"FRIENDSHIPS" IN VERTICAL RELATIONS*

LEONARDO FELLI
(London School of Economics)

J. MIGUEL VILLAS-BOAS
(University of California, Berkeley)

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ABSTRACT. It has been argued that collusion among the members of an organization or a vertical structure creates efficiency losses, and hence should be prevented. This paper shows that whenever collusion takes the form of co-insurance agreements, here called 'friendships', among the members of a vertical structure this may *not* be the case. Indeed, in such a case, collusion yields only a redistribution of surplus among the members of the vertical structure. Hence, its efficiency costs may be reduced by allowing these 'friendships' to take place, rather than preventing them, and accounting for the redistribution in the design of the optimal incentive scheme.

ADDRESS FOR CORRESPONDENCE: Leonardo Felli, The London School of Economics & Political Science, Department of Economics, Houghton Street, London WC2A 2AE, England, e-mail: l.felli@lse.ac.uk.

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1. Introduction

1.1. Overview. It has been argued that collusion among the members of an organization or a vertical relation creates efficiency losses, and hence should be prevented in equilibrium (Tirole 1986, Kofman and Lawarrée 1993, Felli 1996).[1] This paper shows this is not always the case. Indeed, whenever the presence of collusive agreements does *not* affect the information transmitted to the top of the vertical structure but only redistribute surplus among its members, the designer of the incentive mechanism by taking such redistribution of surplus into account may design the optimal incentive scheme without incurring the costs of preventing collusion. Allowing for, potentially harmful, collusive agreements is then the only way to implement the optimal incentive scheme.

Consider a vertical relation in which at least two individuals operate under the same centre or principal. If the principal wants to induce these individuals to exert a productive effort using an incentive scheme, it will accomplish it by introducing some risk in their remuneration schedule. However, since the two individuals do not necessarily have to perform the same task these risks may differ between them. Hence, their share of surplus will, in general, differ for different states of nature. If both individual operate in the same working environment, and at least one of them is risk averse, they will have an incentive to get involved in collusive agreements which take the form of co-insurance agreements, selfish "friendships". In this way, in fact, they may share the risk the principal is imposing on them. These agreements alter their incentives which in principle may yield efficiency losses in the vertical structure.

However, if the designer of the incentive scheme is aware of this phenomenon of collusion, these efficiency losses may be reduced. In fact, if the designer takes this redistribution into account he may generate net transfers to the parties which implement his desired optimal incentive scheme. Conversely, preventing any of such 'friendships', is sub-optimal in such a framework, since it will necessarily imply a constant remuneration, hence no incentives.

[1] Alternatively, there always exists an optimal contract that prevents collusion in equilibrium.

In this paper we consider a very simple three level hierarchy: a principal who is the residual claimant of the organization, a supervisor, who has monitoring or coordination duties, and an agent, who is the only productive unit. We allow all three agents to get involved in risk-sharing agreements, 'friendships'. In particular, this means that the principal, once the supervisor has completed his monitoring task, may get involved in a risk-sharing agreement with the supervisor herself. Subgame perfection implies that this agreement will have effects on the risk-sharing agreement between the supervisor and the agent, which in turn will be taken into account in the design of the optimal incentive scheme for the whole vertical structure.

Consider a risk averse supervisor. Any incentive scheme the principal offers to her will necessarily be renegotiated after the supervisor has performed her duties. Hence, the supervisor and the agent will always negotiate a risk sharing agreement as if the supervisor had been offered full insurance (being the supervisor well aware of the impact of this agreement on the agent's effort level). Therefore, any level of incentive offered to the agent in the original contract will indeed result in collusion in the vertical structure. Furthermore, the principal may be able to restore in some cases the correct (second-best) incentives of the agent by increasing the risk in the agent's remuneration schedule so that, after sharing risks with the supervisor, the agent will have optimal incentives.[2]

The analysis contained in this paper is clearly related to the literature on collusion in hierarchical structures (Tirole 1986, Holmström and Milgrom 1989, Varian 1989, Kofman and Lawarrée 1993, Itoh 1993, Kofman and Lawarrée 1995, Felli 1996). Tirole (1986), Kofman and Lawarrée (1993) and Felli (1996) characterize situations where collusion in a hierarchy needs to be accounted for but can be avoided with contracts that satisfy some kind of *collusion-proof constraint*. We differ from these analyses since in our framework collusion-proofness leads to no incentives.

Holmström and Milgrom (1989), Varian (1989) and Itoh (1993) concentrate on col-

[2]This allocation achieves second-best efficiency provided that the agent has full bargaining power in the negotiation with the supervisor and the principal has full bargaining power in the re-negotiation with the supervisor. This result is consistent with the findings of Matthews (1995). These findings are obtained in an agency framework in which when the principal and the agent renegotiate—once the latter has exerted effort—the agent has full bargaining power.

lusive agreements which are beneficial to the principal, since they take place between agents with superior information; hence, they should be allowed for in equilibrium. These analyses differ from our since we assume that the colluding parties have no informational advantage with respect to the principal. In a word, in our framework collusion is in principle harmful to the principal.

The paper more directly related to our is Kofman and Lawarrée (1995). In this paper collusion is harmful and in some circumstances is allowed since too costly to prevent. We differ from this analysis in the nature of the collusive agreement we consider. Kofman and Lawarrée (1995) focus on agreements that trade information for a monetary transfer, we focus on pure risk-sharing agreements between the colluding parties: informational advantages do not play any role in our analysis.

