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A Theory of Information Flows

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Abstract

Obtaining information about changes in market conditions is vital for the survival of the firms operating in a changing environment. In this paper, we offer a theory of information flows in a setting in which the principal faces a project choice and needs to induce the agent, who is responsible for production, to acquire and transmit a signal to improve the matching between the project and the environment. Distortions in information flows arise since the production cost is known only to the agent and therefore he may protect his information rent by withholding the signal. The optimal incentive scheme exhibits countervailing incentives which create a trade-off between the amount of transmitted information and rent extraction. Our theory offers a rationale for the separation of day-to-day operating decisions from long-term strategic decisions stressed by Williamson.

Key Words: Information Flows, Countervailing Incentives, Multitasking, Asymmetric Information.

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1 Introduction

How to motivate agents to acquire and/or transmit information is a fundamental question in any organization. Information management is particularly important for the firms operating in a changing environment since their success or failure is crucially determined by the ability to adjust to changes, which in turn depends on the ability to obtain information about the changes.[1]

In this paper, we offer a theory of information flows focusing on agent(s)' incentives to acquire and/or transmit information. Indeed, distortions in bottom-up information flows are emphasized by Simon (1961) as a major problem of hierarchies[2] and information withholding is well documented by sociologists like Crozier (1967) and Dalton (1959).[3] In our approach, we distinguish two kinds of information that an agent can possess: information about parameters which directly determine his payoff[4] (such as his ability or his private benefit accruing from some tasks) and other information relevant for the decision making of his organization (such as information about changes in technology or in consumer tastes). When the former is private information, the agent can obtain an information rent. This in turn induces him to be strategic in transmitting the latter while he would transmit it if he did not derive any rent from the former. Therefore, in order to design an incentive scheme to improve information flows, we need to study how the information in question is linked to the underlying information structure generating the rent.

The above ideas are formalized in a principal-agent model in which the principal faces a project choice in an uncertain environment and the agent has to execute two tasks: to acquire and transmit information about the environment, and then to produce. The agent has private information about

[1] For instance, Jeff Papows (1998), president and CEO of Lotus, says, "Today's business climate is characterized by chronic and often radical change. ...... an organization's ability to anticipate and respond to change rests on being able to bring current, targeted information to the right constellation of learners...... (p.122)."

[2] According to Simon, a great difficulty in administrative hierarchies is that much of the information relevant to the decisions at the higher levels originates at lower levels and may not reach the higher levels unless the executive is extraordinarily alert (p. 163).

[3] Moreover, the majority of the literature on collusion in principal-agent frameworks, initiated by Tirole (1986), deals with information withholding. See also Milgrom and Roberts (1990).

[4] Throughout the paper, we use "she" for the principal and "he" for the agent.

his productive efficiency. Our analysis is focused on how rent-seeking behavior affects the incentive to acquire and transmit the information which allows the principal to improve the match between her project and the environment. Therefore, the term "information flow" refers to the bottom-up transmission of this information. We study the optimal incentive scheme to induce the agent to acquire and transmit information when the same agent is charged with production and derive some implications on organizational design.

When the information is good news in the sense that the agent does not suffer any loss in the rent after transmitting the information, there would be no distortion in information flows. Hence, we mostly focus on the case of bad news and find that the optimal incentive scheme exhibits *countervailing incentives* which create a *trade-off between the amount of transmitted information and rent extraction.* Our theory also provides a rationale for 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 M-form structure.

In our model, the principal faces a choice between the default project and a new one. The agent is assumed to be risk neutral and protected by limited liability. He can receive or not a signal which shows that the environment is favorable to the new project. In the absence of the signal, it is optimal for the principal to choose the default project. Because the principal does not know whether or not the agent has received the signal, the agent can withhold it and pretend not to have received any. We distinguish two cases: in the case of information transmission, the agent can receive the signal costlessly before the principal offers a mechanism and in the case of information acquisition and transmission, the principal has to induce the agent to incur a cost to acquire the signal. Both cases are relevant in reality: agents often receive information as by-products of executing their own tasks but sometimes they need to exert effort to look for specific information.

To provide an intuition about the countervailing incentives, let us consider the case of information transmission. Suppose that the agent's type can be either efficient or inefficient. It is well known that given a project choice, the efficient type's incentive constraint is binding and the inefficient type has no information rent. Assume that given a project choice, the efficient type obtains a higher rent under the default project than under the new project. Suppose now that the project choice is endogenous and the agent should be induced to transmit the signal. Then, the principal can induce either both types to transmit the signal or only the type losing less from the change to the new project, i.e., the inefficient type, to transmit the signal. In the first case, in order to induce the efficient type to transmit the signal, the principal has to compensate him for the reduction in his rent and this induces the principal to make him a transfer larger than the inefficient type's production cost under the new project. Therefore, there exist countervailing incentives: the inefficient type can obtain a strictly positive rent by pretending to be the efficient type and by transmitting the signal. However, when the principal induces only the inefficient type to transmit the signal, he does not obtain any rent by transmitting the signal. Therefore, there exists a trade-off between obtaining the signal from the efficient type and extracting the rent from the inefficient type.

This trade-off can make it optimal to induce only the inefficient type to transmit the signal. In this case, the project choice exhibits a bias toward the default project compared to the situation in which the principal herself can obtain the signal and, surprisingly, the principal's expected payoff is strictly decreasing in the probability of facing the efficient type. This happens although both types have the same technology in obtaining the signal and the efficient type has a lower production cost than the inefficient type does. We note that if the principal herself can obtain the signal, her payoff cannot decrease in the probability of facing the efficient type. Our results can provide an explanation of why good firms can go bad: if there is a positive correlation between the successfulness of a firm and the rent that its manager enjoys under the status-quo project, a more successful firm might suffer more from distortions in information flows and fail to adapt its core-activity to the changes in business environment.

Under task separation, there are two agents: one charged with information acquisition and transmission and the other charged with production. As the former does not take into account the negative externalities 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.

Our paper provides other interesting results and insights: it offers a micro-foundation of managerial entrenchment (see Section 4.4.)[5] and two extensions respectively reveal that distortions in information flow can generate both "excess inertia" and "excess momentum" in project choice (see Section 6).[6]

The paper is organized as follows. Section 2 briefly reviews the related literature. Section 3 presents the model. Section 4 provides the key intuition by analyzing the case of information transmission. Section 5 analyzes the case of information acquisition and transmission: we study both the case of bad news and that of good news, compare task separation with integration and derive implications of our results. Section 6 provides two extensions of the model of information transmission and discusses the robustness of the results with respect to relaxing our assumptions. Section 7 provides the conclusion and suggests directions for future research.

2 Related literature

Information acquisition in principal-agent relationships has been studied by Crémer and Khalil (1992), Crémer, Khalil and Rochet (1998a, 1998b), and Lewis and Sappington (1997). In this literature, the agent can acquire information about the cost parameter after incurring some expense. Thus, one important question they ask is whether or not it is better to induce the agent to know his type. In contrast, in our paper, the agent knows his cost parameter at the outset and information acquisition is about the desirability of projects. We are interested in knowing which type of the agent should be given the incentive to acquire information. Putting it in a different way, we deal with a two-dimensional screening problem in which one-dimensional information should be acquired by the agent. To the best of our knowledge, this problem has not been studied before in the literature.

In the literature on multi-tasking, we can distinguish models with moral hazard (Holmström and Milgrom (1990, 1991), Dewatripont and Tirole (1999)) from those with adverse selection (Laffont and Tirole (1991)). Our model belongs to the second. In terms of findings, though, our paper is related to that of Dewatripont and Tirole. They offer an argument favoring advocacy

[5] Regarding managerial entrenchment, see Shleifer and Vishny (1989).

[6] The terms "excess inertia" and "excess momentum" are borrowed from IO literature on technology adoption: see Farrell and Saloner (1986). In our context, excess inertia (momentum) means that the default project (the new project) is excessively chosen.

over nonpartisanship: a nonpartisan's incentives are impaired by his pursuing several conflicting causes at the same time. This argument is similar to the intuition for our result favoring task separation over task integration. However, their result is derived from an incompleteness of the contracts 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.

Hirao (1994) studies when it is optimal to assign both project evaluation and operation tasks to the same agent in a moral hazard setting 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 can get a rent only with the risky one and consequently has a preference for it. Assuming that the signal is soft information, he shows that task separation is optimal when the accuracy of the signal is exogenous. Our paper differs from his not only in terms of modeling choice (we use an adverse selection model and assume that the signal is hard information) but also in terms of the focus (we are interested in the reasons why firms fail to adjust to changes) and the results (we derive countervailing incentives). Levitt and Snyder (1997) also study the interaction between work incentive and the incentive to transmit information in a moral hazard setting. In their setting, after exerting work effort, the agent receives a signal about the success probability of the ongoing 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 starts to work after transmitting the signal.[7]

Countervailing incentives are studied in the principal-agent literature on type-dependent reservation utility (Lewis and Sappington (1989), Maggi and Rodriguez (1995), Jullien (2000)). In our model, the agent has zero reservation utility regardless of type. However, the fact that the principal has

[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 study the interaction between the production incentive and the incentive to transmit information about benefit of project(s).

to rely on the agent for the information justifying a new project makes his utility under the default project play the role of (endogenously determined) type-dependent reservation utility.

3 The Model

3.1 Projects, tasks and technology

There are one principal and one agent. The principal must choose one of two projects: the default project or the new project. The project is denoted by j, where $j = d$ represents the default project and $j = n$ the new project. The environment, denoted by ϵ, is favorable to one of the two projects. If $\epsilon = d$, it is favorable to the default project and if $\epsilon = n$, it is favorable to the new project. Let μ denote the probability of having $\epsilon = d$. For simplicity, we assume $\mu = \frac{1}{2}$.

The agent has two tasks: first, to acquire and transmit information about the environment and then to produce. Before the principal offers the mechanism, the agent discovers his type θ, which represents his productive efficiency. The type is efficient ($\theta = \underline{\theta}$) with probability ν and inefficient ($\theta = \overline{\theta}$) with probability $1 - \nu$. His cost of production, denoted by $C(\theta : j)$, depends on the type and the project[8]: $\underline{C}_j \equiv C(\underline{\theta}, j)$ represents the efficient type's cost under project j while $\overline{C}_j \equiv C(\overline{\theta}, j)$ represents that of the inefficient type. The difference between the two values, denoted by $\Delta C_j \equiv \overline{C}_j - \underline{C}_j$, is assumed to be positive for each j. The agent's type and consequently his production cost are his private information. The distribution of the type is common knowledge.

