Too few cooks spoil the broth

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December 13, 2003

Abstract

We consider a principal-agent relationship in which two tasks need to be carried out. Each task involves a decision. The principal can neither contract on the two decisions nor on the benefit which she receives from them but only on a signal, which simultaneously reflects both. We show that the efficient choice cannot be achieved if the principal employs a single agent. If, however, the principal employs a second agent, she can set a payment scheme such that the efficient choice can be implemented. We also examine when this implementation is vulnerable to collusion.

Keywords: hidden action, moral hazard, optimal contract, job design, asymmetric information

JEL-Codes: M52, D82

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1 Introduction

It is a commonplace that large institutions and organisations often feature positions which are costly but not associated with a productive activity (not even supervision). The tasks associated with these positions may easily be carried out by some other member of the existing work force. So, the position seems redundant. In this paper, we argue how such positions might arise as a second-best solution to an agency problem and suggest which value they contribute. We explain why a seemingly useless additional worker is employed for a task which could be carried out by the existing work force without problems at lower costs.

The analysis deals with "coping organisations" (Wilson 1989) in which neither actions nor output can be enforced directly by contracts. In these organisations, the problem of inducing efficient actions and decisions is most acute. Our analysis suggests that the additional position improves performance because it allows to set more appropriate incentives. In particular, we consider a situation where the only verifiable quantity is a signal which confounds two decisions. Each of these decisions is related to a task and both tasks need to be carried out to produce a benefit. However, only one decision is relevant for the benefit. As an example, consider that the benefit comes from delivering a high quality service to a target audience. The first task is the service itself, the second task is to inform clients about the availability of the service. Whoever carries out the service decides on its quality while marketing can be done in a simple and cheap or a more expensive way, which raises interest in the service even beyond the target audience. Now, suppose that the demand for the service is the only observed variable. Then, a high demand may result from a high quality of the service or from clients not belonging to the target audience. In other words, the only observable signal confounds the two decisions. Hence, using this signal to provide incentives to a worker to deliver a high quality service is problematic. A single worker in charge of both tasks might rather extend the client base instead of providing a high quality service. In some sense, the worker engages in window dressing by allocating too much resources to marketing. Thus, using the signal creates an unwanted distortion.

This distortion can be eliminated by hiring a second worker. As the production and signalling technology remain the same, there is a-priori no reason why the distortion should vanish. However, it becomes possible to use the same single signal to provide incentives because workers decide interactively. While a single worker cannot commit to refrain from window dressing, the incentives to the two workers can be set in such a way that the result from the interaction is the desired performance and not window dressing. Thus, seemingly redundant positions can be explained as a solution to an incentive problem when signals confound the decisions concerning different tasks.

Prendergast (2000) also deals with the problem of inducing efficient actions in coping organisations. He points out that monitoring works less well in such organisations than in the first-best world. Under these conditions, optimal policies are characterised by attributes which are usually associated with inefficient bureaucracies: legitimate claims are ignored, too much unnecessary monitoring occurs, too few errors are corrected, and decisions are delayed. Our work links up to Prendergast's findings and is complementary in two ways. First, our findings concern different elements of a bureaucracy, namely, the above mentioned existence of seemingly redundant positions. Second, this finding is rooted in the relationship between employer (or principal) and workers (or agents) rather than in the triangle between principal, agent, and client. In Prendergast's model, clients are used to monitor the agent. This monitoring is insufficient, because clients ignore unjustified decisions which are to their advantage. To overcome this problem, the principal also conducts costly checks which randomly reveal the true situation. These random checks are the driving force of Prendergast's model. In our model, the principal cannot utilise additional monitoring but she can create a new position, separate tasks, induce a game between the office holders, and thereby improve incentives.

Our work also relates to Dewatripont and Tirole (1999), who consider the problem of gathering information about an unknown dichotomous state of the world. Because effort is not observable and remuneration can only condition on a decision, a single agent has less incentives to inform herself than two agents which are made "advocates" for a particular state of the world. Thus, the model shares with our model the idea that adding an additional agent creates interaction which might be beneficial. However, in our model the second agent only helps to identify the contribution of the first agent, there is no other more direct beneficial effect of the interaction, and the tasks of the agents don't have to be related to gathering information.

