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ABSTRACT

Preventing Collusion through Discretion*

Large public bureaucracies are commonly regarded as less efficient than modern private corporations. This paper explores how the degree of discretionary power might account for this difference in efficiency. Indeed, increasing the discretionary power of the intermediate layers of an organization - delegating power to them - enhances productivity by preventing collusion and capture between middle managers and line workers; provided that this detrimental form of collusion takes place in conditions of asymmetric information.

To understand how this mechanism works requires an explicit model of the penalty for breach of a collusive agreement a party has to incur to walk away from such a side deal. Delegation is then a simple way for the principal to compensate the uninformed colluding party for walking out of collusion and for using/reporting the information leaked in the collusive negotiation. This threat clearly reduces the informed party incentive to participate in side deals and prevents collusion at a reduced cost.

JEL Classification: D73, D78 and D83
Keywords: collusion, communication, delegation and hierarchies

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1. Introduction

1.1. Overview

Large public bureaucracies are commonly regarded as less efficient than modern private corporations. This paper explores how the degree of discretionary power might account for this difference in efficiency. The main insight is that an increase in intermediate layers' discretionary power enhances the productivity of the organization by preventing collusion and capture between middle managers and line workers.

Bureaucratic structures in public administration centralize decision power at the top (Crozier, 1964). Their hierarchies have many layers, but their main function is to transfer information to the next layer in the organization, rather than take independent decisions. In contrast, a private corporation is often characterized by discretionary power of middle managers who are accountable for their decisions. This decision power has increased in recent years in American corporations, through a reduction in the number of hierarchical layers so as to reduce the number of decisions that are "delegated up". Only critical problems are handled by the top of the hierarchy.

The connection between delegation of discretionary power and productivity has obvious policy significance. Bureaucratic public structures have clearly different objectives than modern private corporations. However, they are often criticized, in favor of privatized organizations, on the ground of their inefficiencies. The question is then, short of privatization which clearly alters the organization objectives in an undesired way, what changes need to occur to boost productivity in public organizations. This paper suggests increasing the discretionary power of intermediate layers as a key instrument for reform. In other words, we argue that there is no necessary link between the organization objectives, be it private or social goals, and a bureaucratic and inefficient structure.

Numerous examples suggest that the connection between discretion and collusion is relevant for organizations. In bureaucratic organizations middle managers tend to behave as advocates for their subordinates. They have nothing to gain from assuming a managerial attitude: they cannot fire, hire or promote subordinates. But middle managers gain from building cordial relationships with subordinates: they foster a better climate with employees, unions and peers. Intermediary managers then have the tendency *"... to bias the information they give* [to the top management] *in order to get the maximum of material resources and* *personal favors with which to run their sections smoothly. . . "* (Crozier, 1964, p. 45). In other words, the bureaucratic structure opens the door to harmful collusion between supervisors and employees.

This type of "downward loyalty" is less frequent in private organizations where middle managers have decision power concerning the position and career of their subordinates. Middle managers tend to help the top management in controlling the behavior of their subordinates: *"An unofficial role of staff officers at Milo was to assist higher line executives in learning of irregularities at the production level."* (Dalton, 1959, p. 73).

The intuition behind the relationship between discretionary power and collusive behavior can be captured by the following phenomenon often studied by sociologists. An employee will freely communicate and possibly become friend with a co-worker or even a supervisor in the event that the latter does not have the power to take decisions that will affect the former's work conditions, career or remuneration. If, on the other hand, the supervisor has such a power, communication between these two individuals becomes difficult or even impossible: the employee is afraid of revealing any information that may affect in a negative way the supervisor's decisions. These difficulties in communication are generated by the discretionary power, and not merely by the higher hierarchical ranking, of the supervisor. For example, Crozier (1964) observes that in bureaucratic organizations — where decision power is concentrated at the top management level — employees tend to have friendly relationships with immediate supervisors, who have no discretionary power,[1] and hostile or very difficult relationships with the top management.[2]

Communication is an essential ingredient for reaching a collusive agreement between two employees. Hence, preventing communication between layers can hamper the possibility of harmful collusion. Further, discretionary power hampers all forms of communication which entail, at the same time, revelation of information that the party at the receiving end has the discretion to use at his own advantage and at the disadvantage of the revealing party. In other words, whenever there exist information that may be revealed during the communication aimed at reaching collusive agreements — that is information among colluding parties

[1] *". . . relationships* [with supervisors] *are not bad; one feels free toward them and I myself do not scruple to tell them what I think."* (Crozier, 1964, p. 42).

[2] *"He* [the big boss] *makes me feel helpless, paralyzed. . . . He prevents people from saying anything. I could not speak one word. He did not let us explain . . . I feel paralyzed."* (Crozier, 1964, p. 43).

is asymmetric — a proper allocation of discretionary power may prevent information revelation and communication reducing in this way harmful collusion. There exists, of course, a drawback to such a practice. Communication, even when it takes the form of collusion, may help the principal to implement the desired allocation when the colluding parties have informational advantages that may be exploited by the principal (Holmström and Milgrom, 1989, Itoh, 1993). We shall abstract from these positive aspects of collusion in our analysis and focus on the harmful aspects instead.

The main idea presented in this paper is simple. Suppose that an agent has private information on his productive ability and a supervisor only observes an imperfect signal of such ability. The Principal elicits the information from the supervisor but by doing so he introduces the possibility of collusion between the supervisor and the agent: an agent whose ability is higher than a certain value can extract further rents when the Principal believes he is a low type. To reach a collusive agreement the agent and the supervisor need to communicate and define the terms of the agreement. It may happen that when the agent reveals his intention to participate in collusion, he also signals to the supervisor that his unobservable productivity is higher than the critical value mentioned above. When the supervisor has the authority, hence the option, to exploit this leaked information to the detriment of the agent, the latter will refuse to participate in the collusive bargaining process and collusion will be prevented. In the mechanism we present, increasing the discretionary power of the supervisor gives her the incentive to use the leaked private information and capture the whole informational rent from the agent.

Clearly the supervisor is able to exploit this additional information revealed during collusion only if she can breach the collusion agreement even if at a cost. In what follows we model explicitly the enforceability of collusion and in particular the penalty for breach of collusive agreements. The principal is them able to prevent collusion by introducing in the contract to the supervisor a clause that will allow the supervisor to be compensated for the cost of the penalty for breach of the collusive agreement in exchange for the information the supervisor learns during collusion. Notice that since the final outcome will be for the agent to refuse to participate in collusion this clause never applies in equilibrium and hence collusion is prevented at a zero cost to the principal.

A relevant question is then how much discretion should be attributed to the supervisor.

In our context, it is optimal to allocate only a limited degree of discretionary power to the supervisor. Indeed, making the supervisor fully residual claimant of the agent's behavior — which corresponds to selling the organization to the supervisor — is never optimal when the supervisor is risk averse as in the case considered here.

In our model the contracts between the principal and both the agent and the supervisor are employment contracts. These contracts are characterized by the assumption that the signature of the contract is not binding for the employee: the latter has the option to quit the contractual relation with the employer if he has a better opportunity outside the organization, even if this better opportunity arises after the signature of the contract.[3] This feature of contracts greatly simplifies our analysis and allows us to highlight the mechanism through which collusion is prevented at no cost. However, the mechanism proposed here still allows the principal to considerably reduce the costs of preventing collusion in a setting in which the underlying contracts are not characterized by the free-to-quit clause.[4]

The rest of the paper is organized in the following way. After a brief discussion of the related literature, Section 2 sets up the model. Section 3 analyzes the effects of collusion. In Section 4 we derive the main result of the paper, namely the optimal mechanism that allows the principal to prevent collusion in a costless way. We conclude this Section with an interpretation of this mechanism in terms of delegation of discretionary power to intermediary managers in hierarchical organizations. Section 5 concludes. For ease of exposition all proofs are presented in the Appendix.

1.2. Related Literature

Our analysis is closely related to two strands of the literature on organizations and contracts: the one on delegation, pioneered by Arrow and Radner (1979), and the one on collusion, pioneered by Tirole (1986).

The existing literature on delegation focuses on its informational costs and benefits and on their interplay with incentives and technological complementarities or substitutabilities within the organization (Bolton and Dewatripont, 1994, Severinov, 2008) but has not considered the

[3]This is a feature which is typical of, for example, US employment contracts (Baker, Jensen, and Murphy, 1988). Indeed, US Common Law forbids "voluntary servitude" and a binding employment contract has been interpreted as violating this principle.

[4]See the discussion in Footnote 27 below.

strategic role of an increase of discretionary power — a form of delegation — as a tool for preventing collusive behavior between members of the organization (Bolton and Farrell, 1990, Hortala-Vallve and Sanchez-Villalba, 2010, Melumad, Mookherjee, and Reichelstein, 1995, Radner, 1993). On the other hand, the literature on collusion has depicted the problem as a costly one. It has modeled collusion as a fully enforceable side contract ignoring, in this way, the possibility for the principal to induce one of the colluding parties to breach the side contract and report leaked information rendering, in this way, the side contract disadvantageous for the remaining colluding parties (Faure-Grimaud, Laffont, and Martimort, 2003, Laffont and Martimort, 1997, Tirole, 1986).