3.2 Information about the environment

Let σ be information received about the environment. The agent either receives the signal s (i.e., $\sigma = s$) or does not receive any signal (i.e., $\sigma = \emptyset$). The probability of receiving σ conditional on the realization of the environment

[8]Our results hold when there is uncertainty about the cost under the new project $C(\theta : n)$. See the discussion in Section 6.3.

is given as follows:

	$\epsilon = d$	$\epsilon = n$
$\sigma = \emptyset$	1	$1 - \xi$
$\sigma = s$	0	ξ

Hence, the probability of having $\epsilon = d$ conditional on σ, denoted by μ_σ, is given by:

$$\mu_s = 0,[9] \quad \mu_\emptyset = \frac{1}{2-\xi}.$$

Define x as:

$$x \equiv \frac{\xi}{2}.$$

x represents the ex ante probability of receiving s. The agent can always pretend to have received $\sigma = \emptyset$.

For simplicity, we assume that the signal s is verifiable. However, we would like to emphasize the fact that the outcomes of the optimal mechanisms can be implemented even when the signal cannot be verified by a third-party if the projects are contractible and the principal can understand the meaning of the signal (see remark in section 4). As Dewatripont and Tirole (2003) argue, economic theory has focused on two polar cases of soft and hard information while, in practice, information is often neither soft nor hard and how much a receiver can understand the content of the information transmitted by a sender depends on the former's motivation and ability etc. For instance, in our context, a CEO (the principal) may have too much information to examine and the signal provided by a division manager (the agent) can allow her to focus her attention on the relevant information and to realize that the environment is favorable to the new project.

We distinguish two cases: information transmission and information acquisition and transmission. In the former case, information acquisition is costless and the agent receives σ before the principal offers a mechanism. In the latter case, the agent has to incur a cost $k (\geq 0)$ to receive s and the principal can use her mechanism to induce him to incur the cost. The cost is interpreted as the disutility of exerting effort and therefore the principal cannot observe whether or not the agent incurs the cost.

[9] This is a simplifying assumption. Our results also hold for $\mu_s > 0$.

3.3 Utilities and mechanism

The principal's utility is given by her benefit minus the transfer made to the agent. Her benefit, denoted by B_ϵ^j, depends on the matching between her project choice and the realized environment. We assume that B_ϵ^j is given by:

	$\epsilon = d$	$\epsilon = n$
$j = d$	$B_d^d \equiv B^d > 0$	$B_n^d = 0$
$j = n$	$B_d^n = 0$	$B_n^n \equiv B^n > 0$

An example of the above benefit function is the core activity choice in the high-tech industry. In this sector, core activity must be well adapted to rapidly changing market conditions. Since we have in mind long-term impacts on the principal's payoff, we assume that benefit is not contractible.[10]

The agent's utility is equal to the transfer from the principal minus the information acquisition and production costs. The agent is assumed to have limited liability such that he can quit the organization at any time and gets his reservation utility.[11] Therefore, ex post participation constraints should be satisfied. However, when the agent can costlessly receive the signal before the principal offers a mechanism, our results are obtained even though the participation constraints are written in expected terms. His reservation utility is normalized to zero regardless of type.

According to the revelation principle, we can restrict our attention, without loss of generality, to the set of direct revelation mechanisms:[12]

$$\left\{q(\widehat{\theta}), p(\widehat{\sigma} \mid \widehat{\theta}), p(NA \mid \widehat{\theta}), t(\widehat{\sigma}, j \mid \widehat{\theta}), t(NA, j \mid \widehat{\theta})\right\},$$

where $\widehat{\theta}$ (respectively, $\widehat{\sigma}$) represents the agent's report about the type (respectively, the signal), $q(\cdot)$ is the probability of asking the agent to acquire information, $p(\cdot)$ is the probability of choosing the default project and $t(\cdot)$ is the transfer to the agent. After receiving the agent's report $\widehat{\theta}$, the principal asks him to acquire information with probability $q(\cdot)$. In this case, the agent should make report about the signal after acquiring information and

[10] When the benefit is contractible, our results hold as long as the participation constraints are satisfied ex post: see the discussion in Section 6.3.

[11] This corresponds to what Sappington (1983) calls limited zero-liability. In reality, we rarely observe negative severance pay.

[12] We here present the mechanism for the case of information acquisition and transmission: see Section 4 for the mechanism in the case of information transmission.

the principal implements the contract $\left[p(\widehat{\sigma} \mid \widehat{\theta}), t(\widehat{\sigma}, j \mid \widehat{\theta})\right]$. With probability $1 - q(\cdot)$, the principal does not ask him to acquire information and implements the contract $\left[p(NA \mid \widehat{\theta}), t(NA, j \mid \widehat{\theta})\right]$ where NA means no acquisition of information. Because of the ex post participation constraints, the transfers depend on the project chosen. Since we suppose that the principal must choose one of two projects and cannot choose both projects at the same time, the probability of realizing the new project is equal to $1 - p$.[13]

3.4 Main assumptions

When the cost differential between the two types is larger under the default project than under the new project ($\Delta C_d > \Delta C_n$), the signal is bad news from the efficient type's point of view in the following sense: if the signal s were obtained by the principal, she would choose the new project and this would decrease his rent since the transfer he receives is determined by the inefficient type's cost. Since the inefficient type is indifferent between the two projects, the signal is bad news to the agent in a weak sense when $\Delta C_d > \Delta C_n$ holds. Similarly, when $\Delta C_d \leq \Delta C_n$ holds, the signal is good news. Since distortions in information flow arise only when the signal is bad news, we focus on the case $\Delta C_d > \Delta C_n$[14] although we analyze the opposite case $\Delta C_d \leq \Delta C_n$ as well (see Section 5.2). In most of the sections, we adopt the following assumptions.

Assumption 0: The signal is bad news $(\Delta C_d > \Delta C_n)$.

Assumption 1: $\frac{B^d}{2} - \overline{C}_d - \frac{\nu}{1-\nu}\Delta C_d > \frac{B^n}{2} - \overline{C}_n - \frac{\nu}{1-\nu}\Delta C_n$.

Assumption 2: $x\left(B^n - \underline{C}_n + \underline{C}_d\right) \geq k$.

[13] Hence, there is no possibility of shutdown, which is natural if the project represents core activity.

[14] The inequality $\Delta C_d > \Delta C_n$ is likely to hold often in reality provided that the efficient type is better than the inefficient type at reducing costs. For instance, consider the case in which the principal chooses one among several projects which initially have the same cost differential. Suppose that while working on the project, the agent accumulates know-how to decrease the production cost. If the efficient type accumulates more know-how than the inefficient type does, the cost differential will be larger under the current (default) project than under any other project having the same initial cost differential.

Under assumptions 0 and 1, if information acquisition about the environment is impossible, it is optimal for the principal to keep the default project for both types given the prior on θ.[15] Therefore, assumption 1 justifies the notion of the default project. Under assumptions 0 to 2, in the benchmark in which the principal herself can acquire the signal, it is optimal to acquire the signal regardless of the type and to choose the new project if and only if $\sigma = s$.[16] In other words, under the assumptions, the value of the signal is larger than k for both types in the benchmark.

4 The simple model: information transmission

In this section, we analyze the simple case in which the agent receives $\sigma \in \{\emptyset, s\}$ without any cost ($k = 0$) before the principal offers a mechanism. The case represents the situations in which the agent receives information as by-products of executing his job. The intuition, derived in this section, about the trade-off between the amount of transmitted information and rent extraction can still be applied to the case of information acquisition and transmission, analyzed in the next section. In this section, we consider Bayesian participation constraints. However, it is easy to check that the optimal mechanism derived in this section is still optimal even if we consider ex post participation constraints. The principal's program is similar to that of a standard mechanism design with multi-dimensional screening.

According to the revelation principle, without loss of generality, we can restrict our attention to the set of direct revelation mechanisms:

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

[15] The assumption says that the benefit minus the virtual cost of the inefficient type is larger under the default project than under the new project. Hence, it is optimal to keep the default project when the agent is inefficient. This implies, under assumption 0, that it is also optimal to keep the default project when the agent is efficient.

[16] See Jeon (2002) for the detailed exposition of the benchmark in which the principal herself can acquire σ while the agent has private information on θ. The inequality in assumption 2 means that, conditional on that the agent is efficient, the expected benefit from acquiring information is larger than the cost k. This together with assumption 0 implies that acquiring information is also optimal when the agent is inefficient.

We introduce the following notation regarding the agent's utility:

$$V(\widehat{\sigma},\widehat{\theta}:\sigma,\theta)\equiv t(\widehat{\sigma},\widehat{\theta})-p(\widehat{\sigma},\widehat{\theta})C(\theta,d)-(1-p(\widehat{\sigma},\widehat{\theta}))C(\theta,n),$$
$$U(\sigma,\theta)\equiv V(\sigma,\theta:\sigma,\theta).$$

To induce acceptance, the mechanism should satisfy the following individual rationality constraint for each (σ,θ):

$$(IR:\sigma,\theta)\qquad U(\sigma,\theta)\geq 0. \tag{1}$$

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

$$(IC:(s,\theta)\rightarrow(\widehat{\sigma},\widehat{\theta}))\qquad U(s,\theta)\geq V(\widehat{\sigma},\widehat{\theta}:s,\theta); \tag{2}$$

$$(IC:(\emptyset,\theta)\rightarrow(\emptyset,\widehat{\theta}))\qquad U(\emptyset,\theta)\geq V(\emptyset,\widehat{\theta}:\emptyset,\theta). \tag{3}$$

We note that since s is verifiable, the agent cannot pretend to have received s when $\sigma=\emptyset$.

The principal's program, denoted by P^T, is given by:

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

subject to (1) to (3),

where

$$\begin{aligned}E(NB\quad\mid\quad\theta)\equiv\; & x\left\{p(s,\theta)\mu_s B^d+(1-p(s,\theta))(1-\mu_s)B^n-t(s,\theta)\right\}\\ & +(1-x)\left\{p(\emptyset,\theta)\mu_\emptyset B^d+(1-p(\emptyset,\theta))(1-\mu_\emptyset)B^n-t(\emptyset,\theta)\right\}.\end{aligned}$$

The next proposition characterizes the optimal mechanism.

Proposition 1 *(information transmission) Under assumptions 0 to 2, the optimal mechanism for information transmission is characterized by:*

1. Binding constraints: $(IR:\emptyset,\overline{\theta})$, $(IC:(\emptyset,\underline{\theta})\rightarrow(\emptyset,\overline{\theta}))$, $(IC:(s,\underline{\theta})\rightarrow(\emptyset,\underline{\theta}))$ *and* $(IC:(s,\overline{\theta})\rightarrow(s,\underline{\theta}))$.

2. The optimal mechanism exhibits no bias or a bias toward the default project. In each case, we have:

· *no bias:* $p(s,\theta)=0$, $p(\emptyset,\theta)=1$, $t(s,\theta)=\Delta C_d+\underline{C}_n$, $t(\emptyset,\theta)=\overline{C}_d$.

· *bias toward the default project:*

1) the efficient type: $p(\sigma,\underline{\theta})=1, t(\sigma,\underline{\theta})=\overline{C}_d$.

