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Relying on the Agent in Charge of Production for Project Evaluation

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Relying on the Agent in Charge of Production for Project Evaluation*

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Abstract

I study the optimal project choice when the principal relies on the agent in charge of production for project evaluation. The principal has to choose between a safe project generating a fixed revenue and a risky project generating an uncertain revenue. The agent has private information about the production cost under each project but also about the signal regarding the profitability of the risky project. If the signal favoring the adoption of the risky project is goods news to the agent, integrating production and project evaluation tasks does not generate any loss compared to the benchmark in which the principal herself receives the signal. By contrast, if it is bad news, task integration creates an *endogenous reservation utility which is type-dependent* and thereby generates *countervailing incentives*, which can make a bias toward either project optimal. Our results can offer an explanation for why good firms can go bad and a rationale for the separation of day-to-day operating decisions from long-term strategic decisions stressed by Williamson.

Key Words: Countervailing Incentives, Multi-tasking, Asymmetric Information, Multi-dimensional screening

JEL Classification: D8, L2

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1 Introduction

In many buyer-seller relationships, the buyer relies on the seller to obtain information that allows her to evaluate different alternatives. Furthermore, in these situations, the seller is likely to have private information about the cost of providing each alternative product. For instance, in military procurement, the Department of Defense would be less well informed not only about the cost of producing each weapon system but also about its effectiveness than the firm producing the weapons.[1] Other examples include the relationship between a patient and a doctor, a victim and a lawyer, a driver and a motor mechanic, a person who wants to build a house and an architect etc. A similar situation can arise inside firms between shareholders and a manager (or between a CEO and a division manager) when the former has to choose among alternative projects but has to resort to the latter, who is in charge of production, for the information necessary to evaluate the projects.

In this paper, I study the optimal project choice when the principal should rely on the agent in charge of production for project evaluation. In the model, which is tailored to situations arising in organizations, the principal has to choose between a safe project generating a fixed revenue and a risky project generating an uncertain revenue. I focus on analyzing how integrating production and project evaluation tasks affects the agent's incentive to transmit the information about the profitability of the risky project.[2] For this purpose, I make a conceptual distinction between two kinds of information that the agent can possess: information about the parameter which directly determines his[3] payoff (i.e. his type or productive efficiency) and other information relevant for the decision making of his organization (i.e. the signal about the profitability of the risky project). The main difference between the two kinds of information is that private knowledge of the former can generate an information rent while private knowledge of the latter alone does not generate any rent. Therefore, the agent can be strategic in transmitting the latter when this affects his information rent accruing from the former. This interplay between the two kinds of information captures what happens in all the examples that I mentioned in the

[1]The following statements of defense contractors about Department of Defense officials are striking: "We have the technical superiority and are on the offensive. We spoon-feed them. We ultimately try to load them with our own ideas and designs (Leitzel, 1991)."

[2]Distortions in bottom-up information flows are emphasized by Simon (1961) as a major problem of hierarchies and information withholding is well documented by sociologists like Crozier (1967) and Dalton (1959).

[3]Throughout the paper, I use "she" for the principal and "he" for the agent.

first paragraph.

In the model, the agent is risk neutral and has private information about his type. He can have either a high-cost or a low-cost type and his production cost depends on the type and the project retained and therefore is his private information. His reservation utility is normalized to zero for both types. The signal about the profitability of the risky project is soft information and can be either high or low. As a benchmark, I consider the case in which the principal herself receives the signal. In this benchmark, it is optimal for the principal to choose the risky project if and only if the signal is high and the high signal is called good news (bad news) from the agent's point of view if his information rent under the risky project is weakly larger (smaller) than the one under the safe project.

The mechanism design problem under task integration is a two-dimensional screening problem. It turns out that the agent's incentive to transmit the signal crucially depends on whether the high signal is good or bad news. If it is good news, task integration does not generate any loss compared to the benchmark in which the principal receives the signal. By contrast, if it is bad news, the principal can never achieve the profit of the benchmark under task integration. In particular, even though the agent's outside opportunity is the same regardless of the type, task integration creates an *endogenous reservation utility which is type-dependent* and thereby generates *countervailing incentives*. This raises the cost of obtaining the signal to make the right project choice and therefore can make introducing a bias toward either the safe project or the risky project optimal.

To provide an intuition about the countervailing incentives that arise when the high signal is bad news, I consider the case in which the principal chooses the risky project if and only if the agent reports a high signal. First, an agent who received a low signal has no incentive to report a high signal since the realization of the revenue under the risky project depends on the true signal and, by making the transfer depend on the revenue, the principal can test whether or not the agent transmits the true signal. Second, an agent who received a high signal might have an incentive to report a low signal. Upon receiving a low signal, the principal chooses the safe project and cannot test whether the agent reports the true signal since the revenue under the safe project is constant. Therefore, the utility that an agent can obtain by reporting a low signal becomes an endogenous reservation utility. This reservation utility is type-dependent and only the low-cost type has a (strictly) positive reservation utility. Third, in order to induce the low-cost type who received a high signal to report the true signal, the principal should give him at least the reservation utility. This implies that the expected transfer that the low-cost type receives under the risky project must be larger than the production cost of a high-cost type; for instance, if the transfer under the risky project is just equal to a high-cost type's cost, the low-cost type's rent is smaller under the risky project than under the safe project (this is because we consider the case in which the high signal is bad news) that and therefore will always report a low signal. Finally, this in turn creates countervailing incentives such that a high-cost type who received a high signal can get a positive information rent by pretending to have a low-cost type and reporting the true signal.

The results under task integration have interesting implications. For instance, suppose that in addition to the agent who can have either a low-cost or a high-cost type, there is another agent whose cost is known to the principal[4] and is strictly higher than the high-cost type's cost under each of the two projects. The first agent is called a good agent and the second a bad agent. The principal knows whether an agent is good or bad although the good agent's type is private information. Then, when a project is given, obviously, the principal strictly prefers the good agent to the bad one. However, when the project choice is endogenous and the principal has to resort to the agent in charge of production for the signal allowing her to evaluate the risky project, surprisingly, the expected profit can be higher when the agent is bad than when the agent is good. This result suggests that a firm with inferior technology can have a higher expected profit than a firm with superior technology and therefore provides an explanation for why good firms can go bad. We can interpret the safe project as a current project which generates a fixed revenue and the risky project as a new project generating an uncertain revenue. If a firm's division has some vested interest (or a large rent) attached to the current project, the firm can suffer from distortions in information flows and fail to adapt its project (or core-activity) to the changes in business environment. Furthermore, it is natural to expect that the rent that the division obtains from the current project increases as the current project is more successful, implying that a firm with superior technology might suffer more from distortions in information flows than a firm with inferior technology when the changes in business environment are adverse to the current project. In this sense, my results suggest that today's success may plant a seed for tomorrow's failure as is illustrated by my examples of IBM and Kmart later on.[5]

Under task separation, there are two agents: one charged with production and the other with transmitting the signal. As the former does not take into account the ex-

[4]The argument in this paragraph holds even though each agent's cost is unknown: see proposition 5.

[5]Bower and Christensen (1995) give many examples of leading companies who failed to stay at the top of their industries when markets changes and provide an explanation of the phenomena. My paper offers an alternative explanation.

ternalities which he inflicts on the latter, information flows better under task separation than under integration. This offers a rationale for the separation of day-to-day operating decisions from long-term strategic decisions, which is emphasized as the main feature of M-form structure by Chandler (1966) and Williamson (1975). According to them, the separation is a response to the problem raised by U-form structure in which functional executives took both responsibilities and thus became advocates representing the interests of their respective divisions.

I also analyze the case in which the principal cannot commit in advance to a mechanism to induce the agent to transmit the signal about the profitability of the risky project. Therefore, in this case, the agent decides which signal to release before receiving the principal's offer. I find that if the signal is good news, there is an equilibrium in which the agent always truthfully transmits the signal while if the signal is bad news, such an equilibrium never exists and the distortions in project choice are more severe than the distortions that arise when the principal has commitment power.

Countervailing incentives are studied in the mechanism design literature on type-dependent reservation utility (Lewis and Sappington 1989, Maggi and Rodriguez 1995, Jullien 2000). In our model, the agent has the same zero reservation utility regardless of type. However, the fact that the principal has to rely on the agent for the signal justifying the choice of the risky project makes his utility under the safe project play the role of an endogenous type-dependent reservation utility.

In the literature on multi-dimensional screening (Armstrong 1996 , Armstrong and Rochet 1999, Chone and Rochet 1998, Rochet and Stole 2003), to the best of my knowledge, they have not made the distinction between two kinds of information depending on whether or not its private knowledge generates an information rent and hence have not studied the interplay between the two. Furthermore, I show that depending on whether a signal is good or bad news from the agent's point of view, the nature of the binding incentive constraints dramatically changes.

Lambert (1986) studies how risk aversion affects the agent's incentive to invest in generating information about the profitability of projects and to select the best project. By contrast, in my paper, the agent is risk neutral, the precision of the signal is given and there is no delegation of project choice. Hirao (1994) studies when it is optimal to assign both project evaluation and operation tasks to the same agent in a moral hazard setting with limited liability in which the principal faces the choice between a safe project and a risky one. Since effort is not necessary for the safe one, given a project choice, the agent in charge of operation can get a rent only with the risky one and consequently has a preference for it. He shows that task separation is optimal when the accuracy of the signal is exogenous. Although the intuition underlying the superiority of task separation over task integration that the agent in charge of evaluation does not take into account the externalities that he inflicts on the agent in charge of operation is present in Hirao (1994) (and also in Lewis and Sappington, 1997), my analysis of the task integration, which is the main focus of the paper, is very different from his (and from theirs). My model is an adverse selection model and I distinguish between good and bad news and show that contrary to Hirao (1994), when the signal favoring the selection of the risky project is good news from the agent's point of view, there is no loss from task integration while there is a loss in the case of bad news. In Lewis and Sappington (1997), the agent should be induced to incur a cost to discover his type under task integration while that information will be acquired by the agent in charge of planning under task separation. By contrast, I assume that the agent knows his type from the beginning and show that if he knows, in addition, the signal on the profitability of the project, countervailing incentives can arise.[6]

My paper is also related to Dewatripont and Tirole (1999). They offer an argument favoring advocacy over nonpartisanship: a nonpartisan's incentives are impaired by his pursuing several conflicting objectives at the same time. This argument is similar to the intuition underlying the result that the signal is transmitted better under task separation than under task integration. However, their result is derived from a contractual incompleteness in that they assume that the principal cannot base rewards on information but only on final decisions. Indeed, in their paper, if rewards can be based on information, there is no need for advocacy. In our model, direct rewards based on information are allowed.[7]

[6] Levitt and Snyder (1997) also study the interaction between work incentive and the incentive to transmit information about the profitability of a project. In their setting, after exerting work effort, the agent receives a signal about the profitability of the on-going project, which the principal can use to decide to cancel the project. They show that cancellation undermines work incentive since it obscures the linkage between effort and outcomes. In our model, no such linkage exists since the agent incurs the production cost after transmitting the signal.

[7] There exist other papers on informational integration versus separation. Baron and Besanko (1992) and Gilbert and Riordan (1995) show in the context of regulation of complementary products that the former dominates the latter. On the contrary, Laffont and Martimort (1999) show that separation of regulators dominates integration in dealing with the threat of regulatory capture. These papers basically compare the case in which one agent knows two cost parameters with the case in which each agent knows only one cost parameter and therefore do not make qualitative distiction between cost information and the information regarding the profitability of a project.

The paper is organized as follows. Section 2 presents the model. Section 3 analyzes the case of task integration; after defining the principal's optimization problem, I first analyze the case of good news and then the case of bad news. Section 4 studies the case without commitment. Section 5 discusses some implications of the results. Section 6 provides the conclusion. All the proofs that are not provided in the main text are relegated to the Appendix.

2 The Model

2.1 Projects, tasks and technology

The principal chooses a project denoted by j; she has to choose between a safe project ($j = S$) and a risky project ($j = R$). The safe project always generates a fixed level of revenue y^S. The risky project can generate either a high revenue $y^R = y^H$ or a low revenue $y^R = y^L$ with $y^H > y^L$ and $y^S \neq y^R$ for $y^R = y^H, y^L$. In the absence of any signal about y^R, the probability of having $y^R = y^H$, denoted by μ, is assumed to be equal to $\frac{1}{2}$ for simplicity.

To realize a project, the principal needs to employ an agent who is in charge of production. In addition to the production task, the agent can have the task of transmitting a signal about the likelihood of having $y^R = y^H$. We distinguish task integration from task separation. When the principal contracts only one agent for both tasks, tasks are integrated. By contrast, when the principal contracts one agent for production and another agent to get a signal about y^R, tasks are separated. Before the principal offers her contract, the agent in charge of production discovers his type θ, which represents his productive efficiency. He has a low-cost type ($\theta = \underline{\theta}$) with probability $\nu \in (0, 1)$ and a high-cost type ($\theta = \overline{\theta}$) with probability $1 - \nu$ in the following sense; his cost of production, denoted by $C(\theta, j)$, depends on the type and the project chosen by the principal such that $\Delta C_j \equiv C(\overline{\theta}, j) - C(\underline{\theta}, j) > 0$ for $j \in \{S, R\}$. The agent's type and consequently his production cost are his private information. The distribution of the type is common knowledge.

