model entails an incentive of "downward manipulation." The "good-type" agent (the one with lower production costs) wants to convince the principal that he is the "bad type" (the one with higher costs) in order to pocket the cost difference (the information rent). In the three-tier organization, this information rent also motivates the good-type agent to collude with the supervisor.

Whether the supervisor can downplay the agent's production efficiency depends on the monitoring technology and restrictions imposed by hard information. Tirole (1992) and Baliga (1999) consider what we call a "rent extraction" monitoring technology. In the absence of further information, the principal sets the default policy to preserve production efficiency and let the good-type agent enjoy the information rent. The information collected by the supervisor will tilt the efficiency vs. rent extraction trade-off toward the latter and deprive the good-type agent of the information rent. The good-type agent, therefore, has incentives to collude with the supervisor and suppress the discovered information, so that the principal's belief is kept at the lower level. For this monitoring technology, suppression of information amounts to downward manipulation and is permitted by hard information. What is prohibited is upward manipulation, i.e., reporting that the agent is the good type even when the supervisor does not observe this information. Because

4 See, however, Faure-Grimaud et al. (2003) for an analysis of collusion under soft information.

upward manipulation does not benefit the agent, its feasibility under soft information poses no threat. The principal faces the same binding coalition incentive constraint under hard and soft information; equivalence thus holds.

Here, we consider the robustness of equivalence to monitoring technologies and the supervisor's personal stakes.[5] We construct an alternative monitoring technology, that of "efficiency restoration," under which hard information precludes downward manipulation but admits upward manipulation. The principal sets the default wage at the good-type agent's cost level so that the bad type does not produce, i.e., he sacrifices production efficiency in exchange for the good type's information rent. The supervisor may discover that the agent is indeed the bad type. This information, if reported truthfully, restores production efficiency because the principal will increase the wage offer and let the bad type produce.

Hiding the discovery that the agent is the bad type clearly is not in the agent's interests, but is the only manipulation permitted by hard information for this monitoring technology. The profitable information manipulation of claiming that the agent is the bad type when the supervisor observes nothing is precluded by hard information. Therefore, under hard information the principal can costlessly solicit the supervisor's observation.[6] Soft information, by contrast, permits downward manipulation, which translates into a binding coalition incentive compatibility constraint and reduces the principal's payoff. Equivalence fails for this alternative monitoring technology.

As an application, we consider countervailing incentives and let the good-type agent have a higher reservation utility than the bad-type one. When

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5 Collusion in an organization has been extensively studied in the past decades. Tirole (1986) first proposes the Collusion-Proofness Principle. The literature has considered collusion under asymmetric information (Felli, 1990; Tirole, 1992; Frascatore, 1998), different types of supervisors, i.e., honest vs. dishonest (Kofman and Lawarrée, 1993, 1996), as well as applications (Dessi, 2005), to name a few. In an earlier version of the paper (Chiou, 2007), we also illustrate the fragility of equivalence in the framework of continuous production quantities.

6 Perhaps due to this reason, the literature tends to focus on rent extracting monitoring technology.

the difference in reservation utility is sufficiently large, it becomes more costly to induce participation by the good type, and the bad type has incentives to mimic the good type. The binding incentive constraint becomes that associates with upward manipulation, not downward manipulation. This reversal of interests in information manipulations causes the failure of equivalence under the monitoring technology of Baliga (1999).

We then introduce the supervisor’s career concerns à la Holmström (1999). This new feature in the collusion model generates an incentive of information manipulation that is different from the agent’s information rent. Given a monitoring technology, the supervisor wishes to be perceived by the market as capable of generating the informative observation, i.e., observing that the agent is the good type under the rent extraction monitoring technology, and observing the bad type under the efficiency restoration one. Hiding discovery will be perceived as less capable by the market and harm the supervisor’s career, measured by the rent from future employment.

The supervisor’s disincentive to suppress discovery may align with or work against the agent’s interests. More precisely, hiding discovery corresponds to different manipulations for different monitoring technologies. For the rent extraction monitoring technology, hiding the discovery of good type amounts to downward manipulation, and the supervisor’s loss of future rent from doing so creates conflicts of interests between the colluding parties. This conflict helps the principal to deter collusion at a lower cost; career concerns alleviate the collusion problem. Equivalence also holds. The result of Baliga (1999) extends to this dynamic setting, for downward manipulation is still the binding constraint.

For the efficiency restoration monitoring technology, hiding the discovery of bad type corresponds to upward manipulation, which benefits neither the agent nor the supervisor. Their congruent preferences toward downward manipulation, the agent for information rent and the supervisor for future employment rent, implies a higher cost to deter collusion. Career concerns aggravate the collusion problem. And, since downward manipulation is only feasible under soft information, equivalence fails.

Career concerns crucially depend on what the market can observe about the supervisor's current performance. We follow Mukherjee (2008) and let the principal "manage" career concerns by committing to a disclosure policy as part of the contract offer. For example, the principal controls information flow to the future employer by providing a reference letter. Two instruments, explicit incentives (monetary rewards) and implicit incentives (career concerns), then, are at the principal's disposal. The principal can modify career concerns by partially revealing the supervisor's performance, or even eliminate entirely career concerns by revealing nothing so that a future employer cannot base the hiring decision on current performance.

Indeed, we find that the principal will commit to full information disclosure when career concerns help fight collusion, as in the case of rent extraction technology. When career concerns exacerbate the collusion problem, as in the case of efficiency restoration technology, the principal will limit information flow and prevent the future employer from hiring the most capable supervisor. In other words, the principal may manage intrinsic incentives at the expense of the future employer. We obtain collusion deterrence as another rationale for informational frictions at the labor market (Mukherjee, 2008; Koch and Peyrache, 2011).

We proceed first by introducing the model in section 2. We discuss upward vs. downward manipulations and countervailing incentives in section 3, and address career concerns in section 4. In section 5, we offer some concluding remarks.

2. A Procurement Model

To facilitate comparison, we use the same framework as Tirole (1992) and Baliga (1999). A principal (P) hires an agent (A) to produce an indivisible good, with quantity $x=0$ or 1. Both parties are risk neutral, and the agent has reservation utility zero. The agent's production cost is either high, $\beta_H > 0$ (the bad type), or low, $\beta_L > 0$ (the good type). The cost difference is denoted as $\Delta\beta \equiv \beta_H - \beta_L > 0$. The value of the good to the principal (V) is sufficiently large so that efficiency calls for production of both types,

$V > \beta_H$. The true production cost is the private information of the agent. The principal holds ex ante belief that the bad type occurs with probability $\mu \in (0,1)$.

The delivery of the good is contractible (i.e., observable and verifiable), and the agent learns his production cost before contracting with the principal. Given a binary production activity, $x \in \{0,1\}$, the optimal contract under adverse selection takes a simple form. The principal offers either a wage β_H so that both types of agent will produce, or a wage β_L so that only the good type will produce. The former policy of no screening generates a payoff $V - \beta_H$ for the principal, and the latter of screening a payoff $(1-\mu)(V-\beta_L)$. As in a typical adverse selection problem, the bad type receives no rent in either case, and the good type enjoys the information rent $\Delta\beta$ when the principal does not screen. Define $\bar{\mu}$ by:

$$V - \beta_H \equiv (1-\bar{\mu})(V-\beta_L) \Rightarrow \bar{\mu} = \frac{\Delta\beta}{V - \beta_H + \Delta\beta} \in (0,1). \qquad (1)$$

The principal will screen the agent's type with a wage β_L when the probability of facing the bad type is strictly smaller than $\bar{\mu}$.

A random variable $b \in \{b_L, \phi, b_H\}$ correlates with the production cost: Given β_H, $b = b_H$ with probability $\alpha \in (0,1)$ and $b = \phi$ with probability $1-\alpha$; and given β_L, $b = b_L$ with probability α and $b = \phi$ with probability $1-\alpha$. Hence b has (unconditional) probability distribution $\Pr(b_L) = (1-\mu)\alpha$, $\Pr(\phi) = 1-\alpha$, and $\Pr(b_H) = \mu\alpha$. Conditional on b, the updated beliefs are $\Pr(\beta_H \mid b_H) = 1$, $\Pr(\beta_H \mid \phi) = \mu$, and $\Pr(\beta_H \mid b_L) = 0$. That is, b_L and b_H perfectly inform the agent's type, while ϕ is statistically uninformative.

We construct three monitoring technologies, or signals, based on b. Each signal corresponds to a partition of $\{b_L, \phi, b_H\}$, and an observer learns which set in the partition contains the realized value of b.

(1) σ_L (observing b_L or not; rent extraction): With a partition $\{\{b_L\}, \{\phi, b_H\}\}$, the observer learns one of the two events, $b = b_L$ or $b \in \{\phi, b_H\}$ (i.e., $b \neq b_L$). This is the signal considered in Tirole

(1992) and Baliga (1999), where the event $b \in \{\phi, b_H\}$ is called learning "nothing" ($\emptyset$) in their terminology.[7] Observing b_L reveals that the agent is the good type for sure, and observing $b \neq b_L$ updates the belief to

$$\hat{\mu}_{\sim b_L} \equiv \Pr(\beta_H \mid b \in \{\phi, b_H\}) = \frac{\mu}{\mu + (1-\mu)(1-\alpha)} > \mu. \tag{2}$$

(2) σ_H (observing b_H or not; efficiency restoration): With a partition $\{\{b_H\}, \{b_L, \phi\}\}$, the observer learns $b = b_H$ or $b \neq b_H$. An observation of b_H reveals that the agent is the bad type for sure, and observing $b \in \{b_L, \phi\}$ revises the belief to

$$\hat{\mu}_{\sim b_H} \equiv \Pr(\beta_H \mid b \in \{b_L, \phi\}) = \frac{\mu(1-\alpha)}{\mu(1-\alpha) + (1-\mu)} > \mu. \tag{3}$$

(3) σ (learning b_L or b_H or not; unbiased learning): This monitoring technology has the finest partition $\{\{b_L\}, \{\phi\}, \{b_H\}\}$. The observer either learns (statistically) nothing, $b = \phi$, or the true type of the agent, $b = b_L$ or b_H.