2) the inefficient type: $p(s,\overline{\theta})=0$, $p(\emptyset,\overline{\theta})=1$. $t(s,\overline{\theta})=\overline{C}_n$, $t(\emptyset,\overline{\theta})=\overline{C}_d$.

3. The optimal mechanism exhibits a bias toward the default project if $\nu\in(0,\nu^T)$, *with* ν^T *defined below:*

$$\frac{1-\nu^T}{\nu^T}(\Delta C_d-\Delta C_n)\equiv B^n+\underline{C}_d-\underline{C}_n.$$

In this case, the principal's expected payoff is strictly decreasing in ν.

Proof. See Appendix 1.

Concerning the binding constraints, when the agent received $\emptyset$, as usual, the inefficient type's individual rationality constraint $(IR:\emptyset,\overline{\theta})$ and the efficient type's incentive compatibility constraint $(IC:(\emptyset,\underline{\theta})\to(\emptyset,\overline{\theta}))$ are binding: then, the efficient type gets a rent equal to $U(\emptyset,\underline{\theta})=p(\emptyset,\overline{\theta})(\Delta C_d-\Delta C_n)+\Delta C_n$. Consider now the case in which the agent received s. In order to induce the efficient type to transmit the signal, the principal has to concede him the rent that he would obtain by concealing the signal and reporting truthfully his type, which makes the constraint $(IC:(s,\underline{\theta})\to(\emptyset,\underline{\theta}))$ binding. Since $(IC:(\emptyset,\underline{\theta})\to(\emptyset,\overline{\theta}))$ is binding as well, the efficient type having the signal will obtain a rent equal to $U(s,\underline{\theta})=U(\emptyset,\underline{\theta})$. Since this induces the principal to give a high transfer to the efficient type having the signal, there exist countervailing incentives (i.e., the inefficient type's incentive compatibility constraint $(IC:(s,\overline{\theta})\to(s,\underline{\theta}))$ is binding (see Figure 1)) and the inefficient type can have a positive rent $U(s,\overline{\theta})=\left(p(\emptyset,\overline{\theta})-p(s,\underline{\theta})\right)(\Delta C_d-\Delta C_n)$ if $p(\emptyset,\overline{\theta})>p(s,\underline{\theta})$.[17] Although the agent has the same reservation utility regardless of type, countervailing incentives arise in our model since the agent having the signal can conceal it and obtain the rent he obtains when having no signal: in other words, $U(\emptyset,\theta)$ plays the role of the reservation utility for the agent having the signal.

We now investigate the optimal project choice. First, concerning $p(\emptyset,\underline{\theta})$ and $p(s,\overline{\theta})$, since they do not affect the agent's rent, there is no distortion in project choice and $p(\emptyset,\underline{\theta})=1$ and $p(s,\overline{\theta})=0$ are optimal. Second, an increase in $p(\emptyset,\overline{\theta})$ induces an increase in $U(\emptyset,\underline{\theta})$, $U(s,\underline{\theta})$ and $U(s,\overline{\theta})$. Therefore, the principal has to compare the gain from improving project

[17] $U(s,\overline{\theta})$ is negative when $p(\emptyset,\overline{\theta})\le p(s,\underline{\theta})$ holds and thus the individual rationality constraint might be violated. However, this never happens since we prove that it is optimal to have $p(\emptyset,\overline{\theta})=1$.

$$\begin{tikzcd}
(s,\underline{\theta}) \arrow[r] & (\phi,\underline{\theta}) \arrow[d] \\
(s,\overline{\theta}) \arrow[u] & (\phi,\overline{\theta})
\end{tikzcd}$$

Figure 1: Binding incentive constraints when the signal is bad news

choice with the loss from granting more rent. However, under assumptions 0 to 2, it turns out that the gain is larger than the loss and therefore it is optimal to choose $p(\emptyset, \overline{\theta}) = 1$ (see Appendix 1). Last, since a decrease in $p(s, \underline{\theta})$ induces an increase in $U(s, \overline{\theta})$, the principal faces a trade-off between improving project choice and extracting the inefficient type's rent, which can make a bias toward the default project ($p(s, \underline{\theta}) = 1$) optimal.

To provide an intuition for why this bias can be optimal, we examine the agent's rent. First, the efficient type's rent is given by ΔC_d regardless of whether the mechanism is biased or not. As long as the principal maintains the default project when the inefficient type reports $\emptyset$, the efficient type can always have a rent equal to ΔC_d by adopting the following strategy: he pretends to be the inefficient type and reports $\emptyset$. Second, the inefficient type's rent depends on whether the mechanism exhibits a bias or not. If there is no bias, the principal should compensate the efficient type for the decrease in the rent from ΔC_d to ΔC_n in order to induce him to report the signal. This makes the principal pay a transfer beyond the inefficient type's production cost such that the inefficient type can obtain a rent equal to $\Delta C_d - \Delta C_n$ by reporting the signal. By contrast, if there is the bias, the inefficient type obtains no rent since the principal always maintains the default project for the efficient type.

Therefore, the optimal mechanism will exhibit a bias toward the default project if the expected benefit from choosing the new project instead of the default project when the efficient type transmits the signal $\nu x(B^n + \underline{C}_d - \underline{C}_n)$ is smaller than the expected rent abandoned to the inefficient type $(1-\nu)x(\Delta C_d - \Delta C_n)$. This trade-off can be viewed as a *trade-off between the amount of transmitted information and rent extraction* if we interpret the direct mechanism such that when there is the bias toward the default project, the efficient type does not transmit the signal s. Then, the principal must abandon a larger rent when she induces both types to transmit the signal than when she induces only the inefficient type to transmit the signal.

Remark (implementation when the signal is not verifiable): We can easily show that the outcome of the optimal mechanism can be achieved even though the signal cannot be verified by a third-party if the projects are contractible and the principal can understand the meaning of the signal. For instance, consider the case in which the optimal mechanism involves the bias. Then, the principal can commit to pay the monetary transfer $\overline{C}_d$ ($\overline{C}_n$) if she chooses the default project (the new project) and then ask the agent to transmit σ. Then, only the inefficient agent will transmit s. The principal will find it optimal to choose the new project if she receives s and the default project otherwise.

5 Information acquisition and transmission

In this section, we analyze the case in which the principal must induce the agent to incur cost $k \geq 0$ to obtain the signal s. After analyzing the case of bad news, we briefly study the case of good news and compare task separation with task integration and finally derive some implications of our results.

5.1 When the signal is bad news

As explained in Section 3, the mechanism is given by

$$\left\{q(\widehat{\theta}), p(\widehat{\sigma} \mid \widehat{\theta}), p(NA \mid \widehat{\theta}), t(\widehat{\sigma}, j \mid \widehat{\theta}), t(NA, j \mid \widehat{\theta})\right\}.$$

For expositional facility, we introduce some notation:

$$\begin{aligned}
V(\widehat{\sigma}, \widehat{\theta} : \sigma, \theta) \equiv \quad & p(\widehat{\sigma} \mid \widehat{\theta}) \max\left[0, t(\widehat{\sigma}, d \mid \widehat{\theta}) - C(\theta, d)\right] + \\
& (1 - p(\widehat{\sigma} \mid \widehat{\theta})) \max\left[0, t(\widehat{\sigma}, n \mid \widehat{\theta}) - C(\theta, n)\right], \\
U(\sigma, \theta) \equiv \quad & V(\sigma, \theta : \sigma, \theta).
\end{aligned}$$

$V(\widehat{\sigma}, \widehat{\theta} : NA, \theta)$, $V(NA, \widehat{\theta} : NA, \theta)$ and $U(NA, \theta)$ are similarly defined.

To induce acceptance, the mechanism should satisfy the ex ante individual rationality constraint:

$$(IR:\theta)\quad U(\theta)\equiv q(\theta)\left[xU(s,\theta)+(1-x)U(\emptyset,\theta)-k\right]+(1-q(\theta))U(NA,\theta)\geq 0. \tag{4}$$

To induce truthful report of type, the mechanism should satisfy the incentive compatibility constraint. There are two kinds of incentive constraints since, after announcing the false type $\widehat{\theta}(\neq\theta)$, the agent can decide either to acquire and transmit information,

$$\begin{aligned}(IC:\theta,A)\quad U(\theta)\geq\ & q(\widehat{\theta})\left[xV(s,\widehat{\theta}:s,\theta)+(1-x)V(\emptyset,\widehat{\theta}:\emptyset,\theta)-k\right]+\\ & (1-q(\widehat{\theta}))V(NA,\widehat{\theta}:NA,\theta);\end{aligned} \tag{5}$$

or not to acquire information,

$$(IC:\theta,NA)\quad U(\theta)\geq q(\widehat{\theta})V(\emptyset,\widehat{\theta}:NA,\theta)+(1-q(\widehat{\theta}))V(NA,\widehat{\theta}:NA,\theta). \tag{6}$$

In order to induce the agent to acquire and transmit information after the truthful report of type, the mechanism should satisfy the moral hazard constraint:

$$(MH:\theta)\quad U(\theta)\geq q(\theta)U(\emptyset,\theta:NA,\theta)+(1-q(\theta))U(NA,\theta). \tag{7}$$

Note that $(MH:\theta)$ implies $U(s,\theta)\geq U(\emptyset,\theta)+\frac{k}{x}$: therefore, when the agent obtained the signal, he always has the incentive to transmit it to the principal. Because of limited liability, the mechanism should satisfy the ex post participation constraints for every state of nature:

$$(Expost\ IR:\cdot,j\mid\theta)\quad t(\cdot,j\mid\theta)-C(\theta,j)\geq 0. \tag{8}$$

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

$$\max_{q(\theta),p(\sigma|\theta),p(N|\theta),t(\sigma,j|\theta),t(N,j|\theta)} E\left[NB\right]=\nu E(NB\mid\underline{\theta})+(1-\nu)E(NB\mid\overline{\theta})$$

$$\text{subject to (4) to (8),}$$

where

$$\begin{aligned}&E(NB\mid\theta)\equiv\\ &q(\theta)x\left\{p(s\mid\theta)\left[\mu_sB^d-t(s,d\mid\theta)\right]+(1-p(s\mid\theta))\left[(1-\mu_s)B^n-t(s,n\mid\theta)\right]\right\}+\\ &q(\theta)(1-x)\left\{p(\emptyset\mid\theta)\left[\mu_\emptyset B^d-t(\emptyset,d\mid\theta)\right]+(1-p(\emptyset\mid\theta))\left[(1-\mu_\emptyset)B^n-t(\emptyset,n\mid\theta)\right]\right\}+\\ &(1-q(\theta))\left\{p(NA\mid\theta)\left[\mu B^d-t(NA,d\mid\theta)\right]+(1-p(NA\mid\theta))\left[(1-\mu)B^n-t(NA,n\mid\theta)\right]\right\}.\end{aligned}$$

The next proposition characterizes the optimal mechanism.