One aspect of our model deserves a more detailed discussion: the definition of *collusion*. We model *collusion* as a contractual agreement between two parties. We assume that the contract has a *covert* nature but can nevertheless be enforced by an outside arbitrator or a court at the request of one of the parties. This covertness does imply, however, that collusive contracts cannot be used by third parties in court. In other words third parties cannot verify or write contracts contingent on collusive agreements.

Our approach on the covert nature of contracts is related to the approach followed in Tirole (1986). Alternatively, the enforceability of collusive agreements could be guaranteed by a repeated game type of argument, which is typically not made explicit in the work cited above with the exception of Tirole (1992).

The paper is organized in the following way. We start in Section 2 by presenting the basic model, the timing and the benchmark case (i.e. the optimal structure when collusion is not feasible). Section 3 solves the model and presents the main results of the paper. We discuss in Section 4 the assumptions which drive our results. A summary of the results concludes the paper. Before moving to the basic model we briefly discuss some examples of the risk-sharing agreements, 'friendships', we defined above.

1.2. Examples. Examples of this type of relations may be observed in the vertical structures that correspond to procurement activities, either public or private. The procurement of some good by the government from a private developer (e.g. invention of a helicopter, construction of an highway, etc...) can be looked at as one of such structures. In this case the government may want to use government agencies' expertise to monitor the relationship with the private sector contractor.[3] Another vertical structure can be identified in the acquisition, by a private firm, of a particular good from an outside contractor. The manager of the firm might use the expertise of a purchasing agent to monitor the relationship with the outside supplier.

A relevant characteristic of this type of vertical structures is the existence of *uncertainty* on the final outcome of the development of the project. The likelihood of the success depends—at least partially—on the effort invested by the contractor. Such effort is not observable by either the government or the government agency. This implies that the government needs to create incentives in order to induce the contractor to exert effort. A risky remuneration to the contractor will reach this purpose: a very high transfer if the project is successful and a very low one if it is unsuccessful.[4]

When a vertical structure of this type is established, more than two individuals (the government, the government agency and the contractor, for example), facing personal income situations that differ in the degree of riskiness, live and work in the same environment. This may induce them to get involved in 'friendships'. These 'friendships' may take the form of reciprocal exchange of transfers that equalize, at the margin, the risk each member of the vertical structure face. For example these relationships may take the form of reciprocal transfers between the contractor and the government agency. The contractor may pass some of the risk connected with the

[3]This is consistent with Clarke (1970) who describes the government agencies as *"a large group of specialists...their priority purpose is to support the technical effort by handling the administration of contracts"* (p. 12), or Fox (1988) who qualifies the program manager (government agent) as *"the only official with the breadth of knowledge required to direct, coordinate, and control the numerous organizations involved in the program [provision of good]"* (p. 167).

[4]The perception of the riskiness of this relationship is a real issue for contractors, as documented by the belief that *"tight performance specifications or unpredictable R&D tasks has deprived many contractors of safeguards should they fail in their commitment"* (Clarke, p. 13).

incentive scheme imposed on him to the government agency. Then, in the case the project is successful, the contractor may decide to make a transfer to the government agent in the form of an offer of a future employment,[5] social acceptance,[6] or political assets.[7] If, on the other hand, the project is not successful, the government agent may decide to make transfers to the contractor in the form of support of unlucky contractors by government agencies in order to renegotiate the current contract or get new ones.[8] These relationships between contractor and government agencies have been interpreted in several ways by observers: as a simple friendship relation where contractor and government agent care about each other such that if one of them has a low payoff, then both of them have a low payoff,[9] as "good marketing" policy,[10] as

[5] *"Between 1971 and 1979, according to the Council (of Economic Priorities), 1455 or more officers above the rank of colonel went to work for defense contractors"* (Fox, p. 234), *"they [program managers-government agents] have college-age kids and need the extra income to continue to acquire their personal amenities and to support their families at a comfortable level"* (Fox, p. 238)

[6] *"Industry executives visit military and civilian officials several times a year... pleasantries are exchanged... Many senior defense officials are on the regular guest lists for industry cocktail parties in Washington""* (Fox, p. 142-143)

[7] *"Congressional Committees [government agents] in charge of military programs are so influenced by defense contractors that they won't crack down on wasteful spending"* (Fox, p. 36), *"... defense contractors recognized that the promise of jobs could be used as a lever to gain congressional support"* (Fox, p. 92)

[8] *"the Defense Department feels compelled to continue with the initial contractor no matter how inefficiently resources are utilized"* (Baron 1989, p. 12), *"... trade-off of time, cost and technical performance are often made, without his [government] knowledge, by agencies outside his jurisdiction, to the detriment of the management process"* (Fox, p. 167), *"engineers may normally prefer to work with companies with which smooth patterns of technical interchange have already been established"* (Corey 1983, p. 60), *"purchasing tends to build up... relationships with individual suppliers that exceed any product expertise that may reside in other functional areas"* (Corey, p. 61-62)

[9] *"This [problem of friendship] is not intended to suggest that a buyer, whether a government buyer or one employed in the private industry, is making under-the-table deals, or there is anything ethically wrong in the relationship. It is just that, in many cases, familiarity may not breed contempt, but may breed friendship which prevents the buyer from doing the most effective job at the negotiation table"* (Fox, p. 287), *"Consider... a division manager deciding whether to terminate... an employee... The personal costs of terminating the relationship... include personal discomfort with the task, chastisement by other employees and peers, the loss of important friendships"* (Baker, Jensen and Murphy 1988, p. 614)

[10] *"The Marketing's job is to locate the "right" Government Engineer among the many thousand possible, learn his explicit needs, and convince him that his needs can be filled by the people and facilities represented by Marketing... Marketplace information: his personality and prejudices"* (Clarke, p. 51-53)

simple pressure of sellers on buyers,[11] as a way to build a team spirit,[12] and finally as simple interpersonal relationships.[13]