2.2 Information about the risky project

The agent in charge of transmitting the signal about the profitability of the risky project, denoted by σ, receives either $\sigma = H$ or $\sigma = L$. The probability of receiving σ conditional on the true state of the world is given as follows:

	$y^R = y^H$	$y^R = y^L$
$\sigma = H$	ξ	$1 - \xi$
$\sigma = L$	$1 - \xi$	ξ

where $\xi \in (1/2, 1]$. Hence, the probability of having $y^R = y^H$ conditional on σ, denoted by μ_σ, is given by:

$$\mu_L = 1 - \xi < \mu = \frac{1}{2} < \mu_H = \xi.$$

I assume that σ is soft information in that the agent can pretend to have received any of the two signals. σ is the agent's private information and its distribution is common knowledge.

2.3 Utilities and mechanism

The principal is risk neutral and her profit is equal to the revenue minus the transfer made to the agent. I assume that the revenue is contractible and therefore the transfer can depend on the level of revenue. The agent is risk neutral and his utility is equal to the transfer from the principal minus the production cost. His reservation utility is normalized to zero regardless of type. I assume that the agent has the option of terminating his relationship with the principal at any time before incurring the production cost[8]. This limited liability assumption makes selling the project to the agent suboptimal. I also assume that it is never optimal for the principal to induce the agent not to produce (i.e. shutdown is never optimal).

According to the revelation principle, I can restrict my attention, without loss of generality, to the set of direct revelation mechanisms;

$$\left\{p(\widehat{\sigma}, \widehat{\theta}), t(\widehat{\sigma}, \widehat{\theta}, y)\right\},$$

where $\widehat{\sigma} \in \{H, L\}$ represents the agent's report about the signal, $\widehat{\theta} \in \Theta \equiv \left\{\underline{\theta}, \overline{\theta}\right\})$ represents the agent's report about the type and $y \in \left\{y^S, y^H, y^L\right\}$. $p(\cdot)$ is the probability of choosing the safe project, $1 - p(\cdot)$ is the probability of choosing the risky project and $t(\cdot)$ is the transfer to the agent which depends on the realized revenue y.

[8]Limits on termination penalties are common in practice (Sappington 1983 and Lewis and Sappington 1997). The assumption is needed also to exclude a trivial solution, which is not realistic, to achieve under task integration the outcome of the benchmark: see the remark in section 2.5 regarding what happens in an alternative timing without the limit on termination penalty.

2.4 The main assumption and good and bad news

Consider as a benchmark the case in which the principal herself obtains σ. In order to avoid the problem of informed principal, which is not the focus of the paper, I assume that σ becomes public information. Then, if θ is known to the principal, she chooses the safe project if and only if $y^S - C(\theta, S) > \mu_\sigma y^H + (1-\mu_\sigma)y^L - C(\theta, R)$ holds. If θ is the agent's private information, the agent can get an information rent and as usual the principal should make decision in terms of the virtual cost. Let $C^\nu(\theta, j)$ denote the virtual cost: we have $C^\nu(\underline{\theta}, j) \equiv C(\underline{\theta}, j)$ and $C^\nu(\overline{\theta}, j) \equiv C(\overline{\theta}, j) + \frac{\nu}{1-\nu}\Delta C_j$. In what follows, I make the following assumption:

A1: $\mu_H y^H + (1-\mu_H)y^L - C^\nu(\theta, R) > y^S - C^\nu(\theta, S) > \mu_L y^H + (1-\mu_L)y^L - C^\nu(\theta, R)$ for $\theta \in \Theta$.

The first inequality of A1 (respectively, the second inequality of A1) means that the principal finds it optimal to choose the risky project (respectively, the safe project) for both types when she receives $\sigma = H$ (respectively, $\sigma = L$) when the agent has private information on θ. Furthermore, A1 implies that the principal will make the same project choice even when she has complete information on θ. A1 is chosen in order to identify the distortions in project choice arising from task integration.

Suppose that the cost differential between the two types is larger under the safe project than under the risky project ($\Delta C_S > \Delta C_R$). Then, in the benchmark in which the principal receives σ, A1 implies that the low-cost type gets a larger information rent when $\sigma = L$ than when $\sigma = H$. Therefore, we can regard $\sigma = H$ as bad news from the low-cost type's point of view. By contrast, when $\Delta C_S < \Delta C_R$, $\sigma = H$ is good news from the low-cost type's point of view. Since the high-cost type gets zero rent anyway when the principal herself receives σ, I can say that $\sigma = H$ *is bad news* (*good news*) if $\Delta C_S > \Delta C_R$ ($\Delta C_S < \Delta C_R$) in a weak sense from the agent's point of view.

2.5 Timing

The timing under task integration is given as follows:

1. The agent discovers both θ and σ before receiving the contract from the principal.
2. The principal proposes a contract.
3. The agent accepts or rejects it. If the agent rejects it, the following stages do not occur.
4. The agent reports $(\widehat{\sigma}, \widehat{\theta})$ to the principal.

5. The principal chooses a project according to the rule specified by the contract.

6. The agent decides whether or not to continue the relationship with the principal. If he decides to discontinue the relationship, he gets the reservation utility normalized at zero and the game ends; otherwise, he incurs the production cost.

7. The revenue is realized and the transfer is made.

Note that the agent will incur the cost only if his expected payoff upon incurring the cost is positive. As long as the agent has the incentive to continue the relationship at stage 6, the agent will accept the contract at stage 3. Hence, what matters is the participation at stage 6 not the one at stage 3. Because of this, whether the agent discovers θ and σ before or after the principal's offer is not relevant for the results.

Remark: If the penalty for terminating the relationship is large enough that the agent cannot quit the relationship at stage 6 if he accepted the principal's offer at stage 3, then I can show that the Supremum of the principal's expected profit under task integration is equal to the one in the benchmark in which the principal receives the signal σ since the principal can destroy the agent's incentive to manipulate σ by choosing the risky project with probability $\varepsilon(> 0)$ small enough and making the transfer depend on the match between the reported signal and the realized revenue.

2.6 Benchmark of task separation

Consider as another benchmark the case of task separation; there are two agents (agent 1 and agent 2) such that agent 1 is charged with production while agent 2 is charged with transmitting the signal σ. The timing under task separation is similar to the one defined in section 2.4. Agent 1 privately discovers θ and agent 2 privately discovers σ before receiving the principal's offer of a mechanism which specifies the probability of choosing each project and the transfer made to each agent as functions of the agents' reports. After each agent accepts the offer, each agent reports his information.

It is clear that since agent 2 has no vested interest in any of the two projects, he will report truthfully σ even though the principal does not make any compensation.[9] Therefore, under task separation, the principal can achieve the outcome that she achieves when she herself receives σ.

[9] Although the principal can make her transfer to agent 2 contingent on the realization of revenue, she does not need to use such contingent transfers to induce his truth-telling under the standard tie-breaking rule that the agent tells the truth if he is indifferent.

- **Observation 1**: Under task separation, the principal can achieve the outcome that she achieves when she herself receives σ.

Although this benchmark of task separation is highly stylized (and I will discuss drawbacks of task separation in section 5), it captures a very important property of σ: the information σ is very different from the information θ in that private knowledge of the former alone does not generate any information rent while private knowledge of the second can generate an information rent. This is why agent 2 is not strategic in transmitting σ. In the next section, I focus on how task integration affects agent 1's incentive to transmit σ and thereby the principal's project choice.

3 Task Integration

I first define the principal's optimization problem under task integration. According to the revelation principle, without loss of generality, I can restrict my attention to the set of direct revelation mechanisms:

$$\left\{p(\widehat{\sigma},\widehat{\theta}),t(\widehat{\sigma},\widehat{\theta},y)\right\}.$$

In order to induce the agent to incur the production cost, the following (ex post) individual rationality constraint should be satisfied after the project choice is made:

$$(IR:\sigma,\theta,S) \qquad U(\sigma,\theta,S)\equiv t(\sigma,\theta,y^S)-C(\theta,S)\geq 0; \tag{1}$$

$$(IR:\sigma,\theta,R) \qquad U(\sigma,\theta,R)\equiv \mu_\sigma t(\sigma,\theta,y^H)+(1-\mu_\sigma)t(\sigma,\theta,y^L)-C(\theta,R)\geq 0. \tag{2}$$

For expositional simplicity, I introduce the following notation regarding the agent's utility:

$$\begin{aligned} &V(\widehat{\sigma},\widehat{\theta}:\sigma,\theta)\equiv p(\widehat{\sigma},\widehat{\theta})\max\left\{0,t(\widehat{\sigma},\widehat{\theta},y^S)-C(\theta,S)\right\} \\ &+(1-p(\widehat{\sigma},\widehat{\theta}))\max\left\{0,\mu_\sigma t(\widehat{\sigma},\widehat{\theta},y^H)+(1-\mu_\sigma)t(\widehat{\sigma},\widehat{\theta},y^L)-C(\theta,R)\right\}; \end{aligned} \tag{3}$$

$$U(\sigma,\theta)\equiv V(\sigma,\theta:\sigma,\theta). \tag{4}$$

Although the individual rationality constraint is satisfied when $(\widehat{\sigma},\widehat{\theta})=(\sigma,\theta)$, it may not be satisfied when $(\widehat{\sigma},\widehat{\theta})\neq(\sigma,\theta)$; $V(\widehat{\sigma},\widehat{\theta}:\sigma,\theta)$ takes this into account.

To induce truth-telling, the mechanism should satisfy the following incentive compatibility constraints:

$$(IC : (\sigma,\theta) \to (\widehat{\sigma},\widehat{\theta})) \qquad U(\sigma,\theta) \geq V(\widehat{\sigma},\widehat{\theta} : \sigma,\theta) \text{ for all } (\sigma,\widehat{\sigma}) \in \{H,L\}^2 \text{ and } (\theta,\widehat{\theta}) \in \Theta^2. \tag{5}$$

The principal's program, denoted by P, is given by:

$$\max_{p(\sigma,\theta),t(\sigma,\theta,y)} E[\pi] = \nu E(\pi \mid \underline{\theta}) + (1-\nu)E(\pi \mid \overline{\theta})$$

$$\text{subject to (1) to (5),}$$

where

$$\begin{aligned} E(\pi \mid \theta) \equiv\ & \frac{1}{2}p(H,\theta)\left[y^S - t(H,\theta,y^S)\right] \\ & + \frac{1}{2}(1-p(H,\theta))\left[\mu_H(y^H - t(H,\theta,y^H)) + (1-\mu_H)\left(y^L - t(H,\theta,y^L)\right)\right] \\ & + \frac{1}{2}p(L,\theta)\left[y^S - t(L,\theta,y^S)\right] \\ & + \frac{1}{2}(1-p(L,\theta))\left[\mu_L(y^H - t(L,\theta,y^H)) + (1-\mu_L)\left(y^L - t(L,\theta,y^L)\right)\right]. \end{aligned}$$

P is a two-dimensional screening program. Observe first that in the benchmark in which the principal herself receives the signal σ, only $(IR : \sigma,\theta,j)$ and $(IC : (\sigma,\theta) \to (\sigma,\widehat{\theta}))$ need to be satisfied. Since the incentive constraints that need to be satisfied in the benchmark is a strict subset of the incentive constraints that need to be satisfied under task integration, I have the following observation.

- **Observation 2**: The principal's expected payoff under task integration cannot be higher than the one in the benchmark in which the principal herself receives the signal σ (and therefore the one under task separation).

In what follows, I analyze first the case in which $\sigma = H$ is good news ($\Delta C_S \leq \Delta C_R$) and then the case in which $\sigma = H$ is bad news ($\Delta C_S > \Delta C_R$).

3.1 When $\sigma = H$ is good news ($\Delta C_S \leq \Delta C_R$)

Consider now the case in which $\sigma = H$ is good news (i.e. $\Delta C_S \leq \Delta C_R$). The following proposition shows that in this case, the principal can achieve under task integration the outcome of the benchmark in which the principal herself receives the signal σ.

Proposition 1 *When $\sigma = H$ is good news (i.e. $\Delta C_S \leq \Delta C_R$), under A1, the principal can achieve under task integration the outcome of the benchmark in which the principal herself receives the signal σ.*

Proof. Consider the following mechanism;

$$\begin{aligned} p(L,\theta) &= 1, t(L,\theta,y^S) = C(\overline{\theta},S); \\ p(H,\theta) &= 0, \mu_H t(H,\theta,y^H) + (1-\mu_H)t(H,\theta,y^L) = C(\overline{\theta},R). \end{aligned}$$

Then, $U(H,\overline{\theta}) = U(L,\overline{\theta}) = 0$ and $U(L,\underline{\theta}) = V(L,\overline{\theta};L,\underline{\theta}) = \Delta C_S$ and $U(H,\underline{\theta}) = V(H,\overline{\theta};H,\underline{\theta}) = \Delta C_R$. Obviously, an agent with $\sigma = H$ has no strict incentive to report $\sigma = L$. Furthermore, by choosing $t(H,\theta,y^H)$ large enough and $t(H,\theta,y^L)$ small enough, the principal can destroy the agent's incentive to manipulate σ from L to H at no cost. ■

The intuition of the result in Proposition 1 is the following. If the principal chooses under task integration the same project as in the benchmark in which the principal herself receives the signal σ and just makes the transfer of each agent equal to the high-cost type's cost, a low-cost type gets a rent equal to ΔC_R when $\sigma = H$ and ΔC_S when $\sigma = L$ by reporting truthfully. This might create an incentive for a low-cost type with $\sigma = L$ to announce $\sigma = H$. However, since $\mu_H > \mu_L$ holds, by increasing $t(H,\theta,y^H)$ and reducing $t(H,\theta,y^L)$, the principal can test whether or not the agent reports the true signal and destroy the agent's incentive to manipulate the signal from L to H at no cost.[10] By contrast, this strategy does not work when $\sigma = H$ is bad news (i.e. $\Delta C_S > \Delta C_R$)). Then, under the same mechanism, a low-cost type has an incentive to manipulate the signal from H to L since the principal cannot test whether or not the agent reports the true signal as the revenue under the safe project is constant.