Like in our work, Athey and Roberts (2001) study the effect of signals which confound multiple actions. They derive implications on the allocation of decision rights and the design of incentive schemes, which ultimately may lead to the endogenous formation of a hierarchy between two agents. In their model, the number of agents is taken as fixed, whereas we are particularly interested in the question when it makes sense to increase the work force. Their analysis also differs from ours as all actions have payoff consequences for the principal, while our model contains a decision which chiefly affects the signal.

Because the agent has to make two decisions, which can be regarded as effort choices, the present work is related to the multi-tasking literature initiated by the seminal work of Holmström and Milgrom (1991). It is known from practice (Kerr 1975) and theory (Holmström and Milgrom 1991) that disastrous distortions in the allocation of effort between tasks can result in such settings. The misallocation of effort arises from uncertainty, the composition of signals, or limited contract spaces (for examples see Feltham and Xie 1994, Baker 2002; for an overview see Schnedler 2002) Here, misallocation is entirely due to the structure of the signal and leads to a complete breakdown of incentives in a single agent setting. Holmström and Milgrom (1991) identify two causes for the breakdown of incentives: (i) some tasks are contractible while others are not (ii) some tasks are more precisely measured than others. The reason here falls in neither of the two categories: it is the impossibility to identify the effort from the signal which leads to the breakdown.

The introduction of an additional worker to overcome an observational problem bears similarity to the model of Strausz (1997), where a second agent is brought into a hidden-action model to overtake monitoring activities. In principle, the monitoring could also be undertaken by the principal but she has an incentive to misrepresent the result to her advantage. By offering a contract to an external monitor without vested interest, a commitment to monitor becomes possible. The mechanism underlying this commitment is similar to the mechanism which underpins our result: an interaction between two parties replaces a joint decision and the interactive character rules out certain undesired actions. In the setting of Strausz, the player with the commitment problem is the principal in our setting it is the agent. The solution to the commitment problem in Strausz's setting is an middleman between principal and agent which acts on behalf of the principal and forms an additional hierarchical layer. A casual observer "understands" the role of the additional employee in a hierarchy: this employee monitors the working agent in place of the principal. We provide a rationale why an additional employee improves incentives even if it is not her task to supervise.

The following section sets up the model. Then, in Section 3, we derive the optimal contract for the one-agent case and show that it is not leading to the efficient effort allocations. Next, in Section 4, we compute the optimal contract for the two-agent case in which the efficient allocation can be induced. In Section 5, we discuss the (negative) effects of collusion and in Section 6, we explain under which conditions the principal can overcome collusion. Finally, Section 7 concludes.

2 The modelling framework

Consider a principal, who draws a benefit from the execution of two tasks. The benefit to the principal is conditional on both tasks being performed and depends on how the two tasks are performed. Lacking time or skills, the principal offers one or many agents a contract to carry out the tasks.

As long as at least one agent works on each task, this creates a seizable benefit for the principal which more than offsets the agents' costs. Assuming that it can be verified whether an agent works on a task, a contract can be written which reimburses the agent and stipulates work on all tasks. If the costs of hiring an additional agent κ exceed the productivity gain from this agent, there is no reason to hire more than a single agent. However, the principal in our model has a second interest: she wants the work to be done in a particular way, as this affects the benefit she gets. The way how the work is carried out is beyond direct contractual enforcement. The remainder of the paper examines how to provide incentives for agents to improve performance on the two tasks, under the assumption that both tasks need to be performed.