The following assumption, ensuring that all signals bring useful information, is maintained throughout the analysis.

Assumption 1. $\hat{\mu}_{\sim b_H} < \bar{\mu} < \hat{\mu}_{\sim b_L}$.

We first characterize the principal's collusion-free payoffs, which are equivalent to the case where the principal has direct access to a monitoring technology.[8] For σ_L, an observation of b_L indicates that the agent is the good type for sure and the principal optimally sets the wage at β_L. Upon observing $b \neq b_L$, the principal offers β_H because the belief is revised to $\hat{\mu}_{\sim b_L} > \mu$. The principal obtains

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7 We use different symbols for the statistically uninformative observation ϕ and the event of learning nothing, $\emptyset$, which still tells something about the agent's type.

8 Throughout the paper, we consider the principal's optimization problem under each of the three monitoring technologies, but do not endogenize this choice.

$$\pi^*(\sigma_L) = \Pr(b \neq b_L)(V - \beta_H) + \Pr(b_L)(V - \beta_L) = V - \beta_H + (1-\mu)\alpha\Delta\beta. \quad (4)$$

This monitoring technology is called the rent extraction technology: The principal sets the agent's wage at β_H unless it is learned that the agent is the good type, which occurs with probability $(1-\mu)\alpha$ and allows the principal to extract rent $\Delta\beta$ from the agent.

For signal σ_H, the principal obtains

$$\begin{aligned}\pi^*(\sigma_H) &= \Pr(b \neq b_H)[(1-\hat{\mu}_{\sim b_H})(V - \beta_L)] + \Pr(b_H)(V - \beta_H) \\ &= V - \beta_H + [(1-\mu)\Delta\beta - \mu(1-\alpha)(V - \beta_H)],\end{aligned} \quad (5)$$

by setting the wage at β_H upon observing b_H, and at β_L upon observing $b \neq b_H$. The latter offer comes from $\hat{\mu}_{\sim b_H} < \bar{\mu}$, which also ensures that $(1-\mu)\Delta\beta > \mu(1-\alpha)(V - \beta_H)$. This monitoring technology is one of efficiency restoration. The principal screens (so that only the good type produces) unless it is learned that the agent is the good type. By doing so, the principal leaves no rent to the good type (hence gains $\Delta\beta$ with probability $1-\mu$) at a cost of net surplus $V - \beta_H$ when the signal fails to inform that the agent is indeed the bad type, which occurs with probability $\mu(1-\alpha)$.

For signal σ, the principal's payoff is

$$\begin{aligned}\pi^*(\sigma) &= \Pr(b_L)(V - \beta_L) + \Pr(b_H)(V - \beta_H) \\ &\quad + \Pr(\phi)\max\{V - \beta_H, (1-\mu)(V - \beta_L)\}.\end{aligned} \quad (6)$$

If $\mu \geq \bar{\mu}$, the principal offers the agent a wage β_H for both $b = b_H$ and ϕ, and only an observation of b_L will change the offer to β_L. The signal then resembles σ_L, and the principal also obtains the collusion-free payoff $\pi^*(\sigma \mid \mu \geq \bar{\mu}) = \pi^*(\sigma_L)$. If $\mu < \bar{\mu}$, the principal offers β_L for both $b = b_L$ and ϕ, and β_H for $b = b_H$. The signal resembles σ_H, and the principal obtains $\pi^*(\sigma \mid \mu < \bar{\mu}) = \pi^*(\sigma_H)$.

3. Collusion under Hard and Soft Information

Suppose that the principal hires a risk neutral supervisor (S) for the access to the monitoring technology. The supervisor does not observe the production cost, and has reservation utility zero. Consider the following timing:

(1) Time 1 (information learning): A learns the production cost, and both A and S observe the realization of a signal.

(2) Time 2 (contracting): P offers S and A a contract which specifies payments conditional on the messages sent by S and A and the output level $x \in \{0,1\}$.

(3) Time 3 (collusion): A offers a side contract to S, which consists of messages sent to P, output, and side payment.

(4) Time 4 (implementation): The contracts are executed.

We follow Baliga (1999) at the side contracting stage. Both the supervisor and agent observe the signal and can sign an enforceable side contract, although side monetary transfer entails an efficiency loss $1-k \in [0,1)$. Therefore, the supervisor holds no private information vis-à-vis the agent, and for every dollar paid by the agent, the wealth of the supervisor only increases by k dollars. The Collusion-Proofness Principle holds (Tirole, 1986, 1992), and it is optimal for the principal to deter collusion between the supervisor and agent.[9] Much like the Revelation Principle, should collusion occur, the principal could incorporate the side contract into the grand contract, implement the collusive strategy of the supervisor and agent on their behalf, and save the efficiency loss $\$(1-k)t$ if a side payment $\$t$ is involved.

The distinction between hard and soft information concerns feasible information manipulations. We say that the supervisor and agent engage in upward manipulation (downward manipulation) when they bias the report in

9 As shown in Tirole (1992) and Baliga (1999), other coalitions are not binding and thus are ignored.

order to convince the principal that the agent is more likely (less likely, respectively) to be the good type than their actual observation suggests. In Figure 1, black solid lines represent truthful reports, grey lines indicate upward manipulations, and dashed lines downward manipulations. For signal σ_L, upward manipulation occurs when b_L is reported even though $b \neq b_L$ is observed. Should the principal take the face value of this report, he would believe that the agent is the good type for sure, rather than holding a belief $\hat{\mu}_{\sim b_L}$, as suggested by the true observation. Downward manipulation refers to the case where b_L is observed but $b \neq b_L$ is reported, so that the principal would believe that the agent is less likely to be the good type than informed by b_L. Similarly for the signal σ_H and σ. Note that signal σ admits multiple upward and downward manipulations.

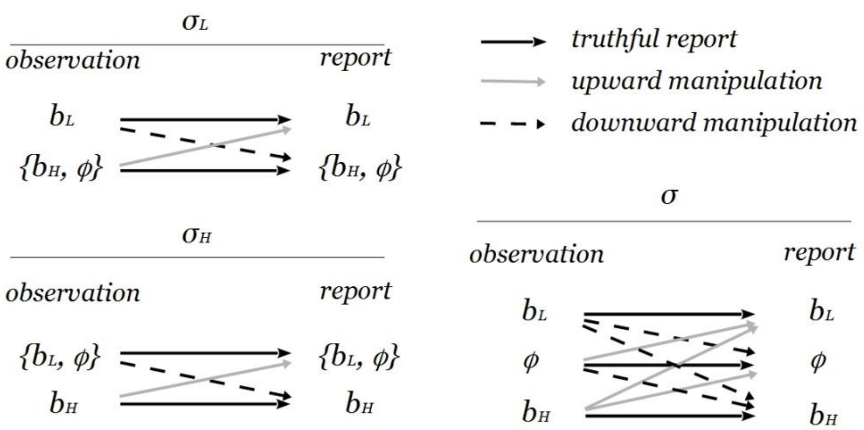

Figure 1 Information Manipulations

Truthful reports are always available, while soft information imposes no restrictions on feasible manipulations. Similar to subjective performance evaluation, a player's report is not constrained by the actual observation.

Hard information, by contrast, precludes certain information manipulations. By definition, hard information allows a fact-finder to hide his finding, but prohibits fabricating unfound information (Tirole, 1986). Signal σ_L lets b_L be discovered; hard information hence allows downward manipulation but precludes upward manipulation. The supervisor can claim no hard evidence is found that indicates that the agent is the good type, but cannot fake evidence of b_L upon no discovery. Interpreting in the same manner, signal σ_H gives the chance to learn b_H; hard information admits upward manipulation but not downward manipulation. Signal σ provides learning of b_L and b_H; only downward manipulation in the former and upward manipulation in the latter are allowed. Figure 2 illustrate feasible reports under hard information.

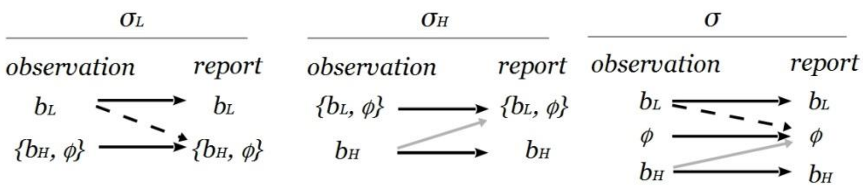

Figure 2 Feasible Manipulations under Hard Information

3.1 The Equivalence between Hard and Soft Information

We first replicate Baliga (1999)'s result. Both Tirole (1992) and Baliga (1999) consider signal σ_L. They also assume $\mu \geq \bar{\mu}$, but we relax the restriction on the prior belief. Under hard information, the good-type agent obtains the information rent $\Delta\beta$ by downward manipulation. To solicit the report b_L, Tirole (1992) shows that the principal needs to pay the supervisor $k\Delta\beta$, the maximal bribe the supervisor can get from the agent. The principal obtains

$$\begin{aligned} &\Pr(b \neq b_L)(V-\beta_H)+\Pr(b_L)(V-\beta_L-k\Delta\beta) \\ &\quad = V-\beta_H+(1-\mu)\alpha(1-k)\Delta\beta \\ &\quad = \pi^*(\sigma_L)-(1-\mu)\alpha k\Delta\beta. \end{aligned} \tag{7}$$

Alternatively, the principal can discard the signal and set a fixed wage for the agent. The supervisor then gets zero payment. The wage offer β_H generates a payoff $V-\beta_H$ for the principal, which is smaller than

$\pi^*(\sigma_L)-(1-\mu)\alpha k\Delta\beta$. The principal only needs to consider the wage β_L, and the optimal collusion-proof payoff under hard information is

$$\pi^h(\sigma_L)=\max\{\pi^*(\sigma_L)-(1-\mu)\alpha k\Delta\beta,(1-\mu)(V-\beta_L)\}. \tag{8}$$

Note that, when $\mu\geq\bar{\mu}$, $V-\beta_H\geq(1-\mu)(V-\beta_L)$ and so $\pi^h(\sigma_L)=\pi^*(\sigma_L)-(1-\mu)\alpha k\Delta\beta$, as in Tirole (1992). When $\mu<\bar{\mu}$, however, fighting collusion may be too costly, and the principal may optimally ignore the signal σ_L. The principal will use σ_L if and only if $\pi^*(\sigma_L)-(1-\mu)\alpha k\Delta\beta\geq(1-\mu)(V-\beta_L)$, or, equivalently

$$\mu(V-\beta_H)\geq(1-\mu)\Delta\beta[1-\alpha(1-k)]. \tag{9}$$

The assumption of $\hat{\mu}_{\sim b_L}>\bar{\mu}$ ensures that $\mu(V-\beta_H)\geq(1-\mu)\Delta\beta(1-\alpha)$. Hence, σ_L will be used when the collusion problem is not too severe (k sufficiently small).