3.2 When $\sigma = H$ is bad news ($\Delta C_S > \Delta C_R$)

I now consider the case in which $\sigma = H$ is bad news ($\Delta C_S > \Delta C_R$). Lemma 1 identifies some monotonicity constraints that the optimal contract should satisfy.

Lemma 1 *(monotonicity constraints) Under A1 and $\Delta C_S > \Delta C_R$, the optimal contract satisfies the following monotonicity constraints, denoted by M;*

(i) $p(\sigma,\underline{\theta}) \geq p(\sigma,\overline{\theta})$ for $\sigma = H, L$.

(ii) $p(L,\overline{\theta}) \geq p(H,\overline{\theta})$.

[10] This result is similar to the findings of Riordan and Sappington (1988) and Crémer and McLean (1988).

The monotonicity constraint with respect to the type (i.e. θ) is easily derived by adding the incentive constraints $(IC : (\sigma, \underline{\theta}) \to (\sigma, \overline{\theta}))$ and $(IC : (\sigma, \overline{\theta}) \to (\sigma, \underline{\theta}))$. However, the other monotonicity constraint $p(L, \overline{\theta}) \geq p(H, \overline{\theta})$ cannot be easily derived in a similar way since the true signal σ affects the expected transfer from $\mu_H > \mu_L$. Let M denote the monotonicity constraints in Lemma 1 (i) and (ii).

Binding constraints given $\{p(\sigma, \theta)\}$

In what follows, I first characterize different regimes according to the binding constraints when $\{p(\sigma, \theta)\}$ is given. However, from Lemma 1, I will consider only $\{p(\sigma, \theta)\}$ that satisfies the monotonicity constraints M. The next lemma characterizes the regime in which task integration does not affect the nature of the binding incentive constraints with respect to the benchmark in which the principal herself receives σ in that only $(IC : (\sigma, \underline{\theta}) \to (\sigma, \overline{\theta}))$ matters among the incentive constraints; I call it *the regular regime.* Let

Lemma 2 *(regular regime) Suppose A1, $\Delta C_S > \Delta C_R$ and M. If we have*

$$p(H, \overline{\theta})\Delta C_S + \left[1 - p(H, \overline{\theta})\right] \Delta C_R \geq A(p(L, \underline{\theta}), p(L, \overline{\theta})),$$

where $A(p(L, \underline{\theta}), p(L, \overline{\theta})) \equiv p(L, \overline{\theta})\Delta C_S + \left[p(L, \underline{\theta}) - p(L, \overline{\theta})\right] \Delta C_R = V(L, \underline{\theta}; H, \underline{\theta})$, *the following constraints bind:*

$$\begin{aligned} (IR &: \sigma, \overline{\theta}, j) \text{ for } \sigma = H, L \text{ and } j = S, R. \\ (IC &: (\sigma, \underline{\theta}) \to (\sigma, \overline{\theta})) \text{ for } \sigma = H, L. \end{aligned}$$

In the regular regime, an agent with $(\sigma, \theta) = (\sigma, \underline{\theta})$ can obtain a rent equal to $p(\sigma, \overline{\theta})\Delta C_S + \left[1 - p(\sigma, \overline{\theta})\right] \Delta C_R$ by reporting $\left(\sigma, \overline{\theta}\right)$ from the binding individual rationality constraint for $(\sigma, \overline{\theta}, j)$. This suggests, from the monotonicity constraint $p(L, \overline{\theta}) \geq p(H, \overline{\theta})$ and $\Delta C_S > \Delta C_R$, that a low-cost type may have an incentive to manipulate report from H to L. Lemma 2 shows, if the rent an agent with $(\sigma, \theta) = (H, \underline{\theta})$ obtains by reporting truthfully is smaller than the rent he obtains by reporting $(L, \underline{\theta})$ (i.e. $V(L, \underline{\theta}; H, \underline{\theta})$), the regular regime holds.[11] Figure 1 describes the binding incentive constraints in the regular regime.

However, why $V(L, \underline{\theta}; H, \underline{\theta})$ is equal to $A(p(L, \underline{\theta}), p(L, \overline{\theta})) \equiv p(L, \overline{\theta})\Delta C_S + \left[p(L, \underline{\theta}) - p(L, \overline{\theta})\right] \Delta C_R$ deserves some explanation since $A(p(L, \underline{\theta}), p(L, \overline{\theta}))$ will be used to define all different

[11] In the proof of lemma 2, I show that $V(L, \underline{\theta}; H, \underline{\theta}) \geq V(L, \overline{\theta}; H, \underline{\theta})$ holds and hence we can neglect the manipulation from $(H, \underline{\theta})$ to $(L, \overline{\theta})$.

regimes. Since an agent with $(\sigma, \theta) = (H, \underline{\theta})$ may have an incentive to report $(L, \underline{\theta})$, when the principal chooses $t(L, \underline{\theta}, y)$, she needs to take into account three aspects in general. First, $t(L, \underline{\theta}, y)$ should give a rent equal to $p(L, \overline{\theta})\Delta C_S + \left[1 - p(L, \overline{\theta})\right] \Delta C_R$ to an agent with $(\sigma, \theta) = (L, \underline{\theta})$ while satisfying his (ex post) individual rationality constraint. Second, $t(L, \underline{\theta}, y)$ should not give any rent to an agent with $(\sigma, \theta) = \left(L, \overline{\theta}\right)$ when he reports $(L, \underline{\theta})$.[12] Third, $t(L, \underline{\theta}, y)$ should minimize the rent that an agent with $(\sigma, \theta) = (H, \underline{\theta})$ obtains by reporting $(L, \underline{\theta})$. If $0 < p(L, \underline{\theta}) = p(L, \overline{\theta}) < 1$, the optimal $t(L, \underline{\theta}, y)$ is simple and is given by $t(L, \underline{\theta}, y^S) = C(\overline{\theta}, S)$ and $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L)t(L, \underline{\theta}, y^L) = C(\overline{\theta}, R)$; otherwise, we have either $t(L, \underline{\theta}, y^S) > C(\overline{\theta}, S)$ or $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L)t(L, \underline{\theta}, y^L) > C(\overline{\theta}, R)$ and an agent with $(\sigma, \theta) = \left(L, \overline{\theta}\right)$ can get a positive rent by reporting $(L, \underline{\theta})$, which is not optimal. Under the optimal transfers, an agent with $(\sigma, \theta) = (H, \underline{\theta})$ obtains only a rent equal to $p(L, \overline{\theta})\Delta C_S$ upon reporting $(L, \underline{\theta})$ since the principal can choose $t(L, \underline{\theta}, y^H)$ small enough and $t(L, \underline{\theta}, y^L)$ large enough while satisfying $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L)t(L, \underline{\theta}, y^L) = C(\overline{\theta}, R)$. Suppose now $p(L, \underline{\theta}) > p(L, \overline{\theta})$. When allocating a given amount of rent $p(L, \overline{\theta})\Delta C_S + \left[1 - p(L, \overline{\theta})\right] \Delta C_R$ for an agent with $(\sigma, \theta) = (L, \underline{\theta})$ between the safe and the risky project, it is optimal to allocate a maximal rent to the risky project conditional on that it does not leave any rent to an agent with $(\sigma, \theta) = \left(L, \overline{\theta}\right)$. This way allows her to minimize the rent that the agent with $(\sigma, \theta) = (H, \underline{\theta})$ can obtain by reporting $(L, \underline{\theta})$. Hence, the optimal transfers are given by $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L)t(L, \underline{\theta}, y^L) = C(\overline{\theta}, R)$ and $t(L, \underline{\theta}, y^S) = C(\underline{\theta}, S) + \frac{p(L,\overline{\theta})}{p(L,\underline{\theta})} \left[\Delta C_S - \Delta C_R\right] + \Delta C_R$. Then, the rent that the agent with $(\sigma, \theta) = (H, \underline{\theta})$ can obtain by reporting $(L, \underline{\theta})$ (i.e. $V(L, \underline{\theta}; H, \underline{\theta})$) is equal to $p(L, \overline{\theta})\Delta C_S + \left[p(L, \underline{\theta}) - p(L, \overline{\theta})\right] \Delta C_R$.

I now consider the case in which task integration qualitatively affects the binding incentive constraints.

Lemma 3 *Suppose A1, $\Delta C_S > \Delta C_R$, and M.*

(i) If $p(H, \overline{\theta}) \left[\Delta C_S - \Delta C_R\right] + \Delta C_R \leq A(p(L, \underline{\theta}), p(L, \overline{\theta}))$ holds, there exist countervailing incentives such that the downward incentive constraint $(IC : (L, \overline{\theta}) \rightarrow (L, \underline{\theta}))$ binds as long as $p(L, \underline{\theta}) < 1$.

(ii) We can distinguish two regimes depending on whether or not the downward incentive constraint $(IC : (H, \overline{\theta}) \rightarrow (H, \underline{\theta}))$ binds.

(ii) (a) (countervailing regime I) If $p(H, \overline{\theta}) \left[\Delta C_S - \Delta C_R\right] + \Delta C_R \leq A(p(L, \underline{\theta}), p(L, \overline{\theta})) \leq p(H, \underline{\theta}) \left[\Delta C_S - \Delta C_R\right] + \Delta C_R$ holds, the following constraints bind:

$$(IR \ : \ \sigma, \overline{\theta}, j) \text{ for } \sigma = H, L \text{ and } j = S, R.$$

[12] It is easy to see that it is optimal to have $V(L, \underline{\theta} : L, \overline{\theta}) = 0$. $V(L, \underline{\theta} : L, \overline{\theta}) > 0$ implies $U(L, \overline{\theta}) > 0$. But an increase in $U(L, \overline{\theta})$ increases $U(L, \underline{\theta})$ from the binding $(IC : (L, \underline{\theta}) \rightarrow (L, \overline{\theta}))$, which in turn makes manipulating signal from H to L more attractive to a low-cost type with $\sigma = H$.

Figure 1: Binding incentive constraints in the regular regime.

$$(IC : (L,\underline{\theta}) \to (L,\overline{\theta})), (IC : (L,\overline{\theta}) \to (L,\underline{\theta})), (IC : (H,\underline{\theta}) \to (L,\underline{\theta})).$$

(ii) (b) (countervailing regime II) If $A(p(L,\underline{\theta}), p(L,\overline{\theta})) \geq p(H,\underline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$ *holds, the following constraints bind:*

$$\begin{aligned} (IR &: L,\overline{\theta},j) \text{ for } j = S,R. \\ (IC &: (L,\underline{\theta}) \to (L,\overline{\theta})), (IC : (L,\overline{\theta}) \to (L,\underline{\theta})), (IC : (H,\underline{\theta}) \to (L,\underline{\theta})), \\ (IC &: (H,\overline{\theta}) \to (H,\underline{\theta})). \end{aligned}$$

Given $p(H,\overline{\theta})$, as $p(L,\overline{\theta})$ increases, a low-cost type with $\sigma = H$ has a larger incentive to manipulate his signal from H to L since the rent that a low-cost type with $\sigma = L$ obtains (i.e. $U(L,\underline{\theta}) \equiv p(L,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$) increases with $p(L,\overline{\theta})$. Therefore, when the difference between $p(L,\overline{\theta})$ and $p(H,\overline{\theta})$ is large enough (i.e. $p(H,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R \leq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ holds), the lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ binds as Lemma 3(ii)(a) and (ii) (b) state. This in turn can create two kinds of countervailing incentives. First, as long as $p(L,\underline{\theta}) < 1$, the downward incentive constraint $(IC : (L,\overline{\theta}) \to (L,\underline{\theta}))$ binds. Otherwise, the principal can satisfy the lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ at no cost by choosing for instance $t(L,\underline{\theta},y^S) = C(\underline{\theta},S)$ and $t(L,\theta,y^H)$ small enough and $t(L,\theta,y^L)$ large enough. However, this strategy requires her to choose $\mu_L t(L,\theta,y^H) + (1-\mu_L)t(L,\theta,y^L)$[13] larger than $C(\overline{\theta},R)$ to satisfy $(IC : (L,\underline{\theta}) \to (L,\overline{\theta}))$, which violates $(IC : (L,\overline{\theta}) \to (L,\underline{\theta}))$. Since giving a positive rent to a high-cost type

[13]It is given by $(1 - p(L,\underline{\theta}))\left[\mu_L t(L,\theta,y^H) + (1-\mu_L)t(L,\theta,y^L) - C(\underline{\theta},R)\right] = p(L,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$.

Figure 2: Binding incentive constraints in the countervailing regime I.

with $\sigma = L$ is not optimal, $(IC : (L,\overline{\theta}) \to (L,\underline{\theta}))$ binds and it is optimal to choose $\mu_L t(L,\theta,y^H) + (1-\mu_L)t(L,\theta,y^L) = C(\overline{\theta},R)$.

Second, as $U(L,\underline{\theta})$ increases, the rent that a low-cost type with $\sigma = H$ obtains from the binding lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ increases so much that the downward incentive constraint $(IC : (H,\overline{\theta}) \to (H,\underline{\theta}))$ can bind. In this case, a high-cost type with $\sigma = H$ can get a positive information rent by announcing $(H,\underline{\theta})$.

