UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Scienze Economiche "Marco Fanno"

CONDITIONAL DELEGATION AND OPTIMAL SUPERVISION

ALFREDO BURLANDO
Boston University

ALBERTO MOTTA
University of Padova

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Conditional Delegation and Optimal Supervision

Alfredo Burlando
Boston University
E-mail: burlando@bu.edu

and

Alberto Motta
Universita' di Padova
E-mail: alberto.motta@unipd.it

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This paper analyzes a simple modification of a standard mechanism in hierarchical centralized structures with hard-information supervision. The supervisor receives a signal about the productive agent's technology. With some probability the supervisor learns the true agent's technology, otherwise she learns nothing. Our design lets the productive agent choose between two competing contracts, a "secure" contract or a grand contract subject to uncertainty. The mechanism eliminates agency costs by providing the productive agent with the possibility of avoiding inspection. When productive agent is risk averse, our mechanism also provides him with an insurance coverage: as a consequence, this mechanism would be worthwhile even abstracting from collusion.

1. INTRODUCTION

In their seminal paper Laffont and Tirole (1991) develop an agency-theoretic approach to interest-group politics. They consider a three-tier hierarchy where Congress (P) relies on information supplied by the agency (S) regarding the firm's (F) technological type[1]; F can be either "efficient" or "inefficient". Laffont and Tirole (1991) conclude that the threat of producer protection, i.e. possibility of collusion between F and S, leads to low-powered incentive schemes with respect to the case in which producer protection is ignored. The intuitive reason for this result is the following: to prevent F from bribing S, P must provide S an incentive for reporting the true information. This incentive must be high enough such that the cost to F of compensating S for the income lost by not reporting exceed its stake. In other word, P must compete with F to have S reporting the true signal: to this purpose, P must reduce the efficient type rent under asymmetric information. Therefore in Laffont and Tirole (1991) collusion reduces social welfare because the inefficient type is given an incentive scheme that is even less powerful than the corresponding scheme in the absence of collusion.

We take Laffont and Tirole (1991) setting seriously into consideration, by focusing on one element which could have been naturally implemented in their approach: that is, we allow F to choose between a regime free of supervision over a regime of supervision. Our mechanism works as follows: F can choose between two competing contracts. The first contract, which we call 'fast contract' for lack of better word, directly specifies payouts to F, and involves no supervision at all. If this contract is rejected, then a grand contract involving P, S and F is implemented, in which S inspects F and reports to P.

Assuming that S and F cannot collude before the acceptance of the fast contract, this mechanism allows P to eliminate the cost related to collusion: intuitively, P can use the intervention of S in the grand contract stage as a credible threat for reducing F's information rent in the fast contract stage, thereby maintaining P's advantage of having a supervisory

[1] We refer to the S and F respectively as "she" and "it".

agency in the first place.

In the second part of the paper, we show that this outcome is achieved on condition that P designs both contracts before F makes a selection. When P designs contracts sequentially or conditionally on the choices made by F, conditional supervision may still bring about better outcomes than centralized supervision alone.

The key advantage of this model, is its simplicity and its applicability. In practical terms, a fast contract is the 'best case scenario' contract that can be designed by P without knowing anything about F or S; it can easily be added into a more complex, contingency-based grand contract suggested by the literature.

Our objective here is to present a new mechanism under the very strict assumptions generally made in this strand of the literature, and leave the relaxation of those assumptions to later research. For instance, we retain frictions in the side-contracting stage of the model. While this assumption can be justified in practice (Laffont and Meleu 1997) and derived from models of repeated games (Martimort 1999), subsequent models of collusion in the presence of 'soft' information do not rely on them (Faure-Grimaud et al, 2003). Importantly, our model is measured against prior mechanisms under a fully centralized system, in which P contracts directly with both S and F. We then avoid, for now, the debate on whether centralized mechanisms performs better (Celik, 2008) or worse (Baliga and Sjorstrom 1998, Faure-Grimaud et al 2003) than full delegation to S[2]. This is an important question that can be addressed in a more general setting by the mechanism presented here[3].

Finally, it is important to emphasize that our model is restricted to unproductive supervision, since in many instances S is barred from entering into the contract. Our model thus cannot inform the debate on hierarchical models where multiple agents are involved in the production process (McAfee and McMillan 1995; Laffont and Martimort 1998; Mookherjee and Tsumagari 2004).

[2] In the Tirole setting, delegation and supervision are equivalent.

[3] The conditional supervision presented in this model allows F to choose between a direct contract with P or a centralized contract; delegation can be obtained by having F contract directly either with P (as a direct contractor) or S (as a subcontractor).

The rest of the paper is organized as follows. Section 2 defines the model and the benchmarks of collusion-free and collusion-proof supervision. Section 3 introduces conditional supervision, and measures it against the benchmarks. Section 4 considers sequential contracting, in which the fast contract and the grand contract are redacted sequentially instead of simultaneosly. Section 5 concludes.