To explain the costs and benefits from the different ways how the tasks are handled, we consider the case, where only a single agent works for the principal. Later, we extend the framework to multiple agents. The agent has to decide how to carry out task I and task II. These action choices are denoted by a_{I} and a_{II}. For simplicity, we assume that there are only two ways how each task can be carried out: $a_{\mathrm{I}} \in \{0,1\}$ and $a_{\mathrm{II}} \in \{0,1\}$. The agent dislikes the high options; this is modelled by costs c_j, which are incurred by the agent when choosing the high option on task j: $a_j = 1$. The disutility from the high option is larger for the first task: $c_{\mathrm{I}} > c_{\mathrm{II}} > 0$. On the other hand, the principal's benefit increases by b_{I}, when the agent performs high on the first task ($a_{\mathrm{I}} = 1$), while there is a lower gain b_{II} from high performance on the second task ($a_{\mathrm{II}} = 1$). The gains occur only if the respective high action has been chosen. The benefit increase from the first task action outweighs the costs of high performance, so that there is even scope to hire a second agent: $b_{\mathrm{I}} > c_{\mathrm{I}} + \kappa$. High performance on the first task is efficient. On the other hand, high performance on the second task is inefficient: $b_{\mathrm{II}} < c_{\mathrm{II}}$. The latter assumption is not crucial; most results hold without it. However, it simplifies the exposition if performance is desired on one and not on the other task.

Think of a two-step production process. First, the agent works on a machine which produces an item. Second, the item is painted by the agent. From the result, it is obvious whether the two steps have been carried out. However, the steps can be carried out in different ways. The agent may be sloppy or accurate when producing, also he may add a second layer of paint. Both activities are costly to the agent, but being accurate while producing is more difficult than adding the extra layer of paint. The principal is interested in longevity of the final product, which is determined by accurate production rather than a second layer of paint. Optimally, the agent would work accurately and add only a single layer of paint.

While it is generally observable that the agent works on a task, it is not observable how he performs. It is thus questionable, whether the efficient performance can be achieved. In fact, it is impossible to convince the agent to perform well on the first task when he is not rewarded for it. To reward the agent, we need some contractible quantity. Usually, there is some information available which is related to performance but often this information is systematically disturbed. Here, we assume that the following signal s is available, which mixes the contribution of the two actions:

$$s := \left\{ \begin{array}{ll} 1 & \text{for } a_{\mathrm{I}} = 1 \text{ or } a_{\mathrm{II}} = 1 \\ 0 & \text{else} \end{array} \right\} = \max\{a_{\mathrm{I}}, a_{\mathrm{II}}\}. \tag{1}$$

Some words about this signalling technology and its relation to benefit creation are in order. This model describes the frequently found situation that the actual objective may be felt by the principal in form of a benefit increase and by the agent in form of costs but is hidden from the eye of an external observer. Thus contracts, which need to be enforced by an external institution, cannot be based on this information. But the observer does have some "impression". This impression is modelled by the signal s. However, the impression does not only depend on the performance in question a_{I} but also on a "masking" action a_{II}. It is this confounding signal which is used in contracts.

In the example of the two-step process, inaccurate production might lead to fissures. With a single layer of paint, the fissures can be detected and the worker can be held responsible. However, the inefficient second layer of paint covers up fissures. So there are three ways of producing a good looking product (high signal): accurate production, two layers of paint, or both. Only if the agent produces inaccurately and applies a single layer, the bad performance becomes apparent.

The signal gives the principal some scope to provide incentives. She can set two transfers depending on the state of the signal t_1 which is paid whenever the signal takes on the high value ($s = 1$) and t_0 which is handed to the agent given the low signal ($s = 0$).

3 One-agent case

To find the optimal contract, we assume that the principal is the mechanism designer and that the rationality of the agent is represented in form of an incentive constraint. A participation constraint ensures that the principal does actually create surplus and is not simply exploiting the agent. For simplicity, the outside option of the agent is standardised to zero.

Given the signal, the principal maximises the joint surplus subject to the incentive and participation constraint:

$$\begin{aligned} \max_{t_1,t_0} \quad & b_{\mathrm{I}}a_{\mathrm{I}} + b_{\mathrm{II}}a_{\mathrm{II}} - (t_1 - t_0)\max\{a_{\mathrm{I}}, a_{\mathrm{II}}\} - t_0 \\ \text{such that} \quad & (a_{\mathrm{I}}, a_{\mathrm{II}}) \in \operatorname{argmax}_{(\tilde{a}_{\mathrm{I}},\tilde{a}_{\mathrm{II}})}(t_1 - t_0)\max\{\tilde{a}_{\mathrm{I}}, \tilde{a}_{\mathrm{II}}\} + t_0 - \tilde{a}_{\mathrm{I}}c_{\mathrm{I}} - \tilde{a}_{\mathrm{II}}c_{\mathrm{II}} \\ \text{and} \quad & (t_1 - t_0)\max\{a_{\mathrm{I}}, a_{\mathrm{II}}\} + t_0 - a_{\mathrm{I}}c_{\mathrm{I}} - a_{\mathrm{II}}c_{\mathrm{II}} \geq 0. \end{aligned}$$