I call the regime in which the lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ and the downward incentive constraint $(IC : (L,\overline{\theta}) \to (L,\underline{\theta}))$ bind while the other downward incentive constraint $(IC : (H,\overline{\theta}) \to (H,\underline{\theta}))$ is slack *the countervailing regime I* and the regime in which the lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ and the two downward incentive constraints $(IC : (\sigma,\overline{\theta}) \to (\sigma,\underline{\theta}))$ for $\sigma = H, L$ bind *the countervailing regime II*. Figure 2 (figure 3) describes the binding incentive constraints in the countervailing regime I (countervailing regime II). Lemma 3 gives the condition under which each regime exists. Since $p(H,\underline{\theta})[\Delta C_S - \Delta C_R] + \Delta C_R \geq p(H,\overline{\theta})[\Delta C_S - \Delta C_R] + \Delta C_R$ holds from the monotonicity constraint $p(H,\underline{\theta}) \geq p(H,\overline{\theta})$, the countervailing regime I does exist. From the binding individual rationality constraints $(IR : L,\overline{\theta},j)$ for $j = S, R$, a high-cost type with $\sigma = L$ can never get any information rent. By contrast, a high-cost type with $\sigma = H$ gets a positive information rent in the countervailing regime II.

Optimal contract

I now find the optimal contract. Note that in Lemma 2 and Lemma 3, the condition for the existence of each regime is defined with weak inequality such that the set of contracts

Figure 3: Binding incentive constraints in the countervailing regime II.

belonging to each regime becomes a closed set. I first consider the optimal contract in each regime starting by the regular regime.

Lemma 4 *Under A1 and* $\Delta C_S > \Delta C_R$*, the optimal contract in the regular regime satisfies the constraint* $p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right] \Delta C_R \geq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ *with equality.*

Lemma 4 suggests that in order to look for the optimal contract in the regular regime, we can look at, without loss of generality, those contracts that satisfy $p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right] \Delta C_R = A(p(L,\underline{\theta}), p(L,\overline{\theta}))$, which are also included in the countervailing regime I.

I now consider the countervailing regime II.

Lemma 5 *Under A1 and* $\Delta C_S > \Delta C_R$*, in the countervailing regime II,*

(i) It is optimal to have $p(H,\overline{\theta}) = 0$.

(ii) The optimal $p(H,\underline{\theta})$ *is* 0 *if the following inequality holds;*

$$\mu_H y^H + (1-\mu_H) y^L - C(\underline{\theta}, R) - \left[y^S - C(\underline{\theta}, S)\right] \geq \frac{1-\nu}{\nu}(\Delta C_S - \Delta C_R). \tag{6}$$

Otherwise, $p(H,\underline{\theta}) = \min\left\{1, \left[A(p(L,\underline{\theta}), p(L,\overline{\theta})) - \Delta C_R\right] / \left[\Delta C_S - \Delta C_R\right]\right\}$.

(iii) (no bias) If the constraint $A(p(L,\underline{\theta}), p(L,\overline{\theta})) \geq p(H,\underline{\theta}) \left[\Delta C_S - \Delta C_R\right] + \Delta C_R$ *does not bind, the optimal contract under the countervailing regime II exhibits no bias in the project choice and is given by:*

$$\begin{aligned} p(L,\theta) &= 1, t(L,\theta,y^S) = C(\overline{\theta}, S); \\ p(H,\theta) &= 0, \mu_H t(H,\theta,y^H) + (1-\mu_H) t(H,\theta,y^L) = C(\underline{\theta}, R) + \Delta C_S. \end{aligned}$$

In the countervailing regime II, $\max\left\{V(L,\underline{\theta};H,\theta),V(L,\overline{\theta};H,\theta)\right\}$ plays the role of an (endogenous) reservation utility to a type-θ agent with $\sigma = H$ since he can manipulate his reports about the signal (from H to L) and the type to get that utility. The reservation utility is zero for a high-cost type with $\sigma = H$ while it is equal to $V(L,\underline{\theta};H,\underline{\theta})(= A(p(L,\underline{\theta}),p(L,\overline{\theta}))) > 0$ for a low-cost type with $\sigma = H$. Since $V(L,\underline{\theta};H,\underline{\theta})$ is larger than the expected cost differential between two types given $p(H,\underline{\theta})$ (i.e. $p(H,\underline{\theta})\Delta C_S + (1-p(H,\underline{\theta}))\Delta C_R$), as is usual in the literature on the type-dependent reservation utility, the high-cost type's incentive constraint ($IC : (H,\overline{\theta}) \to (H,\underline{\theta})$) binds while the low-cost type's incentive constraint ($IC : (H,\underline{\theta}) \to (H,\overline{\theta})$) is slack. Therefore, $p(H,\overline{\theta})$ does not affect any rent and it is optimal to choose $p(H,\overline{\theta}) = 0$.

I now illustrate the trade-off determining the optimal $p(H,\underline{\theta})$ by examining the case of $p(L,\theta) = 1$ for $\theta \in \Theta$. Note that $p(L,\theta) = 1$ implies $V(L,\underline{\theta};H,\underline{\theta})(= A(p(L,\underline{\theta}),p(L,\overline{\theta})) = \Delta C_S$, which in turn implies that the contract should satisfy $U(H,\underline{\theta}) = \Delta C_S$ in order to induce truth-telling of the agent with $(\sigma,\theta) = (H,\underline{\theta})$. Consider first $p(H,\underline{\theta}) = 1$. Then, by choosing $t(H,\underline{\theta},y^S) = C(\overline{\theta},S)$, the principal can satisfy $U(H,\underline{\theta}) = \Delta C_S$ while leaving zero rent to the high-cost type with $\sigma = H$. Consider now $p(H,\underline{\theta}) = 0$. Then, she should choose transfers satisfying $\mu_H t(H,\underline{\theta},y^H) + (1-\mu_H)t(H,\underline{\theta},y^L) = C(\underline{\theta},R) + \Delta C_S$ in order to satisfy $U(H,\underline{\theta}) = \Delta C_S$ and this in turns makes a high-cost type with $\sigma = H$ obtain a rent equal to $\Delta C_S - \Delta C_R$ by announcing $(H,\underline{\theta})$. Therefore, a marginal decrease in $p(H,\underline{\theta})$ increases the expected revenue by $\frac{\nu}{2}\left\{\mu_H y^H + (1-\mu_H)y^L - C(\underline{\theta},R) - \left[y^S - C(\underline{\theta},S)\right]\right\}$ from improving the project choice of the low-cost type with $\sigma = H$, on the one hand, and increases the expected cost by $\frac{1-\nu}{2}\left\{\Delta C_S - \Delta C_R\right\}$ from leaving more rent to the high-cost type with $\sigma = H$ on the other hand. This trade-off between efficiency and rent extraction explains the condition to choose $p(H,\underline{\theta}) = 0$ (i.e. (6)) in Lemma 5. Finally, Lemma 5 (iii) says that if the optimal contract in the countervailing regime II is interior[14], then the project choice should be the same as the one in the benchmark in which the principal receives the signal and in this case a high-cost type with $\sigma = H$ gets a rent equal to $\Delta C_S - \Delta C_R$ while a low-cost type gets a rent equal to ΔC_S regardless of σ.

I now consider the lateral regime without countervailing incentives.

Lemma 6 *In the countervailing regime I,*

(i) $A(p(L,\underline{\theta}),p(L,\overline{\theta}))$ must belong to $[\Delta C_R,\Delta C_S]$ and it is optimal to have $p(H,\overline{\theta}) = 0$ and $p(H,\underline{\theta}) = \frac{A(p(L,\underline{\theta}),p(L,\overline{\theta}))-\Delta C_R}{\Delta C_S-\Delta C_R}$.

(ii) There are three possible optimal contracts:

[14] By an interior contract, I mean a contract satisfying $A(p(L,\underline{\theta}),p(L,\overline{\theta})) \geq p(H,\underline{\theta})\left[\Delta C_S - \Delta C_R\right] + \Delta C_R$ with a strict inequality.

(a) (bias toward the safe project for the low-cost type)
$p(L,\theta) = p(H,\underline{\theta}) = 1, t(\sigma,\theta,y^S) = C(\overline{\theta},S);$
$p(H,\overline{\theta}) = 0, \mu_H t(H,\overline{\theta},y^H) + (1-\mu_H)t(H,\overline{\theta},y^L) = C(\overline{\theta},R).$
(b) (bias toward the risky project for the high-cost type)
$p(L,\underline{\theta}) = 1, t(L,\underline{\theta},y^S) = C(\underline{\theta},S) + \Delta C_R;$
$p(L,\overline{\theta}) = p(H,\theta) = 0, \mu_\sigma t(\sigma,\theta,y^H) + (1-\mu_\sigma)t(\sigma,\theta,y^L) = C(\overline{\theta},R).$
(c) (bias toward the risky project for both types)
$p(L,\theta) = \frac{\Delta C_R}{\Delta C_S}, t(L,\theta,y^S) = C(\overline{\theta},S)$
$p(H,\theta) = 0, \mu_\sigma t(\sigma,\theta,y^H) + (1-\mu_\sigma)t(\sigma,\theta,y^L) = C(\overline{\theta},R).$

In the countervailing regime I, a high-cost type gets no information rent and the rent of the low-cost type with $\sigma = H$ is determined by the lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$. Since $p(H,\theta)$ does not affect any rent, it is optimal to choose $p(H,\overline{\theta}) = 0$ while it is optimal to choose the minimum $p(H,\underline{\theta})$ that satisfies the condition on $A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ stated in Lemma 3 (ii)(b); this minium $p(H,\underline{\theta})$ is described in Lemma 6(i).

The Lemma reveals that there are three possible optimal contracts in the countervailing regime I. In the first case (i.e. Lemma 6 (ii)(a)), there is no distortion in project choice with respect to the benchmark in which the principal receives the signal except for $(\sigma,\theta) = (H,\underline{\theta})$. When $(\sigma,\theta) = (H,\underline{\theta})$, the principal chooses the safe project instead of the risky project and this bias toward the safe project can be optimal since it allows the principal to reduce the rent abandoned to the high-cost type with $\sigma = H$ because of the countervailing incentives as was explained in the paragraph just before Lemma 6.

In the second case (i.e. Lemma 6 (ii)(b)), there is no distortion in project choice except for $(\sigma,\theta) = (L,\overline{\theta})$ and the principal chooses the risky project for that state. This bias toward the risky project allows the principal to reduce the rent given to the low-cost type with $\sigma = L$ from ΔC_S to ΔC_R from the binding incentive constraint $(IC : (L,\underline{\theta}) \to (L,\overline{\theta}))$, which in turn reduces the rent given to the low-cost type with $\sigma = H$ by the same amount from the binding lateral incentive constraint $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$.

Finally, in the last case (i.e. Lemma 6 (ii)(c))[15], there is no distortion in project choice when $\sigma = H$ while when $\sigma = L$ the principal chooses the safe project with probability $p(L,\theta) = \frac{\Delta C_R}{\Delta C_S}$ and the risky project with probability $1 - \frac{\Delta C_R}{\Delta C_S}$ for both types. In this case, a low-cost type with $\sigma = L$ gets a rent equal to $p(L,\theta)(\Delta C_S - \Delta C_R) + \Delta C_R$ from

[15] This case arises when the monotonicity constraint $p(L,\underline{\theta}) \geq p(L,\overline{\theta})$ binds as in the first case (lemma 6 (ii)(a)). It is slack in the second case (lemma 6 (ii)(b)).

the binding $(IC : (L,\underline{\theta}) \to (L,\overline{\theta}))$ while a low-cost type with $\sigma = H$ gets a rent equal to $p(L,\theta)\Delta C_S = \Delta C_R$ from the binding $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$. The reason why the latter gets a smaller rent than the former is that if he reports $\sigma = L$, with probability $1-p(L,\theta)$, the principal chooses the risky project and in this case he does not get any rent since the transfer depends on the match between the reported signal and the realized revenue y^R. Note that there is a regime change at $p(L,\theta) = \frac{\Delta C_R}{\Delta C_S}$; given $p(L,\theta) = p$ and $p(H,\theta) = 0$, if $p < \frac{\Delta C_R}{\Delta C_S}$ holds, we are in the regular regime since $(IC : (H,\underline{\theta}) \to (H,\overline{\theta}))$ binds and $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ and $(IC : (H,\overline{\theta}) \to (H,\underline{\theta}))$ are slack while, if $p > \frac{\Delta C_R}{\Delta C_S}$ holds, we are in the countervailing regime II since $(IC : (H,\underline{\theta}) \to (H,\overline{\theta}))$ is slack and $(IC : (H,\underline{\theta}) \to (L,\underline{\theta}))$ and $(IC : (H,\overline{\theta}) \to (H,\underline{\theta}))$ bind such that $U(H,\overline{\theta}) = p\Delta C_S - \Delta C_R > 0$.

Lemma 4 to Lemma 6 suggest that the optimal contract is one among the four candidates (the one described in Lemma 5 (iii) and the three described in Lemma 6). The following proposition shows that in fact, each of them can be the optimal contract depending on the parameter values.

Proposition 2 *Consider task integration and suppose that A1 holds and $\sigma = H$ is bad news (i.e. $\Delta C_S > \Delta C_R$).*

(i) The principal's expected profit is strictly lower than the one in the benchmark in which the principal receives the signal.

(ii) The optimal contract has

(a) no bias in project choice if both $\mu_H y^H + (1-\mu_H)y^L - y^S$ and $y^S - \mu_L y^H - (1-\mu_L)y^L$ are large enough

(b) a bias toward the safe project for the low-cost type ($p(H,\underline{\theta}) = 1$) if ν is small enough

(c) a bias toward the risky project for the high-cost type ($p(L,\overline{\theta}) = 0$) if $(1-\nu)$ is small enough

(d) a bias toward the risky project for both types $\left(p(L,\theta) = \frac{\Delta C_R}{\Delta C_S} < 1\right)$ if ΔC_S is large enough with respect to $\Delta C_S - \Delta C_R$.