Interpersonal relationships may arise not only between contractors and members of the government agency, but also between members of the government agency and members of the government: the upper tier of the vertical relation. In fact, the government also operates in the same working environment of the agency and may have an interest to provide the agency with some form of insurance especially if the government does not need to provide the agency with incentives. These transfers are usually reciprocal and may take the form of an extra effort by the government in finding a knowledgeable substitute when the government agent leaves the public administration, and support of the government position by the government agent, when employed by the contractor.[14]

The appearance of these relationships (both the contractor/government agent relationship and the government agent/government relationship) play an essential role in the structure of the vertical relation: they change the incentives on the contractor to exert effort (less incentives); hence, they need to be accounted for by the government when determining the rent distribution between the contractor and the government agency.

Another environment in which such type of 'friendships' are observed is the internal organization of a firm. A branch of the literature on efficiency wages (Akerlof 1982, Akerlof 1984, Akerlof and Yellen 1988, Akerlof and Yellen 1990) has interpreted the relationship between employer and employees and among employees as "partial and reciprocal gift exchange" in which *"...the ratio of the perceived value of the "in-*

[11] *"In the defense business, as in the commercial business, the buyers (defense official) are the focus of pressure, both subtle and overt from the sellers (defense contractors)"* (Fox, p. 142)

[12] *"we must get back to the team approach between the Defense Department and the defense industry"* (Fox, p. 144)

[13] *"Understandably, this decision-making process [purchasing] is affected by...performance measures ...and by interpersonal relationships among these involved in the decision"* (Corey, p. 50).

[14] *"There is a positive side to having retired military officers and civil servants working for defense contractors...there is little doubt that the exchange of personnel smooths the contracting process and helps communicate to industry important technical and administrative concerns of the government"* (Fox, p. 237), *"Ability to maintain good relations with both suppliers and internal groups (by purchasing managers) is highly regarded"* (Corey, p. 55)

puts" to the perceived value of the "outcomes" should be equal for the two agents in an exchange" (Akerlof and Yellen, p. 257). Another way to restate the same concept is to say that the two agents involved in a 'friendship' co-insure each other against the risks (income risks in particular) they face in the working environments. Finally, the practice of gift-exchange in Japanese corporations has some of the features of the type of 'friendships' we model in this paper. Indeed, such a practice is extremely spread and customary between individuals in different layers of a Japanese corporation and the existing incentive schemes seem to account for such practices (Aoki 1990, Baron 1988).

2. The Model

2.1. The Parties. The framework of our analysis is a very simple three level hierarchy. The top of the hierarchy is the residual claimant of profits generated by the whole structure: the principal (P). The bottom layer is the agent (A) the only level that actually produces any output. The intermediate layer is a supervisor (S) who is capable of collecting information on the agent's unobservable characteristics.

The agent is the productive unit of the structure, he controls a random technology that can generate two possible outcomes x, that we normalize to zero for the low outcome, and one for the high outcome. When born the agent is endowed with a productivity parameter θ, $\theta \in nn\{\overline{\theta}, \underline{\theta}\}, \overline{\theta} > \underline{\theta}$ which is his private information. He may or may not exert productive effort, which is unobservable to third parties: $e \in \{0, 1\}$. If the agent exerts no effort the probability that the technology will generate a high outcome is γ independently of the agent's productivity:

$$\gamma \equiv \Pr\{x = 1 | e = 0\} \tag{1}$$

If the agent exerts a productive effort the probability of the high outcome will be greater if he is highly productive than if he is not:

$$\gamma + \overline{\alpha} = \Pr\{x = 1 | e = 1, \theta = \overline{\theta}\} \tag{2}$$

$$\gamma + \underline{\alpha} = \Pr\{x = 1 | e = 1, \theta = \underline{\theta}\} \tag{3}$$

$$\overline{\alpha} \; > \underline{\alpha} > \; 0 \tag{4}$$

This inequality translates the intuitive idea that the marginal productivity of effort (related to α) increases in the productivity parameter θ.

Preferences of the risk averse agent are described by the following Von Neumann-Morgenstern utility function separable in income and effort: $U(w)-G(e)$. We assume that the utility of income is strictly concave: $U'(\cdot) > 0, U''(\cdot) < 0$; the disutility of no effort is null: $G(0) = 0$ and a productive effort generates a strictly positive disutility $G(1) = \Delta > 0$. The agent's reservation utility is $U^* = U(w^*)$.

The supervisor has a monitoring role in the structure. She does not contribute to the productive process but just provides information. She has the time and the willingness to collect information on the agent's productivity and, if requested, she can supply such information to the principal. We model this by assuming that the supervisor observes costlessly and perfectly the agent's productivity and this is *hard* information.[15] In other words we assume that the supervisor has to document every report she does to the principal on the agent's productivity, and she has no way to produce enough supporting documentation for a false report. Therefore any outside party—the principal in particular—can verify the truth of the supervisor's report.[16]

Preferences of the risk averse supervisor are described by the following Von Neumann-Morgenstern utility function $V(s)$, strictly concave in income: $V'(\cdot) > 0, V''(\cdot) < 0$. The supervisor has an outside option with a reservation salary s^*.

The principal is a risk neutral individual: he observes the outcome of the productive process—which is *verifiable* to third parties—as well as the report of the supervisor.

2.2. The Timing and Solution Concept. In this subsection we describe the extensive form we are using to model the vertical relation. In Section 4 below we give some motivation and discuss its robustness.