2. BENCHMARKS

We briefly present a simplified version of Laffont and Tirole (1993) setting - hereafter LT: more precisely we adopt the framework proposed by Lambert-Mogiliansky (1998). In the exposition, we restrict our attention to those aspects that are relevant for the purposes of our analysis: we address the reader to the original articles for further details and proofs.

To begin with, we consider the case of full commitment, i.e. some technology is available to P so as to preclude renegotiations at any of the interim stages. Under this assumption, results are substantially identical to those in LT. We consider a three-tier hierarchy: F/S/P, all parties being risk neutral. In order to have F producing the good, P must pay a cost

$$C = \beta - e \tag{1}$$

where β represents the technology parameter, which can take one of the two values: "efficient" ($\underline{\beta}$) with probability v and "inefficient" ($\overline{\beta}$) with probability $(1 - v)$. F knows the realization of $\overline{\beta}$. By exerting effort e, F reduces cost of production but it incurs an increasing and convex disutility $\psi(e)$, where $\psi' > 0$, $\psi'' > 0$ and $\psi''' \geq 0$.

S pays F's costs and it also collects its revenue. t denotes the transfer from P to F. F's utility U defines its participation constraint:

$$PC : U = t - \psi(e) \geq 0 \tag{2}$$

where we normalized F's reservation utility to 0.

S receives a payout s from P. In order to accept the contract, its reservation utility must be met:

$$PC_s : V = s \geq 0 \tag{3}$$

where s is the income granted by P to S, while S's reservation income equals zero. S receives a signal σ about F's technology. With probability ξ S learns the true β ($\sigma = \beta$); with probability $(1-\xi)$ she learns nothing ($\sigma = \varnothing$). She reports $r \in \{\sigma, \varnothing\}$. Finally, S may agree on a side contract with F, which involve receiving a transfer b by F. In doing so the latter incurs a cost $(1+\lambda)\, b$ where $\lambda \geq 0$ denotes the shadow cost of transfers for F. Given LT setting, collusion can arise only if the retention of information benefits F, which happens in this model only for the efficient F. P observes neither β or σ. It observes the cost C and receives S's report r. It designs incentive schemes $s(C, r)$ and $t(C, r)$ for S and F to maximize expected social welfare.

The timing of the game is as follows: at date 0, P learns that $\beta \in \{\underline{\beta}, \overline{\beta}\}$ and F learns β: the probability parameters v and ξ are common knowledge. In the second stage of the game, date 1, P designs a contract for S and F. At date 2, S receives the signal and learns σ. At date 3, S can then sign side contract with F. Next, at date 4, S makes a report to P, and F chooses its effort. Finally, transfers are operated as specified in the contract.

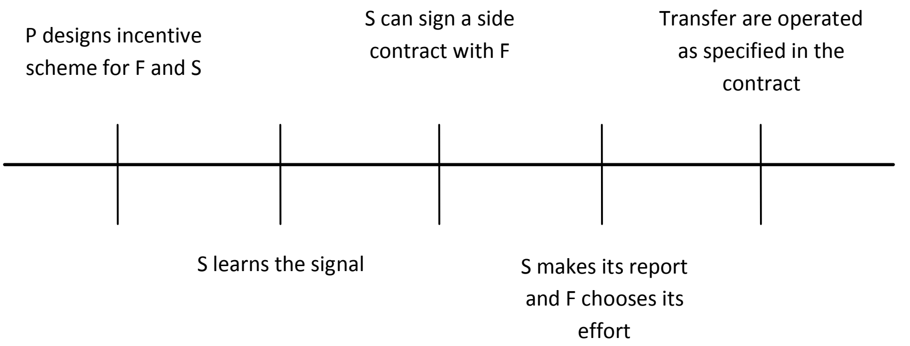

Figure 1: Timing of the Game

The cost parameter β together with the signal received by the agency $\sigma \in \{\underline{\beta}, \overline{\beta}, \varnothing\}$ define four states of the world:

$$\begin{aligned} p_1 &= \Pr(\beta = \underline{\beta}, \sigma = \underline{\beta}) = \nu\xi \\ p_2 &= \Pr(\beta = \overline{\beta}, \sigma = \overline{\beta}) = (1-\nu)\xi \\ p_3 &= \Pr(\beta = \underline{\beta}, \sigma = \varnothing) = \nu(1-\xi) \\ p_4 &= \Pr(\beta = \overline{\beta}, \sigma = \overline{\beta}) = (1-\nu)(1-\xi) \end{aligned}$$

where p_i is the probability of each correspondent state.

Let G denotes the value of the good: we impose G to be sufficiently large to make production worthwhile in all the states of the world. Having this schedule in place, P expected net benefit of the project is

$$\max_{\{e_i, t_i, s_i\}_{i=1,\ldots,4}} W = G - \sum_{i=1}^{4} p_i(t_i + C_i + s_i) \tag{4}$$

Where C_i is defined by (1).

2.1. Collusion-free Supervision (CF)

We first consider the case in which S always reports truthfully. Henceforth we denote this regime as the collusion-free regime CF. It corresponds to the case in which P can directly supervise F. The optimal contract will involve the production of the good in all four states. In order for this production to occur, both F and S need to agree to the contract, and therefore their participation constraints (2) and (3) must be met.