Proof. Since (i) is obvious, I prove only (ii). Let Π^* denote the expected profit in the benchmark in which the principal receives the signal. I compute the difference between Π^* and the profit under task integration for each among the four candidates. First, when there is no bias in project choice, the loss in profit is equal to $\frac{1}{2}(\Delta C_S - \Delta C_R)$. Second, when there is a bias toward the safe project for the low-cost type as described in Lemma 6 (ii)(a), the loss is $\frac{\nu}{2}\left[\mu_H y^H + (1-\mu_H)y^L - C(\overline{\theta},R) - y^S + C(\overline{\theta},S)\right]$. Third, when there is a bias toward the risky project for the high-cost type as described in Lemma 6 (ii)(b), the loss is $\frac{1-\nu}{2}\left[y^S - C^v(\overline{\theta}, S) - \mu_L y^H - (1-\mu_L)y^L + C^v(\overline{\theta}, R)\right]$. Finally, when there is a bias toward the risky project for both types as described in Lemma 6 (ii)(c), the loss is $\frac{1}{2}\frac{\Delta C_S - \Delta C_R}{\Delta C_S}\left[y^S - C(\overline{\theta}, S) - \mu_L y^H - (1-\mu_L)y^L + C(\overline{\theta}, R)\right]$. The result in (ii) follows from comparing the losses. ■

When the gain from having a good project match ($\mu_H y^H + (1-\mu_H)y^L - y^S$ and $y^S - \mu_L y^H - (1-\mu_L)y^L$) is large enough, it is optimal to have no distortion in the project choice. Then, the contract described in Lemma 5 (iii) is optimal. In this case, a low-cost type gets an information rent equal to ΔC_S regardless of the signal he receives while a high-cost type obtains a rent equal to $\Delta C_S - \Delta C_R$ upon receiving $\sigma = H$. By contrast, in the benchmark in which the principal obtains the signal, only a low-cost type gets a rent and his rent is ΔC_S if he receives $\sigma = L$ and ΔC_R if he receives $\sigma = H$. Therefore, task integration generates a loss equal to $\frac{1}{2}(\Delta C_S - \Delta C_R)$ with respect to the benchmark by increasing the cost to obtain the signal.

Proposition 2 says, because of this loss, it can be optimal to introduce a bias toward a safe or a risky project. There are three kinds of trade-off between rent extraction and efficiency loss in terms of the distortion in project choice. First, when the probability of having a low-cost type is small enough, it is optimal to choose the safe project for the low-cost type regardless of the signal. This allows the principal to save the rent that a high-cost type can obtain upon receiving $\sigma = H$ when there is no bias. Second, when the probability of having a high-cost type is small enough, it is optimal to choose the risky project for the high-cost type regardless of the signal. This in particular allows the principal to reduce the rent that a low-cost type obtains regardless of the signal from ΔC_S to ΔC_R with respect to the case without bias. Finally, when ΔC_S is large enough with respect to $\Delta C_S - \Delta C_R$, it is optimal to introduce the same but small bias toward the risky project for both types (i.e. $1 - p(L, \theta) = \frac{\Delta C_S - \Delta C_R}{\Delta C_S}$). This small bias in particular allows the principal to reduce the rent that the agent with $\sigma = H$ obtains regardless of the type by $\Delta C_S - \Delta C_R$ with respect to the case without bias.

4 Extension: no commitment

In this section, I extend the model to the case in which the principal cannot commit in advance to a mechanism to induce the agent to transmit the signal σ. For instance, the signal transmitted by the agent simply may not be contractible or the agent might move first to influence the principal's choice by transmitting information[16]. In this case, the agent would decide which signal to release before the principal proposes an offer. Note first that the principal's expected profit is higher with commitment than without it since with commitment, she can at least commit to the best contract without commitment. Note also that under task separation, the agent in charge of evaluating the risky project will truthfully release the signal even when the principal has no commitment power since the agent always obtains zero rent.

From now on I consider task integration. As is written in section 2, I assume that the shutdown is never optimal and that the agent has the option of terminating his relationship with the principal at any time before incurring the production cost. In the special case with $\Delta C_S = \Delta C_R$, it is easy to see that the agent will transmit the true signal regardless of his type. Therefore, I consider the case with $\Delta C_S \neq \Delta C_R$. For expositional facility, I call $\sigma = H$ a good (bad) signal and $\sigma = L$ a bad (good) signal from the agent's point of view if $\Delta C_S < \Delta C_R$ (if $\Delta C_S > \Delta C_R$). A good (bad) signal is denoted by $\sigma = G$ ($\sigma = B$).

I study the Perfect Bayesian Equilibria (PBE) in which the high-cost type always truthfully releases his signal and the low-cost type truthfully releases the good signal ($\sigma = G$).[17] To define the PBE, I introduce some notation: z represents the probability for the low-cost type to release $\widehat{\sigma} = B$ when he receives the bad signal ($\sigma = B$), $\mu(\widehat{\sigma})$ (respectively, $\nu(\widehat{\sigma})$) represents the principal's revised prior about the probability of having $y^R = y^H$ (respectively, the probability of having $\theta = \underline{\theta}$) conditional on receiving signal $\widehat{\sigma}$ from the agent and $\{p(\theta \mid \widehat{\sigma}), t(\theta, y \mid \widehat{\sigma})\}$ is the mechanism that the principal proposes after receiving $\widehat{\sigma}$. Then, a PBE is defined by:

$$\{z, \mu(\sigma), \nu(\sigma), p(\theta \mid \sigma), t(\theta, y \mid \sigma)\},$$

which satisfies the following three conditions:

1) given $\{\mu(\sigma), \nu(\sigma), p(\theta \mid \sigma), t(\theta, y \mid \sigma)\}$, z maximizes the payoff of the low-cost type who received $\sigma = B$,

2) $\mu(\sigma)$ and $\nu(\sigma)$ satisfy Bayes' rule,

3) given $\{z, \mu(\sigma), \nu(\sigma)\}$, $p(\theta \mid \sigma)$ and $t(\theta, y \mid \sigma)$ maximize the principal's payoff.

[16]This framework is similar to the one chosen by Potters and Van Winden (1992) to study lobbying under asymmetric information.

[17]It can be easily checked that in the equilibria of proposition 3 and proposition 4, the high-cost type always truthfully releases his signal and the low-cost type truthfully releases the good signal.

4.1 When $\sigma = H$ is good news

Consider first the case in which $\sigma = H$ is good news. Then, there exists an equilibrium in which the agent always transmits the true signal.

Proposition 3 *Under A1 and when $\Delta C_S \leq \Delta C_R$ holds, in the absence of commitment, there exists a Perfect Bayesian Equilibrium in which the agent always transmits the true signal σ.*

Proof. With $z = 1$, we have $\mu(\sigma) = \mu_\sigma$, $\nu(\sigma) = \nu$. From A1, when $\sigma = H$, it is optimal to have $p(\theta \mid H) = 0$ and $\mu_H t(\theta, y^H \mid H) + (1 - \mu_H) t(\theta, y^L \mid H) = C(\overline{\theta}, R)$ and when $\sigma = L$, it is optimal to have $p(\theta \mid L) = 1$ and $t(\theta, y^S \mid L) = C(\overline{\theta}, S)$. Furthermore, let $\{t(\theta, y \mid H)\}$ satisfy the following:

$$\mu_L t(\theta, y^H \mid H) + (1 - \mu_L) t(\theta, y^L \mid H) \leq C(\underline{\theta}, R).$$

Given the mechanism, a low-cost type with $\sigma = L$ gets a rent equal to ΔC_S if he transmits L while he gets zero rent if he transmits H. Therefore, $z = 1$ is optimal given the mechanism and we have a PBE in which the agent always transmits the signal. ■

The intuition of the above result is simple. If the agent expects the principal to make the transfer under the risky project depend on the match between the reported signal and the realized revenue such that a high (low) transfer is made if the match is good (bad), then the agent has no incentive to transmit H when he received L.

4.2 When $\sigma = H$ is bad news

Consider now the case in which $\sigma = H$ is bad news. I have the following result:

Proposition 4 *Under A1 and when $\Delta C_S > \Delta C_R$ holds, in the absence of commitment, the Perfect Bayesian Equilibria in which the high-cost type always truthfully releases his signal and the low-cost type truthfully releases $\sigma = L$, $\{z, \mu(\sigma), \nu(\sigma), p(\theta \mid \sigma), t(\theta, y \mid \sigma)\}$, are characterized by:*

(i) There is no equilibrium in which the low-cost type always truthfully releases $\sigma = H$: $z < 1$.

(ii) $\mu(H : z) = \mu_H$; $\nu(H : z) = \frac{\nu z}{1 - \nu + \nu z}$. $p(\theta \mid H) = 0$, $\mu_H t(\theta, y^H \mid H) + (1 - \mu_H) t(\theta, y^L \mid H) = C(\overline{\theta}, R)$.

(iii) $\mu(L : z) = \mu_H \frac{v(1-z)}{1+\nu-\nu z} + \mu_L \frac{1}{1+\nu-\nu z}$; $\nu(L : z) = \frac{\nu(2-z)}{1+\nu-\nu z}$.

There exists ν^* with $0 < \nu^* < 1$ such that:

(a) For all $\nu \in (0, \nu^*)$, there exists a unique equilibrium with $z = 0$ and, in this equilibrium $p(\theta \mid L) = 1$.

(b) For all $\nu \in [\nu^*, 1)$, there are multiple equilibria: for each $z \in [0, z^*(\nu)]$ with $z^*(\nu^*) = 0$ and $\frac{dz^*}{d\nu} > 0$, there exists an equilibrium. The principal's payoff is the largest with $z = z^*(\nu)$. In this equilibrium, $p(\overline{\theta} \mid L) = 0$ and $p(\underline{\theta} \mid L) = 0$ or 1.[18]

It is easy to see that there is no PBE in which the low-cost type always truthfully releases $\sigma = H$. Suppose that $z = 1$. Then, we have $\mu(\sigma) = \mu_\sigma$ and $\nu(\sigma) = \nu$. This implies that $p(\theta \mid H) = 0$, $\mu_H t(\theta, y^H \mid H) + (1 - \mu_H) t(\theta, y^L \mid H) = C(\overline{\theta}, R)$ and $p(\theta \mid L) = 1$ and $t(\theta, y^S \mid L) = C(\overline{\theta}, S)$. Given the principal's response, the low-cost type obtains more rent by transmitting L than by transmitting H when he received H. Thus, there is a contradiction. When the principal receives $\sigma = H$, she knows for sure that the agent received $\sigma = H$. Then, from A1, choosing the risky project is optimal.

For ν small, even though the low-cost type always manipulates the signal from H to L, $\mu(L)$ is close to μ_L. Hence, the principal will maintain the safe project when she receives L and therefore the low-cost type always reports L regardless of the signal he receives. Since the risky project is chosen only when the high-cost type receives H, task integration without commitment creates a bias toward the safe project with respect to the benchmark in which the principal receives the signal.

For ν large, if the low-cost type always manipulates the signal from H to L, $\mu(L)$ is close to μ. Furthermore we have $\nu(L) > \nu$. The two factors make it optimal for the principal to introduce a bias toward the risky project when she receives L in that she always chooses the risky project for the high-cost type (and furthermore it can be optimal to choose the risky project for the low-cost type as well as proposition 4(iii)b shows). Then, the low-cost type obtains the same rent regardless of the signal he releases. Thus, releasing H with a positive probability can be an equilibrium.

Therefore, task integration without commitment creates both a bias toward the safe project and a bias toward the risky project as does task integration with commitment with respect to the benchmark in which the principal receives the signal. However, the cost from lack of commitment can be very high since there are always some distortions in information flows and therefore the principal can never achieve the no-bias outcome (i.e. retaining the risky project if and only if the signal is high) that she can achieve with commitment. Furthermore, as Proposition 4(iii)b shows, surprisingly, the principal can end up choosing the risky project with probability one.

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[18] $p(\underline{\theta} \mid L) = 0$ if $y^S - C(\underline{\theta}, S) - \left[\mu(L : z) y^H + (1 - \mu(L : z)) y^L - C(\underline{\theta}, R)\right] < 0$.