Soft information introduces an additional coalition incentive compatibility constraint corresponding to upward manipulation. The grand contract should also prevent a report of b_L from being sent when $b\neq b_L$ is observed. The agent, however, is not interested in upward manipulation. The good type can enjoy the information rent $\Delta\beta$ by truthfully reporting $b\neq b_L$, while the bad type obtains no information rent whatever the report. Baliga (1999) proposes a mechanism to ensure the same payoff for the principal under soft information, $\pi^s(\sigma_L)=\pi^h(\sigma_L)$. Essentially, the principal uses the agent's report and production decision to check the supervisor's report in order to eliminate the latter's incentive of faking b_L.

3.2 Upward vs. Downward Manipulations

Intuitively, equivalence holds for the rent extraction technology σ_L because the source of collusive gains, the agent's information rent, is only generated by downward manipulation, and the principal has taken care of this manipulation under hard information. This suggests that equivalence hinges on whether downward manipulations are properly addressed under hard information.

For the efficiency restoration monitoring technology σ_H, hard information allows upward manipulation but not downward manipulation; see Figure 2. The agent's lacking of interests in upward manipulation implies that the observation b_H can be solicited at no cost. For both $\mu \gtrless \bar{\mu}$, the principal obtains the collusion-free payoff despite the possibility of collusion, $\pi^h(\sigma_H) = \pi^*(\sigma_H)$.

The collusion-free payoff $\pi^*(\sigma_H)$ is infeasible under soft information, which admits downward manipulation. Equivalence fails. Upon observing $b \neq b_H$ the good-type agent will want to collude with the supervisor to report b_H.[10] To deter collusion, the supervisor needs to be rewarded by an amount $k\Delta\beta$ for reporting $b \neq b_H$ (and when the agent produces at a wage β_L). By doing so, the principal's payoff is $\pi^*(\sigma_H) - (1-\mu)k\Delta\beta$.

The principal can also ignore the signal and set a flat wage β_L or β_H for the agent, and zero for the supervisor. The principal's optimal collusion-proof payoff under soft information is

$$\pi^s(\sigma_H) = \max\{\pi^*(\sigma_H) - (1-\mu)k\Delta\beta, V - \beta_H, (1-\mu)(V-\beta_L)\}, \quad (10)$$

where

$$\begin{aligned} &\pi^*(\sigma_H) - (1-\mu)k\Delta\beta \geq V - \beta_H \\ &\Leftrightarrow (1-\mu)(1-k)\Delta\beta \geq \mu(1-\alpha)(V-\beta_H). \end{aligned} \quad (11)$$

and

$$\begin{aligned} &\pi^*(\sigma_H) - (1-\mu)k\Delta\beta \geq (1-\mu)(V-\beta_L) \\ &\Leftrightarrow \mu\alpha(V-\beta_H) \geq (1-\mu)k\Delta\beta. \end{aligned} \quad (12)$$

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10 Note that in this case collusion occurs under asymmetric information, for the supervisor cannot be sure of the agent's type after observing $b \neq b_H$. We require strong collusion-proofness and assume that the agent and supervisor will exhaust any collusive gains. See Remark 1 for more discussion.

In each case, the principal will use the signal σ_H if k is sufficiently small.[11]

Equivalence may also fail for unbiased learning σ. This monitoring technology illustrates the point that equivalence does not require all downward manipulations to be considered under hard information. Referring to Figure 2, for this monitoring technology hard information excludes two downward manipulations, reporting b_H upon observing b_L or ϕ.

When $\mu \geq \bar{\mu}$, an observation of ϕ calls for no screening of the agent's type. Similar to signal σ_L, under hard information, the good-type agent and supervisor have incentives to engage in downward manipulation (reporting ϕ when observing b_L), but not upward manipulation (reporting ϕ when observing b_H). By rewarding the supervisor an amount of $k\Delta\beta$ for reporting b_L, the principal obtains a payoff [12]

$$\begin{aligned}\pi^h(\sigma \mid \mu \geq \bar{\mu}) &= \Pr(b_L)(V-\beta_L-k\Delta\beta)+[\Pr(\phi)+\Pr(b_H)](V-\beta_H) \\ &= V-\beta_H+(1-\mu)\alpha(1-k)\Delta\beta \qquad (13) \\ &= \pi^h(\sigma_L).\end{aligned}$$

Soft information introduces two more downward manipulations, reporting b_H when observing b_L or ϕ. The principal can ignore these two manipulations, however. Upon observing ϕ, a wage offer β_H already allows the good-type agent to enjoy the information rent $\Delta\beta$. Since the procurement model entails a fixed information rent $\Delta\beta$, collusive gains remain the same whether reporting ϕ or b_H.[13] The principal also obtains

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11 $\hat{\mu}_{\sim b_H} > \bar{\mu}$ is equivalent to $(1-\mu)\Delta\beta > \mu(1-\alpha)(V-\beta_H)$, and imposes a lower bound on α.

12 Recall that $\pi^h(\sigma_L) = \pi^*(\sigma_L) - (1-\mu)\alpha k\Delta\beta$ for $\mu \geq \tilde{\mu}$.

13 Clearly this is not robust to continuous production (Chiou, 2007). If outputs can be adjusted continuously ($x \in [0,\infty)$), then a "smooth" trade-off between efficiency and information rent extraction implies that the principal's optimal collusion-free output is continuous in the updated belief $\hat{\mu}$. Higher $\hat{\mu}$ tilts the trade-off toward efficiency and increases outputs, which in turn raises the good-type agent's information rent. For signal σ, upon observing b_L, the good-type agent receives higher information rent by reporting b_H than ϕ. Since reporting b_H is only feasible under soft information, equivalence breaks down.

$\pi^s(\sigma \mid \mu \geq \bar{\mu}) = \pi^h(\sigma \mid \mu \geq \bar{\mu})$ under soft information, and equivalence holds.

If $\mu < \bar{\mu}$, to utilize the signal the principal offers the agent a wage β_H if and only if observing b_H, and the only profitable information manipulations are reporting b_H upon observing b_L or ϕ. Hard information precludes both manipulations (see Figure 2), hence the principal can costlessly solicit true observations and obtain the collusion-free payoff, $\pi^*(\sigma \mid \mu < \bar{\mu}) = \pi^*(\sigma_H)$. Under soft information, by contrast, the principal needs to reward the supervisor for reporting b_L and ϕ, which causes equivalence to fail. The principal faces the same problem as under signal σ_H and soft information, and obtains the optimal collusion-proof payoff $\pi^s(\sigma \mid \mu < \bar{\mu}) = \pi^s(\sigma_H)$.

Proposition 1.

Equivalence of hard and soft information holds for the rent extraction monitoring technology σ_L and unbiased learning σ with $\mu \geq \bar{\mu}$, but fails for the efficiency restoration monitoring technology σ_H and unbiased learning σ with $\mu < \bar{\mu}$.

For each monitoring technology, the principal's optimal collusion-proof payoffs are, respectively, $\pi^h(\sigma_L) = \pi^s(\sigma_L)$, $\pi^h(\sigma|\mu \geq \bar{\mu}) = \pi^s(\sigma|\mu \geq \bar{\mu})$, $\pi^h(\sigma_H) > \pi^s(\sigma_H)$, and $\pi^h(\sigma|\mu < \bar{\mu}) > \pi^s(\sigma|\mu < \bar{\mu})$.

Remark 1. A robust insight from economic theory is that asymmetric information tends to generate transaction costs and prevent the realization of gains from trade. The same is true at side contracting (Felli, 1990; Tirole, 1992). Tirole (1992), for instance, modifies signal σ_L (under hard information) by allowing $\Pr(\beta_H \mid b_L) > 0$, so that an observation of b_L cannot eliminate the possibility of the bad type.[14] When the supervisor is not

[14] The modification of $\Pr(\beta_L \mid b_H) > 0$, so that an observation of b_H cannot rule out the good type, is less interesting as long as the principal will not screen after a truthful report of b_H, i.e., $\Pr(\beta_H \mid b_H) \geq \bar{\mu}$. The agent will not want to collude, and so has no incentive to make any side offers.

sure of the agent's type, the latter's side offer may reveal further information. This signaling issue may prevent the agent and supervisor from realizing collusive gains, and the principal can deter collusion at no cost along the equilibrium path.