In particular, while the early literature on collusion (starting from Tirole 1986) has analyzed collusion under hard or verifiable information,[5] in recent years a number of papers have considered collusion-proof mechanisms in the presence of soft or unverifiable information (Laffont and Martimort 1997, 1999, 2000 and Faure-Grimaud, Laffont, and Martimort 1999, 2000, 2001, 2003). The last four papers are the closest to our. They consider an incentive contract involving a principal, a supervisor and an agent and allow parties to setup fully enforceable collusive side contracts. They show that the Collusion-Proof Principle (Laffont and Martimort, 1997) holds in this environment. This principle implies that the optimal mechanism is equivalent to a mechanism such that in equilibrium the parties to the contract do not engage in collusion. In other words, the optimal contract is the solution to the principal's payoff maximization problem subject to the constraint that supervisor and agent do not get involved in collusion (as well as the standard individual rationality and incentive compatibility constraints). In particular, Faure-Grimaud, Laffont, and Martimort (2003) show that the "equivalence principle" holds, like in our setting, and delegation is a way to implement the optimal collusion-proof mechanism.

The approach we present here differs from these paper in that we model explicitly what it means for a side contract to be binding. We then allow the principal to offer the supervisor a mechanism that compensate her for breaching the side deal with the agent and reporting any information she might have learned in the collusion game to the principal.[6] When collusion

[5]See for example Kofman and Lawarrée (1993, 1996).

[6]In this respect our approach is similar to the augmented revelation mechanisms (Ma, Moore, and Turnbull, 1988, Mookherjee and Reichelstein, 1990) that allow a mechanism designer (the principal) to prevent strategies coordination — as opposed to collusion — among agents. See also Demsky and Sappington (1989) for a hierarchical model where coordination between the supervisor and the agent is a concern that needs to be

takes place under asymmetric information, this supervisor's option may lead the agent to refuse to participate in collusion and hence prevent it at a low cost to the principal.

More recently a number of papers have explicitly considered the effect of delegation on parties' incentives to engage in collusive agreements. Baliga and Sjöström (1998) have explored the effect of delegation in a moral hazard setting in the presence of colluding parties' limited liability. They identify the optimal delegation mechanism that achieves the outcome that is optimal in the absence of collusion. The optimal delegated mechanism we derive below achieves the same type of outcome under adverse selection. However, it does not rely on limited liability but rather on the colluding parties' option to breach the side contract at a cost.

Che and Kim (2006) and Celik (2009) both analyze delegation in the presence of collusion in a hidden information framework. Both papers ask whether delegation can achieve the same outcome that is optimal in the absence of collusion. While Che and Kim (2006) reach a positive answer in a very general framework, both in terms of the technology and the number of parties involved in collusion, possibly excluding some of the parties from the side deal, they do impose restrictions on the correlation between the colluding parties' information structure. Celik (2009), on the other hand, focus on an organizational and informational structure similar to the one we consider here. He shows that delegation is not necessarily an optimal mechanism. In this paper we focus on a different aspect of delegation: the fact that in a delegated framework the colluding parties may have the incentive to breach the side contract and exploit the information they learn during collusion to their advantage and to the disadvantage of the other parties to collusion. This is the reason why in our framework delegation is indeed an optimal mechanism.

Finally, Quesada (2005) explicitly models the *informed principal* problem that may arise when collusion takes place under asymmetric information.[7] The paper derives the optimal collusion-proof contract and shows that, depending on the timing of the side contract, the outcome achievable in the absence of collusion may not be feasible when collusion is possible. In our context collusion does not lead to an informed principal situation for two competing reasons. The supervisors and the agent's information structures are nested: the supervisor

addressed by the optimal mechanism selected by the principal.

[7]In the collusion context the *informed principal* problem arises when the party offering the side contract has private information not available to the other party.

knows less than the agent. We model collusion in a way that is agnostic on the extensive form of the collusion game. In other words, it is not crucial for the result we derive the identity of the "principal" in the side contract.

2. The Model

2.1. The Parties

We model the organization as a three-level hierarchy. The top of the hierarchy is the residual claimant of profits: the principal (P). The bottom layer is the only level that actually produces any output: the agent (A). The intermediate level consists of a supervisor (S), who is capable of collecting information about the agent's relevant characteristics.

The agent is the productive unit of the hierarchy. He is endowed with a productivity parameter θ^A, $\theta^A \in \Theta^A \equiv \{\theta_1^A, \theta_2^A\}$, $\theta_2^A > \theta_1^A$. He may or may not exert a productive effort $e^A \in \mathbb{R}$, and both effort and productivity will generate an output x according to the following simple technology:

$$x = \theta^A + e^A \tag{1}$$

The agent is assumed to be risk neutral in income. His utility function is linear in income and strictly concave in effort. Disutility of effort is expressed, in monetary terms, by $d(e^A)$, where $d'(\cdot) > 0$, $d''(\cdot) > 0$, $d'''(\cdot) > 0$, $d(0) = d'(0) = 0$, $d(e^A) = 0 \; \forall \, e^A < 0$.[8] The agent's objective function is then: $[w - d(e^A)]$; his reservation wage is $\bar{w}$.

The supervisor has a monitoring role. She does not contribute directly to the productive process, but just provides information. If requested, she can supply the information to the principal. This is modeled by assuming that the supervisor observes a noisy signal, $\theta^S \in \Theta^S \equiv \{\theta_1^S, \theta_2^S\}, \theta_2^S > \theta_1^S$, of the agent's productivity parameter θ^A. This signal is *soft* or *unverifiable* information, in the sense that an outside party — the principal in particular — has no way to verify the real value of the signal besides asking the supervisor for a report and inducing, through incentives, truthful revelation. This signal is observed by the supervisor at no cost.[9]

[8] The role of negative effort is to keep things simple and allow the high productivity agent to mimic the low productivity agent. The assumption on the third derivative of the disutility function assures concavity of the optimization problems considered later.

[9] In principle, the supervisor might have to spend a costly effort to get a strictly informative signal, as in Demsky and Sappington (1989). However, such generalization does not add much to the analysis of collusion, while considerably complicating the notation and the presentation of the model.

The supervisor is risk averse: her utility function $V(s)$ is strictly concave in the salary s: $V'(\cdot) > 0, V''(\cdot) < 0$. The supervisor has an outside option with a reservation salary $\bar{s}$.

The principal is risk neutral, and is the residual claimant of the organization.

2.2. The Information Structure

The principal is the least informed party in the organization. His information set includes only the final levels of output x. The supervisor costlessly observes the noisy signal θ^S of the agent's productivity θ^A, and observes x. Finally, the agent has the best information structure: he knows θ^A, and can observe both the signal θ^S and x.[10] We take x to be the only *verifiable* information of the model, while θ^A is *observable* only to the agent and θ^S is *observable* to both the agent and the supervisor.

The agent's productivity θ^A and the supervisor's signal θ^S are positively, but imperfectly, correlated. Let:

$$q_i^S = Pr\{\theta^S = \theta_1^S \mid \theta^A = \theta_i^A\} \qquad i \in \{1, 2\} \tag{2}$$

That is, q_1^S is the probability that the signal θ_1^S is correct and q_2^S is the probability that the same signal is not correct. We take θ^S to be a strictly but not fully informative signal of θ^A:

$$0 < q_2^S < \frac{1}{2} < q_1^S < 1 \tag{3}$$

2.3. The Timing and Solution Concept

Before contracting, θ^A is determined randomly by nature and is the agent's private information. The other players share the same prior distribution $p^A = Pr\ \{\theta^A\ =\ \theta_1^A\}$. Negotiations take place in which the principal is assumed to have all the bargaining power. He proposes a *take-it-or-leave-it* contractual offer $C = (C^A, C^S)$ to both the agent and the supervisor, which specifies a schedule of compensations for them.

Supervisor and agent simultaneously and independently decide whether to accept or reject the principal's offer. If the agent rejects the offer, negotiation with both parties ends and the game ends. If the supervisor rejects the offer negotiation proceeds involving only the agent. The game then becomes a standard two tier principal-agent problem.[11] If the principal wishes,

[10] The fact that A observes θ^S is clearly a simplifying assumption. However, the main result of the analysis does not change if we assume that only x and θ^A are observed by the agent.

he can make degenerate offers to the supervisor, which amount to a decision on his part to negotiate only with the agent. If both supervisor and agent accept the offer a contract is signed.

After the contract is signed, supervisor and agent observe the signal θ^S, which remains their private information. At this stage the collusive negotiation between the supervisor and the agent takes place. In Section 3 below we provide a general characterization of this negotiation.