5 Applications and discussions

The results under task integration can provide an explanation for why good firms can go bad. For this application, I now suppose that there are two agents (a good agent and a bad agent) and the principal knows whether his agent is good or bad. Each (good or bad) agent can have a low-cost type ($\theta = \underline{\theta}$) with probability ν and a high-cost type $\left(\theta = \overline{\theta}\right)$ with probability $1 - \nu$. In the case of the good agent, his production cost is given as before $C^G(\theta, j) \equiv C(\theta, j)$ for $\theta \in \left\{\underline{\theta}, \overline{\theta}\right\}$ and $j \in \{S, R\}$. In the case of the bad agent, his cost is given as follows: $C^B(\overline{\theta}, j) \equiv C^G(\overline{\theta}, j) + c$ and $C^B(\underline{\theta}, j) \equiv C^B(\overline{\theta}, j) - k\Delta C_j$ where $c > 0$ and $k \in [0, 1]$. The type of each agent is his private information. Given a type θ and a project, a bad agent's cost is strictly higher than a good agent's one. Therefore, it is obvious that given a project choice, the principal's profit is strictly higher when the agent is good than when he is bad. Consider now the case in which the principal needs to choose between the two projects. I am interested in comparing the principal's expected profit when the agent is good with the one when the agent is bad. Each agent is assumed to receive the signal $\sigma \in \{G, B\}$ with the same precision ξ.[19] The next proposition shows that the principal's profit when the agent is bad can be larger than the one when the agent is good:

Proposition 5 *Suppose A1, commitment power, and $\Delta C_S > \Delta C_R$ (i.e. $\sigma = H$ is bad news). There exists a $\overline{k} \in (0, 1]$ such that for any given $k \in \left[0, \overline{k}\right)$, the principal's expected profit is higher when the agent is bad than when he is good for all $c \in [0, \overline{c}(k))$ with $\overline{c}(k) > 0$.*

Proof. Note first that under A1 and $\Delta C_S > \Delta C_R$, the principal's optimal project choice in the benchmark in which she receives σ does not depend on whether the agent is good or bad. Consider the case in which $k = 0$. First, in the benchmark in which she receives σ, the reduction in her profit when she is matched with the bad agent instead of the good one is c. Second, if the agent is bad, there is no loss from task integration and the principal achieves the profit under the benchmark. Third, if the agent is good, then there is a loss from task integration: let $\overline{c}(0)$ denote the minimum among all the four losses from task integration that I derived in the proof of proposition 2. From the previous arguments, when $k = 0$, the principal's expected profit is higher when the agent is bad than when he is good for $c \in [0, \overline{c}(0))$. By continuity, for some $\overline{k}$ strictly positive, there exists $\overline{c}(\overline{k}) > 0$

[19] I can assume that the bad agent receives the signal with a lower precision than does the good agent and can still obtain a result similar to that of proposition 5.

such that for any $k \in \left[0, \overline{k}\right)$ and $c \in [0, \overline{c}(k))$, the principal's expected profit is higher when the agent is bad than when he is good. $k = 1$ is impossible since when $k = 1$, the profit is strictly higher with the good agent than with the bad agent for any $c > 0$. ■

Example 1 *If $\mu_H y^H + (1 - \mu_H) y^L - y^S$ and $y^S - \mu_L y^H - (1 - \mu_L) y^L$ are large enough, for any $k \in [0, 1)$ and for any $c < \overline{c}(k) = \frac{1-k}{2} (\Delta C_S - \Delta C_R)$, the principal's expected profit is higher when the agent is bad than when he is good.*

The above proposition provides a channel through which good firms can go bad. Interpret the safe project as the current project which generates a fixed revenue and the risky project as a new project generating an uncertain revenue. The good (bad) agent represents a firm with superior (inferior) technology. For this application, I assume that the principal cannot change his current match with a good or bad agent.[20] Although a technologically superior firm has a lower cost of production than the other in each project, if the former's division has some vested interest (or a large rent) attached to the current project, it can have difficulties in obtaining information relevant to project choice and might have an expected profit lower than that of the technologically inferior firm. Furthermore, it is natural to expect that the rent that the division obtains from the current project increases as the project is more successful, which implies that a successful firm might suffer more from difficulties in obtaining information than an unsuccessful firm when the changes in business environment are adverse to the current project. In this sense, my results suggest that today's success can plant a seed for tomorrow's failure.

As an illustration, consider IBM's core activity choice in the past. During the eighties, IBM's core activity consisted of mainframe production while market demand was shifting toward microcomputers. According to Friesen and Mills (1996, p. 88), IBM faced a serious crisis in the nineties since it failed to make changes in a timely manner and exhibited inertia. Our model suggests that the inertia could have resulted from the distortions in information flows from the mainframe division. In fact, the same authors mention that division executives began to put the welfare of their own organizations above that of the corporation as a whole and that this was manifested in the resistance of the mainframe division to the introduction of new technology that might damage sales of its products (pp. 128-29).

[20] As it will be clear in the examples (IBM and Kmart) that I give below, the agent can represent a whole division. In this case, the principal can destroy the current division and build a new one only with a prohibitive cost.

Kmart (Kresge)'s failure to adopt a computerized ordering system can be another illustration. By 1973 when Kresge was the leader of the industry, it still used the antiquated system of having managers at each of the company's 673 stores fill out order books by hand and mail in each day's invoices to headquarters. That year, several Kresge executives proposed replacing the order books with computers. However, it provoked furious opposition from store managers who viewed computerized ordering as an attempt by headquarters to take power away from the field and opposing people argued that a computerized system would make the company lose store managers' expertise in managing stocks. (Ortega 1998, p. 121). Note however that proposition 2 and 4 suggest that distortions in information flows can generate not only a bias toward the current or safe project but also a bias toward the risky project.

My results also provide an insight about path dependency. Suppose that there are three projects ($j = A, B, C$) with $\Delta_A < \Delta_C < \Delta_B$ where $\Delta_j \equiv C(\overline{\theta}, j) - C(\underline{\theta}, j) > 0$. I consider a two-period model in which the principal makes a choice between A and B at $t = 1$ and then between the one chosen at $t = 1$ and C at $t = 2$. Assume that the principal cannot commit to a long-term contract and that C is a risky project while the revenue from the project chosen at $t = 1$ is known at $t = 2$. Then, the previous analysis implies that if A was retained at $t = 1$, the agent will release truthfully the signal regarding the profitability of project C at $t = 2$ without any extra compensation while if B was retained at $t = 1$, the principal cannot receive the true signal without any extra compensation.

Although my description of task separation is too stylized, the comparison between task separation and integration sheds light on the separation of day-to-day operating decisions from long-term strategic decisions, stressed by Chandler (1966) and Williamson (1975) as the major characteristic of the M-form structure. Under the M-form structure, day-to-day operating decisions are assigned to functional divisions and long-term strategic decisions are assigned to the general office while, under the U-form structure, functional executives have responsibility for both decisions. The U-form structure suffered from distortions in strategic information flows since functional executives became advocates representing the interests of their respective divisions, as Williamson notes. One can improve information flows by assigning the long-term strategic decision to general office which does not have any vested interest accruing from operational tasks.

However, in reality, task separation has some drawbacks. First of all, agents do not have equal access to information. For instance, a marketing division has better access to information about demand while an R&D division has better access to information about new technology. Thus, the elite staff has some disadvantage compared to divisions in terms of access to information. In other words, the precision of the signal can be lower (or the cost of getting the signal can be higher) under task separation than under task integration. Then, task integration will strictly dominate task separation when the signal favoring the adoption of the risky project is good news. Second, the fact that the agent in charge of project evaluation under task separation has no information rent can have its own negative consequence when the principal has to rely on the agent's initiative to get information because she lacks commitment power and information acquisition is costly. Then, it is easy to see that the agent will take the initiative only under task integration.

Proposition 5 also suggests that in a buyer-seller relationship (when the principal can choose between a good and a bad agent), it can be optimal for the buyer (for instance, the department of defense) to buy from a seller (a defense contractor) with inferior technology instead of buying from a seller with superior technology when the buyer should choose between a project of which the surplus is known and a new and risky project of which the surplus is uncertain. This happens when the seller with superior technology has a vested interest in the first project. I showed that the distortions in project choice can arise even if the buyer's surplus under each project is contractible. The distortions will be more severe if the surplus is not contractible.

For simplicity, I considered a model à la Baron and Myerson (1982) in which the agent's cost is his private information. As an alternative, it would be interesting to consider a model à la Laffont and Tirole (1993) in which the agent's realized cost can be observed by the principal but the cost is determined by his effort (moral hazard) and his cost parameter (adverse selection). In this setup, I still expect that when the signal favoring the adoption of the risky project is bad news from the agent's point of view, there will be countervailing incentives due to the endogenous type-dependent reservation utility. However, the principal can choose the power of the incentive scheme under each project[21] in order to affect the agent's incentive to transmit the signal. I conjecture that in this case, it would be optimal for the principal to choose a low-powered (a high-powered) incentive scheme for the safe project (for the risky project).

6 Concluding remarks

When agents have rents accruing from a current project, they might try to resist the adoption of a new and risky project by misrepresenting information favorable to the new

[21] An incentive scheme is a menu of cost reimbursement rules and the power of a reimbursement rule increases as the fraction of the cost overrun that the agent should bear increases.

project. I tried to capture this situation by distinguishing the information which generates an information rent and the information which affects the adoption of the new project. The utility that the agent can obtain by misrepresenting the information favorable to the new project becomes an endogenous type-dependent reservation utility and this can generate countervailing incentives making a right project choice costly. The results can offer an explanation for why good firms can go bad and a rational for the separation of day-to-day operating decisions from long-term strategic decisions. Although I mainly applied the model to organizations, it can also be adapted to buyer-seller situations (in particular, procurement). It would be interesting to extend the model to include both adverse selection and moral hazard in order to investigate the relationship between the power of the incentive scheme and information flows. Another interesting extension would be to study the relationship between the agent's incentive to build reputation and information flows in a dynamic setting.[22]

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[22] See Gromb and Martimort (2003) for instance.

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Appendix
Proof of Lemma 1

(i) The proof is standard; from summing $(IC : (\sigma, \underline{\theta}) \rightarrow (\sigma, \overline{\theta}))$ and $(IC : (\sigma, \overline{\theta}) \rightarrow (\sigma, \underline{\theta}))$, we obtain the monotonicity constraint. $p(\sigma, \underline{\theta}) \geq p(\sigma, \overline{\theta})$

(ii) I below show that the optimal contract conditional on $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$ and $p(\sigma, \underline{\theta}) \geq p(\sigma, \overline{\theta})$ satisfies $p(L, \overline{\theta}) = p(H, \overline{\theta})$: hence, we can neglect $p(L, \overline{\theta}) < p(H, \overline{\theta})$. Suppose $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$. Consider first the case in which the agent can lie only about θ. Then, it is obvious to see that given σ, the high cost type's individual rationality constraint $(IR : \sigma, \overline{\theta}, j)$ binds and the low cost type's incentive compatibility constraint $(IC : (\sigma, \underline{\theta}) \rightarrow (\sigma, \overline{\theta}))$ binds such that the low cost type can get a rent equal to $p(\sigma, \overline{\theta}) [\Delta C_S - \Delta C_R] + \Delta C_R$. $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$ implies that a low cost type with $\sigma = L$ gets a smaller rent than a low cost type with $\sigma = H$. In what follows, I first neglect all the other constraints, show that the optimal contract conditional on $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$ and $p(\sigma, \underline{\theta}) \geq p(\sigma, \overline{\theta})$ satisfies $p(L, \overline{\theta}) = p(H, \overline{\theta})$ and then show that when $p(L, \overline{\theta}) = p(H, \overline{\theta})$ holds, the other constraints are in fact slack.

Let $p(H, \overline{\theta}) = p$ be given. If I neglect all the other constraints, A1 and $p(\sigma, \underline{\theta}) \geq p(\sigma, \overline{\theta})$ imply that it is optimal to have (i) $p(L, \underline{\theta}) = 1$ (ii) $p(H, \underline{\theta}) = p$ (i.e. the minimum $p(H, \underline{\theta})$ satisfying $p(H, \underline{\theta}) \geq p(H, \overline{\theta})$) (iii) $p(L, \overline{\theta}) = p$ (i.e. the maximum $p(L, \overline{\theta})$ satisfying $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$). To implement this project choice, I consider the following transfers;

$$\begin{aligned}
t(\sigma, \overline{\theta}, y^S) &= C(\overline{\theta}, S), \mu_\sigma t(\sigma, \overline{\theta}, y^H) + (1 - \mu_\sigma) t(\sigma, \overline{\theta}, y^L) = C(\overline{\theta}, R); \\
t(L, \underline{\theta}, y^S) &= C(\underline{\theta}, S) + p [\Delta C_S - \Delta C_R] + \Delta C_R; \\
t(H, \underline{\theta}, y^S) &= C(\overline{\theta}, S), \mu_\sigma t(\sigma, \underline{\theta}, y^H) + (1 - \mu_\sigma) t(\sigma, \underline{\theta}, y^L) = C(\overline{\theta}, R).
\end{aligned}$$

Then, the principal can satisfy all the other constraints at no cost by using the above transfers and by choosing $t(\sigma, \theta, y^{\sigma})$ large and $t(\sigma, \theta, y^{\widehat{\sigma}})$ small (with $\sigma \neq \widehat{\sigma}$). Therefore, the optimal contract conditional on $p(L, \overline{\theta}) \leq p(H, \overline{\theta})$ and $p(\sigma, \underline{\theta}) \geq p(\sigma, \overline{\theta})$ satisfies $p(L, \overline{\theta}) = p(H, \overline{\theta})$.

Proof of Lemma 2

Consider first the case in which the agent can lie only about θ. Then, only the low cost type gets a rent which is equal to $p(\sigma, \overline{\theta}) [\Delta C_S - \Delta C_R] + \Delta C_R$ as is shown in the proof of Lemma 1. Note that a low cost type with $\sigma = L$ gets a higher rent than a low cost type with $\sigma = H$ because of $p(L, \overline{\theta}) \geq p(H, \overline{\theta})$.

Consider now the possibility that a low cost type can lie about both θ and σ. Given $p(L, \overline{\theta}) \geq p(H, \overline{\theta})$, a low cost type with $\sigma = H$ may have an incentive to announce $\sigma = L$. Suppose first that an agent with $(\sigma, \theta) = (H, \underline{\theta})$ announces $(L, \overline{\theta})$. Then, with probability $p(L, \overline{\theta})$, the safe project is chosen and he gets a rent equal to ΔC_S from the binding $\big(IR : L, \overline{\theta}, S\big)$. However, with probability $1 - p(L, \overline{\theta})$, the risky project is chosen and the payment he receives depends on the realization of the state. By increasing $t(L, \overline{\theta}, y^L)$ and decreasing $t(L, \overline{\theta}, y^H)$, the principal can satisfy $\big(IR : L, \overline{\theta}, R\big)$ with equality and at the same time satisfy

$$\mu_H t(L, \overline{\theta}, y^H) + (1 - \mu_H) t(L, \overline{\theta}, y^L) \leq C(\underline{\theta}, R).$$

Therefore, $V(L, \overline{\theta} : H, \underline{\theta}) = p(L, \overline{\theta}) \Delta C_S$.