Two remarks are in order. First, the equilibrium of no collusion is not unique. There exists another equilibrium where the supervisor and agent can realize collusive gains.[15] When the latter equilibrium prevails, the principal can only deter collusion by properly rewarding the supervisor and eliminating any collusive gains. Our results hold. Second, the failure to realize collusive gains does not depend on the signal being hard information. To the extent that the principal can rely on trading inefficiency at side bargaining to deter collusion, the distinction between hard and soft information becomes irrelevant.[16]

For instance, the same signaling issue may also arise for signal σ_H and σ. When observing $b \neq b_H$ under signal σ_H, or observing ϕ under signal σ (with $\mu < \bar{\mu}$), the supervisor is not sure of the agent's true type. Should asymmetric information prevent the supervisor and agent from colluding, the principal can also obtain the collusion-free payoff under soft information. Equivalence holds because profitable manipulations are handicapped by asymmetric information, whether the information is hard or soft.

Relying on asymmetric information to deter collusion somewhat changes the focus of analysis. By emphasizing the distinction of hard and soft information, we are concerned with how the principal responds to the addition of incentive constraints. On the other hand, asymmetric information generates

15 Multiple equilibria bring the distinction between weak and strong collusion proofness. By Tirole (1992): "An allocation is *weakly collusion proof* if there exists some equilibrium of the collusion game in which the null side contract is signed in all states of nature. It is *strongly collusion proof* if it is the only equilibrium allocation." Frascatore (1998) shows that intuitive criterion can eliminate the equilibrium of no collusion.

16 Indeed, the augmented revelation mechanism used by Tirole (1992) to illustrate the signaling issue incorporates soft information (the supervisor's subject belief) into the message space reported by the supervisor to the principal, even when the signal is hard information.

trading inefficiency in that collusive parties fail to realize collusive gains associated with a given information manipulation. Since the distinction of information is fundamental to our analysis, we keep asymmetric information at the minimal level, and insist on the realization of collusive gains by the supervisor and agent.

Remark 2. Suppose that only the supervisor, but not the agent, observes the signal. This alternative setting introduces more frictions at side contracting, and generates an interesting case where the agent's type is never common knowledge between the supervisor and agent. Consider signal σ_L (similarly for other signals). When privately observing b_L, the supervisor learns that the agent is the good type, but the agent cannot be sure that the supervisor knows his type, for the latter may also observe $b \neq b_L$. And for the bad-type agent, he knows that the supervisor must observe $b \neq b_L$, in which case the supervisor cannot rule out the possibility of the good type.

How does this modification affect our result? For the efficiency restoration signal σ_H, the good-type agent knows for sure that, given his type, the supervisor must observe $b \neq b_H$. For unbiased learning σ with $\mu < \bar{\mu}$, although the good type does not know whether the supervisor observes b_L or ϕ, both observations, if reported truthfully, reduce the wage to β_L. Private access to the monitoring signal does not create uncertainty (and so information asymmetry) about the existence of profitable collusion opportunity for the good-type agent. Previous analysis holds.

By contrast, for the rent extraction monitoring technology σ_L or unbiased learning σ with $\mu \geq \bar{\mu}$, not observing the signal puts the good-type agent at a disadvantaged position. Without learning the supervisor's observation, the good type cannot selectively collude and offer a bribe only when the supervisor observes b_L. This two-sided asymmetric information may help the principal deter collusion at a lower cost.

The inefficiency at the side contracting, again, doesn't seem to depend on the information being hard or soft. Hard information only prevents the supervisor from reporting b_L upon observing $b \neq b_L$, but the agent wouldn't want him to do so anyway. Furthermore, inefficiency could be minimized by the introduction of a fictitious player to organize the side contracting, a methodology developed by Laffont and Martimort (1997). We present such a mechanism in Appendix 2. This side mechanism applies to both hard and soft information, and realizes all possible collusive gains. The principal, therefore, needs to reward the supervisor $k\Delta\beta$ to deter collusion; our analysis holds.

3.3 Countervailing Incentives

Downward manipulations are not always the binding incentive constraints. The literature of principal-agent theory has also discussed when the agent may want to engage in upward manipulations. A typical situation involves the agent's type-dependent reservation utility. Intuitively, when the good-type agent has higher reservation utility than the bad type, the principal needs to raise the former's rent to induce participation.[17] Too high a rent may more than compensate the cost difference and induce the bad type to mimic the good type. When this occurs, upward manipulation becomes the one to

[17] The difference in reservation utility may come from the fixed cost of the agent, with a higher fixed cost for the good type (Lewis and Sappington, 1989); or the agent may have another job opportunity, and the good type receives higher returns from the outside offer. Type-dependent reservation utilities have been analyzed in a number of contexts. Lewis and Sappington (1989), which coined the term "countervailing incentives," assumes that the fixed cost component of a monopolist is negatively correlated with the marginal cost. Therefore, the good type (the one with alower marginal cost) needs more rent from production to induce participation. In Laffont and Tirole (1990), the value of a consumer's outside option depends on his marginal valuation of the product (his type). Higher valuation consumers (the good type) also derive higher value from another supplier's products. Jeon and Laffont (1999) considers laying off public-sector employees, i.e., downsizing the public sector, where employers with different ability receive different rent from private-sector jobs. The theoretical challenge brought by countervailing incentives is "to perturb the natural ordering of the incentive and participation constraints" (Laffont and Martimort, 2002), i.e., we may no longer have the standard case of a binding participation constraint of the bad type and binding incentive compatibility constraint of the good type. If, instead, the bad type has a higher reservation utility, it is equivalent to a higher β_H and reinforces the good type's incentive to mimic the bad type. Standard analysis applies. For more references and a textbook treatment of countervailing incentives, see Laffont and Martimort (2002).

watch, and equivalence no longer holds for signal σ_L.

To illustrate this point, we change the good type's reservation utility to $u_0 > 0$ but maintain the bad-type agent's reservation utility at zero. The good type's participation constraint now requires a wage higher than $u_0 + \beta_L \equiv \tilde{\beta}_L$. We assume:

Assumption 2. $V > \tilde{\beta}_L > \beta_H$.

By $V > \tilde{\beta}_L$, efficiency requires both types of agent to produce. By $\tilde{\beta}_L - \beta_H \equiv \Delta\tilde{\beta} > 0$, the bad-type agent obtains strictly positive rent by mimicking the good type.

In fact, after this modification, the roles of good type and bad type switch. Now it costs less for the principal to induce production when the agent has cost β_H. To avoid confusion, we use the L-type and H-type in this subsection. Now, the principal offers either a wage $\tilde{\beta}_L$ so that both types will produce (no screening), or β_H so that only the H-type will produce (screening). Define $\bar{\mu}_o$ by

$$\bar{\mu}_o(V - \beta_H) \equiv V - \tilde{\beta}_L \Rightarrow \bar{\mu}_o = \frac{V - \tilde{\beta}_L}{V - \beta_H} \quad \in (0,1). \tag{14}$$

When $\mu > \bar{\mu}_o$, the principal will screen with a wage β_H. The following assumption is the counterpart of Assumption 1.

Assumption 3. $\hat{\mu}_{\sim b_H} < \bar{\mu}_o < \hat{\mu}_{\sim b_L}$.

Consider signal σ_L, under which equivalence holds previously. Absent collusion, P will set the agent's wage at $\tilde{\beta}_L$ when observing b_L, and at β_H when observing $b \neq b_L$. In the latter case, only the H-type agent will produce. Resembling the previous case of σ_H, the principal's collusion-free optimal payoff is

$$\pi_o^*(\sigma_L) = V - \tilde{\beta}_L + [\mu\Delta\tilde{\beta} - (1-\mu)(1-\alpha)(V - \tilde{\beta}_L)], \tag{15}$$

where $\mu\Delta\tilde{\beta} > (1-\mu)(1-\alpha)(V-\tilde{\beta}_L)$ for $\hat{\mu}_{\sim b_L} > \bar{\mu}_o$.

When collusion may occur (and both the supervisor and agent observe σ_L), the agent's interests lie in upward manipulation, not downward manipulation. By reporting b_L when observing $b \neq b_L$, the H-type agent enjoys a rent $\Delta\tilde{\beta}_L > 0$. Hard information prohibits upward manipulation and allows the principal to solicit the true observation at no cost, with a payoff $\pi_o^h(\sigma_L) = \pi_o^*(\sigma_L)$. Under soft information, the principal either deters collusion by rewarding the supervisor for reporting $b \neq b_L$ (and when the agent produces at the wage β_H), or discards the signal. The optimal collusion-proof payoff is

$$\pi_o^s(\sigma_L) = \max\{\pi_o^*(\sigma_L) - \mu k\Delta\tilde{\beta}, \mu(V-\beta_H), V-\tilde{\beta}_L\}, \qquad (16)$$

and equivalence of hard and soft information fails.

The reversal of types implies that equivalence now holds for signal σ_H, for upward manipulation is feasible under both hard and soft information. The principal obtains the same collusion-proof payoff

$$\pi_o^h(\sigma_H) = \pi_o^s(\sigma_H) = \max\{V-\tilde{\beta}_L + \mu\alpha(1-k)\Delta\tilde{\beta}, \mu(V-\beta_H)\}. \qquad (17)$$

The analysis of signal σ with $\mu > \bar{\mu}_o$ ($\mu \leq \bar{\mu}_o$) is similar to signal σ_L (signal σ_H, respectively). Equivalence fails for $\mu > \bar{\mu}_o$ and holds for $\mu \leq \bar{\mu}_o$.

Corollary.

In the presence of type-dependent reservation utility, equivalence fails for signal σ_L and signal σ with $\mu > \bar{\mu}_o$, but holds for signal σ_H and signal σ with $\mu \leq \bar{\mu}_o$.