Because the signal is positively associated with the desired high performance on the first task, a first intuition might be to reward the agent for the high signal. Re-considering the example, intuition suggests that once the agent is rewarded for a good looking product, he will produce it in the cheapest and not necessarily in the best way. So production will be inaccurate and the agent will cover it up with a second layer of paint. Formally, the following result holds:

Result 1 (Window-dressing by a single agent). *If there is a single agent and $t_1 - t_0 \geq c_{II}$, the agent chooses $a_I = 0$ and $a_{II} = 1$*

Proof. The cheapest way to secure a high signal by the agent is to exert $a_{\mathrm{II}} = 1$. This costs only c_{II}, whereas the efficient action $a_{\mathrm{I}} = 0$ is more expensive: $c_{\mathrm{I}} > c_{\mathrm{II}}$. Choosing $a_{\mathrm{II}} = 1$ to get the high signal suffices to secure t_1. Picking $a_{\mathrm{I}} = 1$ only inflicts additional costs on the agent. The agent prefers the high signal to the low signal, if the corresponding transfer difference $t_1 - t_0$ more than pays for the costs of obtaining this signal. We computed these costs to be c_{II} and they are lower. □

Of course, principal and agent foresee the incentive of the agent not to exert the productive effort but to engage in window dressing. Incentivising the agent to perform well on the second task is costly (c_{II}), while the respective benefits are meager (b_{II}). Principal and agent loose $c_{\mathrm{II}} - b_{\mathrm{II}} > 0$ from a scheme which rewards the agent ($t_1 - t_0 \geq c_{\mathrm{II}}$). Thus, the optimal choice in the single agent case is to give up on incentives:

Result 2 (No incentive provision). *In the single agent case, it is optimal to choose the transfers such that: $t_1 - t_0 < c_{II}$.*

Proof. By the previous result $t_1 - t_0 \geq c_{\mathrm{II}}$ leads to $a_{\mathrm{II}} = 1$. This results in costs c_{II}, benefit b_{II}, and a loss of $c_{\mathrm{II}} - b_{\mathrm{II}} > 0$. If $t_1 - t_0 < c_{\mathrm{II}}$, the agent has no incentive to choose a high action ($a_{\mathrm{I}} = a_{\mathrm{II}} = 0$). The respective costs, benefit, and losses are zero. So, it is optimal not to provide incentives. □

The ability of the agent to cover up bad performance on the first task by a good performance on the second task undermines any well-meant incentive scheme. An obvious solution would be to prohibit the agent from doing the second task. This is no option in our setting because the principal prefers a bad performance on the second task to no performance at all: the second task needs to be carried out because it is essential for production. However, the principal can hire a second agent for the second task. This avenue will be explored in what follows.

4 Two-agent case

When there are multiple agents, it needs to be specified, who determines which action. In reality, the problem is not so much to assign agents to tasks but to ensure that the assignment has binding character. This can be done by withholding material needed for this task, not granting access to a locality at which the task has to be performed, or not training or preparing the worker to carry out the task. In other words, the principal controls the access of agent i to task j. Let $\alpha_j^i = 1$ denote that agent i is enabled to carry out an action at task j and $\alpha_j^i = 0$ the opposite. Due to the production technology, the principal has to grant at least one agent access to each task: $\sum_i \alpha_j^i \geq 1$ for j =I,II. But what happens if two agents work on the same task? Then, we have to define the action a_j at task j, which results from the actions a_j^i and a_j^k taken by agents i and k. We abstract from this issue by assuming that there is at most one agent working on each task: $\sum_i \alpha_j^i = 1$ for j =I,II. In addition, we only consider a maximum of two agents. All these assumptions are not essential but facilitate the exposition. Basically, the problem for the principal now boils down to sticking with agent A and granting him access to both tasks or hiring an additional agent B at costs κ and transferring the responsibility of one task to agent B.