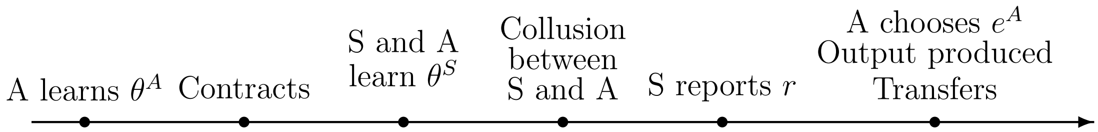
After contract C is signed and before performing according to it both agent and supervisor are assumed to have the option to *quit* contract C and obtain their outside option. As we mentioned above, this is a simplifying assumption that is also meant to capture a feature of employment contracts: the employee's option to quit the contract at each instant of time if he has a better opportunity outside the organization. This is a realistic feature of employment contracts. In the US a contract that commits the employee to stay in an employment relationship against his/her will will be regarded by courts as "voluntary servitude" and as such deemed unenforceable. We model the employee's free-to-quit option assuming that each employee quits the *official* contract by *refusing to perform* according to it, in other words the *quitting* option is not available once the employee has performed according to the contract. This characterization of the parties' quitting option is consistent with the discipline of employment contracts according to which employees' quitting decision dispense both parties from legal obligations associated with future contractual performances but not with past ones (Calamari and Perillo, 1987, Ch. 12 and 21).

At a predetermined time — intermediate between the initial contracting date and the date at which the agent produces output x — the supervisor may or may not (depending on whether she uses her quitting option) produce a report r of her observed signal that becomes public information.[12] The agent then may or may not (again depending on whether he uses his quitting option) exert his productive effort, the outcome of production becomes publicly

[11] Alternatively, the principal could make a unique offer to the agent that specifies a contractual arrangement, if the supervisor accepts the principal's offer and a different arrangement if the supervisor rejects the principal's offer; nothing would change.

[12] In principle it might be of use to the principal to ask the agent, as well as the supervisor, to report the signal θ^S. This is not the case in our framework, however, independently of whether the parties may collude or not. Indeed, the optimal mechanism we derive in the presence and in the absence of collusion induces the supervisor to report the truth at no explicit cost for the principal.

observable and remunerations are paid to the parties that did not quit the employment contract C.[13] We assume that all this structure — summarized in the figure below — is common knowledge to all the parties.



Revelation Principle implies that, without loss of generality, we can restrict attention to the following revelation game. Everything proceeds in the way described above up to the collusion game. Then the supervisor decides whether to announce or not the signal she observed, while the agent after having observed the supervisor's decision, announces his productivity to the principal. The principal then dictates the effort level the agent is required to exert and the remunerations supervisor and agent will receive. Finally, the agent decides whether or not to exert the effort chosen by the principal.[14]

In the revelation game the supervisor's strategy space is the set of all possible mappings from the signal space Θ^S into her decision whether to report her private information or not, $\psi^S \in \Psi^S = \{0,1\}$, and, if she decides to make the report $\psi^S = 1$, into her message space Θ^S.[15] The agent has two distinct moves in the extensive form of the direct revelation mechanism. He reports his own productivity parameter to the principal at the same time of the supervisor's report and, when information is revealed, he decides whether to exert the productive effort or not. The agent's strategy space is then for his first move the set of all possible mappings from the space of the productivity parameters Θ^A into the message space Θ^A. While, the agent's strategy space for his second move is the set of all mappings from the space of the revealed information $\Theta^S \times \Theta^A$ into his decision whether to exert effort or not: $\psi^A \in \Psi^A = \{0,1\}$, if the supervisor decided to make a report, $\psi^S = 1$. Conversely, if the

[13] We take the timing of the supervisor's report as exogenously given. This is a simplifying assumption. However, our main result — the fact that collusion can be prevented at no additional costs — suggests a reason why the principal might want to specify the timing we analyze. See (Felli, 1990, Chapter 2, Section 6) for a discussion of the case in which the timing of the supervisor's report is endogenous.

[14] There is no loss in generality in assuming that the agent's quitting option is taken only once when he decides whether to exert a productive effort.

[15] Notice that ψ^h $h \in \{A, S\}$ can also be interpreted as h's decision to quit. $\psi^h = 1$ denotes h's decision to perform according to the contract C while $\psi^h = 0$ denotes his/her decision *not* to perform according to the contract C.

supervisor decided not to make any report, $\psi^S = 0$, the agent's strategy space for his second move is the set of all possible mappings from the space of his productivity parameter Θ^A into his decision whether to exert effort or not, Ψ^A.

The mechanism is then a triple specifying a salary for the supervisor, a wage for the agent and an output: $C = [s(\hat{\theta}^A, \hat{\theta}^S, \psi^A), w(\hat{\theta}^A, \hat{\theta}^S \cdot \psi^S), x(\hat{\theta}^A, \hat{\theta}^S \cdot \psi^S)]$.[16]

In what follows we focus on the Perfect Bayesian Equilibria (PBE) of this game (Fudenberg and Tirole, 1991).

2.4. Collusion-Free Contract

We derive first the benchmark case: the optimal contracts when collusion is not a feasible option for the supervisor and the agent.

The simple structure of the collusion-free environment allows the risk neutral principal to pay a constant salary to the risk averse supervisor

$$s(\hat{\theta}_i^S, \hat{\theta}_j^A, \psi^A) = \bar{s} \quad \forall i, j \in \{1, 2\} \quad \forall \psi^A \in \Psi^A \tag{4}$$

and induce her to report the truth.[17]

The principal inherits, in this way, the information structure of the supervisor and can sign a contract with the agent that induces him to report the truth. This incentive contract is contingent on the information θ^S that the supervisor reports as well as the agent's report. Moreover, the optimization problem that defines the agent's incentive contract is separable in the two values of the signal θ^S because the agent can still quit the contract with the principal if, when the supervisor's report becomes public, he does not receive at least his reservation utility. The program that defines the principal's optimal incentive scheme for the agent, given the supervisor's strategy choice, is therefore characterized by the following three

[16] The agent's wages and output levels are independent of the supervisor's report whenever the latter decides to quit, hence *not* to make any report: $w(\hat{\theta}^A, 0)$, $x(\hat{\theta}^A, 0)$. The output level is also a function of supervisor's message because of the sequentiality of the report of the supervisor and the production decision of the agent.

[17] In case of indifference we assume that each party behaves in the way the principal wants it to behave according to the outstanding contracts. This tie breaking rule is used to avoid multiple equilibria in the subgame played by the supervisor and the agent that arise when both parties are indifferent between their actions. The same result could be obtained by augmenting the collusion-free mechanism described in this section, as in Ma, Moore, and Turnbull (1988), using nuisance strategies that allow the principal to induce the supervisor and the agent to coordinate on the equilibrium the principal desires.

separate maximization problems, one for every value of $j \in \{0, 1, 2\}$.[18]

$$\max_{\{x_{ij}, w_{ij}\}} \quad q_j^A (x_{1j} - w_{1j}) + (1 - q_j^A)(x_{2j} - w_{2j}) \tag{5}$$

$$s.t. \quad w_{1j} - d(x_{1j} - \theta_1^A) \geq \bar{w} \tag{6}$$

$$w_{2j} - d(x_{2j} - \theta_2^A) \geq w_{1j} - d(x_{1j} - \theta_2^A) \tag{7}$$

Where $x_{ij} = x(\hat{\theta}_i^A, \hat{\theta}_j^S \cdot \psi^S)$, $w_{ij} = w(\hat{\theta}_i^A, \hat{\theta}_j^S \cdot \psi^S)$, for every $i \in \{1, 2\}$ and every $j \in \{1, 2\}$ if $\psi^S = 1$ and $j = 0$ if $\psi^S = 0$. While $q_j^A = Pr\{\theta^A = \theta_1^A \mid \theta^S = \theta_j^S\}$, for every $j \in \{1, 2\}$ and $q_0^A = p^A$. The conditional probability q_j^A, $j \in \{1, 2\}$ may be computed using definition (2), the marginal probability p^A, and Bayes rule.

Problem (5) is standard. Equation (6) is the *individual rationality* constraint for the low productivity agent, which states that such an agent must obtain at least his reservation utility. Equation (7) is the *incentive compatibility* constraint for the high productivity agent. It prevents the high productivity agent from pretending to be a low productivity agent. We omit individual rationality and incentive compatibility constraints for the high, respectively low, productivity agent since, as it is well known, these constraints are not binding in equilibrium.

From Problem (5), for each value of the supervisor's signal θ_j^S, we get:

$$x_{21} = x_{22} = x_2 \qquad x_{11} > x_{12} \tag{8}$$

$$w_{21} - d(x_2 - \theta_2^A) > w_{22} - d(x_2 - \theta_2^A) > \bar{w} \tag{9}$$

$$w_{21} - d(x_2 - \theta_2^A) = w_{11} - d(x_{11} - \theta_2^A) \tag{10}$$

$$w_{22} - d(x_2 - \theta_2^A) = w_{12} - d(x_{12} - \theta_2^A) \tag{11}$$

$$w_{11} - d(x_{11} - \theta_1^A) = w_{12} - d(x_{12} - \theta_1^A) = \bar{w} \tag{12}$$

These conditions, together with (4) and the conditions which determine x_{i0} and w_{i0}, fully characterize the optimal collusion-free contract CF.[19]

The following Proposition 1 highlights the key feature of contract CF relevant for our

[18] We are here taking for granted that in equilibrium the principal wants to separate the two types of agent. In other case, there would be no need for the additional information provided by the supervisor. The optimality of separation follows immediately from the definition of an optimal pooling contract and the strict convexity of the function $d(\cdot)$.