Proposition 2 *(information acquisition and transmission) Under assumptions 0 to 2, the optimal mechanism for information acquisition and transmission is characterized by:*

1. The binding constraints: $(Expost\ IR : \emptyset, j \mid \overline{\theta}), (Expost\ IR : NA, j \mid \overline{\theta})$, $(IC : \underline{\theta}, NA)$, $(MH : \underline{\theta})$, $(IC : \overline{\theta}, A)$.

2. The optimal mechanism exhibits either no bias or a bias toward the default project. In each case, we have:

· no bias: $q(\theta) = 1$, $p(s \mid \theta) = 0$, $p(\emptyset \mid \theta) = 1$. $t(s, n \mid \theta) = \Delta C_d + \underline{C}_n + \frac{k}{x}$, $t(\emptyset, d \mid \theta) = \overline{C}_d$.

· a bias toward the default project:

1) the efficient type: $q(\underline{\theta}) = 0$, $p(NA \mid \underline{\theta}) = 1$, $t(NA, d \mid \theta) = \overline{C}_d$.

2) the inefficient type: $q(\overline{\theta}) = 1$, $p(s \mid \overline{\theta}) = 0$, $p(\emptyset \mid \overline{\theta}) = 1$, $t(s, n \mid \overline{\theta}) = \overline{C}_n + \frac{k}{x}$, $t(\emptyset, d \mid \overline{\theta}) = \overline{C}_d$.

3. The optimal mechanism exhibits a bias toward the default project for $\nu \in (0, \nu^A)$, *with* $\nu^A (\geq \nu^T)$ *defined below:*

$$\frac{1 - \nu^A}{\nu^A}(\Delta C_d - \Delta C_n) \equiv B^n + \underline{C}_d - \underline{C}_n - \frac{k}{x}$$

In this case, the principal's expected payoff is strictly decreasing in ν.

Proof. See Appendix 2.

The features of the optimal mechanism characterized above are very similar to those of the optimal mechanism characterized in Proposition 1. First, the nature of the binding constraints is similar. The inefficient type's ex post participation constraint is binding when he reports $\emptyset$ or when he is not asked to acquire information. The efficient type's rent is equal to the rent that he obtains when he pretends to be the inefficient type and does not acquire information. Since it is more difficult to induce the efficient type to acquire and transmit information, the moral hazard constraint is binding for the efficient type. This can make the principal pay a high transfer to the efficient type transmitting s that there are countervailing incentives: the inefficient type may obtain a positive rent by pretending to be the efficient type and acquiring and transmitting s.

Second, in both cases, the optimal mechanism can exhibit either no bias or a bias toward the default project. If it does not exhibit any bias, the inefficient type can obtain a positive rent when he reports the signal s. If it exhibits a bias toward the default project, only the inefficient type is asked to acquire information and the principal maintains always the default project for the efficient type. In this case, her expected payoff is strictly decreasing in the probability of facing the efficient type. We note that a distortion occurs only in information acquisition policy $q(\cdot)$ and not in project choice $p(\cdot)$ since, because of the cost k, the principal prefers inducing no information acquisition to inducing acquisition and choosing the default project when s is reported.

Third, whether or not the optimal mechanism exhibits the bias is determined by the trade-off between the amount of transmitted information and rent extraction. The principal compares the gain from inducing the efficient type to acquire and transmit information with the loss from giving a positive rent to the inefficient type. A minor difference with respect to the case of information transmission comes from the fact that when information acquisition is endogenous, the principal takes into account the cost of information acquisition. This makes the bias toward the default project more likely in the case of information acquisition and transmission.

Last, it is easy to see that the outcome of the optimal mechanism can be implemented even though the signal is not verifiable as in the previous section.

5.2 When the signal is good news

In this section, we briefly examine the case in which the signal is good news ($\Delta C_d \leq \Delta C_n$). Then, the assumptions should be modified as follows:

Assumption 0′: the signal is good news $(\Delta C_d \leq \Delta C_n)$.

Assumption 1′: $\frac{B^d}{2} - \underline{C}_d > \frac{B^n}{2} - \underline{C}_n$.

Assumption 2′: $B^n + \overline{C}_d + \frac{\nu}{1-\nu}\Delta C_d - \overline{C}_n - \frac{\nu}{1-\nu}\Delta C_n > k$.

Given the prior on θ, under assumption 1′, if information acquisition is impossible, the principal maintains the default project. Given the prior on θ, under assumption 2′, in the benchmark in which the principal herself can acquire information, she finds it optimal to always acquire information and to choose the new project if and only if $\sigma = s$.

Under the above assumptions, the outcome of the benchmark in which the principal herself can acquire information can be achieved even when the agent

Figure 2: Binding incentive constraints when the signal is good news

should be induced to acquire information through the following mechanism:

$$q(\theta) = 1, p(s \mid \theta) = 0, p(\emptyset \mid \theta) = 1. t(s, n \mid \theta) = \overline{C}_n + \frac{k}{x}, t(\emptyset, d \mid \theta) = \overline{C}_d.$$

Under the mechanism, we have:

$$\begin{aligned} U(s, \overline{\theta}) - \frac{k}{x} &= U(\emptyset, \overline{\theta}) = 0 : \\ U(s, \underline{\theta}) - \frac{k}{x} &= \Delta C_n \geq \Delta C_d = U(\emptyset, \underline{\theta}) > 0. \end{aligned}$$

Since the efficient type's rent is greater under the new project than under the default project, the principal does not need to concede any compensation beyond the cost of information acquisition in order to induce the efficient type to report the signal. Therefore, there is no countervailing incentive and the incentive constraints are binding as when the principal herself can acquire information (see Figure 2). Summarizing, we have:

Proposition 3 *(good news) When the signal is good news, under assumptions* $1'$ *and* $2'$*, the outcome when the principal herself can acquire information can be achieved even when the agent should be induced to acquire information.*

5.3 Task separation versus integration

Under task separation, there are two agents: A_1 entrusted with information acquisition and A_2 assigned to production. The cost of acquiring information under task separation is given by k^S. We assume that the agent in charge of production has some advantage in information acquisition over A_1, i.e., $\Delta k \equiv k^S - k > 0$. For instance, when shareholders want to know about the profitability of a project, they can ask either the manager to acquire the information or contract an external consultant to find out about it. The manager is likely to have easier access to the relevant information than an external consultant.

We assume that the principal can decide whether or not A_1 should acquire information after receiving A_2's report about his type and the signal s is contractible such that the principal can just pay an expected transfer equal to k^S to induce A_1 to acquire and transmit the signal. Then, task separation is equivalent to the case in which the principal herself can acquire information with cost k^S.[18] In both cases, only the efficient type's incentive constraint is binding as in Figure 2. Therefore, when the signal is good news, from Proposition 3, task integration dominates task separation. When the signal is bad news, the principal finds it optimal to induce A_1 to acquire information regardless of the report made by A_2 if $x\left(B^n - \underline{C}_n + \underline{C}_d\right) \geq k^S$ holds while she induces A_1 to acquire information only when A_2 reports $\overline{\theta}$ if $x\left(B^n - \overline{C}_n + \overline{C}_d + \frac{\nu}{1-\nu}(\Delta C_d - \Delta C_n)\right) \geq k^S > x\left(B^n - \underline{C}_n + \underline{C}_d\right)$ is satisfied. In both cases, the principal chooses the new project if and only if A_1 reports s. In what follows, we compare the principal's payoff under task separation with the one under task integration assuming that the signal is bad news.

Let Π_S^N (respectively, Π_I^N) denotes the principal's expected payoff under task separation (respectively, under task integration) when there is no bias in project choice. Then, we have:

$$\Pi_S^N - \Pi_I^N = x\left(\Delta C_d - \Delta C_n\right) - \Delta k.$$

Under task separation, there is no countervailing incentive since the agent charged with information acquisition does not take into account the negative externalities that he inflicts on the other agent. Therefore, the inefficient type never obtains any rent while the efficient type's rent can be either ΔC_d or ΔC_n depending on A_1's report. In contrast, under task integration, the efficient type's rent is always equal to ΔC_d while the inefficient type obtains

[18] We admit that the assumption that s is verifiable greatly simplifies the analysis of task separation. It would be interesting to study how relaxing the assumption would affect the comparison between task separation and task integration. For the analysis of the delegation of information acquisition in an environment with soft information, see the recent work of Gromb and Martimort (2003).

a positive rent $\Delta C_d - \Delta C_n$ if he reports the signal. Similarly, when there is a bias toward the default project (i.e., the principal induces information acquisition only if she receives the report $\overline{\theta}$), we have:

$$\Pi_S^B - \Pi_I^B = \nu x \left(\Delta C_d - \Delta C_n\right) - (1-\nu)\Delta k,$$

where Π_S^B (respectively, Π_I^B) denotes the principal's expected payoff under task separation (respectively, under task integration) when there is the bias.

Summarizing, we have:

Proposition 4 *(task separation versus integration)*

1. When the signal is good news, task separation is dominated by task integration.

2. When the signal is bad news, task separation is likely to dominate task integration as the change is more likely (x high), the efficient type's vested interest in the default project is larger ($\Delta C_d - \Delta C_n$ high) and the disadvantage in cost of information acquisition is smaller (Δk small).

5.4 Implications

We here derive some implications of our results.

M-form versus U-form structure

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.

Managerial entrenchment

According to Shleifer and Vishny (1988, pp. 123-24), a manager has an incentive to invest the firm's resources in assets whose value is higher under him than under the best alternative manager even when such investments are not *ex ante* value-maximizing. But they assume that the board of directors cannot interfere with the investment made by the manager. Our model predicts that managerial entrenchment can occur even when the board (the principal) has a formal control of the investment choice. For this purpose, we can interpret our model in the following way. Suppose that the board has to choose between investing in the default project and investing in the new project. Assume that the production cost is the same for both types (this is only for simplicity) but that the manager (the agent) of type θ obtains a private benefit $b(\theta, j)$ when the board chooses to invest in project j. Then the signal is bad news if both types enjoy more benefit under the default project than under the new one $b(\theta, d) > b(\theta, n)$. Our analysis suggests that the board may choose too often the default project since it can be very costly for them to obtain the information favoring the new project from the manager. Hence, our model provides a micro-foundation of managerial entrenchment and offers a justification for the use of external information to mitigate distortions in information flows. It would be desirable to employ outsiders as advocates for changes and it would be better to choose as a CEO a person with a good understanding of broad market trends than someone with specialized knowledge about some products.

Why do good firms go bad?