Note, that the costly hiring of agent B entails no direct benefit. Moreover, it is not obvious, why it can help to solve the incentive problem for agent A. Transferring task II from agent A to B prevents agent A from masking sluggishness on task I, but the structure of the signal stays the same: there is still one signal confounding the two tasks. So, if the principal sees the "good" signal, she still does not know, whether it results from the desired performance or not. Without loss of generality, we suppose that agent A works on task I and agent B on task II. To denote that transfers can depend on the identity of the agent, we use an additional index: t_s^i is the transfer received by agent i when the signal is s. Using this notation, we can write the maximisation programme of the principal as:

$$\begin{aligned}
\max_{t_1^{\mathrm{A}}, t_0^{\mathrm{A}}, t_1^{\mathrm{B}}, t_0^{\mathrm{B}}} \quad & b_{\mathrm{I}} a_{\mathrm{I}} + b_{\mathrm{II}} a_{\mathrm{II}} - (t_1^{\mathrm{A}} + t_1^{\mathrm{B}} - t_0^{\mathrm{A}} - t_0^{\mathrm{B}}) \max\{a_{\mathrm{I}}, a_{\mathrm{II}}\} - t_0^{\mathrm{A}} - t_0^{\mathrm{B}} \\
\text{s. t.} \quad & (a_{\mathrm{I}}, a_{\mathrm{II}}) \text{ is a Nash equilibrium of the game depicted in Table 4} \\
\text{and} \quad & (t_1^i - t_0^i) \cdot \max\{a_{\mathrm{I}}, a_{\mathrm{II}}\} + t_0^i - \alpha_{\mathrm{I}}^i a_{\mathrm{I}} c_{\mathrm{I}} - \alpha_{\mathrm{II}}^i a_{\mathrm{II}} c_{\mathrm{II}} \geq 0 \text{ for } i = \mathrm{A, B}.
\end{aligned}$$

The first side condition indicates that action choices are determined interac-

		Agent B	
		L	H
Agent A	L	$(t_0^{\mathrm{A}}, t_0^{\mathrm{B}})$	$(t_1^{\mathrm{A}}, t_1^{\mathrm{B}} - c_{\mathrm{II}})$
	H	$(t_1^{\mathrm{A}} - c_{\mathrm{I}}, t_1^{\mathrm{B}})$	$(t_1^{\mathrm{A}} - c_{\mathrm{I}}, t_1^{\mathrm{B}} - c_{\mathrm{II}})$

Table 1: Interaction between Agent A and B

This game represents individual rationality in the maximisation programme. The first payoff in each payoff pair relates to agent A, the second payoff to agent B.

tively between agents. This disciplines the agent on task I in a way which is not possible in the single agent case. Moreover, the principal has substantial influence on the structure of the game. For example she can reward agent A for the high signal to elicit the high action at task I while punishing agent B for the same signal to avoid window dressing on the behalf of the latter. Using such a scheme, the efficient outcome can be achieved as a solution to the two-agent maximisation programme.

Result 3 (Unique efficient equilibrium). *The efficient allocation ($a_I = 1, a_{II} = 0$) is implemented as the unique Nash-equilibrium of the game from Table 4, if transfers a chosen such that $t_1^A - c_I \geq t_0^A$ and $t_1^B - c_{II} \leq t_0^B$.*

Proof. Take transfers fulfilling the conditions. Observe that no agent has an incentive to deviate from the efficient allocation, while at least one agent will deviate from any other allocation. □

If the inequalities for the transfer scheme hold strictly, the efficient allocation is even a strict Nash-equilibrium. The implementation does not even have to involve punishment for agent B: suppose B gets a flat salary ($t_1^{\mathrm{B}} = t_0^{\mathrm{B}} = 0$), then he has no incentive to choose the costly high action; if agent A obtains a premium for the high signal ($t_1^{\mathrm{A}} \in (c_{\mathrm{I}}, b_{\mathrm{I}}]$ and $t_0^{\mathrm{B}} = 0$), he will carry out the desired action. By manipulating the transfers, the principal may obtain all but the high cost allocation, $(a_{\mathrm{I}}, a_{\mathrm{II}}) = (1, 1)$, as an equilibrium – see Figure 1.