The information structure is such that before contracting the agent knows his

[15] Cf. Tirole (1986) for the definition of hard information.

[16] This is clearly a simplifying assumption. However, the main result of the analysis does not change if we allow for more complex information revelation.

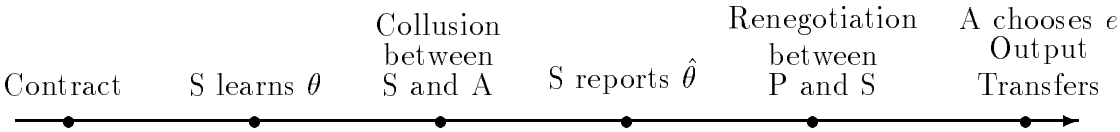

Figure 1: Timing of the model.

unobservable productivity while the other parties share a common prior $r \equiv \Pr\{\theta = \overline{\theta}\}$. Negotiation takes place among the principal, the supervisor and the agent. The principal is assumed to have all the bargaining power: he proposes a *take-it-or-leave-it* offer C to both the agent and the supervisor which specifies a schedule of compensations for both the agent and the supervisor as a function of the outcome and the report of the supervisor. The agent and the supervisor observe each other's contracts and take the decision to accept or reject C, individually and simultaneously.

If the contract is accepted, the supervisor learns the productivity of the agent and the collusive bargaining process between the agent and the supervisor takes place. We assume, for simplicity, that in the collusion game the agent has all the bargaining power and makes a *take-it-or-leave-it* offer to the supervisor. The supervisor can only accept or reject the offer.[17]

The supervisor then produces a report for the principal. This report is public information. Collusion between the principal and the supervisor follows. We assume that the principal has all the bargaining power and makes a *take-it-or-leave-it* offer to the supervisor in such renegotiation.[18]

Finally, the agent chooses effort, uncertainty is resolved, and the three parties exchange transfers according to the latest contractual agreements.

The timing is summarized in Figure 1.

We look for a *Subgame Perfect Equilibrium* of this game, and we restrict attention on pure strategies.[19] In this respect our analysis is similar to Matthews (1995) which in a different framework (a two-tier principal-agent contract) focuses on pure strategy

[17]Notice that at this stage both the agent and the supervisor have symmetric information.

[18]This assumption is equivalent to the one made in the renegotiation between the principal and the agent in Matthews (1995).

[19]The fact that the supervisor's private information is verifiable (*hard*) allows us to focus on *Subgame Perfect* equilibria rather than *Perfect Bayesian* equilibria.

renegotiation, and differs from the one of Fudenberg and Tirole (1990) which obtain a mixed strategies equilibrium.

2.3. The Collusion-Free Contract. In this section we present the benchmark case in which collusion is not a feasible option for the parties involved in the main contract C. In this case the risk neutral principal pays a constant salary s^* to the risk averse supervisor who accurately reports the agent's productivity. The principal receives perfect information on the productivity of the agent and faces only the moral hazard problem of inducing the agent to exert unobservable effort.[20]

Let us consider the problem in the case the productivity of the agent is high:[21]

$$\min_{\{\overline{w}_i\}} \quad (\gamma + \overline{\alpha})\,\overline{w}_1 + (1 - \gamma - \overline{\alpha})\overline{w}_0 \tag{5}$$

$$s.t. \quad (\gamma + \overline{\alpha})U(\overline{w}_1) + (1 - \gamma - \overline{\alpha})U(\overline{w}_0) \geq U^* + \Delta \tag{6}$$

$$\overline{\alpha}[U(\overline{w}_1) - U(\overline{w}_0)] \geq \Delta \tag{7}$$

Problem (5) is quite standard. Equation (6) is the agent's *individual rationality* constraint. It states that the agent must obtain at least his reservation utility. Equation (7) is the agent's *no-shirking* constraint, making him weakly prefer to exert effort in equilibrium . The solutions to Problem (5) and to the corresponding problem for the low productivity agent are such that they satisfy the following conditions:

$$\underline{w}_0 \;<\; \overline{w}_0 \;<\; \overline{w}_1 \;<\; \underline{w}_1 \tag{8}$$

$$(\gamma + \underline{\alpha})U(\underline{w}_1) + (1 - \gamma - \underline{\alpha})U(\underline{w}_0) = U^* + \Delta \tag{9}$$

$$(\gamma + \overline{\alpha})U(\overline{w}_1) + (1 - \gamma - \overline{\alpha})U(\overline{w}_0) = U^* + \Delta \tag{10}$$

$$\overline{\alpha}[U(\overline{w}_1) - U(\overline{w}_0)] = \underline{\alpha}[U(\underline{w}_1) - U(\underline{w}_0)] = \Delta \tag{11}$$

[20] We assume Δ sufficiently small, such that it is always optimal for the principal to induce the agent to exert effort.

[21] We use $\underline{w}_i$ and $\overline{w}_i$, $(i = 0, 1)$ to indicate wages offered to low, respectively high, productivity agents, while the subscript refers to the final outcome x.

The intuition behind such conditions is straightforward. In particular, condition (8) tells us that the less productive the agent, the riskier (i.e. the more expensive for the principal) the wage schedule that induces him to exert effort. We will see that this feature of the collusion-free optimal contract will play a critical role in our analysis. Conditions (9) and (10), i.e., the binding individual rationality constraints, are the consequence of our assumption that the whole bargaining power in the negotiation lies with the principal. Condition (11) indicates that in both problems the no-shirking constraint is binding and the agent is indifferent between exerting effort and shirking. The assumption that breaks this indifference is that every party, when indifferent, behaves in the way the principal wants him to.