4. Career Concerns of the Supervisor

So far collusion has been motivated by the agent's information rent. In addition to new information, a new member (the supervisor here) may also bring personal agenda into the organization. Here we consider career concerns of the supervisor à la Holmström (1999). Besides the satisfaction or failure of equivalence, this exercise illustrates the point that career concerns may exacerbate or alleviate the collusion problem. In turn, the principal may respond by limiting information flow, which creates informational frictions in the labor market.[18]

Consider a two-period extension of the procurement model. Each period, the project has the same characteristics $(V, \beta_L, \beta_H, \mu, k)$, and production costs are independently distributed. The principal and agent are short-term players, and different periods have different principals and agents. Only the supervisor may be employed in both projects.[19] Players are risk neutral, and the discount factor is set to one.

A pool of supervisors have access to the same monitoring technology. Supervisors differ in $\alpha \in \{\bar{\alpha}, \underline{\alpha}\}$, the capability of generating informative observations b_L or b_H. A supervisor has high capability $\bar{\alpha}$ with probability $\zeta \in (0,1)$, and low capability $\underline{\alpha}$ with probability $1-\zeta$, with $0 < \underline{\alpha} < \bar{\alpha} \le 1$. No one learns the true α of a supervisor, including himself (Holmström,

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[18] Our purpose here is to examine the impact of another player's incentives to collude that are independent of the agent's information rent. If the agent has career concerns, these considerations will be weighed against the (short-term) information rent and factored into the agent's overall preferences over upward vs. downward manipulations. Since we have illustrated the reversal of preferences with countervailing incentives, we option for the supervisor's career concerns. Furthermore, the principal may (weakly) prefer to hire the good type for the optimal payoff is (weakly) decreasing in μ. Being perceived as a good type may only cost the agent the future rent, because the future employer will reduce the wage to β_L when convinced that he hires the good type.

[19] For collusion with long-term relationships, with and without enforceable side contracts, see Martimort (1999) and Acemoglu (1994), respectively.

1999). All parties hold the same ex ante belief that a supervisor has an average capability $\alpha^0 \equiv \zeta\overline{\alpha} + (1-\zeta)\underline{\alpha}$. The timing is:

(1) Time 1.1 (information learning): The first agent (A_1) learns his production cost.

(2) Time 1.2 (contracting): The first principal (P_1) hires a supervisor (S_1) and offers a contract to S_1 and A_1.

(3) Time 1.3 (collusion): Both S_1 and A_1 observe the realization of the signal. A_1 offers a side contract to S_1.

(4) Time 1.4 (implementation): Contract implementation. P_1 discloses information to the second principal (P_2), who then decides whether to hire S_1 or a new supervisor.

(5) Time 2.1 (information learning): A new, second agent (A_2) learns his production cost.

(6) Time 2.2 (contracting): P_2 makes the contract offer.

(7) Time 2.3 (collusion): Both the agent and supervisor observe the realization of the signal. The agent offers a side contract to the supervisor.

(8) Time 2.4 (implementation): Contract implementation.

We keep agents and supervisor's reservation utility at zero, but alter the timing so that the signal is observed after the principal's contract offer. To prevent surplus extraction, we further assume non-negative payments to the supervisor (as well as to agent) in all states of nature, e.g., due to limited liability constraint. Otherwise, zero future rent renders career concerns irrelevant.

The second principal faces the same problem as in section 3.1 and 3.2, except the additional hiring decision, which affects the prevailing capacity $\hat{\alpha}$. Recall that when the collusion problem is too severe (k too large), the principal will optimally ignore the signal. In this case, the supervisor receives zero payment and career concerns disappear. To simplify the analysis, we rule out this case by assuming that condition (9), (11), and (12) holds for $\underline{\alpha}$. By Proposition 1, given capacity $\hat{\alpha} \in [\underline{\alpha}, \overline{\alpha}]$, P_2's optimal payoffs are:

$$\begin{aligned}\pi^h(\sigma_L) &= \pi^s(\sigma_L) = \pi^h(\sigma \mid \mu \geq \overline{\mu}) = \pi^s(\sigma \mid \mu \geq \overline{\mu}) \\ &= V - \beta_H + (1-\mu)\hat{\alpha}(1-k)\Delta\beta,\end{aligned} \tag{18}$$

$$\pi^h(\sigma_H) = \pi^h(\sigma \mid \mu < \overline{\mu}) = [1-\mu(1-\hat{\alpha})](V-\beta_H) + (1-\mu)\Delta\beta, \tag{19}$$

and

$$\pi^s(\sigma_H) = \pi^s(\sigma \mid \mu < \overline{\mu}) = [1-\mu(1-\hat{\alpha})](V-\beta_H) + (1-\mu)(1-k)\Delta\beta. \tag{20}$$

For all signals, P_2's payoffs are increasing in $\hat{\alpha}$. There is a preference of hiring a more capable supervisor. In the presence of a pool of "fresh" supervisors with capability α^0, we assume that P_2 will retain S_1 if and only if the latter has perceived capability strictly higher than α^0.[20] To assess S_1's capacity, we assume that P_2's only source of information is P_2, who specifies an information disclosure rule in the contract offered to A_1 and S_1, and then truthfully discloses to P_2 at time 1.4 free of charge according to the disclosure rule (e.g., by providing a recommendation letter).[21]

Given collusion deterrence, along the equilibrium path, both S_1 and A_1 will truthfully report to P_1. We only refer to as S_1's report to P_1. We say that P_1 adopts a full disclosure rule when he fully reveals S_1's report to P_2. For instance, for signal σ_L, full disclosure allows P_2 to learn whether S_1 has reported b_L or $b \neq b_L$ to P_1. For signal σ, under full disclosure P_2 learns whether S_1 has reported $b = b_L$, ϕ, or b_H. By partial disclosure (no

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[20] We break the indifference in favor of a fresh supervisor in order to simplify the analysis. See the discussion in footnote 23.

[21] P_1 is no longer a player at time 2, and so has no incentive to distort information at time 1.4. For sure, S_1 would like to collude with P_1 against P_2, and P_2 may also approach A_1 for the information. We discuss these as well as P_1's commitment issue in section 5.

disclosure), by contrast, P_1 withholds some (all, respectively) of S_1's report from P_2.

P_2 updates the belief about S_1's capacity by using the information P_1 reveals, which, given collusion deterrence, must be S_1's true observation along the equilibrium path. Under full disclosure, for signal σ_L, observing b_L and $b \neq b_L$ revise the belief to

$$\Pr(\bar{\alpha} \mid b_L) \equiv \hat{\zeta}^{+} = \frac{\zeta(1-\mu)\bar{\alpha}}{\zeta(1-\mu)\bar{\alpha} + (1-\zeta)(1-\mu)\underline{\alpha}} = \frac{\zeta\bar{\alpha}}{\alpha^0} > \zeta, \tag{21}$$

and

$$\Pr(\bar{\alpha} \mid \{\phi, b_H\}) \equiv \hat{\zeta}_{\sim b_L} = \frac{\zeta[1-(1-\mu)\bar{\alpha}]}{\zeta[1-(1-\mu)\bar{\alpha}] + (1-\zeta)[1-(1-\mu)\underline{\alpha}]} < \zeta, \tag{22}$$

respectively; for signal σ_H, observing b_H and $b \neq b_H$ generate updated beliefs

$$\Pr(\bar{\alpha} \mid b_H) = \frac{\zeta\mu\bar{\alpha}}{\zeta\mu\bar{\alpha} + (1-\zeta)\mu\underline{\alpha}} = \hat{\zeta}^{+}, \tag{23}$$

and

$$\Pr(\bar{\alpha} \mid \{\phi, b_L\}) \equiv \hat{\zeta}_{\sim b_H} = \frac{\zeta(1-\mu\bar{\alpha})}{\zeta(1-\mu\bar{\alpha}) + (1-\zeta)(1-\mu\underline{\alpha})} < \zeta, \tag{24}$$

and for signal σ, observing b_L or b_H updates the belief to ζ^{+}, and observing ϕ to

$$\Pr(\bar{\alpha} \mid \phi) \equiv \hat{\zeta}^{-} = \frac{\zeta(1-\bar{\alpha})}{\zeta(1-\bar{\alpha}) + (1-\zeta)(1-\underline{\alpha})} = \frac{\zeta(1-\bar{\alpha})}{(1-\alpha^0)} < \zeta. \tag{25}$$

Define $\hat{\alpha}^{+} \equiv \zeta^{+}\bar{\alpha} + (1-\zeta^{+})\underline{\alpha}$ as the capability corresponding to ζ^{+}, and define $\hat{\alpha}_{\sim b_H}$, $\hat{\alpha}_{\sim b_L}$, and $\hat{\alpha}^{-}$ similarly. We have $\hat{\alpha}^{+} > \alpha^0$ while $\hat{\alpha}_{\sim b_H}$, $\hat{\alpha}_{\sim b_L}$, and $\hat{\alpha}^{-} < \alpha^0$. P_2 chooses S_1 over a fresh supervisor if and only if P_1 reveals that S_1 has observed b_L or b_H.

The desire to be hired by P_2 (i.e., career concerns) may induce S_1 to distort the report to P_1. Referring to Figure 3, given P_1's full disclosure rule, for signal σ_L, future employment drives S_1 to report b_L whatever his observations (as represented by black lines). And for signal σ_H, S_1 prefers to report b_H in order to obtain the future job.

Grey lines in Figure 3 depict the (good-type) agent's incentives of downward manipulations. For signal σ_L, the agent prefers to report $b \neq b_L$; and for σ_H, the preferred report is b_H. Comparing the two collusive parties' preferred reports gives an intuitive understanding of the effects of career concerns on the collusion problem.

Career concerns alleviate the collusion problem when the agent and supervisor prefer to send different reports, as in the case of σ_L. Upon observing b_L, A_1 has to compensate S_1 for the loss of future employment rent in order to persuade the latter to engage in downward manipulation. Collusive gains shrink, and P_1 can deter collusion by a smaller payment to S_1. By contrast, collusion deterrence becomes more costly when their preferred report coincides. For signal σ_H, upon observing $b \neq b_H$, both the (good-type) agent and supervisor have a stake in downward manipulation. For signal σ, which is not shown in Figure 3, the interests of A_1 and S_1 are partially aligned: the supervisor would like to report b_L or b_H, and the agent b_H (and also ϕ for $\mu \geq \overline{\mu}$).