However, the surplus obtained from the other allocations is always lower than the surplus from the efficient allocation, which generates $b_{\mathrm{I}} - c_{\mathrm{I}} - \kappa > 0$. The low-cost allocation, $(a_{\mathrm{I}}, a_{\mathrm{II}}) = (0, 0)$, leads only to a surplus of zero in the single-agent case and $(-\kappa)$ in the two-agent case. The window-dressing

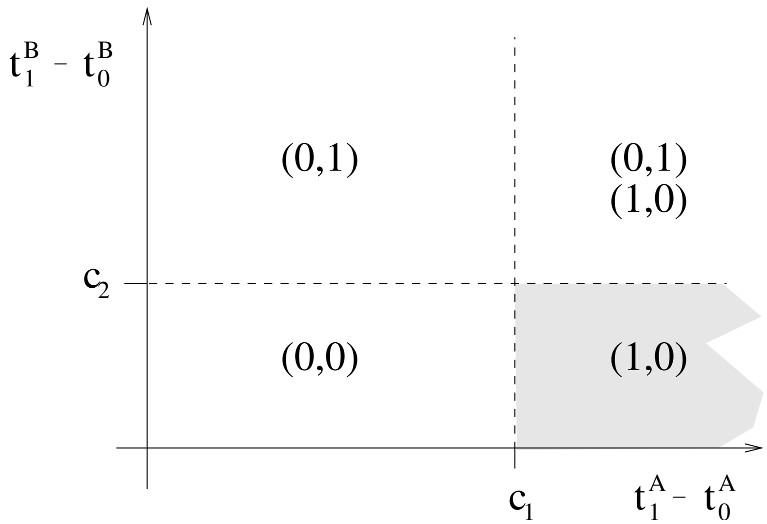

Figure 1: Implementable action pairs

Depending on the difference in transfers between the two signal outcomes various action choices can be implemented. Most importantly, there are transfers which uniquely implement the efficient allocation, $(a_I, a_{II}) = (1, 0)$.

allocation, $(a_{\mathrm{I}}, a_{\mathrm{II}}) = (0, 1)$, results in a surplus of $b_{\mathrm{II}} - c_{\mathrm{II}} < 0$, where an additional κ has to be subtracted in the two-agent case.

So, the principal will hire agent B solely to provide incentives for agent A. The idea of separating tasks to overcome incentive problems dates back to the multitasking models of Holmström and Milgrom (1991), who rule out this possibility. A decisive feature of the model here is that task separation does not entail a separation of signals. Thus, hiring agent B in itself does not create a meaningful signal but providing the right incentives to agent B renders the signal meaningful for agent A's action. In the language of the initial example: agent B is neither rewarded nor punished for visible fissures and hence only uses one layer of paint. Consequently, fissures will show up when agent A worked inaccurately and the final state of the product may be used to provide incentives for A.

This logic is similar to the justification of advocates put forward by Dewatripont and Tirole (1999). Whereas in Dewatripont and Tirole's model the second agent contributes directly to overall surplus and there are thus potentially two reasons to hire this agent: incentives and work load sharing. In our setting, as agent B does not directly contribute to the surplus, he is employed merely for incentive reasons. As the only verifiable bit for an outside observer is the signal and as agent B has no incentive to improve appearance, it looks as if agent B is reducing productivity; products which looked impeccable, now may exhibit fissures.

Since the signalling technology is not altered by hiring the second agent, the implementation of the efficient allocation is vulnerable to an arrangement in which the two agents act as if they were one agent. In other words, the two agents might collude and thereby undermine the incentive scheme. This problem is explored in the following section.