[19] We omit the conditions determining x_{i0} and w_{i0} since in the collusion-free world the supervisor always decides to make a report, $\psi^S = 1$ from equation (4).

analysis of collusion.

Proposition 1: *The premium paid in equilibrium to the high productivity agent is higher if the supervisor reports* $\hat{\theta}_1^S$ *rather than* $\hat{\theta}_2^S$: $w_{21} > w_{22}$. ■

The intuition behind this result is very simple. The principal's costs of inducing a high productivity agent to separate himself from a low productivity agent are of two types: a premium, in utility terms, for the high productivity agent and an inefficient effort (output) level that the low productivity agent is required to produce.[20] Whenever the supervisor tells the principal that she thinks the agent has low productivity — that is she observed a low signal — the principal updates his prior distribution increasing the probability that the agent has a low productivity θ_1^A. This increases, in expected terms, the costs of having the low productivity agent produce an inefficient level of output, while reducing, in expected terms, the costs of a premium for the high productivity agent. Of course, the situation is symmetric and opposite whenever the supervisor reports to the principal a high signal. Therefore, the principal, in equilibrium, trades-off these two costs and offers a higher premium to the high productivity agent, if the supervisor's report is low, than if it is high — Proposition 1 and equation (9) — and requires the low productivity agent to exert a higher effort, if the supervisor's report is low, than if it is high — equation (8).

A final question is whether, in a collusion-free world, a principal would want to hire a supervisor in the first place. The answer depends on the reservation salary of the supervisor $\bar{s}$. If the constant salary paid to the supervisor does not exceed the principal's gains generated by the availability of the signal θ^S the principal strictly prefers to hire a supervisor.[21]

3. The Collusion Problem

3.1. The Collusion Contract

In our setup collusion typically takes place between two asymmetrically informed parties: the agent and the supervisor. Therefore, in principle it is possible that during the collusion nego-

[20]Inefficiency is here defined with respect to an hypothetical first best, obtained in the case the principal observes perfectly the productivity or the effort of the agent.

[21] The proof that an additional strictly informative signal generates a positive welfare improvement to the principal goes as follows. The standard two tier principal-agent optimization problem can always be written in the form of Problem (5) adding the two constraints $x_{ih} = x_{ik}$, $\forall h \neq k$, $h, k \in \{1, 2\}$. These two constraints turn out to be binding at the optimum. Equation (8) shows that this is not true whenever the information reported by the supervisor is available. Thus, the principal is strictly better off in the latter case.

tiation the uninformed party, the supervisor, learns the private information of the informed party, the agent. Of course, depending on the extensive form of the collusion negotiation this revelation of information might occur before the uninformed party commits to the collusive agreement or after this occurs. The implications of this timing differ depending on how "enforceable" the collusion agreement is: whether the uninformed party can walk away from collusion and what penalties for breach she is required to pay if she does. In modeling collusion we want to specify a general model that encompass this additional source of information for the supervisor and allows her to walk away from the collusive agreement, possibly at a cost.

We therefore take a collusive contract to be a transfer β from the agent to the supervisor in exchange for a given report that the supervisor makes to the principal. We take transfers to be paid upfront. This implies that bribes cannot be contingent on the level of output the agent produces and whether the agent decides to quit the contract with the principal.[22]

Negotiation of the collusive contract takes place between asymmetrically informed parties. This typically leads to multiple equilibria. What matters for our analysis is whether these equilibria separate the two types of agent during the collusion subgame. Indeed, all separating equilibria reveal the type of the agent to the supervisor hence the information of the supervisor improves.

In what follows we do not specify an extensive form for the collusion negotiation game, but rather assume the existence of a *collusion designer*. The colluding parties report their private information to the collusion designer: in our setup the only informed party, the agent, reports his private information. The designer then assigns to the colluding parties an allocation of surplus through the transfer that the agent makes to the supervisor, $[\beta(\tilde{\theta}_1^A), \beta(\tilde{\theta}_2^A)]$, a given report $\hat{\theta}^S(\tilde{\theta}_j^A)$, $j \in \{1, 2\}$, that the supervisor makes to the principal depending on the agent's report $\tilde{\theta}_j^A$ to the collusion designer and an effort choice for the two types of agent. By revelation principle we restrict attention to equilibria of the collusion subgame where the agent reports the truth, $\tilde{\theta}_j^A = \theta_j^A$: reports are incentive compatible. Clearly if equilibrium transfers are such that $\beta(\theta_1^A) \neq \beta(\theta_2^A)$ then the equilibrium of the collusion game is a separating one and the supervisor learns the agent's private information in the collusion subgame. Finally,

[22]Contingent bribes are in general harder to enforce, but, if enforced, they yield a larger set of collusive agreements. We assume here that bribes are paid upfront for simplicity. Our result, however, is robust to the use of contingent bribes.

collusion is a voluntary agreement, hence both parties will agree to participate in the collusion contract only if the allocation induced by the collusive agreement is individually rational. In our environment this implies that the allocation induced by the collusion game has to be strictly better than the allocation induced by the contracts offered by the principal if the parties decide not to participate in collusion.

The enforceability of a side contract between two parties is an open issue in the literature on collusion. Often a long term relationship or a reputational argument is quoted, in the background, to justify the enforceability of the side contract.[23] In our analysis we use a different approach. We explicitly specify the penalty for breach, denoted $\kappa \in \mathbb{R}_+$, that a party to collusion, typically the supervisor, has to pay to her counterpart, typically the agent, to walk out of the collusive agreement. We use this approach because we do believe that a tool for preventing collusion that has been overlooked by the existing literature is the possibility for the principal to induce parties to breach their collusive agreement.

We do regard this as a realistic mechanism. For example Dalton (1959) describes the following situation. A supervisor is involved in a collusive agreement with the workers of his division. This agreement consists in the supervisor pressuring the higher staff to reduce "working standards" for his subordinates so that *"... an unskilled operator could make "fat bonuses" without corresponding increases in production ... "*. The subordinates, on their part, have *"... to "lay down" in order not to "kill" a good rate"*.[24] This general practice continues until the supervisor receives an order that has to be completed at once. In this case the supervisor, knowing that the higher staff manager would not tolerate the slowdown (implicit in the collusive agreement) *"...* [reneges] *on his agreement and* [orders] *the workers to step up production ... "* to the points that the production rate indicates a performance four times greater than the previous ones.

3.2. Strongly Collusion Proof Contracts

As mentioned above, in our setting collusive negotiation takes place between asymmetrically informed parties. This implies that in general the equilibrium outcome of the collusive game is not unique. Hence, the principal's objectives when facing the collusion problem are not at

[23]See Aghion and Caillaud (1988) for a paper that explicitly analyze this long term relationship.

[24]To "kill a rate" means to produce so much that the resulting bonus induces the higher staff to revise the "working standards".

all obvious.

A possible objective might be for the principal to offer a contract to the supervisor and the agent such that when they get involved in the collusion game there exists at least one equilibrium of such a game in which no collusive agreement is enforced.

We use, instead, a stronger notion of collusion-proofness in our analysis. This is defined as follows.

Definition 1*: A contract is strongly collusion-proof if the only equilibria of the collusion game between the parties involved are such that no collusive agreement is enforced and the equilibrium of the corresponding continuation game coincides with the equilibrium of the continuation game in the collusion-free model.*[25]

We identify below a *strongly collusion-proof optimal contract.*

3.3. Collusion under Contract CF

We begin by observing that the optimal collusion-free contract CF presented in the previous section is not strongly collusion-proof. In other words, if the principal offers such a contract to both the supervisor and the agent, inequality (9) implies that in the event $\theta^S = \theta_2^S$ the high productivity agent is willing to pay at most

$$b = w_{21} - w_{22} > 0 \tag{13}$$

to the supervisor for her to report $\hat{\theta}_1^S$ while from equation (12) the low productivity agent is not willing to pay any positive amount to the supervisor for the same report. In the event $\theta^S = \theta_1^S$, instead, neither type of agent is willing to pay any amount to the supervisor for changing her report.

In other words, there exists a whole set of equilibria of the collusion game between the supervisor and the agent in which the supervisor observes the signal θ_2^S, and the high productivity agent pays a positive bribe to the supervisor to induce him to report a low signal.

[25] In our environment the continuation game includes the revelation game in which both the agent and the supervisor report their private information to the principal, and the agent's subsequent decision whether and how much effort to exhert. The requirement that the equilibrium of the continuation game coincides with the one of the collusion-free model is introduced so as to rule out situations in which the agent and the supervisor do not reach any collusive agreement but the information revealed by the agent during the collusion negotiation induce the supervisor to behave in a different way from how he would have behaved in a collusion-free model.

These equilibria differ depending on the size of the transfer the high productivity agent pays to the supervisor.

Lemma 1: *The contract CF is not strongly-collusion proof. Under contract CF there exists a whole set of equilibria of the collusion game such that: the high productivity agent pays a positive bribe to the supervisor, $\beta(\theta_2^A) \in (0, b)$, as from equation (13), who observes the signal θ_2^S, and reports $\hat{\theta}_1^S$. The low productivity agent does not participate in collusion ($\beta(\theta_1^A) = 0$).*

This result shows that the supervisor and the agent may successfully engage in collusion when the collusion-free contract is offered to them. It is critical for our analysis that all the equilibria of the collusion game characterized in Lemma 1 above are separating equilibria: $\beta(\theta_2^A) > \beta(\theta_1^A) = 0$. In other words, the high productivity agent reveals his type by participating in collusion and making a positive transfer to the supervisor while the low productivity agent dos not. This implies that, in spite of the asymmetry of information that characterizes the collusive negotiation, the supervisor, once the collusion negotiation is over, knows the exact value of the productivity of the agent.