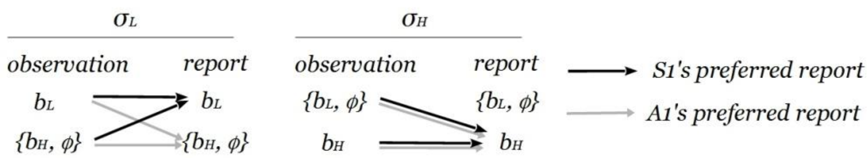

Figure 3 Information Manipulations and Career Concerns

For sure, not all preferred reports are feasible under hard information, and P_1 may refrain from full information disclosure. After all, P_1 can eliminate career concerns by committing to no disclosure, by which P_2 obtains no information and so S_1's report does not affect his job prospect.

With a careful choice of disclosure policy, career concerns would weakly benefit P_1. We consider P_1's optimal policy for each signal.

For signal σ_L, by Proposition 1, equivalence holds for P_2, whose supervisor obtains

$$v_{\sigma_L}(\hat{\alpha}) = (1-\mu)\hat{\alpha}k\Delta\beta < k\Delta\beta, \quad \forall\hat{\alpha}. \tag{26}$$

Suppose that P_1 commits to full disclosure. Under hard information, an observation of b_L at the first project raises the capacity to $\hat{\alpha}^+$, and S_1 will obtain a future rent $v_{\sigma_L}(\hat{\alpha}^+)$ if this information is learned by P_2, who then offers the job to S_1. If S_1 reports $b \neq b_L$ to P_1 instead, this report will be passed to P_2 and a fresh supervisor will be hired. Colluding to report $b \neq b_L$ costs S_1 future employment rent, and now a payment of $k\Delta\beta - v_{\sigma_L}(\hat{\alpha}^+)$ suffices to induce S_1 to truthfully report b_L. Career concerns help deter collusion, and P_1 obtains a payoff

$$\pi_1(\sigma_L) = V - \beta_H + (1-\mu)\alpha^0[(1-k)\Delta\beta + v_{\sigma_L}(\hat{\alpha}^+)]. \tag{27}$$

Under soft information, upon observing $b \neq b_L$, upward manipulation becomes feasible, and S_1 would like to report b_L in order to obtain the future employment rent $v_{\sigma_L}(\hat{\alpha}_{\sim b_L}) < k\Delta\beta$. This manipulation, however, will cost the good-type A_1 the information rent $\Delta\beta$, and bad-type A_1 will also incur a loss $\Delta\beta$ to produce at a wage β_L. Neither type is willing to do so, and the truthful report of $b \neq b_L$ can be guaranteed.[22] Equivalence also holds for P_1, who will optimally commit to full disclosure and obtain a payoff $\pi_1(\sigma_L)$ for both hard and soft information.

For signal σ_H, under hard information P_2 can solicit the information at no cost, and the supervisor receives no rent from the second project (Proposition 1). Career concerns disappear, and previous analysis also applies

22 The cross-checking mechanism of Baliga (1999) can prevent unilateral deviation: If A_1 and S_1 send different reports, then P_1 pays both zero and will reveal to P_2 that S_1 has reported $b \neq b_L$.

to the first project. P_1 induces truthful reports at no cost, and obtains a payoff $\pi^*(\sigma_H)$, evaluated at $\alpha = \alpha^0$. There is no loss for P_1 to commit to full disclosure.

Under soft information, the supervisor working for the second project receives $k\Delta\beta$ for reporting $b \neq b_H$, conditional on production by A_2. The employment rent is

$$v_{\sigma_H} = (1-\mu)k\Delta\beta. \tag{28}$$

At time 1, a reward $k\Delta\beta$ no longer suffices to deter collusion. As discussed earlier, the coincidence of preferred reports implies that career concerns exacerbate the collusion problem; see Figure 3. Upon observing $b \neq b_H$, the good-type A_1 can match the offer $k\Delta\beta$, and career concerns will induce S_1 to report b_H. The optimal disclosure rule of P_1 is no disclosure, which eliminates career concerns and leads to a payoff $\pi^s(\sigma_H) = \mu\alpha^0(V-\beta_H) + (1-\mu)(V-\beta_L-k\Delta\beta)$.[23]

Note that equivalence holds for the rent extraction monitoring technology σ_L, but not for the efficiency restoration technology σ_H. The equivalence result of Baliga (1999) extends to this dynamic setting. Intuitively, the supervisor's career is built on discovering some information (b_L in σ_L and b_H in σ_H). Faking discovery, only feasible under soft information, exerts opposite impacts on the agent under σ_L and σ_H. Under σ_L, reporting b_L upon observing $b \neq b_L$ corresponds to upward manipulation that deprive the good-type agent of the information rent. This conflict turns out to resolve in the agent's favor, and so the principal can solicit the truthful report of $b \neq b_L$ at no cost. The upward manipulation permitted by soft information imposes no binding constraint on P_1, hence equivalence

23 Under no disclosure, P_2 maintains a belief α^0 about S_1, while the latter possesses private information about his own capability. If P_2 hires S_1, then formally P_2's contracting problem needs to include incentive compatibility constraint regarding S_1's "type." Since more constraints will (weakly) reduce P_2's optimal payoff, we assume that for the same capability, P_2 will hire a new supervisor and circumvent this complication altogether.

holds. Under σ_H, reporting b_H upon observing $b \neq b_H$ benefits both the supervisor and agent. The no disclosure rule dissipates the supervisor's collusive gains, but not the agent's information rent. Therefore, equivalence again fails for σ_H.

For signal σ, with the possibility of learning b_L, b_H, and ϕ, under full information disclosure, S_1's career is hurt only when reporting ϕ, but not others. Reporting b_L or b_H when observing ϕ is excluded by hard information. The manipulations permitted by hard information, reporting ϕ upon observing b_L or b_H, either render career concerns irrelevant or confer a beneficial effect in that career concerns help deter collusion. The former case occurs when $\mu < \bar{\mu}$, so that only a report b_H will persuade the principal to set the agent's wage at β_H. In this case, suppressing the information b_L cannot give the agent the information rent. Similar to signal σ_H under hard information, the supervisor obtains no rent from the second project; career concerns disappear. The agent's preferred report b_H cannot be faked upon other observations, hence P_1 obtains the collusion-free payoff $\pi^*(\sigma_H)$, evaluated at capability α^0.

The latter case where career concerns help deter collusion occurs when $\mu \geq \bar{\mu}$, so that a report ϕ suffices for the good-type agent to obtain the information rent. Since S_1 loses future job by reporting ϕ, P_1 can deter collusion with a payment $k\Delta\beta - v_{\sigma_L}(\hat{\alpha}^+)$, similar to the case of σ_L. By full information disclosure, P_1 obtains a payoff $\pi_1(\sigma_L)$ and P_2 can efficiently employ the supervisor according to the received information.[24]

When σ is soft information, for both $\mu \gtrless \bar{\mu}$ the supervisor obtains a rent from the second project (see section 3.2). In addition, under full disclosure, two downward manipulations become available that would help the good-type A_1 to keep the information rent without jeopardizing S_1's career. Referring to Figure 4, reporting b_H upon observing b_L and ϕ will

[24] P_1 can also obtain $\pi_1(\sigma_L)$ by other disclosure policies; see the proof of Proposition 2. We assume that P_1 adopts the full disclosure policy upon indifference.

keep the agent's wage at β_H and P_2's perception of S_1's capacity at $\hat{\alpha}^+$.[25] P_1 needs to carefully "manage" career concerns by properly selecting the disclosure rule.

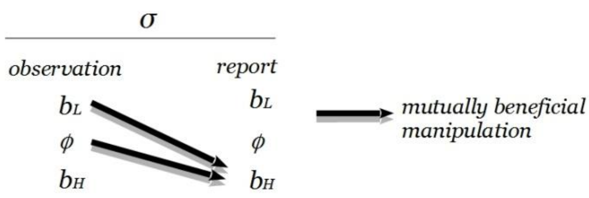

Figure 4 σ and Soft Information

P_1's optimal policy turns out to be a partial disclosure rule of revealing to P_2 whether S_1 has reported b_L or not. Under this rule, P_2 will retain S_1 if and only if S_1 reports b_L. Any downward manipulation of reporting ϕ or b_H will necessarily terminate S_1's career, and discourage the latter from collusion. This partial disclosure rule creates internal conflict between A_1 and S_1, and reduces the payment to induce truthful reports, as in the case of σ_L.[26]

When $\mu \geq \bar{\mu}$, this partial disclosure rule effectively brings P_1's optimization problem back to that under the signal σ_L. P_1 obtains a payoff $\pi_1(\sigma_L)$, the same as under hard information. Note that P_1 only achieves the same payoff by adopting different disclosure policies. Equivalence holds only for P_1, but not for P_2 and S_1. The partial disclosure policy under soft information leads to lower payoffs for both S_1 and P_2, for the failure to let a

25 Under limited liability, successful collusion may call for side payments from S_1's future wage from the second project. A_1, then, cannot "die out" after the completion of the first project. To make things more interesting, we assume both conditions hold.

26 For other disclosure policies, intuitively, no disclosure totally shuts down career concerns, and we go back to the case of section 3.2. Disclosing ϕ or not is equivalent to full disclosure, for the updated belief after learning $b \neq \phi$ is the same as that of learning b_L or b_H. And disclosing b_H or not exacerbates the collusion problem, for the supervisor also wants to engage in downward manipulation in order to obtain the future employment rent. For more details, see the proof of Proposition 2.

more capable supervisor S_1 work for P_2 after S_1 has observed b_H at time 1.