5 Collusion

For a successful collusion, there must exist some deviation from the implemented actions which improves the joint situation of both agents under the given contractual arrangement. In other words, the sum of the transfers received by both agents minus the costs must be larger for the deviating actions than for the prescribed actions. The obvious deviation candidate is window dressing: the first agent chooses the low action and the second agent chooses the high action, so that they save the costs for the expensive first task and only have to pay for the cheaper second task. In our setting, if the two agents decide to maximise their joint pay-off, they can be better off.

Result 4. *If the two agents collude and maximise their joint pay-offs, there exists a deviation from the efficient allocation which is profitable for the agents.*

Proof. The maximisation problem of the joint payoff is identical to the maximisation problem of a single agent from Result 1. Thus, the window dressing allocation maximises the joint payoff. If agent A chooses the low action and agent B commits to the high action, the signal remains high. So, the joint received transfers of the agents remain the same. However, the costs to them are reduced by $c_{\mathrm{I}} - c_{\mathrm{II}}$. □

So, if agents can collude, they obstruct the incentive scheme and switch from the productive allocation to window dressing. This should not surprise because agents share all costs and benefits and hence act as if they were a single agent.

Collusion is a collective action: agents need to commit to behave cooperatively. However, their self interest may not be aligned with their joint interest. Hence, some commitment device becomes necessary to make collusion enforceable. In our setting we need a double-sided commitment.

Result 5 (Double-sided commitment for collusion). *If and only if the second agent can commit to the window-dressing activity and the first agent can commit to compensate the second agent, collusion can be sustained.*

Proof. Under a payment scheme which fulfils $t_1^{\mathrm{A}} - c_{\mathrm{I}} \geq t_0^{\mathrm{A}}$ and $t_1^{\mathrm{B}} - c_{\mathrm{II}} < t_0^{\mathrm{B}}$, agent B is individually better off when choosing the low action. Collusion is only profitable when it leads to window dressing. But window dressing requires agent B to carry out the high action. This is why the commitment of B to the high action is necessary. It is only optimal for agent B to commit, if he gets at least reimbursed for the costs of this action c_{II}. So, agent A must simultaneously with B commit to pay agent B. Simultaneity is required because the second-mover would have no incentive to commit. If both agents can simultaneously commit, this leads to window dressing and hence both agents have an incentive to do so. □

How can the double commitment be enforced? If agent A and B are interacting infinitely many times and sufficiently patient, they could punish each other in case of a deviation. However, in such a setting the principal is likely to be engaged in infinitely repeated interactions as well. In order to explain collusion, one thus has to explain, why the principal cannot find a self-enforcing agreement with the agents. More plausibly, the double commitment may be enforced from an external agency, which is not accessible to the principal. If the principal is law-abiding and the agents are not, the contract could be enforced using an illegal enforcement institution like the Mafia. In any case, it is crucial that the agents can do something which the principal cannot do: they must be able to contract on the second action a_{II}. In other words, they have a richer contract space. This, however, is not the only requirement. The collusion contract between the agents must also be hidden to the external world. Otherwise, the principal could disallow collusion. The principal seems to be more likely to spot a collusion, if she deals with both agents rather than just with a single agent. Accepting this claim, hierarchical relationships between the agents (Kofman and Lawarree 1993, Strausz 1997, Olsen and Torsvik 1998) are more prone to collusion, than the situation considered here.

But what if agents nevertheless find some way to commit and hence collude? The next section examines what the principal can do if agents can secretly write contracts on action a_{II}, while the principal cannot.

6 Heterogeneous agents

Assume that agents are facing a richer contract space than the principal and unlike the latter are able to contract upon the second task action. As we have seen in the previous section, this opens up the possibility of collusion. In this section, we consider how the possibility of having heterogeneous agents, who are not equally good at all tasks, may alter our results.

We previously assumed that the costs c_{I} and c_{II} did not vary with the agent's identity. Here, we relax this assumption and index costs by the agent's identity: c^i_j is the costs of agent i at task j. These costs are observable to the principal, so that she can carry out allocation of tasks according to costs.