3. Results

3.1. Insurance Collusion. Collusion in our model takes the form of an agreement between two parties who exchange bribes with the sole purpose of redistributing the risk between themselves. This is insurance collusion that, as we argued in the introduction, can take various forms: favours, friendship, etc.[22] We assume for the sake of simplicity that this collusion takes a monetary form, and that bribes transfer wealth between individuals. One way to accommodate the discussion in the Introduction with this assumption is to think of the monetary equivalent of the 'friendships' in question.

The existence of insurance collusion relies on the assumption that parties can exchange bribes contingent on the final outcome of the random production, which we assume is the case. Furthermore, we assume that the agent has all the bargaining power in the collusion game with the supervisor, and that the contract signed by the agent and the supervisor with the principal specifies the wage and salary schedules $w_i, s_i, i \in \{0, 1\}$ contingent on the report of the supervisor.[23] Then—when faced with the collusion game—a type θ agent computes the maximal expected utility he could reach when he exchanges bribes with the supervisor, does or does not exert effort,

[22] This type of collusion is the one considered in Itoh (1993) and Holmström and Milgrom (1989).

[23] The definition of the symbols used to indicate salaries for the supervisor is coherent with the one of the symbols that indicates wages for the agent (see Footnote 21).

and leaves the supervisor with at least the same expected utility she would enjoy in the absence of collusion, i.e. the solution to the following problems.[24]

$$\max_{\{b_i\}} \quad (\gamma+\alpha)U(w_1-b_1)+(1-\gamma-\alpha)U(w_0-b_0)-\Delta \tag{12}$$

$$s.t. \quad (\gamma+\alpha)V(s_1+b_1)+(1-\gamma-\alpha)V(s_0+b_0)$$

$$\geq (\gamma+\alpha)V(s_1)+(1-\gamma-\alpha)V(s_0) \tag{13}$$

$$U(w_1-b_1)-U(w_0-b_0)\geq(\Delta/\alpha) \tag{14}$$

$$\max_{\{b_i'\}} \quad \gamma U(w_1-b_1')+(1-\gamma)U(w_0-b_0') \tag{15}$$

$$s.t. \quad \gamma V(s_1+b_1')+(1-\gamma)V(s_0+b_0')\geq\gamma V(s_1)+(1-\gamma)V(s_0) \tag{16}$$

$$U(w_1-b_1')-U(w_0-b_0')\leq(\Delta/\alpha) \tag{17}$$

Problem (12) refers to the case in which the agent exerts effort while Problem (15) to the case in which the agent does not exert effort.

A comparison of the optimal values of equation (12) and (15) will determine whether the agent makes a collusive offer to the supervisor, as well as whether he exerts effort or not. In fact it is possible that co-insurance between the supervisor and the agent induces the agent to violate the no shirking condition that the principal imposed in the original contractual offer.

Problems (12) and (15) suggest the following lemma.

Lemma 1. *Every collusion-proof optimal contract that prevents supervisor and agent from engaging in any form of collusion and induces the agent to exert high effort, needs to satisfy the following modified version of an optimal co-insurance*

[24] In the statement of the problems that follow we use b_i to indicate the bribes that the supervisor and agent exchange when the agent exerts effort and b_i' to indicate the bribes in the case the agent exerts no effort.

rule.[25]

$$\frac{(\gamma+\alpha+\mu)}{(\gamma+\alpha)}\frac{U'(w_1)}{V'(s_1)} = \frac{(1-\gamma-\alpha-\mu)}{(1-\gamma-\alpha)}\frac{U'(w_0)}{V'(s_0)} \tag{18}$$

Proof. Condition (18) follows from the first order conditions of Problem (12). ■

Condition (18) represents an efficient way for two risk averse individuals to distribute the risk. The modification to the classic co-insurance rule is due to the moral hazard constraint.

3.2. Collusion between the Principal and the Supervisor. The collusion between the principal and the supervisor has, in our model, the flavour of renegotiation. In fact both parties are already engaged by a contract when they get to the collusion stage. The hidden nature of the collusive agreement, though, makes our "renegotiation" different from the one that is usually considered in the existing literature (Dewatripont 1989, Dewatripont and Maskin 1988, e.g.). According to this literature, renegotiation produces, if any, an *official* and public contract that substitutes the existing one. This is not true in our case. The new contract the supervisor and the principal sign is a secret contract that adds to the existing one (which remains the only publicly enforceable agreement between these two parties). This is because in the collusive agreement between the principal and the supervisor we want to capture a 'friendship' that can be established between these two parties and that surely does not substitute the existing employment contract of the supervisor. Throughout this paper we use the term renegotiation to indicate collusion between the supervisor and the principal in order to make clear the distinction with the collusion between the supervisor and the agent.

When the principal and the supervisor enter the renegotiation stage, we assume for simplicity that the principal has all the bargaining power.[26] Then the principal will face the following minimization problem:

[25] In the statement of condition (18) μ is a non negative lagrange multiplier associated with inequality (14) in Problem (12).

[26] This assumption is not crucial in our analysis: our results generalize to any distribution of the bargaining power between the principal and the supervisor except for the extreme case when the supervisor has all the bargaining power (in this case the principal is not able to induce any effort from the agent).

$$\min_{\{s_i'\}} \quad (\gamma+\alpha)(s_1'-s_1)+(1-\gamma-\alpha)(s_0'-s_0) \tag{19}$$

$$s.t. \quad (\gamma+\alpha)V(s_1'+b_1)+(1-\gamma-\alpha)V(s_0'+b_0)$$

$$\geq (\gamma+\alpha)V(s_1+b_1)+(1-\gamma-\alpha)V(s_0+b_0) \tag{20}$$

where $s_i, i \in \{0,1\}$ is the initial salary schedule offered to the supervisor (contingent on her own report) while the side transfers to which principal and supervisor agree at the renegotiation stage are given by $(s_i'-s_i), i \in \{0,1\}$. On the other hand $b_i, i \in \{0,1\}$ are the bribes the supervisor and the agent eventually exchanged at the collusion phase. The solution to Problem (19) allows us to prove the following result.