4. The Collusion-Proof Optimal Mechanism

4.1. Preamble

In this section we present the main result of the paper. We propose a mechanism which allows the principal to prevent collusion between the supervisor and the agent in a costless way. In this mechanism the principal asks the supervisor to report the additional signal — leaked during the collusion game — that the productivity of the agent is high, in exchange for a premium that compensate the supervisor for paying the penalty for breaching the collusive agreement. In principle, such a promise does not involve any extra cost for the principal: it is never carried out in equilibrium. If the high productivity agent observes this clause of the employment contract of the supervisor, he will never agree to participate in collusion since by doing so he looses the informational rent that otherwise he would have gained.

Our objective is to construct a strongly collusion-proof optimal contract CP that prevents collusion between the supervisor and the agent in a costless way, that is coincides with the contract CF in equilibrium. We proceed in the following manner. We first propose a candidate collusion-proof contract that the principal offers to both the agent and the supervisor. We then prove that such a contract is strongly collusion-proof. Finally, we show that the principal, by delegating a certain amount of discretion to the supervisor, is able to implement the strongly collusion-proof mechanism CP.

4.2. Candidate Contract

Recall that if the contract CF is enforced, the supervisor may observe two different signals of the agent's productivity: the standard signal $\theta^S \in \Theta^S$ and the information possibly leaked during the collusion game. The latter takes the form of the agent's truthful report in the collusion game, which, under contract CF, fully reveals the productivity of the agent (by Lemma 1 all equilibria of the collusion game are separating ones).

It is, therefore, critical for the construction of the collusion-proof contract to enlarge the message space of the supervisor allowing her to report to the principal that the agent has high productivity with certainty once she sees the agent's optimal strategy in the collusion game: $\Theta^S \cup \{\ell_2^A\}$, where ℓ_2^A denotes the message that the agent is high productivity according to the information the supervisor learns during collusion. As with every message, ℓ_2^A is soft or unverifiable information. In other words, it is possible that $\ell_2^A \neq \theta_2^A$.[26] The message space of the agent may be left unmodified.

We now specify the part of the strongly collusion-proof candidate contract that concerns the employment contract of the agent: CP^A. If the supervisor either reports any of the messages in Θ^S or quits the contract with the principal, and the agent reports any of the messages in Θ^A the agent's payoffs are, as in the contract CF, characterized by the solution to Problem (5). If the supervisor reports the information learned during the collusion game, ℓ_2^A, and the agent reports $\hat{\theta}_2^A$ we assume that the agent is asked to produce output x_2, defined in equation (8), and is paid a wage $\tilde{w}$ such that overall the agent receives his reservation utility:

$$\tilde{w} = \bar{w} - \kappa + d(x_2 - \theta_2^A) \tag{14}$$

[26]The reader may wonder whether it is sufficient to prevent collusion between the supervisor and the agent to allow the supervisor to report that she believes — after the collusion game — that the productivity of the agent is low. Although such an enlargement of the message space of the supervisor makes collusion more difficult it does not solve the problem. Such an enlargement of the message space of the supervisor destroys the collusive agreement described in Lemma 1. However, there still exists an equilibrium of the collusion game between the supervisor and the agent such that the same collusive agreement, described in Lemma 1, is always rejected by the low productivity agent and accepted with a strictly positive, but lower than one, probability by the high productivity agent.

where $\bar{w}$ is the reservation utility, κ the payment the agent receives when the collusive agreement is breached, and $d(x_2 - \theta_2^A)$ is his disutility of effort.

The same remuneration $\tilde{w}$ applies to the agent if the supervisor reports ℓ_2^A and the agent reports $\hat{\theta}_1^A$. In this case as well the agent is asked to produce output x_2.

We now characterize the collusion-proof candidate contract between the principal and the supervisor: CP^S. If the supervisor reports any of the signals in Θ^S she is paid her constant reservation wage $\bar{s}$, as in equation (4), whatever the agent's strategy choice.

If the supervisor reports the leaked information ℓ_2^A and the agent reports $\hat{\theta}_2^A$ and does not quit the contract with the principal, the supervisor gets her reservation salary plus a premium γ equal to the penalty κ the supervisor has to pay to breach the collusive agreement and report the leaked information to the principal:

$$s(\ell_2^A, \hat{\theta}_2^A, 1) = \bar{s} + \gamma, \qquad \gamma = \kappa \tag{15}$$

Finally, if the supervisor reports ℓ_2^A and the agent, reports $\hat{\theta}_1^A$ and does *not* quit the contract with the principal the supervisor receives her reservation salary minus a positive punishment μ.

$$s(\ell_2^A, \hat{\theta}_1^A, 1) = \bar{s} - \mu, \quad \mu > 0 \tag{16}$$

The same treatment is reserved to the supervisor if she reports ℓ_2^A and the agent, whatever his report, ends up quitting the contractual relationship with the principal.

$$s(\ell_2^A, \hat{\theta}_i^A, 0) = \bar{s} - \mu \quad \forall i \in \{1, 2\} \quad \mu > 0 \tag{17}$$

We impose a constraint on the size of the punishment μ so as to prevent the supervisor, if the agent does not engage in collusion, to report that she observed the leaked information ℓ_2^A anyway.

$$q_2^A\, V(\bar{s} - \mu) + (1 - q_2^A)\, V(\bar{s} + \gamma) = V(\bar{s}) \tag{18}$$

Indeed, condition (18) implies that after observing the signal θ_1^S

$$q_1^A\, V(\bar{s} - \mu) + (1 - q_1^A)\, V(\bar{s} + \gamma) < V(\bar{s}) \tag{19}$$

The table below summarizes the description of the candidate collusion-proof contract CP.

S's report \ A's report:	$\hat{\theta}_1^A$	$\hat{\theta}_2^A$	A quits
ℓ_2^A	$CP^S = [\,\bar{s} - \mu\,]$ $CP^A = [\,\tilde{w},\, x_2\,]$	$CP^S = [\,\bar{s} + \gamma\,]$ $CP^A = [\,\tilde{w},\, x_2\,]$	$CP^S = [\,\bar{s} - \mu\,]$
$\hat{\theta}_1^S$	$CP^S = [\,\bar{s}\,]$ $CP^A = [\,w_{11},\, x_{11}\,]$	$CP^S = [\,\bar{s}\,]$ $CP^A = [\,w_{21},\, x_{21}\,]$	$CP^S = [\,\bar{s}\,]$
$\hat{\theta}_2^S$	$CP^S = [\,\bar{s}\,]$ $CP^A = [\,w_{12},\, x_{12}\,]$	$CP^S = [\,\bar{s}\,]$ $CP^A = [\,w_{22},\, x_{22}\,]$	$CP^S = [\,\bar{s}\,]$
S quits	$CP^A = [\,w_{10},\, x_{10}\,]$	$CP^A = [\,w_{20},\, x_{20}\,]$	

4.3. Collusion Proofness

We are now in the position to state and prove the main result of our analysis. We proceed in two steps.

Assume that the principal offers the contract CP to both the supervisor and the agent and that they both observe the signal θ_2^S. We first prove that the collusive agreement we presented in Lemma 1 cannot arise under contract CP.

Lemma 2: *There exists no equilibrium collusive agreement such that the supervisor, after observing the signal θ_2^S, reports the message $\theta^S(\theta_2^A) = \hat{\theta}_1^S$ and the θ_2^A agent makes a transfer $\beta(\theta_2^A) \in (0, b)$, as from equation (13).*

Next we show that under contract CP no other type of collusion can arise. In particular, the enlargement of the supervisor's message space and especially the payoffs associated with the new message ℓ_2^A do not introduce an additional opportunity for a collusive agreement between the supervisor and the agent. The reason why this additional collusion may occur is that the premium γ the supervisor receives if she reports the message $\hat{\theta}_2^A$ to the principal might be so large as to induce the supervisor to try to capture at least part of it offering the remaining part to the high productivity agent so as to compensate him for the loss of the informational rent he will otherwise receive if the message $\hat{\theta}_2^S$ is reported. We also show that the allocation implemented by contract CP coincides with the optimal allocation in the absence of collusion.

Proposition 2: *The contract CP is strongly collusion-proof. Moreover, the PBE of the continuation game between the supervisor and the agent coincides with the PBE of the corresponding continuation game under contract CF (Proposition 1).*

The main intuition behind this result is simple to describe. Notice first that Lemma 1 implies that all collusive agreements between the supervisor and the agent under contract CF lead to separating equilibria and hence leak the true type of the agent to the supervisor. Moreover, contract CP specifies payments to both the supervisor and the agent that coincide with contract CF whenever the supervisor reports $\hat{\theta}^S \in \{\theta_1^S, \theta_2^S\}$ or quits. However, contract CP also offers to the supervisor that engaged in collusion the option to breach the collusive agreement at no cost, $\gamma = \kappa$, if the supervisor is certain that the agent is high productivity and reports ℓ_2^A to the principal. In the latter case the supervisor payoff is $\bar{s} + \beta(\theta_2^A)$ which coincides with her payoff is she goes along with collusion.[27] The result is that the supervisor is always compensated for breaching the collusion agreement contract. She is thus indifferent and reports the leaked information to the principal. According to contract CP the high productivity agent is then strictly better off by not engaging in collusion.