In order to make the setup more interesting, we assume that agent B is strictly worse than agent A. That is, even at the cheaper second task, this agent has higher costs than agent one: $c^{\mathrm{A}}_{\mathrm{I}} < c^{\mathrm{B}}_{\mathrm{II}}$. Considering these costs, the hiring costs of κ, and neglecting any incentive effects, there would be no reason to employ agent two. However, it is precisely the incompetence of agent two even at task two which make him valuable for implementing the efficient solution.

Theorem 1 (Unique efficient outcome under collusion). *Given the assumptions of this section, a transfer scheme with $t^A_1 - c^A_I \geq t^A_0$ and $t^B_1 - c^B_{II} < t^B_0$ implements the efficient equilibrium as a unique and collusion-proof equilibrium.*

Proof. By Result 3, a transfer scheme fulfilling the above inequalities leads to the implementation of the efficient activities in a unique equilibrium. So all that remains to be shown is that the equilibrium is collusion-proof. Again, the most profitable deviation which agents may achieve jointly is the window-dressing situation where agent one does nothing $a_{\mathrm{I}} = 0$ and agent two masks the inactivity $a_{\mathrm{II}} = 1$ (agent one cannot do the window-dressing because he lacks the training). By this deviation, the superficial appearance does not change the signal ($s = 1$) and the sum of transfers received by the agents remains the same. On the cost side, the agents now jointly incur $c_{\mathrm{II}}^{\mathrm{B}}$ which is above $c_{\mathrm{I}}^{\mathrm{A}}$. Hence, the costs of this deviation are larger than the gains. □

Observable heterogeneity amongst agents thus helps to implement the efficient activity. The observable characteristics of this implementation are absurd: the principal employs a seemingly superfluous worker for a task which is essential but at which the worker is particularly bad while at the same time, the task could be overtaken by the existing work-force. If high performance were efficient on the second task but performance on the first task were more important, the principal might even forego efficiency on the second task and pay the second agent to be destructive, only to set the right incentives.

But not all phenomena around confounded signals are necessarily negative. There is a less grim interpretation of the exceedingly high costs of agent B to carry out the masking: agent B might be morally inhibited to act against the principal and to cover up for agent A's poor performance.

7 Conclusion

Creating a team when a single worker can do the job has several disadvantages. There might be problems of coordination and it can become more difficult to identify individual contributions which complicates the provision of incentives. This is particularly true, if there are no individual performance signals but only a common one. The setting analysed here features only a single common signal and there are no economies of scope or scale from hiring a second worker. Intuitively, there is thus no reason to employ more than one worker. However, we have shown that hiring another worker does not always blur the signal but may actually help to identify the contribution of the first worker; it is in the interest of all involved parties to incur costs and hire the additional worker because it then becomes possible to provide better incentives for the first worker. Hence, the sole purpose of the additional worker is to enable the operation of a profitable incentive scheme.

The presence of the new worker alters the incentives because the first worker's action is now exposed. A single worker has all reason to cover up bad work; once working with a second worker, it becomes considerably more complicated to hide sluggishness. The second worker has no reason to straighten the matter out for the sluggish worker –unless they achieve an informal agreement. Informal agreements are only possible under special conditions. We have seen that even under these conditions, collusion can be avoided by the selection of an appropriate co-worker: someone who is unable or unwilling to engage in window-dressing.

The importance of the co-worker is concealed to the eye of a superficial observer: the worker is neither controlling the first worker nor reporting to the employer. Also, looking merely at the actual productivity, the additional worker seems superfluous; the contribution to production of this worker is negligible and below costs. Moreover, the second worker seems to be badly incentivised as he is not rewarded for a good-looking final product. As we have seen, collusion can be prevented if the second worker is not very good at improving appearance. In other words, it looks as if an incompetent agent is hired to fill a seemingly superfluous position. To the initial worker, the additional worker appears like a bureaucrat who is just doing his job and is unwilling or unable to collude and find a pragmatic solution which could increase the workers' joint welfare. On a broader context, however, once we consider the employer's welfare too, the presence of the second worker is indeed efficient. Once the employer's utility is incorporated, the second cook still looks unnecessary but in fact helps saving the broth.

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