Lemma 2. *Every renegotiation-proof optimal contract that prevents principal and supervisor from renegotiating in equilibrium fully insures the supervisor against the uncertainty on the final outcome of the production process.*

Proof. It follows from the first order conditions of Problem (19). These first order conditions specify a constant marginal utility for the supervisor, i.e. $s_1+b_1 = s_0+b_0$. ■

The message of this lemma is very intuitive. A risk neutral principal will always fully insure a risk averse supervisor once the principal does not need to provide the supervisor with any incentive (the role of the supervisor in the organization is completed: she does not exert any effort or report any new information). Obviously, if the original contract is collusion-proof, Lemma 2 implies that the only renegotiation-proof contract between the principal and the supervisor yields $s_1 = s_0$.

3.3. The Equilibrium Contract. We now possess the tools necessary to state and prove our first result.

Proposition 3. *No equilibrium contract between the principal and the supervisor can be at the same time collusion-proof and renegotiation-proof and provide the agent with enough incentives to exert effort.*

Proof. It follows from Lemma 2 that, whenever the original contract is collusion-proof, $s_1 = s_0$. Substituting $s_1 = s_0$ in (18) two cases may happen: $\mu = 0$ or $\mu \neq 0$.

If $\mu = 0$ we get $w_1 = w_0$, which is clearly a wage schedule that does not satisfy the no shirking constraint (7) for the agent. If $\mu \neq 0$ we get that the solution to Problem (12) yields a level of the agent's utility $\gamma U(w_1) + (1-\gamma)U(w_0)$ as (14) holds with equality. Furthermore the solution to Problem (15) yields $b'_1 \neq 0$ and $b'_0 \neq 0$. Then, the solution to Problem (15) yields a level of the agent utility greater than $\gamma U(w_1) + (1-\gamma)U(w_0)$ (which would be the solution had we restricted $b'_1 = 0$ and $b'_0 = 0$) which is exactly equal to the utility the agent gets when solving Problem (12). Then, if $\mu \neq 0$ the agent and the supervisor would collude and no effort would be exerted. ■

Proposition 3 shows the basic trade-off of our model. On the one hand the priority of the principal to generate incentives for the agent to exert effort induces the principal to offer a risky optimal wage schedule to the agent, while on the other hand both the requirements of collusion and renegotiation proofness induce the principal to offer a flat wage schedule to the agent. The extreme nature of this trade-off compels the principal to choose among the three possible objectives—incentives, collusion and renegotiation proofness—when he offers an optimal contract to both the agent and the supervisor. If Δ is small enough the principal will always want to provide the agent with incentives to exert effort. Therefore our program will be to check if allowing the agent and supervisor to engage in collusion and/or the principal and the supervisor to renegotiate will still induce the principal to hire the supervisor.[27]

Our first step in this program will be to show that every time that agent and supervisor engage in a collusive agreement between themselves, there exists room for the principal and the supervisor to renegotiate, i.e., collusion and renegotiation always come as a pair. The following proposition helps us in this direction.

Proposition 4. *Every time the agent and the supervisor engage in an insurance-collusion agreement, the bribes that are paid by the agent to the supervisor are reimbursed to the supervisor by the principal at the renegotiation stage.*

[27]Note that the principal has no incentive whatsoever to renegotiate with the agent, given the timing we described in Section 2. For a discussion on the rational of our timing see Section 4 below.

Proof. The perfectness requirement of our equilibrium concept implies that when agent and supervisor engage in collusive negotiation, in the form presented in Problems (12) and (15), they will behave as if the salary schedule of the supervisor is constant. Since the equilibrium wages of the agent generate a risky payoff structure (due to incentives), the optimal solution of Problems (12) and (15) will always imply bribes different from zero. Now, when the principal and the supervisor get to the renegotiation stage the net income of the supervisor will be risky—due to the bribes paid to and received from the agent. The solution to Problem (19) will now imply that the optimal strategy for the principal will be to restore a constant income for the supervisor reimbursing the bribes the supervisor paid and collecting the ones the supervisor received from the agent. The fact that the transfers coincide in the collusion and the renegotiation phases is a consequence of our simplifying assumption on the distribution of the bargaining power in the two negotiations. Note that even if the principal does not observe the side contract between the supervisor and the agent he still has all the information necessary to compute the amount of the bribes and the incentive to compensate the supervisor: he gains the risk premium associated with the supervisor's risk aversion. ■

The intuition behind this result is that the principal is providing, through the supervisor, a form of co-insurance to the agent. The risk aversion of the intermediary—the supervisor—allows the principal to leave some risk in the wage schedule of the agent so that the principal can still induce the agent to exert effort. The principal cannot prevent these co-insurance agreements from taking place in equilibrium (as opposed to Tirole (1986) and Felli (1996)) since, by assumption, he cannot commit not to renegotiate with the supervisor.

The second step in our program will be to show that the principal can allow insurance-collusion to take place between the agent and the supervisor and still induce the agent to exert an optimal amount of effort. For this purpose we need to formulate the no shirking constraint in the case where we allow collusion to take place.