Our result that the principal's profit can decrease in the probability of having the efficient type provides a new insight on the question of why good firms go bad. If the project choice is given, one can never have such a result. However, when the environment is changing and hence the project choice is endogenous, the very fact that the agent is more efficient can imply that he has more rent attached to the current project and hence more reluctant to transmit the information favoring a change. To some extent, our result suggests that today's success can have a seed for tomorrow's failure and offers an explanation of Drucker's claim:

"... when market or industry structure changes, the producers or suppliers who are today's industry leaders will be found neglecting the fastest-growing market segments (Drucker (1985), p. 86)."

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 an 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).

6 Extensions and robustness

In this section, we present two extensions of the simple model analyzed in Section 4 and also discuss the robustness of our results with respect to relaxing some assumptions made in our model. In the first extension, we show that the countervailing incentives exist in the general case of continuum of types. In the second, we relax the assumption that the principal is the first mover and consider the case in which the agent decides whether or not to send the signal before receiving the principal's contract offer. In both extensions, we find that the distortions in information flows can result in both excess inertia and excess momentum in project choice.

6.1 A continuum of types

We extend the simple model by assuming that there are a continuum of types: θ follows the distribution function $F(\cdot)$ with density $f(\cdot)(>0)$ and support $\left[\underline{\theta},\overline{\theta}\right]$. Type θ's cost of production under project j is given by $C(\theta,j)$ with $C_\theta(\theta,j)>0$. We want to identify the distortions created by task integration with respect to a benchmark in which the principal can get $\sigma\in\{s,\emptyset\}$ for free and makes it public. The signal is bad news (good news) if $C_\theta(\theta,d)-C_\theta(\theta,n)>0$ ($C_\theta(\theta,d)-C_\theta(\theta,n)<0$). We note that the single-crossing condition is satisfied if $C_\theta(\theta,d)-C_\theta(\theta,n) >$ or < 0. We below focus on the case of bad news.

Let $p^*(\sigma,\widehat{\theta})$ ($p^I(\widehat{\sigma},\widehat{\theta})$) denote the probability to choose the default project when the agent reports $\widehat{\theta}$ given the signal σ in the benchmark (when the agent reports $(\widehat{\sigma},\widehat{\theta})$ under task integration). In order to compare $p^*(\sigma,\theta)$ with $p^I(\sigma,\theta)$, we examine below how type θ's virtual cost is determined in each case. We note that in both cases, the incentive constraints together with $C_\theta(\theta,d)-C_\theta(\theta,n)>0$ imply that $p^*(\sigma,\theta)$ and $p^I(\sigma,\theta)$ are decreasing in θ.

Since studying bunching is not our purpose, we assume that in each case the monotonicity constraint in $p^*(\sigma,\theta)$ (or in $p^I(\sigma,\theta)$) is slack in the principal's optimization problem.[19] Under the benchmark, the incentive constraints bind for upward manipulations of report and, as usual, type θ's virtual cost is given by $C(\theta,j)+\frac{F(\theta)}{f(\theta)}C_\theta(\theta,j)$. Therefore, $p^*(\sigma,\theta)=1$ if the following condition holds:

$$\mu_\sigma B^d-\left[C(\theta,d)+\frac{F(\theta)}{f(\theta)}C_\theta(\theta,d)\right]>(1-\mu_\sigma)B^n-\left[C(\theta,n)+\frac{F(\theta)}{f(\theta)}C_\theta(\theta,n)\right]. \tag{9}$$

Consider now task integration and assume that $p^I(\emptyset,\theta)\geq p^I(s,\theta)$ holds for each θ.[20] First, when $\sigma=s$, it turns out that there are countervailing incentives such that the incentive constraints bind for downward manipulations of report. Therefore, type θ's virtual cost is given by $C(\theta,j)-\frac{1-F(\theta)}{f(\theta)}C_\theta(\theta,j)$ and $p^I(s,\theta)=0$ if the following condition holds:

$$B^n-\left[C(\theta,n)-\frac{1-F(\theta)}{f(\theta)}C_\theta(\theta,n)\right]>-\left[C(\theta,d)-\frac{1-F(\theta)}{f(\theta)}C_\theta(\theta,d)\right] \tag{10}$$

When we compare (10) with the condition for $p^*(s,\theta)=0$, there exists "excess inertia" under task integration: i.e., the principal chooses the default project too often under task integration compared to the benchmark. Second, when $\sigma=\emptyset$, type θ's virtual cost is given by $C(\theta,j)+\left(\frac{x}{1-x}\frac{1}{f(\theta)}+\frac{F(\theta)}{f(\theta)}\right)C_\theta(\theta,j)$. Compared to the virtual cost under the benchmark, an additional distortion $\frac{x}{1-x}\frac{1}{f(\theta)}C_\theta(\theta,j)$ appears because an increase in $p^I(\emptyset,\theta)$ increases the rent that the agent obtains by concealing s when $\sigma=s$.[21] Therefore, $p^I(\emptyset,\theta)=1$ if the following condition holds:

$$\begin{aligned}\mu_\emptyset B^d-\left[C(\theta,d)+\left(\frac{x}{1-x}\frac{1}{f(\theta)}+\frac{F(\theta)}{f(\theta)}\right)C_\theta(\theta,d)\right]>\\ (1-\mu_\emptyset)B^n-\left[C(\theta,n)+\left(\frac{x}{1-x}\frac{1}{f(\theta)}+\frac{F(\theta)}{f(\theta)}\right)C_\theta(\theta,n)\right].\end{aligned} \tag{11}$$

[19]The monotonicity constraint is slack in the benchmark if $C_{\theta\theta}(\theta,d)-C_{\theta\theta}(\theta,n)\geq 0$ and $\frac{F(\theta)}{f(\theta)}$ is increasing in the benchmark: it is slack under task integration if $C_{\theta\theta}(\theta,d)-C_{\theta\theta}(\theta,n)=0$ and $-\frac{1-F(\theta)}{f(\theta)}$ and $\frac{x}{1-x}\frac{1}{f(\theta)}+\frac{F(\theta)}{f(\theta)}$ are increasing.

[20]It holds if $\frac{B^d+B^n}{2}\geq\frac{C_\theta(\theta,d)-C_\theta(\theta,n)}{f(\theta)}$ is satisfied.

[21]Note that when $\sigma=\emptyset$ incentive constraints bind for upward manipulations. Furthermore, when $\theta=\underline{\theta}$, the incentive constraint to induce the agent to report $\sigma=s$ instead of $\sigma=\emptyset$ binds.

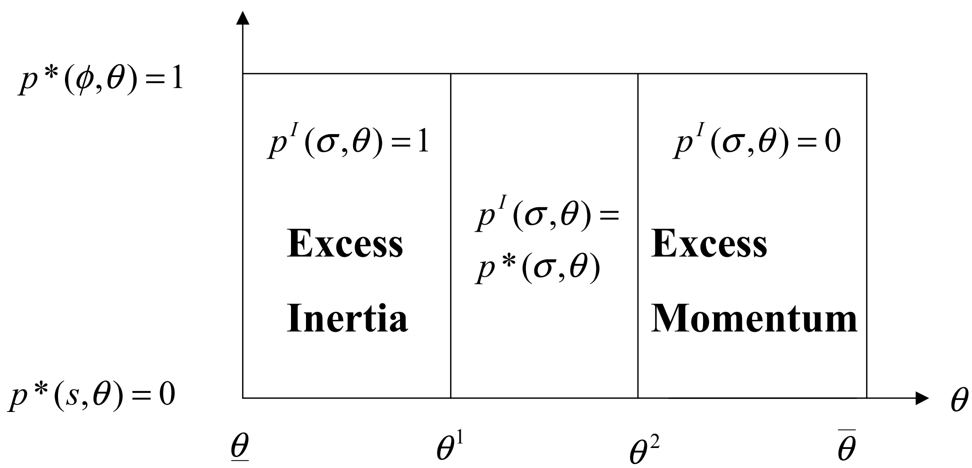

Figure 3: Excess inertia and excess momentum under task integration

When we compare (11) with the condition for $p^I(\emptyset, \theta) = 1$, there exists "excess momentum" under task integration: i.e., the principal chooses the new project too often under task integration compared to the benchmark.

To illustrate our result, suppose that in the benchmark it is optimal to have $p^*(s, \theta) = 0$ and $p^*(\emptyset, \theta) = 1$ for all θ. Figure 3 describes excess inertia and momentum under task integration. The monotonicity constraint implies that excess inertia should arise for low values of θ while excess momentum should arise for high values of θ. In figure 3, excess inertia arise for $\theta \in \left[\underline{\theta}, \theta^1\right]$ and excess momentum arises for $\theta \in \left[\theta^2, \overline{\theta}\right]$: in the two intervals, the project choice is not responsive to σ.

Proposition 5 *(continuum of types) Consider the case of continuum of types. When the news is bad, project choice under task integration exhibits both excess inertia and excess momentum compared to the benchmark in which the principal receives σ for free and makes it public.*

Proof. See Appendix 3.

Finally, we note that when the signal is good news $(C_\theta(\theta, d) - C_\theta(\theta, n) < 0)$, task integration is equivalent to the benchmark as long as each type of agent gets a higher rent when $\sigma = s$ than when $\sigma = \emptyset$ under the benchmark.

6.2 No commitment

Consider the simple model with two types and suppose now that the principal cannot commit in advance to a mechanism to induce the agent to transmit the signal s. For instance, the agent may observe changes in the environment before the principal even becomes aware of the possibility of the changes and evaluates their likely consequences in terms of project choice. In this case, the agent decides whether or not to release the signal before the principal designs a mechanism and, when designing her mechanism, she takes into account the released signal.[22] We consider the case in which the signal s is bad news.

We study the Perfect Bayesian Equilibria (PBE) in which the inefficient type always truthfully releases his signal. To define the PBE, we introduce some notation: z represents the probability for the efficient type to release s when he receives s, $\mu(\widehat{\sigma})$ (respectively, $\nu(\widehat{\sigma})$) represents the principal's revised prior about the probability that $\epsilon = d$ (respectively, the probability that $\theta = \underline{\theta}$) conditional on receiving signal $\widehat{\sigma}$ from the agent and $\{p(\theta \mid \widehat{\sigma}), t(\theta \mid \widehat{\sigma})\}$ is the mechanism that the principal proposes after receiving $\widehat{\sigma}$. Then, a PBE is defined by:

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

which satisfies the following three conditions:

1) given $\{\mu(\sigma), \nu(\sigma), p(\theta \mid \sigma), t(\theta \mid \sigma)\}$, z maximizes the efficient type's payoff,

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

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

In the next proposition, we characterize the PBEs.

Proposition 6 *(no commitment) Suppose that the agent receives σ without incurring any cost and decides whether or not to release the signal s before the principal offers a mechanism. Under assumptions 0 to 2, the Perfect Bayesian Equilibria in which the inefficient type always truthfully releases his signal $\{z, \mu(\sigma), \nu(\sigma), p(\theta \mid \sigma), t(\theta \mid \sigma)\}$ are characterized by:*

1. There is no equilibrium in which the efficient type always truthfully releases his signal: $z < 1$.

2. $p(\theta \mid s) = 0$, $t(\theta \mid s) = \overline{C}_n$.