Suppose now that an agent with $(\sigma, \theta) = (H, \underline{\theta})$ announces $(L, \underline{\theta})$. Given $p\,(L, \underline{\theta})$, let $t(L, \underline{\theta}, y)$ be such that

$$\begin{aligned} &U\,(L, \underline{\theta}) \equiv p(L, \underline{\theta}) \left[t(L, \underline{\theta}, y^S) - C(\underline{\theta}, S)\right] \\ &+(1 - p(L, \underline{\theta})) \left[\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L) t(L, \underline{\theta}, y^L) - C(\underline{\theta}, R)\right] = p(L, \overline{\theta}) \left[\Delta C_S - \Delta C_R\right] + \Delta C_R, \end{aligned} \tag{7}$$

where $t(L, \underline{\theta}, y^S) \geq C(\underline{\theta}, S)$ and $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L) t(L, \underline{\theta}, y^L) \geq C(\underline{\theta}, R)$ must hold to satisfy the individual rationality constraints. The principal wants to choose $t(L, \underline{\theta}, y)$ to maintain $V(L, \underline{\theta} : L, \overline{\theta}) = 0$ and at the same time to minimize $V(L, \underline{\theta} : H, \underline{\theta})$ given by

$$\begin{aligned} &V(L, \underline{\theta} : H, \underline{\theta}) \equiv p(L, \underline{\theta}) \left[t(L, \underline{\theta}, y^S) - C(\underline{\theta}, S)\right] \\ &+(1 - p(L, \underline{\theta})) \max\left\{0, \mu_H t(L, \underline{\theta}, y^H) + (1 - \mu_H) t(L, \underline{\theta}, y^L) - C(\underline{\theta}, R)\right\}. \end{aligned} \tag{8}$$

Then, by increasing $t(L, \underline{\theta}, y^L)$ and decreasing $t(L, \underline{\theta}, y^H)$, the principal can satisfy $\mu_L t(L, \underline{\theta}, y^H) + (1 - \mu_L) t(L, \underline{\theta}, y^L) = C(\overline{\theta}, R)$ and at the same time $\mu_H t(L, \underline{\theta}, y^H) + (1 - \mu_H) t(L, \underline{\theta}, y^L) < C(\underline{\theta}, R)$. Therefore, from (7) and (8), we have $V(L, \underline{\theta} : H, \underline{\theta}) = p(L, \overline{\theta}) \Delta C_S + \left[p(L, \underline{\theta}) - p(L, \overline{\theta})\right] \Delta C_R$.

Finally, since $p(L,\underline{\theta}) \geq p(L,\overline{\theta})$, we have $V(L,\underline{\theta} : H,\underline{\theta}) \geq V(L,\overline{\theta} : H,\underline{\theta})$. Therefore, if $p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right]\Delta C_R \geq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ holds, $V(H,\overline{\theta} : H,\underline{\theta}) \geq V(L,\underline{\theta} : H,\underline{\theta})$. The optimal transfers under the regular regime are given by[23]

$$\begin{aligned} t(\sigma,\overline{\theta},y^S) &= C(\overline{\theta},S), \mu_\sigma t(\sigma,\overline{\theta},y^H) + (1-\mu_\sigma)t(\sigma,\overline{\theta},y^L) = C(\overline{\theta},R); \\ t(\sigma,\underline{\theta},y^S) &= C(\underline{\theta},S) + \frac{p(\sigma,\overline{\theta})}{p(\sigma,\underline{\theta})}\left[\Delta C_S - \Delta C_R\right] + \Delta C_R; \\ \mu_\sigma t(\sigma,\underline{\theta},y^H) + (1-\mu_\sigma)t(\sigma,\underline{\theta},y^L) &= C(\overline{\theta},R); \end{aligned}$$

where the principal should choose $t(\sigma,\theta,y^\sigma)$ large and $t(\sigma,\theta,y^{\widehat{\sigma}})$ (with $\sigma \neq \widehat{\sigma}$) small. Although I chose $\mu_\sigma t(\sigma,\underline{\theta},y^H) + (1-\mu_\sigma)t(\sigma,\underline{\theta},y^L) = C(\overline{\theta},R)$, when both $p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right]\Delta C_R \geq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ and $p(\sigma,\underline{\theta}) \geq p(\sigma,\overline{\theta})$ hold strictly, the principal can achieve the same profit by choosing transfers satisfying $\mu_\sigma t(\sigma,\underline{\theta},y^H) + (1-\mu_\sigma)t(\sigma,\underline{\theta},y^L) < C(\overline{\theta},R)$.

Proof of Lemma 3

(i) The proof is done in the text right after Lemma 3.

(ii) When $p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right]\Delta C_R \leq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ holds, $V(L,\underline{\theta} : H,\underline{\theta}) \geq p(H,\overline{\theta})\Delta C_S + \left[1 - p(H,\overline{\theta})\right]\Delta C_R$. Therefore, a low cost type with $\sigma = H$ has an incentive to report $(L,\underline{\theta})$.

Given $p(H,\underline{\theta})$, let $t(H,\underline{\theta},y)$ be such that

$$\begin{aligned} &U(H,\underline{\theta}) \equiv p(H,\underline{\theta})\left[t(H,\underline{\theta},y^S) - C(\underline{\theta},S)\right] \\ &+(1-p(H,\underline{\theta}))\left[\mu_H t(H,\underline{\theta},y^H) + (1-\mu_H)t(H,\underline{\theta},y^L) - C(\underline{\theta},R)\right] \\ &= p(L,\overline{\theta})\Delta C_S + \left[p(L,\underline{\theta}) - p(L,\overline{\theta})\right]\Delta C_R, \end{aligned}$$

where $t(H,\underline{\theta},y^S) \geq C(\underline{\theta},S)$ and $\mu_H t(H,\underline{\theta},y^H) + (1-\mu_H)t(H,\underline{\theta},y^L) \geq C(\underline{\theta},R)$ must hold to satisfy the individual rationality constraints. Then, the principal wants to choose $t(H,\underline{\theta},y)$ to minimize $V(H,\underline{\theta} : H,\overline{\theta})$, given by

$$\begin{aligned} &V(H,\underline{\theta} : H,\overline{\theta}) = p(H,\underline{\theta})\max\left\{0, t(H,\underline{\theta},y^S) - C(\overline{\theta},S)\right\} \\ &+(1-p(H,\underline{\theta}))\max\left\{0, \mu_H t(H,\underline{\theta},y^H) + (1-\mu_H)t(H,\underline{\theta},y^L) - C(\overline{\theta},R)\right\}. \end{aligned}$$

By choosing $t(H,\underline{\theta},y^S) = C(\overline{\theta},S)$ and $\mu_H t(H,\underline{\theta},y^H) + (1-\mu_H)t(H,\underline{\theta},y^L) = C(\overline{\theta},R)$, the principal can give a rent $p(H,\underline{\theta})\left[\Delta C_S - \Delta C_R\right] + \Delta C_R$ to the low-cost type while making

[23] If $p(\sigma,\underline{\theta}) = 0$, then $p(\sigma,\overline{\theta}) = 0$ from the monotonicity constraint. Then, $V(\sigma,\overline{\theta} : \sigma,\underline{\theta}) = \Delta C_R$. Therefore, $t(\sigma,\underline{\theta},y^S)$ is irrelevant and $\mu_\sigma t(\sigma,\underline{\theta},y^H) + (1-\mu_\sigma)t(\sigma,\underline{\theta},y^L) = C(\overline{\theta},R)$ is optimal.

$V(H,\underline{\theta}:H,\overline{\theta})=0$. Therefore, if $A(p(L,\underline{\theta}),p(L,\overline{\theta}))\leq p(H,\underline{\theta})\left[\Delta C_S-\Delta C_R\right]+\Delta C_R$, the principal can satisfy $(IC:(H,\overline{\theta})\rightarrow(H,\underline{\theta}))$ at no cost. However, if $A(p(L,\underline{\theta}),p(L,\overline{\theta}))>p(H,\underline{\theta})\left[\Delta C_S-\Delta C_R\right]+\Delta C_R$ holds, then there are countervailing incentives such that a high cost type with $\sigma=H$ can get a rent equal to $V(H,\underline{\theta}:H,\overline{\theta})=A(p(L,\underline{\theta}),p(L,\overline{\theta}))-p(H,\underline{\theta})\left[\Delta C_S-\Delta C_R\right]-\Delta C_R>0$.

The optimal transfers under the countervailing regime I are given by:

$$\begin{aligned}
t(\sigma,\overline{\theta},y^S) &= C(\overline{\theta},S),\mu_\sigma t(\sigma,\overline{\theta},y^H)+(1-\mu_\sigma)t(\sigma,\overline{\theta},y^L)=C(\overline{\theta},R);\\
t(L,\underline{\theta},y^S) &= C(\underline{\theta},S)+\frac{p(L,\overline{\theta})}{p(L,\underline{\theta})}\left[\Delta C_S-\Delta C_R\right]+\Delta C_R;\\
\mu_L t(L,\underline{\theta},y^H)+(1-\mu_L)t(L,\underline{\theta},y^L) &= C(\overline{\theta},R);\\
t(H,\underline{\theta},y^S) &= C(\underline{\theta},S)+a;\\
\mu_H t(H,\underline{\theta},y^H)+(1-\mu_H)t(H,\underline{\theta},y^L) &= C(\underline{\theta},R)+b,
\end{aligned}$$

where $a\in[0,\Delta C_S]$, $b\in[0,\Delta C_R]$ and $p(H,\underline{\theta})a+(1-p(H,\underline{\theta}))b=A(p(L,\underline{\theta}),p(L,\overline{\theta}))$. The optimal transfers under the countervailing regime II are given by:

$$\begin{aligned}
t(L,\overline{\theta},y^S) &= C(\overline{\theta},S),\mu_L t(L,\overline{\theta},y^H)+(1-\mu_L)t(L,\overline{\theta},y^L)=C(\overline{\theta},R);\\
t(L,\underline{\theta},y^S) &= C(\underline{\theta},S)+\frac{p(L,\overline{\theta})}{p(L,\underline{\theta})}\left[\Delta C_S-\Delta C_R\right]+\Delta C_R;\\
\mu_L t(L,\underline{\theta},y^H)+(1-\mu_L)t(L,\underline{\theta},y^L) &= C(\overline{\theta},R);\\
t(H,\theta,y^S) &= C(\overline{\theta},S);\\
\mu_H t(H,\underline{\theta},y^H)+(1-\mu_H)t(H,\underline{\theta},y^L) &= C(\underline{\theta},R)+b;\\
\mu_H t(H,\overline{\theta},y^H)+(1-\mu_H)t(H,\overline{\theta},y^L) &= C(\overline{\theta},R)+\frac{U(H,\overline{\theta})}{1-p(H,\overline{\theta})},
\end{aligned}$$

where $U(H,\overline{\theta})=A(p(L,\underline{\theta}),p(L,\overline{\theta}))-p(H,\underline{\theta})\left[\Delta C_S-\Delta C_R\right]-\Delta C_R$ and b satisfies $b\geq 0$ and $p(H,\underline{\theta})\Delta C_S+(1-p(H,\underline{\theta}))b=A(p(L,\underline{\theta}),p(L,\overline{\theta}))$. Note that the principal should choose $t(\sigma,\theta,y^\sigma)$ large and $t(\sigma,\theta,y^{\widehat{\sigma}})$ (with $\sigma\neq\widehat{\sigma}$) small in order to minimize the agent's incentive to misrepresent σ. Note also that in the optimal transfers in both regimes, the downward incentive constraint $(IC:(L,\overline{\theta})\rightarrow(L,\underline{\theta}))$ binds in that $\mu_L t(L,\underline{\theta},y^H)+(1-\mu_L)t(L,\underline{\theta},y^L)=C(\overline{\theta},R)$.

Proof of Lemma 4

Under the regular regime, from the optimal transfers in Lemma 2, the rents are given as follows;

$$U(\sigma,\overline{\theta}) = 0$$

$$U(\sigma,\underline{\theta}) \;=\; p(\sigma,\overline{\theta})\Delta C_S + \left[1-p(\sigma,\overline{\theta})\right]\Delta C_R \text{ for } \sigma = H, L.$$

Suppose now that the constraint $p(H,\overline{\theta})\Delta C_S + \left[1-p(H,\overline{\theta})\right]\Delta C_R \geq A(p(L,\underline{\theta}), p(L,\overline{\theta}))$ is slack. Then, from A1, it is optimal to have $p(L,\theta) = 1$ and $p(H,\theta) = 0$. However, this violates the constraint, which is contradictory.

Proof of Lemma 5

Under the countervailing regime I, from the optimal transfers in Lemma 3, the rents are given as follows;

$$\begin{aligned}
U(L,\overline{\theta}) &= 0\\
U(L,\underline{\theta}) &= p(L,\overline{\theta})\Delta C_S + \left[1-p(L,\overline{\theta})\right]\Delta C_R\\
U(H,\underline{\theta}) &= A(p(L,\underline{\theta}), p(L,\overline{\theta}))\\
U(H,\overline{\theta}) &= A(p(L,\underline{\theta}), p(L,\overline{\theta})) - p(H,\underline{\theta})\left[\Delta C_S - \Delta C_R\right] - \Delta C_R.
\end{aligned}$$

(i) Since $p(H,\overline{\theta})$ does not affect any rent, from A1, it is optimal to have $p(H,\overline{\theta}) = 0$.