The key point is that in our framework the *only* equilibria of the collusion game between the supervisor and the agent are *separating* ones, which by their own nature do reveal the exact productivity of the agent to the supervisor. Hence, giving the supervisor the discretionary

[27]Recall that bribes are paid upfront and are not refundable. Notice, however, that the penalty for breach κ may well exceed the bribe paid upfront and hence be regarded as a refund of this bribe in the event of a breach.

power to report this leaked information to the principal destroys these separating equilibria and, in this way, all equilibria of the collusion game. Clearly, the same mechanism would not be so successful in a model in which pooling equilibria of the collusion game might arise. However, the mechanism described in Proposition 2 would still be of use to the principal even in a framework in which there exist pooling equilibria of collusive negotiation. Pooling equilibria of the collusion game need to specify transfers $\beta(\theta_1^A) = \beta(\theta_2^A)$ that are not higher than the minimum willingness to pay of the two types of agent for the report of the supervisor. Therefore such a mechanism would reduce the costs necessary to prevent collusion. Costly resources would be needed only to get rid of the pooling equilibria of the collusion game, while the separating ones could still be costlessly eliminated as in CP.

Notice that the existence of any level of asymmetric information is enough for CP to be successful in eliminating collusion. Indeed, CP prevents collusion in a costless way whatever the precision of the signal θ_2^S with the exception of the limit case: $q_1^S = 1$.[28] Clearly in such a limit case CP is *not* well defined.

Corollary 1: *The contract described in Table 1 is strongly collusion-proof for any imperfect signal θ_2^S observed by the supervisor:* $(1 - q_2^A) < 1$.

This result implies that the costs of preventing collusion are discontinuous in the limit. If we assume that the supervisor's private information is *hard* information — in the terminology of Tirole (1986) — preventing collusion becomes costly for the principal. In this case the particular nature of the information induces the supervisor and the agent to collude only when the supervisor perfectly observes the productivity of the agent. The mechanism CP is then of no use to the principal.

It is worth observing that the mechanism we described in contract CP allows the principal to prevent collusion in a costless way when the signal θ_1^S is a perfect signal: when q_2^S converges to zero, or equivalently q_1^A converges to one. In such a case collusion occurs only when both the supervisor and the agent observe the signal θ_2^S, which is not a perfect signal: the probability that the agent is low productivity is not null, $q_2^A > 0$.[29] This implies that the collusion

[28]This implies, using Bayes rule, that q_2^A converge to zero: if the supervisor observes a high signal the agent's productivity is *certainly* high.

[29]Notice that if θ_1^S is a perfect signal collusion between the supervisor and the agent, even when contract CF is offered, will take a slightly different form. In fact, in such a case there will be no need for the principal to

game can still reveal some information to the supervisor. Therefore contract CP is strongly collusion proof at no additional costs for the principal (the proof of Proposition 2 applies).

A final observation concerns the willingness of the principal to use a supervisor. Since the solution to the collusion problem we propose is costless for the principal, the same considerations we presented at the end of Subsection 2.4 apply in this case. There exist values of the reservation salary of the supervisor for which the principal has a strictly positive gain by hiring her.

4.4. Delegation as a Collusion-Proof Mechanism

The construction of contract CP, in the previous section, made heavy use of the direct mechanism — introduced at the end of Subsection 2.3 — in which the supervisor and the agent report their private information to the principal who decides the actions the two players take. In this section we ask ourselves if it is possible to find an indirect (and more realistic) mechanism which implements contract CP. This is indeed the case. We characterize below an indirect *delegated mechanism* which gives us an appealing and realistic interpretation of the enlargement of the supervisor's strategy space in terms of an increase of her degree of discretionary power.

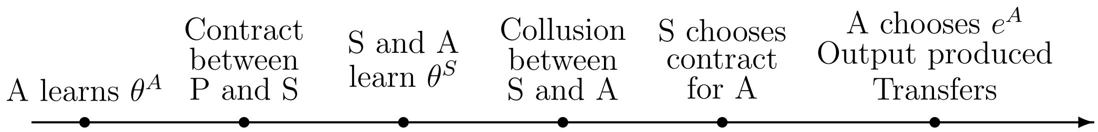
The main reason why contract CP is strongly collusion proof is that the principal, enlarging the message space of the supervisor, succeeds in transforming a situation in which the supervisor and the agent have an interest to play cooperatively in a situation in which the supervisor can gain to the detriment of the agent.

This situation can be reproduced in an indirect mechanism making the supervisor, at least partially, residual claimant of the behavior of the agent so that she has an interest to use every information she has on the productivity of the agent. To be more specific, we modify the role of the supervisor in the hierarchical structure giving her the task to choose the employment contract for the agent in a menu of feasible contracts that the principal specifies. Furthermore, we make the supervisor's remuneration residual with respect to the wage paid

specify a payoff for the high productivity agent if the supervisor reports $\hat{\theta}_1^S$: the signal is perfect, so, provided the supervisor reports the truth, the agent's productivity is certainly low. However, it is still profitable for the high productivity agent to bribe the supervisor to report signal $\hat{\theta}_1^S$ when θ_2^S is observed but this report requires the agent to report $\hat{\theta}_1^A$ or, equivalently, to produce a low output. Indeed, the premium the high productivity agent gets in this way is greater than the informational rent he would get if the supervisor reports the truth.

to the agent. In other words, the supervisor is offered a budget schedule, contingent on the output produced by the agent. The supervisor assigns a portion of this budget to the agent and is left with the remaining portion. In this situation, if the supervisor observes the exact signal of the productivity of the agent, via the collusion negotiation, she pays the agent the minimum necessary to induce him to produce. In this way she is left with a higher portion of the budget than if her only information were the signal θ^S.

In this setting the role of the supervisor is not to report information to the principal but to choose in a menu of contracts specified by the principal the employment contract for the agent. The figure below makes this new timing explicit. We do assume that the principal can *verify* ex-post whether the contract chosen by the supervisor is in the pre-specified menu.



The principal offers the supervisor an employment contract which specifies: a schedule of budgets B and a menu M of contracts. The supervisor has to choose in M the incentive contract she wants to offer the agent. The budgets B are contingent on both the output produced by the agent and the contract offered by the supervisor to the agent. Notice that M is not only a component of the contract offered by the principal to the supervisor, it is also the strategy space of the supervisor. Hence, M has an appealing interpretation in terms of the discretionary power the supervisor has in the hierarchical structure. The elements of M take the usual form of a schedule of remunerations contingent on the output produced by the agent. The rest of the structure is left unmodified. We denote DM this indirect delegated mechanism.

The situation we have described does not modify in any relevant way the structure we dealt with in the previous section. As a matter of fact, we can prove the following property of DM.

Lemma 3: *The direct mechanism that, through the Revelation Principle, corresponds to the indirect delegated mechanism DM is contract CP.*

Lemma 3 is a direct application of the equivalence principle (Faure-Grimaud, Laffont, and Martimort, 2003).

The indirect delegated mechanism described above has an appealing interpretation in terms of an organization design which prescribes partial delegation of discretionary power from the principal to the supervisor. Indeed, following (Milgrom and Roberts, 1992, Ch. 4) a decision is centralized if it is made at a higher level and imposed on an individual, while it is decentralized if it is left to the individual alone to make. In the delegated mechanism described above the supervisor does take decisions rather then just report information, hence the choice of the contract for the agent is a decentralized decision. However, the range of the possible choices is limited by the menu M. This menu plays a critical role since it summarizes both the amount of discretionary power left to the supervisor and the limits that the principal wants to impose to such a power. These are both critical elements of a decentralized organization. Indeed, *"in a system with both centralized and decentralized decisions, the centralized decisions serve to define the parameters of the decentralized ones and to put constraints on the local decision makers."* (Milgrom and Roberts, 1992, p. 114). The purpose of this decentralization is to allow the organization to make an efficient use of whatever information becomes, eventually, available, even information revealed during collusion. Clearly it is this option left to the supervisor to use the information revealed during collusion that ultimately inhibits the agent from participating in any collusion, and prevents collusive agreements from forming.

An alternative sense in which the indirect mechanism we are proposing captures the features of the delegation of discretionary power has to do with the way in which the agent perceives the supervisor. In the indirect "delegated" mechanism the agent perceives the supervisor as his own boss, the individual he has to respond to, who has the authority to choose, even if in a restricted menu, his remuneration schedule and to whom an output has to be delivered at the end of the production activity.

We shall now derive the optimal degree of discretionary power that in the indirect delegated mechanism it is optimal for the principal to leave to the supervisor. Not surprisingly, this is characterized by the following property.