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

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

1) For all $\nu \in (0, \nu^*)$, there exists a unique equilibrium with $z = 0$ and, in this equilibrium, the principal's payoff is strictly decreasing in ν.

2) 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 at least one equilibrium. The principal's payoff is the largest with $z = z^*(\nu)$. In this equilibrium, $p(\overline{\theta} \mid \emptyset) = 0$ and $p(\underline{\theta} \mid \emptyset) = 1$ hold and the principal's payoff is strictly increasing in ν.

Proof. See Appendix 4.

We can easily show that there is no PBE in which the efficient type always truthfully releases his signal. Suppose that $z = 1$. Then, we have $\mu(\sigma) = \mu_\sigma$ and $\nu(\sigma) = \nu$. This implies that $p(\theta \mid s) = 0$, $p(\theta \mid \emptyset) = 1$, $t(\theta \mid s) = \overline{C}_n$, $t(\theta \mid \emptyset) = \overline{C}_d$. Given the principal's strategy, the efficient type obtains more rent by withholding s. Thus, there is a contradiction.

For ν small, when the efficient type withholds the signal s, its impact on $\mu(\emptyset)$ and $\nu(\emptyset)$ is marginal: $\mu(\emptyset)$ and $\nu(\emptyset)$ are close to $\mu_\emptyset$ and ν. Hence, the principal will maintain the default project when she does not receive s and the efficient type always conceal s. Since the new project is chosen only when the inefficient type receives s, for ν small enough, the lack of commitment does not generate any loss compared to the outcome under commitment.

For ν large, if the efficient type withholds the signal, its impact on $\mu(\emptyset)$ and $\nu(\emptyset)$ is large: $\mu(\emptyset) << \mu_\emptyset$ and $\nu(\emptyset) >> \nu$. Consequently, it becomes optimal for the principal to introduce a bias toward the new project when she does not receive s: she always chooses the new project for the inefficient type. Then, the efficient type obtains the same rent regardless of whether or not he releases the signal. Thus, releasing the signal with a positive probability can be an equilibrium. In this case, the lack of commitment generates two sorts of loss compared to the outcome under commitment: the loss from excess momentum (the bias toward the new project) and the loss from excess inertia (the bias toward the default project since the efficient type conceals the signal with a positive probability).

6.3 Discussion of assumptions

When the benefit is contractible, transfers can be contingent both on the project choice and on the realized environment: $t(\widehat{\sigma}, \widehat{\theta}, j, \epsilon)$. However, benefit contractibility does not affect our results as long as the participation constraints have to be satisfied ex post as follows:

$$t(\sigma, \theta, j, \epsilon) - C(\theta, j) \geq 0.$$

In this case, the transfer to the inefficient type cannot be lower than his cost and this allows the efficient type to obtain an information rent ΔC_d by pretending to be inefficient and withholding s. Thus, in order to induce the efficient type to transmit s, the principal has to give him a rent equal to ΔC_d, which in turn allows the inefficient type to get a rent by transmitting s and pretending to be the efficient type: i.e., there are countervailing incentives.

Consider now uncertainty about the cost under the new project and assume that the cost is given by $C(\theta, n) + \eta$ where η is a shock with zero mean and support $\left[\underline{\eta}, \overline{\eta}\right]$ and is realized after the project choice is made. In the simple model of information transmission with Bayesian participation constraints, our results are not affected by the uncertainty since we just need to replace $C(\theta, n)$ with its expectation $C(\theta, n) + E(\eta) = C(\theta, n)$. If there is limited liability, we can assume that shutdown is not optimal and hence the principal finds it optimal to pay the maximal cost $C(\overline{\theta}, n) + \overline{\eta}$ when the new project is exogenously chosen. Then, the signal is bad news for the efficient type if $\Delta C_d > \Delta C_n + \overline{\eta}$ while the signal is always good news for the inefficient type since he can get an expected rent $\overline{\eta}$ because of the uncertainty if the new project is chosen. Therefore, under task integration, the principal will still face the trade-off between inducing the efficient type to transmit the signal and extracting the inefficient type's rent because of the countervailing incentives.

We assumed that the agent's reservation utility is normalized to zero regardless of type. Because of this, given a project choice, only the efficient type can obtain a rent. However, when the reservation utility is type-dependent, it is possible that the inefficient type obtains a rent while the efficient type has no rent. Then, it would be the inefficient type who resists the adoption of the new project.

7 Concluding remarks

We studied the interaction between the incentive to produce and the incentive to transmit information relevant to project choice in a changing environment. When agents have rents accruing from the status-quo project, they might try to resist the adoption of a new project by withholding information favorable to a new project. We identified a trade-off between the amount of the information transmitted and rent extraction. What is interesting in our model is that a more efficient agent can have a higher incentive to conceal the information than a less efficient one. This offers a new insight on the question of why good firms can go bad. We have also shown that the separation of day-to-day operating decisions from long-term strategic decisions can be an organizational response to improve information flows.

Our model offers some clues to the process through which organizational knowledge is created and it will be interesting to pursue our research in this direction. In this regard, one central question is how the principal's investment in knowledge affects agents' incentives to invest in knowledge. For instance, both investments are substitutes in Aghion and Tirole (1997) while they are complements in Dewatripont and Tirole (2003) and Ellman (1999).

Finally, it would be interesting to study in a dynamic extension how booms and recessions affect information flows inside a firm. This will help us to understand how fat is accumulated in a firm and also suggest interesting implications on downsizing strategies.[23]

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Appendix 1

Define the reduced program, denoted by RP^T, as follows:

$$\max_{p(\sigma,\theta),t(\sigma,\theta)} E\left[NB\right]$$

subject to

$$(IR:\emptyset,\overline{\theta}),(IC:(\emptyset,\underline{\theta})\to(\emptyset,\overline{\theta})),(IC:(s,\underline{\theta})\to(\emptyset,\underline{\theta})),(IC:(s,\overline{\theta})\to(s,\underline{\theta})).$$

We here solve the reduced program. It is easy to check that the other neglected constraints in the original program are satisfied by the solution of the reduced program.

From the binding $(IR: \emptyset, \overline{\theta})$, $(IC: (\emptyset, \underline{\theta}) \rightarrow (\emptyset, \overline{\theta}))$ and $(IC: (s, \underline{\theta}) \rightarrow (\emptyset, \underline{\theta}))$, we have:

$$\underline{U} \equiv U(\emptyset, \underline{\theta}) = U(s, \underline{\theta}) = p(\emptyset, \overline{\theta})(\Delta C_d - \Delta C_n) + \Delta C_n. \tag{12}$$

From the binding $(IC: (s, \overline{\theta}) \rightarrow (s, \underline{\theta}))$ and $(IC: (s, \underline{\theta}) \rightarrow (\emptyset, \underline{\theta}))$, we have:

$$U(s, \overline{\theta}) = \left(p(\emptyset, \overline{\theta}) - p(s, \underline{\theta})\right)(\Delta C_d - \Delta C_n). \tag{13}$$

Therefore all the rents (hence all the transfers) in the reduced program can be written only in terms of $\{p(\sigma, \theta)\}$. In what follows, we optimize the principal's objective with respect to $\{p(\sigma, \theta)\}$.

• Optimization with respect to $p(\emptyset, \underline{\theta})$

Since $p(\emptyset, \underline{\theta})$ does not affect neither $\underline{U}$ nor $U(s, \overline{\theta})$, it is optimal to have no distortion in project choice ($p(\emptyset, \underline{\theta}) = 1$).

• Optimization with respect to $p(s, \overline{\theta})$

Since $p(s, \overline{\theta})$ does not affect neither $\underline{U}$ nor $U(s, \overline{\theta})$, it is optimal to have no distortion in project choice $\left(p(s, \overline{\theta}) = 0\right)$.

• Optimization with respect to $p(s, \underline{\theta})$

Since a decrease in $p(s, \underline{\theta})$ induces an increase in $U(s, \overline{\theta})$, there is a trade-off between good project choice and extraction of the inefficient type's rent. The optimal $p(s, \underline{\theta})$ is obtained by maximizing the following objective:

$$\nu x \left\{p(s, \underline{\theta})(-\underline{C}_d) + (1 - p(s, \underline{\theta}))\left(B^n - \underline{C}_n\right)\right\} - (1 - \nu) x U(s, \overline{\theta}),$$

where $U(s, \overline{\theta})$ is given by (13). Therefore, we have

$$\begin{aligned} p(s, \underline{\theta}) &= 0, \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) \geq 0, \\ p(s, \underline{\theta}) &= 1, \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) < 0. \end{aligned}$$

• Optimization with respect to $p(\emptyset, \overline{\theta})$

Since an increase in $p(\emptyset, \overline{\theta})$ induces an increase in $\underline{U}$ and in $U(s, \overline{\theta})$, there is a trade-off between good project choice and rent extraction. The optimal $p(\emptyset, \overline{\theta})$ is obtained by maximizing the following objective:

$$\begin{aligned} &(1 - \nu)(1 - x)\left[p(\emptyset, \overline{\theta})(\mu_\emptyset B^d - \overline{C}_d) + (1 - p(\emptyset, \overline{\theta}))((1 - \mu_\emptyset) B^n - \overline{C}_n)\right] \\ &- \nu \underline{U} - (1 - \nu) x U(s, \overline{\theta}), \end{aligned}$$

where $U(s,\overline{\theta})$ is given by (13) and $\underline{U}$ is given by (12). Since the first-order derivative of the above objective with respect to $p(\emptyset,\overline{\theta})$ is positive, we have $p(\emptyset,\overline{\theta})=1$.

Appendix 2

We define the reduced program[24], denoted by RP^A, as follows:

$$\max \quad E\left[NB\right]$$

$$\text{subject to}$$

$$\begin{array}{rcl}(IC & : & \underline{\theta},NA),(IC:\overline{\theta},A),(MH:\underline{\theta}),\\ (LL & : & \emptyset,j\mid\overline{\theta}),(LL:NA,j\mid\overline{\theta}).\end{array}$$

We here solve the reduced program. It is easy to check that the other neglected constraints in the original program are satisfied by the solution of the reduced program.

From the binding $(LL:\emptyset,j\mid\overline{\theta})$ and $(LL:NA,j\mid\overline{\theta})$, we have:

$$t(\emptyset,j\mid\overline{\theta})=t(NA,j\mid\overline{\theta})=\overline{C}_j. \tag{14}$$

From the binding $(IC:\underline{\theta},NA)$, we obtain the following expression for the efficient type's rent:

$$U(\underline{\theta})\equiv\underline{U}=\underline{a}(\Delta C_d-\Delta C_n)+\Delta C_n, \tag{15}$$

where $\underline{a}\equiv q(\overline{\theta})p(\emptyset\mid\overline{\theta})+(1-q(\overline{\theta}))p(NA\mid\overline{\theta})$ with $0\leq\underline{a}\leq 1$.