Let $\mathcal{V}(w_1, w_0, s \mid \gamma+\alpha, \alpha)$, respectively $\mathcal{V}(w_1, w_0, s \mid \gamma, \alpha)$, be the maximum values of the objective functions of the following problems:

$$\max_{\{b_i\}} \quad (\gamma+\alpha)U(w_1-b_1)+(1-\gamma-\alpha)U(w_0-b_0)-\Delta \tag{21}$$

$$s.t. \quad (\gamma+\alpha)V(s+b_1)+(1-\gamma-\alpha)V(s+b_0)\geq V(s) \tag{22}$$

$$U(w_1-b_1)-U(w_0-b_0)\geq(\Delta/\alpha) \tag{23}$$

$$\max_{\{b'_i\}} \quad \gamma U(w_1-b'_1)+(1-\gamma)U(w_0-b'_0) \tag{24}$$

$$s.t. \quad \gamma V(s+b'_1)+(1-\gamma)V(s+b'_0)\geq V(s) \tag{25}$$

$$U(w_1-b'_1)-U(w_0-b'_0)\leq(\Delta/\alpha) \tag{26}$$

We can now state the no-shirking constraints for the optimal program of the principal compatible with equilibrium collusion.

$$\mathcal{V}(\overline{w}_1,\overline{w}_0,\overline{s}\mid\gamma+\overline{\alpha},\overline{\alpha}) \quad\geq\quad \mathcal{V}(\overline{w}_1,\overline{w}_0,\overline{s}\mid\gamma,\overline{\alpha}) \tag{27}$$

$$\mathcal{V}(\underline{w}_1,\underline{w}_0,\underline{s}\mid\gamma+\underline{\alpha},\underline{\alpha}) \quad\geq\quad \mathcal{V}(\underline{w}_1,\underline{w}_0,\underline{s}\mid\gamma,\underline{\alpha}) \tag{28}$$

With these instruments, we can now present the final result of the paper: under certain conditions the principal finds optimal to hire the supervisor.

Proposition 5. *There exist values of the parameters of the problem for which the principal wants to hire both the agent and the supervisor, and the optimal contract is characterized by both insurance-collusion and renegotiation.*

Proof. If the principal hires the supervisor, his problem is for each type of agent to set s and the w_i, $(i=0,1)$ in order to maximize his welfare (i.e. to solve Problem (5) replacing $\overline{w}_i$ with w_i-b_i) subject to the no shirking constraint (27) or (28) (depending on which is the type of agent considered) and to the supervisor's individual rationality constraint. The proof involves five steps:

1) Notice first that the greater is w_1 and the lower is w_0, the more likely it is for Problem (21) to yield a higher value of the objective function than Problem (24) (this is because the greater is w_1 and the lower is w_0, the more binding is constraint (26) and the less binding is constraint (23)).

2) If there exists a vector (w_1, w_0) such that Problem (21) has constraint (23) not binding, then the value of the objective function of Problem (21) is strictly higher than that of Problem (24). Then if constraint (23) is binding up to an arbitrary small $\varepsilon > 0$, the value of the objective function of Problem (21) is still strictly higher than that of Problem (24).

3) Consider a vector (x_1, x_0) such that $U(x_1) - U(x_0) = (\Delta/\alpha)$. Then one can compute a continuum of pairs (w_1, w_0) such that the solution to Problem (21) has $x_1 = w_1 - b_1$ and $x_0 = w_0 - b_0$. Hence, each pair of this continuum satisfies $w_1 = f(w_0)$ where $f(\cdot)$ is negatively sloped.

4) Consider the pair (x_1, x_0) that solves the (collusion-free) Problem (5). We can find a pair (w_1, w_0) such that the pair (b_1, b_0) that solve Problem (21) satisfy $w_1 - b_1 = x_1$ and $w_0 - b_0 = x_0$, and such that the maximum value of Problem (21) is higher than the maximum value of Problem (24).

5) Hence, the solution to the principal's problem when he hires a supervisor and collusion is possible, yields the same principal's payoff as the solution to Problem (5).

The difference is that when collusion is feasible the principal has to offer a higher w_1 and a lower w_0, so that after the collusion between the agent and the supervisor, $w_1 - b_1$ and $w_0 - b_0$ provide the same incentives as w_1 and w_0 when collusion were not possible. Then, as in the collusion-free case, the principal hires the supervisor if s^* is sufficiently low. ■

As it is made clear in the proof, collusion (and renegotiation) are not harmful to the principal if he accounts for it in the design of the incentive scheme to the agent and supervisor. This involves offering a riskier wage schedule to the agent. Notice that the fact that the optimal incentive scheme yields to the principal the same surplus as the optimal scheme in the absence of any collusion is *not* a robust

feature of our analysis. Indeed, collusion would become harmful to the principal had we imposed a lower bound (say zero) on the wages offered by the principal. In this case, if the supervisor has a sufficiently low risk aversion, the absolute value of the bribes may be sufficiently large as to make the lower bound of w_0 binding. In this case, the principal suffers from the existence of collusion between the agent and the supervisor. The costs to the supervisor from the existence of collusion are then higher the lower is the risk aversion of the supervisor and the higher is the risk aversion of the agent. It is however still the case that from the principal's view point allowing harmful collusion is cheaper than preventing it.

4. Discussion of Assumptions

In this section we briefly discuss some of the assumptions of the model and their role in the derivation of our results. In particular, we concentrate our attention on the analysis of how essential each assumption is.

Uncertainty Uncertainty in the outcome, given effort and type of the agent, is essential for the results of the model. Without uncertainty there is no renegotiation between principal and supervisor and no insurance collusion between supervisor and agent.