Proposition 3: *The optimal indirect delegated mechanism is the one which prescribes a menu M containing only three contracts: each one corresponding to one of the signals observed by the supervisor θ_i^S, $i \in \{1,2\}$ and, most importantly, to the signal ℓ_2^A. The optimal budget schedule B may be obtained by summing the remunerations specified by contract CP for both the agent and the supervisor.*

The intuition behind the result just presented is the following. First, a three contract menu, of the type described in Proposition 3 dominates a menu comprising only two contracts corresponding to each value of the signal θ^S observed by the supervisor. Indeed, the three contract menu allows the principal to prevent the supervisor from colluding with the agent, while a small degree of discretionary power opens the door to harmful collusion between the supervisor and the agent. Second, a three contract menu dominates an unrestricted menu of contracts which leaves the supervisor fully residual claimant of the agent's behavior because of the supervisor's risk aversion. Indeed, there exists an amount of surplus which may be captured by the principal providing the risk averse supervisor with a limited amount of insurance through a careful choice of the budget schedule. In a word, it is never optimal for the principal to sell the organization to the supervisor, provided that the supervisor is strictly risk averse.

Finally, the principal might leave full discretionary power to the supervisor and let her design the incentive scheme for the agent.[30] This implies that the only verifiable information on which contracts — in this case budgets — can be designed is the output produced by the agent. The budget schedule obtained summing the remunerations of both the agent and the supervisor specified by contract CP shows that even this provision is not optimal. Whenever the agent is high productivity the output the agent is required to produce according to contract CP is the same whatever the supervisor's report. This entails that a budget contingent only on output has to be the same in this two cases, however contract CP specifies two different remunerations for the agent. Hence the supervisor, if left with unrestricted discretion, will pay the agent the lowest amount capturing in this way a higher residual remuneration.[31] This implies that the information available to the supervisor will not be used efficiently. In other words the supervisor's unrestricted discretionary power yields a situation in which the objectives of the principal and the supervisor are not perfectly aligned.

[30]This case is equivalent to a situation in which the contract offered by the supervisor to the agent is not verifiable.

[31]Anderlini (1989) makes such an argument explicit in the context of a pure moral hazard model. He shows that the supervisor has an incentive to *"... unduly amplify the 'marginal product' of its supervisory function ..."* when asked to act as a principal of the agent and design the agent's incentive scheme.

5. Concluding Remarks

In this paper we showed — using a very simple three level structure — that potential collusion between intermediate and bottom layers of an organization makes it desirable for the principal to increase the discretionary power of supervisors. In doing so the top management aligns the objectives of the supervisor with his own, since it reduces the opportunity of collusive behavior between layers and, ultimately, enhances efficiency. On the other hand, this alignment of objectives disappears when supervisors are left with full discretionary power in the decisions concerning their subordinates.

This analysis sheds light on the use of rules versus discretion in the design of the map of the optimal degree of decision power of members of an organization. Tirole (1986) argues that fixed rules, as opposed to discretion, may be explained as a way to reduce patterns of collusive behavior in big organizations. In this paper, we show that, whenever collusion takes place in conditions of asymmetric information, an increase in the discretionary power of employees, as opposed to fixed rules, has a beneficial effect in reducing the possibility of collusion.

One interpretation of the result presented in this paper is a way to implement a particular outcome enlarging the strategy space of a subordinate. The basic intuition goes as follows.[32] We learned from the literature on commitment that under certain conditions a player can increase his welfare restricting, in a credible way, his choices: his strategy space.[33] This paper complements this literature showing that an enlargement of the strategy space of a subordinate may help the residual claimant of an organization to enhance his own welfare, reducing the welfare of his subordinate.

Finally, the mechanism derived in this paper might be helpful in shedding some light on frequently used organizational practices such as rewarding whistle-blowing or setting up immunity systems.

Appendix

Proof of Lemma 1: Assume that the contract CF binds the principal, the supervisor and the agent. Assume that S observes the signal θ_2^S. The collusion contracts $\mathcal{C} = \{\beta(\theta_1^A), \beta(\theta_2^A); \hat{\theta}^S(\theta_2^A) = \hat{\theta}_1^S, \hat{\theta}^S(\theta_1^A) = \hat{\theta}_2^S\}$, such

[32] We are indebted to David Canning for this intuition.

[33] See for example Laffont and Tirole (1988).

that $\beta(\theta_1^A) = 0$, $\beta(\theta_2^A) \in (0, b)$ — as defined in equation (13) — and S reports $\hat{\theta}_1^S$ if the agent reports θ_2^A to the collusion designer and $\hat{\theta}_2^S$ if the agent reports θ_1^A to the collusion designer, satisfies the collusion-game incentive compatibility and individual rationality constraints for the θ_2^A agent but does not satisfy the collusion-game individual rationality constraint for the θ_1^A agent.

Consider first the collusion game incentive compatibility constraint for the θ_2^A agent

$$w_{21} - \beta(\theta_2^A) - d(x_2 - \theta_2^A) \geq w_{22} - \beta(\theta_1^A) - d(x_2 - \theta_2^A) \quad \text{(A.1)}$$

Equations (9), (13), $0 < \beta(\theta_2^A) < b$ and $\beta(\theta_1^A) = 0$ imply that (A.1) holds with a strict inequality.[34] Consider now the collusion-game individual rationality constraint for the θ_2^A agent:

$$w_{21} - \beta(\theta_2^A) - d(x_2 - \theta_2^A) \geq w_{22} - d(x_2 - \theta_2^A) \quad \text{(A.2)}$$

Equations (9), (13) and $0 < \beta(\theta_2^A) < b$ imply that (A.2) also holds with a strict inequality. The collusion-game individual rationality constraint for the θ_1^A agent is instead:

$$w_{12} - \beta(\theta_1^A) - d(x_{12} - \theta_1^A) \geq w_{12} - d(x_{12} - \theta_1^A) \quad \text{(A.3)}$$

From $\beta(\theta_1^A) = 0$ it follows that (A.3) holds with equality. This means that the θ_1^A agent does not participate in the collusion game since, when indifferent, the agent does what the principal would like him to do.[35]

Consider now the supervisor's collusion-game individual rationality constraints associated with the collusion contract $\mathcal{C}$. This is:

$$\mu V(\bar{s} + \beta(\theta_2^A)) + (1 - \mu)V(\bar{s}) \geq V(\bar{s}) \quad \text{(A.4)}$$

where μ denotes the supervisor's beliefs at the collusion stage that the type of the agent is θ_2^A. Clearly, if $\mu > 0$ and $\beta(\theta_2^A) > 0$ constraint (A.4) is satisfied with a strict inequality. In other words, under contract CF it is an equilibrium of the collusion game for both the type θ_2^A agent and the supervisor to accept any of the collusion contracts $\mathcal{C}$. ■

Proof of Lemma 2: Assume that the supervisor observes the signal θ_2^S. Consider any incentive compatible collusive contract such that the supervisor reports $\theta^S(\theta_2^A) = \hat{\theta}_1^S$ and the θ_2^A agent pays the bribe $\beta(\theta_2^A) \in (0, b)$, as in equation (13). We proceed in four steps.

Step 1: *The agent always reports the truth to the principal whatever his productivity and the outcome of the collusion game.*

[34] Notice that equation (11) and $\beta(\theta_1^A) = 0$ imply that, following the deviation of the θ_2^A agent in the report to the collusion designer, this agent will be indifferent when making his report to the principal and hence will report the truth.

[35] Notice that a similar argument shows that neither the θ_1^A agent nor the θ_2^A participate in collusion if the contract $\mathcal{C}$ is such that $\beta(\theta_2^A) = b$.

We start from the high productivity agent. Assume that the θ_2^A agent participates in collusion, this agent's payoff is then either $w_{21} - \beta(\theta_2^A) - d(x_2 - \theta_2^A)$, if he reports the truth, or $w_{11} - \beta(\theta_2^A) - d(x_{11} - \theta_2^A)$, if he does not. Equation (10) implies that the agent is indifferent between these two payoffs, hence he reports the truth. Conversely, assume that the θ_2^A agent does not participate in collusion and the supervisor reports the observed signal θ_2^S. The binding incentive compatibility constraint for the high productivity agent, equation (10), implies that the agent reports the truth. Finally, assume that the supervisor reports the additional signal ℓ_2^A the agent's payoff is then $\bar{w}$ if either he reports the truth or he does not. Hence, the high productivity agent is indifferent and reports the truth.

Consider, now, the low productivity agent. Assume that the θ_1^A agent participates in collusion, the agent's payoff is $\bar{w} - \beta(\theta_1^A)$ whatever his report, which implies that the agent, being indifferent, reports the truth. Conversely, assume that the θ_1^A agent does not participate in collusion and the supervisor reports the observed signal $\hat{\theta}_2^S$. The incentive compatibility constraint for the low productivity agent — implied by $\theta_2^A > \theta_1^A$ and equation (11) — holds, hence the agent reports the truth. Finally, assume the supervisor reports the additional signal ℓ_2^A, the agent's payoff is, by equation (14), either $\bar{w}$, if the supervisor participated in collusion but then breaches the collusion contract and pays κ to the agent, or $\tilde{w} - d(x_2 - \theta_1^A)$ if she reports the additional signal ℓ_2^A without participating in collusion. In the former case, the agent, being indifferent, reports the truth. In the latter case, by equation (14), if $\kappa > 0$ the payoff $\tilde{w} - d(x_2 - \theta_1^A)$ is strictly lower than the agent's reservation wage $\bar{w}$. This implies that the agent, when deciding whether to produce any output, uses his quitting option and receives his reservation wage $\bar{w}$. Once again, he is indifferent and reports the truth .