(ii) Concerning $p(H,\underline{\theta})$, the objective is given by

$$\begin{aligned}
&\frac{\nu}{2}\left\{p(H,\underline{\theta})\left[y^S - C(\underline{\theta},S)\right] + (1-p(H,\underline{\theta}))\left[\mu_H y^H + (1-\mu_H)y^L - C(\underline{\theta},R)\right]\right\}\\
&+\frac{1-\nu}{2}\max\left\{0, A(p(L,\underline{\theta}), p(L,\overline{\theta})) - p(H,\underline{\theta})\left[\Delta C_S - \Delta C_R\right] - \Delta C_R\right\}.
\end{aligned}$$

The first order derivative with respect to $p(H,\underline{\theta})$ is given by:

$$\begin{array}{ll}
\frac{\nu}{2}\left[y^S - C(\underline{\theta},S)\right] - \frac{\nu}{2}\left[\mu_H y^H + (1-\mu_H)y^L - C(\underline{\theta},R)\right] + \frac{1-\nu}{2}(\Delta C_S - \Delta C_R) & \text{if } U(H,\overline{\theta}) > 0\\
\frac{\nu}{2}\left[y^S - C(\underline{\theta},S)\right] - \frac{\nu}{2}\left[\mu_H y^H + (1-\mu_H)y^L - C(\underline{\theta},R)\right] & \text{otherwise.}
\end{array}$$

Therefore, if (6) holds, it is optimal to have $p(H,\underline{\theta}) = 0$. If (6) does not hold, as long as $p(H,\underline{\theta}) \leq 1$ holds, it is optimal to increase $p(H,\underline{\theta})$ up to when $U(H,\overline{\theta}) = 0$ (i.e. to choose $p(H,\underline{\theta}) = \left[A(p(L,\underline{\theta}), p(L,\overline{\theta})) - \Delta C_R\right] / \left[\Delta C_S - \Delta C_R\right]$); otherwise, $p(H,\underline{\theta}) = 1$ is optimal.

(iii) Suppose that the constraint $A(p(L,\underline{\theta}), p(L,\overline{\theta})) \geq p(H,\underline{\theta})\left[\Delta C_S - \Delta C_R\right] + \Delta C_R$ does not bind. Then, $p(H,\underline{\theta})$ is either zero or one. Concerning $p(L,\theta)$, the objective is given by:

$$\begin{aligned}
&\frac{\nu}{2}\left\{p(L,\underline{\theta})\left[y^S - C(\underline{\theta},S)\right] + (1-p(L,\underline{\theta}))\left[\mu_L y^H + (1-\mu_L)y^L - C(\underline{\theta},R)\right]\right\}\\
&-\frac{\nu}{2}\left\{p(L,\overline{\theta})\Delta C_S + \left[1-p(L,\overline{\theta})\right]\Delta C_R\right\}\\
&+\frac{1-\nu}{2}\left\{p(L,\overline{\theta})\left[y^S - C(\overline{\theta},S)\right] + (1-p(L,\overline{\theta}))\left[\mu_L y^H + (1-\mu_L)y^L - C(\overline{\theta},R)\right]\right\}\\
&-\frac{1}{2}A(p(L,\underline{\theta}), p(L,\overline{\theta})).
\end{aligned}$$

In addition, the monotonicity constraint $p(L,\underline{\theta}) \geq p(L,\overline{\theta})$ must be satisfied. There are three candidate solutions; $p(L,\underline{\theta}) = p(L,\overline{\theta}) = 1$ or $p(L,\underline{\theta}) = p(L,\overline{\theta}) = 0$ or $p(L,\underline{\theta}) = 1$ and $p(L,\overline{\theta}) = 0$. Given that $p(H,\overline{\theta}) = 0$ and $p(H,\underline{\theta}) = 0$ or 1, the only one among the three which strictly satisfies the constraint $A(p(L,\underline{\theta}), p(L,\overline{\theta})) \geq p(H,\underline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$ is $p(L,\theta) = 1$ and $p(H,\theta) = 0$. In this case, the optimal transfers are as described in Lemma 5.

Proof of Lemma 6

In the countervailing regime I, from the optimal transfers in Lemma 3**,** the rents are given as follows;

$$\begin{aligned}
U(\sigma,\overline{\theta}) &= 0 \\
U(L,\underline{\theta}) &= p(L,\overline{\theta})\Delta C_S + \left[1 - p(L,\overline{\theta})\right]\Delta C_R \\
U(H,\underline{\theta}) &= A(p(L,\underline{\theta}), p(L,\overline{\theta})).
\end{aligned}$$

(i) Note first that $p(H,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R \leq A(p(L,\underline{\theta}), p(L,\overline{\theta})) \leq p(H,\underline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$ implies $\Delta C_R \leq A(p(L,\underline{\theta}), p(L,\overline{\theta})) \leq \Delta C_S$ since $p(H,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R \geq \Delta C_R$ and $p(H,\underline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R \leq \Delta C_S$ hold. As $p(H,\theta)$ does not affect any rent, from A1, it is optimal to choose the minium $p(H,\theta)$ satisfying $p(H,\overline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R \leq A(p(L,\underline{\theta}), p(L,\overline{\theta})) \leq p(H,\underline{\theta})\,[\Delta C_S - \Delta C_R] + \Delta C_R$. This implies $p(H,\overline{\theta}) = 0$ and $p(H,\underline{\theta}) = \frac{A(p(L,\underline{\theta}),p(L,\overline{\theta})) - \Delta C_R}{\Delta C_S - \Delta C_R}$, which also satisfy the monotonicity constraint $p(H,\overline{\theta}) \leq p(H,\underline{\theta})$.

(ii) Concerning $p(L,\theta)$, consider first the case in which $p(L,\underline{\theta}) > p(L,\overline{\theta})$. The objective is given by:

$$\begin{aligned}
&\frac{\nu}{2}\left\{p(L,\underline{\theta})\left[y^S - C(\underline{\theta},S)\right] + (1 - p(L,\underline{\theta}))\left[\mu_L y^H + (1-\mu_L)y^L - C(\underline{\theta},R)\right]\right\} \\
&-\frac{\nu}{2}\left\{p(L,\overline{\theta})\Delta C_S + \left[1 - p(L,\overline{\theta})\right]\Delta C_R\right\} \\
&+\frac{1-\nu}{2}\left\{p(L,\overline{\theta})\left[y^S - C(\overline{\theta},S)\right] + (1 - p(L,\overline{\theta}))\left[\mu_L y^H + (1-\mu_L)y^L - C(\overline{\theta},R)\right]\right\} \\
&+\frac{\nu}{2}\left\{p(H,\underline{\theta})\left[y^S - C(\underline{\theta},S)\right] + (1 - p(H,\underline{\theta})\left[\mu_H y^H + (1-\mu_H)y^L - C(\underline{\theta},R)\right]\right\} \\
&-\frac{\nu}{2}A(p(L,\underline{\theta}), p(L,\overline{\theta}))
\end{aligned}$$

where $p(H,\underline{\theta}) = \frac{A(p(L,\underline{\theta}),p(L,\overline{\theta})) - \Delta C_R}{\Delta C_S - \Delta C_R}$. The solution of this program satisfies $p(L,\underline{\theta}) > p(L,\overline{\theta})$ only when the first-order derivative with respect to $p(L,\underline{\theta})$ is positive while the one with respect to $p(L,\overline{\theta})$ is negative and in this case we have $p(L,\underline{\theta}) = 1, p(L,\overline{\theta}) = 0$, which implies $p(H,\theta) = 0$. Consider now the case in which $p(L,\underline{\theta}) = p(L,\overline{\theta})$ holds (i.e. the monotonicity constraint binds). Then, $A(p(L,\theta)) = p(L,\theta)\Delta C_S$, implying that $\Delta C_R/\Delta C_S \le p(L,\theta) \le 1$. If the first-order derivative with respect to $p(L,\theta)$ is positive, we have $p(L,\theta) = 1$; otherwise, we have $p(L,\theta) = \Delta C_R/\Delta C_S$. In the first case, we have $p(H,\underline{\theta}) = 1, p(H,\overline{\theta}) = 0$ while in the second case, we have $p(H,\theta) = 0$. The optimal transfers are as described in Lemma 6. Note that the principal has enough degree of freedom to satisfy $V(\widehat{\sigma},\widehat{\theta} : \sigma,\theta) \le U(\sigma,\theta)$ for any $(\widehat{\sigma},\widehat{\theta})$.

Proof of Proposition 4

I already proved that $z < 1$. When $\widehat{\sigma} = H$, we have:

$$\mu(H : z) = \mu_H \text{ for any } z;\ \nu(H : z) = \frac{\nu z}{1-\nu+\nu z} \le \nu.$$

Therefore from $\nu(H : z) \le \nu$ and A1, it is optimal to have $p(\theta \mid H) = 0$, $\mu_H t(\theta, y^H \mid H) + (1-\mu_H)t(\theta, y^L \mid H) = C(\overline{\theta}, R)$.

When $\widehat{\sigma} = L$, we have:

$$\mu(L : z) = \mu_H \frac{v(1-z)}{1+\nu-\nu z} + \mu_L \frac{1}{1+\nu-\nu z};\ \nu(L : z) = \frac{\nu(2-z)}{1+\nu-\nu z} \ge \nu.$$

Define $\Pi(\nu, z)$ as follows:

$$\Pi(\nu,z) \equiv y^S - C(\overline{\theta},S) - \left[\mu(L:z)y^H + (1-\mu(L:z))y^L - C(\overline{\theta},R)\right] - \frac{\nu(L:z)}{1-\nu(L:z)}\left(\Delta C_S - \Delta C_R\right).$$

I note that $\frac{\partial \Pi}{\partial \nu} < 0$, $\frac{\partial \Pi}{\partial z} > 0$ and $y^S - C(\underline{\theta},S) - \left[\mu(L:z)y^H + (1-\mu(L:z))y^L - C(\underline{\theta},R)\right] > \Pi(\nu,z)$ hold.

I have the following Lemma.

Lemma 7 *(i) When $\Pi(\nu,0) > 0$, there exists a unique equilibrium with $z = 0$.*

(ii) When $\Pi(\nu,0) = 0$, there exists a unique equilibrium with $z = 0$.

(iii) When $\Pi(\nu,0) < 0$, for each $z \in [0, z^*(\nu)]$ with $\frac{dz^*}{d\nu} > 0$, there exists an equilibrium.

Proof. (i) When $\Pi(\nu,0) > 0$ and $z = 0$, it is optimal to have $p(\theta \mid L) = 1$ and $t(\theta, y^S \mid L) = C(\overline{\theta}, S)$ for $\theta \in \Theta$. Thus, $z = 0$ is the unique best response for the low-cost type.

(ii) If $\Pi(\nu,0) = 0$ and $z = 0$, it is optimal to choose $p(\underline{\theta} \mid L) = 1$ and any $p(\overline{\theta} \mid L) \in [0,1]$. The optimal transfers are $t(\underline{\theta}, y^S \mid L) = C(\underline{\theta}, S) + \Delta C_R + p(\overline{\theta} \mid L)(\Delta C_S - \Delta C_R)$, $t(\overline{\theta}, y^S \mid L) = C(\overline{\theta}, S)$ and $\mu_L t(\overline{\theta}, y^H \mid L) + (1-\mu_L)t(\overline{\theta}, y^L \mid L) = C(\overline{\theta}, R)$. In this case, $z = 0$ is the unique best response for $p(\overline{\theta} \mid L) > 0$ and one among the best responses for

$p(\overline{\theta} \mid L) = 0$. There cannot be any other equilibrium with $z > 0$. If $z > 0$, it is optimal to choose $p(\underline{\theta} \mid L) = p(\overline{\theta} \mid L) = 1$. However, in this case, $z = 0$ is the unique best response for the low-cost type as in the proof of (i).

(iii) If z is such that $\Pi(\nu, z) < 0$, it is optimal to have $p(\overline{\theta} \mid L) = 0$. $p(\underline{\theta} \mid L) = 1$ if $y^S - C(\underline{\theta}, S) - \left[\mu(L : z)y^H + (1 - \mu(L : z))y^L - C(\underline{\theta}, R)\right] > 0$; otherwise, $p(\underline{\theta} \mid L) = 0$. If $p(\overline{\theta} \mid L) = 0$ and $p(\underline{\theta} \mid L) = 1$, it is optimal to choose $t(\overline{\theta} \mid L) = C(\overline{\theta}, R)$ and $t(\underline{\theta} \mid L) = C(\underline{\theta}, S) + \Delta C_R$. If $p(\overline{\theta} \mid L) = 0 = p(\underline{\theta} \mid L)$, it is optimal to choose $t(\theta \mid L) = C(\overline{\theta}, R)$ for $\theta \in \Theta$. Since, in both cases, the low-cost type has the same rent regardless of whether he reports H or L, each $z \in [0, z^*(\nu)]$ constitutes an equilibrium, where z^* is defined by $\Pi(\nu, z^*) \equiv 0$. Since $\frac{\partial \Pi}{\partial \nu} < 0$ and $\frac{\partial \Pi}{\partial z} > 0$ hold, we have $\frac{dz^*}{d\nu} > 0$. ■

The result of proposition 4(iii) follows from the previous Lemma.