From the binding $(IC:\overline{\theta},A)$, we have the expression for the inefficient type's rent:

$$\begin{aligned}U(\overline{\theta})\equiv\overline{U}= \quad & q(\underline{\theta})\left[xV(s,\underline{\theta}:s,\overline{\theta})+(1-x)V(\emptyset,\underline{\theta}:\emptyset,\overline{\theta})-k\right]\\ & +(1-q(\underline{\theta}))V(NA,\underline{\theta}:NA,\overline{\theta}).\end{aligned} \tag{16}$$

We below solve the reduced program in two steps. In the first step, we suppose that $\underline{a}$ (hence, $\underline{U}$) is given and solve the efficient type's program, denoted by $RP^A(\underline{\theta})$, with respect to $\{q(\underline{\theta}),p(\cdot\mid\underline{\theta}),t(\cdot,j\mid\underline{\theta})\}$. This will in turn allow us to determine $U(\overline{\theta})$ from (16) as a function of $\underline{a}$. In the second step, we solve the reduced program RP^A with respect to $\left\{q(\overline{\theta}),p(\cdot\mid\overline{\theta}),t(s,j\mid\overline{\theta})\right\}$.

We have the next lemma:

[24] We remind that the incentive and moral hazard constraints include limited liability constraints in their original definitions: see Section 5.

Lemma 1 *Given* $\underline{a}$ *with* $0 \leq \underline{a} \leq 1$, *the optimal* $\{q(\underline{\theta}),\ p(\cdot \mid \underline{\theta}),\ t(\cdot, j \mid \underline{\theta})\}$ *is characterized by:*

(a) $p(s \mid \underline{\theta}) = 0, p(\emptyset \mid \underline{\theta}) = p(NA \mid \underline{\theta}) = 1.$

(b) $q(\underline{\theta}) = 1$ *and* $U(\overline{\theta}) = x\underline{a}(\Delta C_d - \Delta C_n)$, *if* $B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) \geq \frac{k}{x}$,

$q(\underline{\theta}) = 1 - \underline{a}$ *and* $U(\overline{\theta}) = 0$ *if* $B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) < \frac{k}{x}$.

The lemma states that there is a trade-off between inducing the efficient type to acquire and transmit information and extracting the inefficient type's rent.

Proof. Define the program $RP^A(\underline{\theta})$ as follows:

$$\max_{q(\underline{\theta}),p(\cdot|\underline{\theta}),t(\cdot,j|\underline{\theta})} \nu E(NB \mid \underline{\theta}) - (1-\nu)\overline{U}$$

$$\text{subject to } (15), (16), (MH : \underline{\theta}).$$

The question in $RP^A(\underline{\theta})$ is how to make the best trade-off between inducing the efficient type to acquire and transmit information and extracting the inefficient type's rent while ensuring the rent $\underline{U} = \underline{a}(\Delta C_d - \Delta C_n) + \Delta C_n$ to the efficient type. We solve the program in two steps: we first solve it for a given $q(\underline{\theta}) \equiv \underline{q}$ and then optimize the objective with respect to $q(\underline{\theta})$.

Step 1: Optimization with given $q(\underline{\theta})$

Define α and β as follows: $\underline{a} \equiv \underline{q}\alpha + (1-\underline{q})\beta$: α and β represent how the rent to the efficient type is distributed according to whether or not he is requested to acquire information. Without loss of generality, we can focus on $\alpha \geq 0$ and $\beta \geq 0$.[25]

Given α, from the binding $(MH : \underline{\theta})$, we have:

$$U(s, \underline{\theta}) - \frac{k}{x} = U(\emptyset, \underline{\theta}) = \alpha(\Delta C_d - \Delta C_n) + \Delta C_n.$$

From the definition of β, we have

$$U(NA, \underline{\theta}) = \beta(\Delta C_d - \Delta C_n) + \Delta C_n.$$

[25] As long as the transfer given to the efficient type is lower than his cost plus ΔC_n, the inefficient type can never obtain a rent by pretending to be the efficient type. If for instance $\alpha < 0$ and $\beta > 0$ hold, there is a slack: the transfer is strictly lower than the efficient type's cost plus ΔC_n. Then, given $\underline{a}$, the principal can increase α up to 0 and decrease β. This reduces the inefficient type's incentive to pretend to be efficient.

Claim 1: Given $\alpha \geq 0$, the optimal $p(s \mid \underline{\theta})$ and $t(s, j \mid \underline{\theta})$ are such that:

$$\begin{aligned} p(s, \underline{\theta}) &= 0, \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) \geq 0, \\ p(s, \underline{\theta}) &= \min[\alpha, 1] \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) < 0. \\ V(s, \underline{\theta} &: s, \overline{\theta}) = \frac{k}{x} + (\alpha - p(s \mid \underline{\theta}))(\Delta C_d - \Delta C_n) \end{aligned}$$

Proof. Given α, the optimal $p(s \mid \underline{\theta})$ and $t(s, j \mid \underline{\theta})$ are obtained from the following program:

$$\max_{p(s|\underline{\theta}), t(s,j|\underline{\theta})} \nu \left\{ p(s \mid \underline{\theta}) \left[-\underline{C}_d \right] \right] + (1 - p(s \mid \underline{\theta})) \left[B^n - \underline{C}_n \right] \} - (1-\nu) \left[V(s, \underline{\theta} : s, \overline{\theta}) - \frac{k}{x} \right]$$

$$\text{subject to } U(s, \underline{\theta}) - \frac{k}{x} = \alpha(\Delta C_d - \Delta C_n) + \Delta C_n,$$

where

$$U(s, \underline{\theta}) \equiv p(s \mid \underline{\theta}) \left[t(s, d \mid \underline{\theta}) - \underline{C}_d \right] + (1 - p(s \mid \underline{\theta})) \left[t(s, n \mid \underline{\theta}) - \underline{C}_n \right]. \quad (17)$$

The principal has to make the best trade-off between good project choice and extracting the inefficient type's rent while ensuring the rent $\alpha(\Delta C_d - \Delta C_n) + \Delta C_n + \frac{k}{x}$ to the efficient type. Given $p(s \mid \underline{\theta})$, from (17), the expected transfer to the efficient type $p(s \mid \underline{\theta}) t(s, d \mid \underline{\theta}) + (1 - p(s \mid \underline{\theta})) t(s, n \mid \underline{\theta})$ is given by $\frac{k}{x} + \alpha(\Delta C_d - \Delta C_n) + \Delta C_n + p(s \mid \underline{\theta}) \underline{C}_d + (1 - p(s \mid \underline{\theta})) \underline{C}_n$. If the expected transfer is smaller than $p(s \mid \underline{\theta}) \overline{C}_d + (1 - p(s \mid \underline{\theta})) \overline{C}_n$ (i.e., $\frac{k}{x} + \alpha(\Delta C_d - \Delta C_n) < p(s \mid \underline{\theta})(\Delta C_d - \Delta C_n)$ holds), we can choose the transfers such that $V(s, \underline{\theta} : s, \overline{\theta}) = 0$. In this case, since a decrease in $p(s \mid \underline{\theta})$ improves project choice but does not affect the inefficient type's rent, the principal can decrease $p(s \mid \underline{\theta})$ up to the point where $\frac{k}{x} + \alpha(\Delta C_d - \Delta C_n) = p(s \mid \underline{\theta})(\Delta C_d - \Delta C_n)$ holds.

Therefore, we consider the case in which $\frac{k}{x} + \alpha(\Delta C_d - \Delta C_n) \geq p(s \mid \underline{\theta})(\Delta C_d - \Delta C_n)$ holds. In this case, there is no loss of generality in restricting our attention to the transfers with $t(s, j \mid \underline{\theta}) \geq \overline{C}_j$.[26] Then, we have $V(s, \underline{\theta} : s, \overline{\theta}) = \frac{k}{x} + (\alpha - p(s \mid \underline{\theta}))(\Delta C_d - \Delta C_n)$. Therefore, there exists a

[26] When the inequality $\frac{k}{x} + \alpha(\Delta C_d - \Delta C_n) \geq p(s \mid \underline{\theta})(\Delta C_d - \Delta C_n)$ holds, if $t(s, j \mid \underline{\theta}) < \overline{C}_j$ holds for some j, we must have $t(s, j' \mid \underline{\theta}) > \overline{C}_{j'}$ for $j' \neq j$. Then, by increasing $t(s, j \mid \underline{\theta})$ and reducing $t(s, j' \mid \underline{\theta})$, the principal can reduce the inefficient type's rent.

trade-off between good project choice and extraction of the inefficient type's rent and, from this trade-off, we obtain the optimal choice of $p(s, \underline{\theta})$ as in Claim1.■

Claim 2: (i) Given $\alpha \geq 0$, the optimal $p(\emptyset \mid \underline{\theta})$ and $t(\emptyset, j \mid \underline{\theta})$ are such that:

$$p(\emptyset : \underline{\theta}) = 1, V(\emptyset, \underline{\theta} : \emptyset, \overline{\theta}) = \max\left[0, (\alpha - 1)(\Delta C_d - \Delta C_n)\right].$$

(ii) Given $\beta \geq 0$, the optimal $p(NA \mid \underline{\theta})$ and $t(NA, j \mid \underline{\theta})$ are such that:

$$p(NA : \underline{\theta}) = 1, V(NA, \underline{\theta} : NA, \overline{\theta}) = \max\left[0, (\beta - 1)(\Delta C_d - \Delta C_n)\right].$$

Proof. The optimal $p(\emptyset \mid \underline{\theta})$ and $t(\emptyset, j \mid \underline{\theta})$ (respectively, $p(NA \mid \underline{\theta})$ and $t(NA, j \mid \underline{\theta})$) are obtained by maximizing the objective of $RP^A(\underline{\theta})$ with respect to $p(\emptyset \mid \underline{\theta})$ and $t(\emptyset, j \mid \underline{\theta})$ (respectively, $p(NA \mid \underline{\theta})$ and $t(NA, j \mid \underline{\theta})$) under the constraint $U(\emptyset, \underline{\theta}) = \alpha(\Delta C_d - \Delta C_n) + \Delta C_n$ (respectively, $U(NA, \underline{\theta}) = \beta(\Delta C_d - \Delta C_n) + \Delta C_n$). In both cases, making good project choice ($p(\emptyset : \underline{\theta}) = p(NA : \underline{\theta}) = 1$) minimizes the inefficient type's rent and the inefficient type can get a rent only if $\alpha > 1$ or $\beta > 1$.■

We now solve $RP^A(\underline{\theta})$ with respect to (α, β) given $\left(\underline{a}, \underline{q}\right)$.