When $\mu < \bar{\mu}$, the supervisor obtains a rent v_{σ_H} from the second project. If P_1 adopts the partial disclosure rule, S_1 only obtains this rent by reporting b_L. Upon observing b_L, a reward $k\Delta\beta - v_{\sigma_H} = \mu k\Delta\beta$ suffices to induce S_1 to report the truth. And upon observing ϕ, P_1 still needs to ensure truth-telling by a payment $k\Delta\beta$ to S_1, conditional on A_1's production at a wage β_L. Under this partial disclosure policy, P_1 obtains

$$\begin{aligned}&(1-\mu)\alpha^0(V-\beta_L-\mu k\Delta\beta)+(1-\alpha^0)(1-\mu)(V-\beta_L-k\Delta\beta)\\&+\mu\alpha^0(V-\beta_H)=\pi^s(\sigma_H)+(1-\mu)\alpha^0(1-\mu)k\Delta\beta,\end{aligned} \tag{29}$$

where $\pi^s(\sigma_H)$ is evaluated at α^0. The following table and Proposition 2 summarize the results.

Table Career Concerns and Information Disclosure

	σ_L	σ_H	$\sigma(\mu \geq \bar{\mu})$	$\sigma(\mu < \bar{\mu})$
Equivalence	Yes	No	Only for P_1	No
Information disclosure				
hard information	Full	Full	Full	Full
soft information	Full	No	Partial: b_L or not	Partial: b_L or not

Proposition 2.

Suppose that P_1 can commit to an information disclosure policy.

(1) *For signal σ_L, equivalence of hard and soft information holds. P_1 optimally fully discloses information to P_2, and obtains the optimal collusion-proof payoff $\pi_1(\sigma_L)$.*

(2) *For signal σ_H, equivalence fails. P_1 obtains $\pi^*(\sigma_H)$ with full disclosure under hard information, but changes to no disclosure under soft information, with a payoff $\pi^s(\sigma_H)$.*

(3) *For signal* σ, *when* $\mu \geq \bar{\mu}$, *equivalence only holds for* P_1, *who obtains the optimal collusion-proof payoff* $\pi_1(\sigma_L)$ *by choosing full information disclosure under hard information and partial disclosure (revealing* b_L *or not) under soft information. When* $\mu < \bar{\mu}$, *equivalence fails.* P_1 *chooses full disclosure and obtains a payoff* $\pi^*(\sigma_H)$ *under hard information; and under soft information,* P_1 *reveals whether* S_1 *has reported* b_L *or not, and obtains the optimal collusion-proof payoff* $\pi^s(\sigma_H) + (1-\mu)\alpha^0(1-\mu)k\Delta\beta$.

5. Concluding Remarks

We examined the robustness of the equivalence result of Baliga (1999), and incorporated the supervisor's career concerns into the collusion model. The former provides a better understanding of the limitation, or usefulness of the hard information assumption. The latter illustrates how intrinsic and extrinsic motivations interact to shape the optimal collusion-deterrence policy.

Sometimes information can be verified or "hardened" at a cost (Dewatripont and Tirole, 2005). For instance, the principal can hire an external (and less bribable) auditor to verify submitted reports (Kofman and Lawarrée, 1993). Our discussion of upward vs. downward manipulations suggests that not all reports should receive the same level of scrutiny. Since, except for the existence of countervailing incentives, the colluding parties have incentives to engage in downward, but not upward manipulations, only the former should be subject to contingent auditing.

For career concerns, we obtain an interesting result that selective information disclosure can create conflicts between two colluding parties. Crucial to our analysis are the assumptions that the current employer (P_1) is the only source of information and can commit to a disclosure rule

(Mukherjee, 2008).[27] Lacking commitment, S_1 has incentives to collude with P_1 at Time 1.4 to reveal $b \neq \phi$ to P_2. Two issues then arise: P_2 may no longer trust P_1's recommendations, and helping S_1 ex post may undermine any disciplinary function career concerns exert on S_1 against collusive efforts of A_1. In other words, P_1 may face a dynamic inconsistency problem.

On the other hand, P_2 could also approach A_1 for the information. This alternative source of information is a feature of a three-tier organization and deserves further exploration. First, S_1 would also want to collude with A_1. It is interesting to see to what extent P_2 can solicit useful information from A_1 and P_1, despite S_1's collusive offers. Second, as we've shown, unconstrained information flow to P_2 may generate career concerns that exacerbate P_1's collusion problem. P_1 may want to prevent A_1's information leakage, e.g., by imposing a "non-disclosure" agreement on A_1. Even if such an agreement is enforceable, A_1 may not get on board without proper compensation for such valuable information. The analysis of strategic information disclosure and its impacts on the collusion problem are exciting topics for future research.

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27 Different from Mukherjee (2008), however, the two principals are not competing in the labor market. At Time 1.4, P_1 is indifferent to the information he provides to P_2.

Appendix 1 Proofs

Proposition 1.

Proof. The result of signal σ_L is obtained by Tirole (1992) and Baliga (1999). The analysis of signal σ with $\mu \geq \bar{\mu}$ is similar to signal σ_L in that the principal optimally treats the observation $b = \phi$ and b_H in the same way.

Consider signal σ_H. In a triplet (v_L, v_H, v_S), let v_L and v_H be the rent of the good-type and bad-type agent, respectively, and v_S the expected rent of the supervisor. When the principal directly observes σ_H, the optimal wage offer to the supervisor is zero, and to the agent is β_H upon observing b_H and β_L upon $b \neq b_H$, with $(v_L, v_H, v_S) = (\Delta\beta, 0, 0)$ upon b_H, and $(v_L, v_H, v_S) = (0,0,0)$ upon $b \neq b_H$.[28] The good-type agent has incentives to report b_H upon observing $b \neq b_H$ (i.e., downward manipulation), which is precluded by hard information. Therefore, this allocation is feasible and we have $\pi^h(\sigma_H) = \pi^*(\sigma_H)$. To implement this allocation, the principal can offer the following mechanism: If the supervisor and agent send different reports, or if agent does not produce, then both receive zero wage. If supervisor and agent send the same report, the supervisor's wage is still zero for both reports of b_H and $b \neq b_H$. If they report b_H, then the agent receives a wage β_H by delivering the good; and if they report $b \neq b_H$ the agent receives a wage β_L after delivery.

Under soft information, downward manipulation becomes available. The principal can ignore the monitoring technology σ_H and obtain $V - \beta_H$ or $(1-\mu)(V - \beta_L)$. To use the monitoring technology, the principal needs to deter collusion and reward the supervisor an amount $k\Delta\beta$ when $b \neq b_H$ is reported and *A* delivers the good at a wage β_L. We have $(v_L, v_H, v_S) =$ $(\Delta\beta, 0, 0)$ upon b_H, and $(0, 0, (1-\hat{\mu}_{\sim b_H})k\Delta\beta)$ upon $b \neq b_H$. Since the bad-type and good-type agent's maximal willingness to pay is zero and $\Delta\beta$, respectively, taking into account the loss in side transfer, $1-k$, these pairs of

[28] Note that, upon b_H, the agent must be the bad type.

payoffs exhaust any collusive gains. Any smaller reward to the supervisor cannot deter collusion, and larger reward is unnecessary. In this case, the principal obtains

$$\begin{aligned}&\Pr(b \neq b_H)(1-\hat{\mu}_{\sim b_H})(V-\beta_L-k\Delta\beta)+\Pr(b_H)(V-\beta_H)\\&\quad=\mu\alpha(V-\beta_H)+(1-\mu)(V-\beta_L-k\Delta\beta)\\&\quad=\pi^*(\sigma_H)-(1-\mu)k\Delta\beta,\end{aligned} \tag{A1}$$

and comparing this payoff with other two leads to the optimal payoff $\pi^s(\sigma_H)$. To implement this allocation, the principal offers: If the supervisor and agent send different reports, or if the agent does not produce, then both receive zero wage. If the supervisor and agent report $b \neq b_H$ and agent delivers the good, the supervisor receives a wage $k\Delta\beta$; otherwise the supervisor's wage is zero. If they report b_H, then the agent decides whether to produce at a wage β_H; and if they report $b \neq b_H$, then the agent decides whether to produce at a wage β_L. □

Proposition 2.

Proof. For signal σ_H, under soft information P_1 chooses between no disclosure or full disclosure. No disclosure mutes career concerns and gives P_1 a payoff $\pi^s(\sigma_H)$. If P_1 discloses S_1's report, then P_2 will hire S_1 when S_1 has reported b_H to P_1. Factoring career concerns into the previous contract, surplus of A_1 and S_1 are $(v_L, v_H, v_S)=(0,0,(1-\hat{\mu}_{\sim b_H})k\Delta\beta)$ upon $b \neq b_H$, and $(\Delta\beta, 0, (1-\mu)k\Delta\beta)$ upon b_H, and no longer collusion-proof.[29]

[29] For instance, following Tirole (1992), both types of agent can offer the side contract to S_1 upon observing $b \neq b_H$: A_1 sends a message β_L or β_H to S_1; if the message is β_H, then both A_1 and S_1 report $b \neq b_H$ to P_1 and A_1 makes no side transfer to S_1, and if the message is β_L, then both A_1 and S_1 report b_H to P_1 and A_1 transfers $\mu\Delta\beta$ to S_1. This side mechanism is incentive compatible: the bad-type A_1 will send a message of β_H to S_1, rather than β_L and pay $\mu\Delta\beta$; and the good-type A_1 gains $(1-\mu)\Delta\beta$ by sending a message of β_L to S_1 rather than β_H and obtains zero payoff. Given belief $\hat{\mu}_{\sim b_H}$, by accepting the side offer S_1 obtains $(1-\hat{\mu}_{\sim b_H})$ $[k\mu\Delta\beta+(1-\mu)k\Delta\beta]=(1-\hat{\mu}_{\sim b_H})k\Delta\beta$, where $(1-\mu)k\Delta\beta$ comes

Full disclosure makes the collusion-deterrence constraint more stringent and reduces P_1's payoff.