Step 2: *Derivation of the supervisor's best response when the supervisor observes θ_2^S.*

Denote π the supervisor's belief that the agent is of type θ_1^A after collusion negotiation. Assume, first, that both the agent and the supervisor accept to participate in collusion. The supervisor's payoff is then $V(\bar{s} + \beta(\theta_j^A))$, where $j \in \{1, 2\}$, if she complies with the collusion contract and reports $\theta^S(\theta_j^A) = \hat{\theta}_1^S$. The supervisor expected payoff is instead $\pi V(\bar{s} + \beta(\theta_j^A) - \mu - \kappa) + (1-\pi)V(\bar{s} + \beta(\theta_j^A))$ if she breaches the collusion contract and reports the additional signal ℓ_2^A. Equation (15) implies that if $\pi > 0$ the former option yields a higher payoff to the supervisor, hence she will comply with the collusion contract. If, instead, $\pi = 0$ the supervisor is indifferent between the two options, hence she acts in the way most preferred by the principal: she breaches the collusion contract and reports the signal ℓ_2^A to the principal.

Consider now the supervisor decision whether to participate in the collusion game. As seen above her payoff, whether she breaches the collusion contract or not, is $V(\bar{s} + \beta(\theta_j^A))$ while her payoff is $V(\bar{s})$ if she refuses to partipate in the collusion game and reports the observed signal $\hat{\theta}_2^S$. Clearly, if $\beta(\theta_j^A) > 0$ the supervisor is better off accepting to participate in collusion. Only if $\beta(\theta_j^A) = 0$ the supervisor is indifferent and refuses to participate in the collusion game.

Step 3: *The value of the supervisor's belief $\pi = 0$ is the only one consistent with the low productivity agent's behavior.*

Assume $\pi > 0$ and consider the behavior of the low productivity agent. Given the supervisor's best response (Step 2) the agent's payoff is either $\bar{w} - \beta(\theta_1^A)$, if he participates in the collusion game, or $\bar{w}$, if he does not. Clearly the low productivity agent always refuses to participate in the collusive for $\beta(\theta_1^A) \geq 0$. This contradicts $\pi > 0$.

Step 4*: The agent always refuses to participate in the collusion game whatever his productivity.*

We start from the low productivity agent. Given Step 2 and 3, the agent's payoff is $\tilde{w} - d(x_2 - \theta_1^A) + \kappa$ if he participates in the collusion game and produces output x_2. Such payoff, by equation (14), is strictly lower than the agent's reservation wage $\bar{w}$; hence, the agent, when deciding whether to produce any output, uses his quitting option and receives his reservation wage $\bar{w}$. Conversely, if the agent refuses to participate in the collusion game his payoff is $\bar{w}$, by equation (12). Hence, the low productivity agent behaves in the way most preferred by the principal and refuses to partipate in the collusion game.

Finally, consider the high productivity agent. Steps 1, 2 and 3 imply that if he accepts the collusive offer his payoff is, by equation (14), $\bar{w} - \beta(\theta_2^A)$. Conversely, if he rejects the collusive offer his payoff is $w_{22} - d(x_{22} - \theta_2^A)$ which, by equation (9), is strictly greater than $\bar{w} - \beta(\theta_2^A)$. Hence, the high productivity agent refuses to participate in the collusion game. ■

Proof of Proposition 2: Lemma 2 shows that following θ_2^S there exists no equilibrium collusive agreement where the supervisor reports $\hat{\theta}_1^S$. We now proceed in three steps.

Step 1*: The agent always reports the truth, whatever his productivity and the supervisor's report.*

We start from the high productivity agent. If the supervisor reports the signal $\hat{\theta}_i^S$, $i \in \{1, 2\}$, the agent's payoffs are either $w_{1i} - d(x_{1i} - \theta_2^A)$, if the agent reports $\hat{\theta}_1^A$, or $w_{2i} - d(x_{2i} - \theta_2^A)$, if the agent reports $\hat{\theta}_2^A$. These payoffs are equal by equation (10) and (11), hence, the agent, being indifferent, reports the truth. Conversely, if the supervisor reports the additional signal ℓ_2^A, the agent's payoff is $\bar{w}$ whether the agent reports $\hat{\theta}_1^A$ or $\hat{\theta}_2^A$. Hence, the high productivity agent always reports the truth.

Consider now the low productivity agent. If the supervisor reports the signal $\hat{\theta}_i^S$, $i \in \{1, 2\}$, the agent's payoffs are either $\bar{w}$, if the agent reports $\hat{\theta}_1^A$, or $w_{2i} - d(x_2 - \theta_1^A)$, if the agent reports $\hat{\theta}_2^A$. Equations (10), (11), (12) and $\theta_1^A < \theta_2^A$ imply that the agent is strictly better off if he does report the truth: $w_{2i} - d(x_2 - \theta_1^A) < \bar{w}$. Conversely, if the supervisor reports the additional signal ℓ_2^A, the agent's payoff is $\tilde{w} - d(x_2 - \theta_1^A)$ whether the agent reports $\hat{\theta}_1^A$ or $\hat{\theta}_2^A$. Equation (14) and $\theta_1^A < \theta_2^A$ imply that both these payoffs are strictly lower than $\bar{w}$. Hence, the agent uses his quitting option, receives payoff $\bar{w}$ and, being indifferent, reports the truth $\hat{\theta}_1^A$.

Step 2*: Following θ_1^S there exists no equilibrium collusive agreement such that the supervisor reports $\hat{\theta}_2^S$.*

Equation (9) shows that the high productivity agent is strictly better off by not participating in such a collusion agreement. Moreover, equation (12) shows that the low productivity agent is indifferent and hence does not participate in the collusion game either.

Step 3*: There does not exist an equilibrium collusion agreement where the supervisor reports the additional information ℓ_2^A, transfers $\hat{\beta} \in [0, \gamma]$ to the agent, who announces θ_2^A.*

Assume that such an equilibrium collusive agreement exists. Assume first that the agent participate in collusion. We start from the high productivity agent. The agent's payoff is then $\tilde{w} - d(x_2 - \theta_2^A) + \hat{\beta}$. If instead the agent uses his quitting option he obtains payoff $\overline{w} + \hat{\beta} - \kappa$. In other words, from $\gamma = \kappa$ and (14) the agent is indifferent between breaching the collusive agreement or not. He therefore quits. Consider next the low productivity agent. His payoff is $\tilde{w} - d(x_2 - \theta_1^A) + \hat{\beta}$ if he does not breach the collusive agreement and $\overline{w} + \hat{\beta} - \kappa$ if he does. From $\theta_1^A < \theta_2^A$ and equation (14) the low productivity agent is strictly better off by breaching the collusive agreement and quitting.

In either case under collusion the supervisor payoff is $\bar{s} - \mu - \hat{\beta}$ and is $\bar{s}$ if she decide not to participate in the collusion game. Clearly, she strictly prefers not to participate in this type of collusion.

Step 4*: In the absence of collusion the supervisor reports the observed signal θ_i^S, $i \in \{1, 2\}$ and not the additional information ℓ_2^A.*

In the absence of collusion $\pi = q_2^A$ hence by equation (18) the supervisor is indifferent between reporting the additional signal ℓ_2^A and the observed signal θ_i^S, $i \in \{1, 2\}$. She then reports the truth. ■

Proof of Corollary 1: For the proof of Proposition 2 to hold it is sufficient that — whenever the signal θ_2^S is observed by both the supervisor and the agent — there still exists a residual, strictly positive, probability that the agent is low productivity. In this case, in fact, the collusion game can reveal some information to the supervisor that she can exploit, off the equilibrium path, to her advantage and to the detriment of the agent. When the precision of the signal θ_2^S increases, without becoming a perfect signal, an additional opportunity for a collusive agreement arises. In fact, the supervisor may find profitable to bribe the agent so as to be able to obtain at least part of the premium γ. However, Step 3 of Proposition 2 proves that such agreement cannot arise as an equilibrium of the collusion game between the supervisor and the agent. ■

Proof of Lemma 3: The proof is a direct application of Revelation Principle. ■

Proof of Proposition 3: Contract CP, as described above, is the optimal direct delegated mechanism. This contract shows that the supervisor's minimal-size message space contains three messages corresponding, respectively, to the signals θ_i^S, $i \in \{1, 2\}$ and to the signal eventually leaked during collusive negotiation ℓ_2^A. Further, by Revelation Principle there exists a one to one relation between the supervisor's choice of a contract in the menu M, in the indirect delegated mechanism, and the supervisor's choice of a message to report in her message space, in the direct delegated mechanism. Moreover, there is a one to one mapping between the output produced by the agent in DM and the agent's report of his productivity to the principal in CP. The optimality of DM then follows directly from Lemma 3. ■

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