Moral Hazard The existence of moral hazard induces the principal to offer a risky wage schedule to the agent. This brings up the insurance problems between agent and supervisor. Without moral hazard the principal would offer a flat wage schedule, given the agent's type, to both the agent and the supervisor: both would then be fully insured and this contract would be collusion and renegotiation-proof.

Asymmetry of Information Without asymmetric information between the principal and the supervisor it would never be profitable for the principal to hire a supervisor (the supervisor is assumed to report the type of the agent). Alternatively, we could have assumed that the supervisor reports on the effort level. In this case renegotiation between supervisor and principal would be relevant only after the agent exerts effort and before the outcome is realized. But in that case there would be no reason for the

principal not to renegotiate with the agent too—this is the case analyzed in Fudenberg and Tirole (1990). Unlike in their model, the agent's full bargaining power at the renegotiation stage—in line with Matthews (1995) assumption—allows us to show that the equilibrium is in pure strategies with the agent exerting effort.

Two Levels of Effort and the Timing of the Supervisor's Report We assume that the supervisor's report on the type of the agent takes place before the exertion of effort. This assumption is justified in the case of continuous effort because if information is reported before effort, the principal can enforce a more efficient level of effort than in the case of simultaneous report and effort. The critical question is why do we make the same assumption in a discrete effort framework. First, one must note that the results of the model can be extended to the continuous effort case. Secondly, one could envision an argument for this timing to be the only renegotiation-proof one. Assume that the initial contract sets the supervisor to report the agent's type simultaneously with the revelation of the outcome. Then, the principal and the supervisor have an incentive to secretly collude on the timing of the report in order for the former to fully insure the latter. Foreseeing this event, the agent and the supervisor have an incentive to engage in insurance-collusion, and everything would be as if the initial contract had instructed the supervisor to make a report before the revelation of the outcome.

The Quality of The Supervisor's Information We assume the supervisor has hard and perfect information on the agent's type. All the results of the model would go through had we assumed hard and imperfect information as in Tirole (1986). Our perfect information assumption allows us to simplify the wage schedule offered by the principal. If we had used imperfect information (as in Tirole (1986)), we would have eight wage levels for the agent and three salary levels for the supervisor, instead of, respectively, four and two.

The Collusion Contracts We assume that two parties can sign collusive contracts that are only verified by third parties if at least one of the contracting parties agrees to do so. This assumption allows the principal to fully insure the supervisor in the

renegotiation phase.

Without this assumption (which means all contracts between the principal and the supervisor are public, even the collusion ones) the agent and the supervisor could, at the collusion stage, sign a contract (which could be enforced by some kind of repeated game type of argument) that was contingent on the insurance payments received by the supervisor at the renegotiation stage. In particular, the agent and the supervisor could sign a contract that would enforce optimal co-insurance between themselves (given wages and insurance payments to the supervisor). In this case, the principal could offer an initial contract which were collusion and renegotiation-proof.

Another assumption equivalent to ours (in the sense that allows us to get collusion and renegotiation in equilibrium) is the following one: the collusive contract between agent and supervisor can only be contingent on the outcome of the production phase and not on the insurance payments of the renegotiation phase. Notice also that the initial contract could have the following clause: if in the renegotiation phase the principal learns about collusion between the supervisor and the agent, then, he can extract whatever large amount he wants from the latter. But, then, in the collusive contract between agent and supervisor there should be a clause that allows the agent to extract a larger amount from the supervisor if the principal extracts anything from the agent. Therefore, in the renegotiation stage there should be a clause that allows the supervisor to extract from the principal an even larger amount if the principal extracts anything from the agent. This chain of clauses has the function of not allowing the principal to make use of the information he obtains at the renegotiation stage and is derived from the optimal behaviour of both the agent and the supervisor.

Other Renegotiations We assume that after the renegotiation between principal and supervisor there cannot be any other renegotiation between any other parties. In fact, in our model, the agent and the supervisor would like to renegotiate their insurance payments on their collusive agreement after the supervisor-principal renegotiation.

In the hard and imperfect information case there is one further profitable renegotiation after the principal-supervisor one. After this event, the principal has perfect information about the type of the agent: this can be used by these individuals in

another renegotiation round.

Bargaining Power We assume the principal has the bargaining power when negotiating with either the agent or the supervisor and the agent has the bargaining power when negotiating with the supervisor.

The assumption on the bargaining power between principal and agent or between principal and supervisor is traditional in the literature. The assumption on the bargaining power between the supervisor and the agent is not critical for our results but allows us to simplify the analysis: the insurance payments from the supervisor to the agent are reimbursed by the principal at the renegotiation stage. Without this assumption, the insurance payments between supervisor and agent would be different from the insurance payments between principal and supervisor, and this would mean, more control variables in the principal's problem.

5. Concluding Remarks

Our analysis explains the appearance of 'selfish friendships' in vertical relations as co-insurance agreements among its several members. The appearance of these friendships has to be accounted for by the organization designer in the sense that the distribution of rents among the lower tiers of the hierarchy has to be modified. This can also be viewed as an optimal incentive contract where collusion has to be allowed for. In other words, these 'friendships' are the only way to implement the optimal incentive scheme. Indeed, in some cases such equilibrium collusion does not imply any efficiency loss for the vertical structure.

Our analysis only considers a one shot contract. This gives us only partial insights in the examples described in the Introduction. Indeed, the transfers stipulated in the co-insurance agreements can involve actions in later contracts of the hierarchy (as in many of the examples presented in the Introduction). Further, the analysis presented is silent on the question why and how the hierarchical relationship began. In fact, one important component of the analysis of procurement problems is, without any doubt, the choice of the contractor with whom the firm will make business.

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