Claim 3: Given $\left(\underline{a}, \underline{q}\right)$, the optimal (α, β) are such that:

(i) For $\underline{a} \leq 1 - \underline{q}$, $\left(\alpha = 0, \beta = \frac{\underline{a}}{(1-\underline{q})}\right)$

(ii) For $\underline{a} > 1 - \underline{q}$, $\left(\alpha = \frac{\underline{a}-(1-\underline{q})}{\underline{q}}, \beta = 1\right)$.

Proof. When $\underline{a} \leq 1 - \underline{q}$, $\left(\alpha = 0, \beta = \frac{\underline{a}}{(1-\underline{q})}\right)$ is optimal since, in this case, there is no distortion in the project choice and no rent to the inefficient type. The optimal (α, β) when $\underline{a} > 1 - \underline{q}$ holds is easily derived from Claims 1 and 2: basically, once β reaches one, it is optimal to increase α from zero since the inefficient type cannot get any rent when he receives $\sigma = \emptyset$..■

Step 2: Optimization with respect to $q(\underline{\theta})$

We now solve $RP^A(\underline{\theta})$ with respect to $\underline{q}$ given $\underline{a}$. It is obvious that for $\underline{q} \leq 1 - \underline{a}$, $\underline{q} = 1 - \underline{a}$ is optimal: as long as no rent is given to the inefficient type, it is optimal to induce the efficient type to acquire information. Hence, without loss of generality, we focus on $\underline{q} \geq 1 - \underline{a}$.

Claim 4: Given $\underline{a}$, the optimal $q(\underline{\theta})$ is such that:

$$
\begin{aligned}
\underline{q} &= 1 \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) \geq \frac{k}{x} \\
\underline{q} &= 1 - \underline{a} \text{ if } B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) < \frac{k}{x}.
\end{aligned}
$$

Proof. We distinguish two cases depending upon the value of B^n.

Case 1: $B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) < 0$

The program is given by:

$$
\begin{array}{ll}
\max_{\underline{q}} & \underline{q}x\left[-\alpha(\underline{q})\underline{C}_d + (1-\alpha(\underline{q}))(B^n - \underline{C}_n)\right] \\
& +\underline{q}(1-x)\left[\mu_\emptyset B^d - \underline{C}_d\right] + (1-\underline{q})\left[\frac{B^d}{2} - \underline{C}_d\right] - \underline{q}k \\
\text{subject to} & \underline{a} = \alpha\underline{q} + (1-\underline{q})
\end{array}
$$

The first-order derivative of the objective with respect to $\underline{q}$ is equal to $-k$. Hence, $\underline{q} = 1 - \underline{a}$ is optimal.

Case 2: $B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) \geq 0$

The program is given by:

$$
\begin{array}{ll}
\max_{\underline{q}} & \underline{q}x\left[(B^n - \underline{C}_n)\right] + \underline{q}(1-x)\left[\mu_\emptyset B^d - \underline{C}_d\right] + (1-\underline{q})\left[\frac{B^d}{2} - \underline{C}_d\right] \\
& -\underline{q}k - \frac{1-\nu}{\nu}\underline{q}x\alpha(\underline{q})(\Delta C_d - \Delta C_n) \\
\text{subject to} & \underline{a} = \alpha\underline{q} + (1-\underline{q})
\end{array}
$$

The first-order derivative of the objective with respect to $\underline{q}$ is given as follows:

$$
x\left[B^n - \underline{C}_n + \underline{C}_d - \frac{1-\nu}{\nu}(\Delta C_d - \Delta C_n) - \frac{k}{x}\right].
$$

Therefore, we have the result described in Claim 4.■

Claims 1 to 4 prove the results in Lemma 1 and in particular the lemma allows us to express each type's rent as a function of $\underline{a}$. Finally, inserting the results of Lemma 1 into the reduced program RP^A and optimizing with respect to $\left\{q(\overline{\theta}), p(\cdot \mid \overline{\theta})\right\}$ yields:

$$
\overline{q} = 1, p(s, \overline{\theta}) = 0, p(\emptyset, \overline{\theta}) = 1.
$$

The optimal transfers are easily obtained from the rents.

Appendix 3

Since the optimal mechanism design under the benchmark is a very standard problem, we only consider task integration. The mechanism is given by $\{p(\sigma,\theta),t(\sigma,\theta)\}$. We can solve the program in two steps. In the first step, given $[p(\emptyset,\theta),t(\emptyset,\theta)]$, we maximize the principal's payoff with respect to $[p(s,\theta),t(s,\theta)]$. In the second step, we maximize the principal's payoff with respect to $[p(\emptyset,\theta),t(\emptyset,\theta)]$. Define $U(\widehat{\sigma},\widehat{\theta}:\sigma,\theta)$ and $U(\sigma,\theta)$ as in Section 4. Then, the slope of the utility $U(\sigma,\theta)$ is given by:

$$U_\theta(\sigma,\theta) = -\left[p(\sigma,\theta)\left(C_\theta(\theta,d)-C_\theta(\theta,n)\right)+C_\theta(\theta,n)\right] \leq 0.$$

We observe that the utility is decreasing in θ and that the absolute slope of the utility is increasing in $p(\sigma,\theta)$. Since we assumed $p(s,\theta) \leq p(\emptyset,\theta)$, the utility decreases more quickly when $\sigma=\emptyset$ than when $\sigma=s$.

The second order condition is satisfied if $p(\sigma,\theta)$ is decreasing in θ for each σ.

It is easy to see that when $\sigma=\emptyset$, the utility is given by:

$$U(\emptyset,\theta) = \int_\theta^{\overline{\theta}} \left[p(\emptyset,\widetilde{\theta})\left(C_\theta(\widetilde{\theta},d)-C_\theta(\widetilde{\theta},n)\right)+C_\theta(\widetilde{\theta},n)\right] d\widetilde{\theta},$$

where the individual rationality constraint is binding for $\overline{\theta}$ and $IC((\emptyset,\theta)\to(\emptyset,\widehat{\theta}))$ is binding for upward manipulations.

When $\sigma=s$, the agent of type θ can obtain at least $U(\emptyset,\theta)$ by concealing the signal. Hence, $U(\emptyset,\theta)$ plays the role of type-dependent reservation utility. Since the utility decreases more quickly when $\sigma=\emptyset$ than when $\sigma=s$, the incentive compatibility constraint $IC((s,\theta)\to(\emptyset,\theta))$ is binding for $\underline{\theta}$ and the utility is given by:

$$U(s,\theta) = U(\emptyset,\underline{\theta}) - \int_{\underline{\theta}}^{\theta} \left[p(s,\widetilde{\theta})\left(C_\theta(\widetilde{\theta},d)-C_\theta(\widetilde{\theta},n)\right)+C_\theta(\widetilde{\theta},n)\right] d\widetilde{\theta}.$$

There are countervailing incentives in the sense that the incentive compatibility constraint $IC((s,\theta)\to(s,\widehat{\theta}))$ is binding for downward manipulations.

After inserting the above utilities into the principal's objective, we can obtain the first order conditions with respect to $p(\sigma,\theta)$, as described in Section 6.1.

Appendix 4

We already proved that $z < 1$. It is obvious that $\mu(s) = 0$, $\nu(s) < \nu$. From assumption 2, we have $p(\theta \mid s) = 0$, $t(\theta \mid s) = \overline{C}_n$.

Given $z \geq 0$, we have:

$$\mu(\emptyset : z) = \frac{1}{2\left[(1-x) + \nu x(1-z)\right]}, \ \nu(\emptyset : z) = \frac{\nu(1-x) + \nu x(1-z)}{(1-x) + \nu x(1-z)}.$$

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

$$\Pi(\nu, z) \equiv \mu(\emptyset : z)B^d - \left[1 - \mu(\emptyset : z)\right] B^n - \overline{C}_d + \overline{C}_n - \frac{\nu(\emptyset : z)}{1 - \nu(\emptyset : z)} \left(\Delta C_d - \Delta C_n\right).$$

We note that $\frac{\partial \Pi}{\partial \nu} < 0$ and $\frac{\partial \Pi}{\partial z} > 0$.

We have two following lemmas.

Lemma 2 *There always exists an equilibrium with $z = 0$.*

Proof. If $\Pi(\nu, 0) > 0$, we have $p(\theta \mid \emptyset) = 1$ and $t(\theta \mid \emptyset) = \overline{C}_d \ \forall\theta$. Thus, $z = 0$ is the best response to the efficient type. If $\Pi(\nu, 0) < 0$, we have $p(\underline{\theta} \mid \emptyset) = 1$ and $t(\underline{\theta} \mid \emptyset) = \underline{C}_d + \Delta C_n$, $p(\overline{\theta} \mid \emptyset) = 0$, $t(\overline{\theta} \mid \emptyset) = \overline{C}_n$. Since the efficient type has the same rent regardless of whether he reports s or $\emptyset$, $z = 0$ is one among the best responses. If $\Pi(\nu) = 0$, the principal can adopt a mixed strategy: $0 \leq p(\overline{\theta} \mid \emptyset) \leq 1$. In this case, if $p(\overline{\theta} \mid \emptyset) > 0$, $z = 0$ is the best response and if $p(\overline{\theta} \mid \emptyset) = 0$, $z = 0$ is one among the best responses. ■

Lemma 3 *When $\Pi(\nu, 0) < 0$, for each $z \in (0, z^*(\nu)]$ with $\frac{dz^*}{d\nu} > 0$, there exists an equilibrium.*

Proof. When $\Pi(\nu, z) > 0$, we have that $p(\theta \mid \emptyset) = 1$, $t(\theta \mid \emptyset) = \overline{C}_d$. Thus, $z > 0$ cannot be an equilibrium. Moreover, since $\frac{\partial \Pi}{\partial z} > 0$ holds, $z > 0$ cannot be an equilibrium when $\Pi(\nu, 0) > 0$. When $\Pi(\nu, 0) < 0$, we have that $p(\underline{\theta} \mid \emptyset) = 1$, $t(\underline{\theta} \mid \emptyset) = \underline{C}_d + \Delta C_n$, $p(\overline{\theta} \mid \emptyset) = 0$, $t(\overline{\theta} \mid \emptyset) = \overline{C}_n$. Since the efficient type has the same rent regardless of whether he reports s or $\emptyset$, 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 $\frac{dz^*}{d\nu} > 0$. ■

Because we have $\Pi(0, 0) > 0$, $\lim_{\nu \to 1} \Pi(\nu, 0) = -\infty$, $\frac{\partial \Pi}{\partial \nu} < 0$, there exists ν^* with $0 < \nu^* < 1$ such that:

1) for all $\nu \in (0, \nu^*)$, there exists a unique equilibrium with $z = 0$. In this case, the principal's net benefit is strictly decreasing in ν,

2) for all $\nu \in [\nu^*, 1)$, there are multiple equilibria. In this case, the principal's payoff is largest with $z = z^*(\nu)$. Under this equilibrium, the principal's net benefit is strictly increasing in ν.