For signal σ, with $\mu \geq \bar{\mu}$, under hard information P_1 obtains a payoff $\pi_1(\sigma_L)$ with full information disclosure. By previous analysis, P_2's payoff is $\pi^h(\sigma) = \pi^h(\sigma_L)$, and the supervisor obtains $v_{\sigma_L} = (1-\mu)\hat{\alpha}k\Delta\beta > 0$, given capability $\hat{\alpha}$. Under full disclosure, by $\hat{\alpha}^- < \alpha^0 < \hat{\alpha}^+$, P_2 will retain S_1 if and only if the latter has reported $b \neq \phi$ to P_1. For P_1, the analysis is similar to σ_L under hard information. At time 1, the feasible downward manipulation of reporting ϕ upon observing b_L benefits A_1 but costs S_1 the future rent $v_{\sigma_L}(\hat{\alpha})$. It suffices to offer S_1 a payment $k\Delta\beta - v_{\sigma_L}(\hat{\alpha}^+)$ to deter collusion, and P_1 can obtain a payoff $\pi_1(\sigma_L)$. (The upward manipulation of reporting ϕ upon observing b_H only hurts S_1 but does not affect A_1.)

For other disclosure rules: P_1's payoff under no disclosure is $\pi^h(\sigma \mid \mu \geq \bar{\mu}) = \pi^h(\sigma_L)$, evaluated at α^0, the same as no career concerns. If P_1 discloses $b = \phi$ or not, S_1 will be employed by P_2 for reporting b_L or b_H, and career concerns work in the same way as under full disclosure. P_1 still obtains $\pi_1(\sigma_L)$. If P_1 discloses $b = b_L$ or not, then P_2 hires S_1 when P_1 reveals that S_1 has reported b_L. Due to career concerns, P_1 can induce a truthful report of b_L by a smaller payment; and since S_1 will be unemployed at time 2 whether reporting ϕ or b_H, in the latter two cases there is no incentive for the agent or supervisor to manipulate the information. P_1 obtains $\pi_1(\sigma_L)$. Lastly, if P_1 discloses whether S_1 has reported $b = b_H$ or not, then P_2 will hire S_1 when P_1 reveals that S_1 has reported b_H. Since reporting b_L and ϕ will both cause future unemployment, P_1 needs to reward S_1 by an amount $k\Delta\beta$ for reporting β_L. Career concerns cannot help deter collusion, and this policy gives P_1 a lower payoff than $\pi_1(\sigma_L)$.

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from
rent of employment at time 2, and is willing to accept the offer. (And the good-type A_1 can increase the side transfer by $\varepsilon > 0$ to break the indifference.)

Under soft information, P_1 can obtain $\pi_1(\sigma_L)$ by disclosing that S_1's report is b_L or not. Both full information disclosure and partial disclosure of revealing that S_1 has reported ϕ or not exacerbate the collusion problem. Upon observing b_L, A_1 and S_1 can collude to report b_H without jeopardizing the latter's career. In addition, upon observing ϕ, although A_1 can already receive a payment β_H, S_1 has incentives to collude and send a report b_H.[30] P_1 needs to reward S_1 with a payment $k\Delta\beta$ for reporting b_L, and reward A_1 with $kv_{\sigma_L}(\hat{\alpha}^-)$ for reporting ϕ. And if P_1 partially discloses whether S_1 reports $b = b_H$ or not, then upon observing b_L both the good-type agent and supervisor want to report b_H, the former for the information rent $\Delta\beta$ and the latter for future rent. This policy is suboptimal for P_1 for it raises the difficulty of inducing a truthful report of b_L.

When $\mu < \bar{\mu}$, under hard information P_1 can obtain the collusion-free payoff by committing to full information disclosure. (The analysis replicates that of σ_H under hard information.) Under soft information, the supervisor obtains a rent v_{σ_H} at time 2. At time 1, full information disclosure gives rise to two incentive constraints associated with downward manipulations, i.e., reporting b_H when observing b_L or ϕ. Since reporting b_H will not endanger the career, upon observing b_L, S_1 needs to be rewarded at least $k\Delta\beta$ to induce truth-telling. Upon observing ϕ, a truthful report will cause a lower wage β_L for A_1 and future unemployment for S_1. Both (good-type) A_1 and S_1 strictly prefer to reporting b_H, the former for a higher wage β_H and the latter for future employment. Therefore, P_1's payoff under full disclosure is strictly lower than $\pi^s(\sigma_H)$, the payoff he can obtain by not revealing any information to P_2 and hence eliminating career concerns. From previous analysis, no disclosure is better for P_1 than partial disclosure of revealing that S_1 reports b_H or not. Lastly, consider the partial disclosure of revealing that S_1 has reported b_L or not.[31] In this case, S_1 obtains a future rent v_{σ_H} at time 2 when reporting b_L. P_1 needs to reward the supervisor $\mu k\Delta\beta$ to

30 This is the case where S_1 bribes A_1 from the future wage.

31 Revealing that S_1 has reported ϕ or not is equivalent to full information disclosure, for both b_L and b_H generate the same updated belief $\hat{\zeta}^+$.

solicit a truthful report b_L. Upon observing ϕ, P_1 can still ensure truth-telling by reward the supervisor $k\Delta\beta$ when reporting ϕ and A_1 produces with a wage β_L. Under this partial disclosure policy, P_1 can obtain a payoff $\pi^s(\sigma_H)+(1-\mu)\alpha^0(1-\mu)k\Delta\beta$, where $\pi^s(\sigma_H)$ is evaluated at α^0. P_1's optimal disclosure policy is to partially reveal whether receiving a report of b_L or not. □

Appendix 2 Efficient Side Contracting

Suppose that only the supervisor has access to signal σ_L, and the principal only rewards the supervisor $\tilde{s} \in [0, k\Delta\beta]$ for reporting b_L, hence there are collusive gains $k\Delta\beta - \tilde{s} > 0$. Let the fictitious player, unaware of two collusive parties' private information, offer the side mechanism. Both the supervisor and agent send a report to the fictitious player, who then coordinates their reports to the principal as well as side payments as follows: If the supervisor reports b_L and agent reports β_L, then the supervisor will report to the principal $b \neq b_L$ and the agent report β_L; in addition, the agent will make a side payment $t \in (\tilde{s}/k, \Delta\beta)$ to the supervisor. If the supervisor reports $b \neq b_L$ and the agent reports β_L or β_H, then they send the same report to the principal and no side payment is exchange. And if the supervisor claims b_L but the agent claims β_H, then both are punished by an amount of $-\infty$.[32]

The coalition participation constraints are satisfied. If rejecting the side offer, the supervisor's outside option value is what he gets from the grand contract, i.e., $\tilde{s}$ when observing b_L and zero otherwise; and the agent's outside option value is $(1-\alpha)\Delta\beta$ for the good type and zero for the bad type.[33] By participating and truth-telling, the supervisor receives $kt > \tilde{s}$ when observing b_L and zero otherwise; the good-type agent obtains $\alpha(\Delta\beta - t) + (1-\alpha)\Delta\beta$ and bad-type zero.

For the coalition incentive compatibility constraint, first suppose that the agent tells the truth. Upon observing β_L, the supervisor knows that the agent must be the good type. Truth-telling generates a payoff kt, greater than zero, the payoff of claiming $b \neq b_L$. If the supervisor observes $b \neq b_L$,

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[32] The balanced-budget requirement or limited liability render this side mechanism infeasible, and contributes to inefficiency at the side contracting. However, it doesn't seem that hard or soft information would generate different levels of inefficiency.

[33] Since a third player makes the side offer, the signaling issue disappears.

truth-telling generates a payoff zero. But claiming b_L faces a probability $\hat{\mu}_{\sim b_L}$ of receiving $-\infty$, when the agent truthfully reveals that he is the bad type. The supervisor will also tell the truth.

For the agent, the bad type knows that the supervisor must observe $b \neq b_L$, which will pass to the principal. His payoff is zero whether reporting β_L or β_H. The good type is not sure what the supervisor observes. If he falsely reports β_H, there is a probability α that the supervisor will truthfully report b_L and reduce the payoff to $-\infty$. Both types of agent will tell the truth.

This side mechanism ensures the exhaustion of collusive gains, and thus the principal needs to set the supervisor's reward at $k\Delta\beta$ to deter collusion. Note that this side mechanism applies to both hard and soft information, for the supervisor is never asked to report b_L to the principal when the true observation is $b \neq b_L$. Equivalence of hard and soft information holds.[34]

[34] The signal σ with $\mu \geq \bar{\mu}$ is similar to σ_L, i.e., the side contract can give the same treatment to the supervisor's report of ϕ and b_H. We omit the details.

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組織勾結與資訊性質

邱敬淵

摘　要

相較於硬性資訊，軟性資訊容許資訊蒐集者更多詮釋、操弄資訊的自由。但 Baliga (1999) 的分析顯示，當負責蒐集資訊的監督人可能與代理人勾結時，委託人所得到的利潤不因資訊性質為硬性資訊或軟性資訊而改變。本文從數個觀點驗證這個等價結果是否仍然成立，包括引進不同資訊蒐集技術、允許代理人的保留價格隨其私有資訊變異、以及考慮監督人的事業誘因等等。本文同時發現監督人的事業誘因可能加重或減緩組織內的勾結問題。而當事業誘因加深勾結問題時，委託人不會對未來雇主充分揭露監督人的工作表現，使得未來雇主無法雇用最有能力的監督人。亦即，勾結問題可能產生就業市場上的資訊摩擦。

關鍵詞：事業誘因、勾結、硬性資訊、軟性資訊
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