Furthermore, the contract must meet the revelation principle: in each state of the world, F must reveal its technology parameter β to P. Note that in states of the world 1 and 2, P knows from S the technology parameter of F. When the signal received is $\varnothing$, P must provide an incentive to the efficient F so that F does not mimic the inefficient (high cost) one.

The relevant incentive compatibility constraint (IC) involves the low type (efficient) F

$$IC_f : t_3 - \psi(e_3) \geq t_4 - \psi(e_4 - \triangle\beta) \tag{5}$$

Thus, the collusion-free contract CF is obtained by maximizing (4) with respect to constraints (2), (3) and (5). The standard solution (fully discussed in LM) has the following characteristics:

a) F earns zero rents when it is inefficient (state 2 and 4) and when it is efficient but the signal is informative (state 1): $t_i = \psi(e_i)$ for $i = 1, 2, 4$;

b) S never earns any rents: $s_i = 0$ for $i = 1, 2, 3, 4$;

c) when the signal is not informative and F is efficient (state 3), the information rent surrendered to F is $\Phi(e_4)$:

$$\Phi(e_4) = \psi(e_4) - \psi(e_4 - \triangle\beta)$$

d) finally, effort levels of F solve the following first order conditions:

$$\begin{aligned} \psi'(e_i^*) &= 1 \qquad for\ i = 1,2,3 \\ \nu(1-\xi)\Phi'(e_4^{CF}) + (1-\nu)(1-\xi)\psi'(e_4^{CF}) &= (1-\nu)(1-\xi) \end{aligned} \tag{6}$$

Where the superscript CF denotes the collusion-free outcome. The equilibrium outcome is typical for this type of problems: the efficient F's effort is always at the optimal level, whereas the inefficient F receives lower-powered incentive in one state of the world, since $e_4^{CF} < e_4^*$.

To conclude, the equilibrium welfare level when S cannot be bribed is now

$$W_{CF}^* = G - \sum_{i=1}^{3} p_i \left\{\psi(e_i^*) + \beta_i - e_i^*\right\} - p_4 \left\{\psi(e_4^{CF}) + \beta_i - e_4^{CF}\right\} - \nu(1-\xi)\Phi(e_4^{CF}) \tag{7}$$

2.2. Collusion-proof Supervision (CP)

We now proceed with the case in which S and F can collude. When this is the case, there is a possibility of bribe exchanges between S and F.

The problem of bribing arises when F is efficient. Under collusion-free supervision, F would earn a rent of $\Phi(e_4)$ if S were to report $r = \varnothing$ to P. In state 1, S knows that F is efficient, and may therefore want to share the information rent with F. It could do so by asking a bribe b to F in exchange for sending the message $r = \varnothing$. Under the assumptions of the model so far, F is willing to pay the bribe as long as

$$b \leq \frac{1}{1+\lambda}\Phi(e_4)$$

When such an exchange occurs, S foregoes payment s_1 and receives instead payment $s_{3.}$ Thus, to prevent F from bribing the agency, the agency's income s_1 contingent on reporting an efficient F ($r = \underline{\beta}$) must exceed F's stake in collusion,

$$IC_s : s_1 \geq s_3 + \frac{1}{1+\lambda}\Phi(e_4) \tag{8}$$

LM show that with full commitment, there is no loss of generality in focusing on collusion-proof mechanism (henceforth, CP) where (8) is met. The mechanism CP is then characterized by a contract that maximizes (4) subject to constraints (2), (3) and (5), as in the CF problem. Moreover, collusion-proofness requires meeting (8). In that case, the solutions (a) and (d) in the CF problem remain the same. The additional constraint modifies part (b) as follows:

b') $s_i = 0$ for $i = 2, 3, 4$; $s_1 = \frac{1}{1+\lambda}\Phi(e_4)$

That is, collution proofness requires leaving some rents to S in state 1, in addition to the rents to F in state 3.

Part (d) is modified as follows:

d')

$$\begin{aligned} \psi'(e_i^*) &= 1, \quad i = 1, 2, 3 \\ \Phi'(e_4^{CP})\left[\frac{\xi\nu}{1+\lambda} + \nu(1-\xi)\right] + (1-\nu)(1-\xi)\psi'(e_4^{CP}) &= (1-\nu)(1-\xi) \end{aligned} \tag{9}$$

That is, there is an additional distortion away from efficiency that is due to the possibility of collusion between S and F: note that $e_4^{CP} < e_4^{CF}$. This distortion is due to the trade off between allocation efficiency and F's information rents in state 3, $\Phi(e_4)$, as well as S's transfer in state 1, $s_1 = \frac{1}{1+\lambda}\Phi(e_4)$.

Given the solutions indicated from (**a**) to (**d'**), the welfare level at equilibrium is

$$W_{CP}^{*}=S-\sum_{i=1}^{3}p_i\left\{\psi(e_i^{*})+\beta_i-e_i^{*}\right\}-p_4\left\{\psi(e_4^{CP})+\beta_i-e_4^{CP}\right\}-\left\{\frac{\xi\nu}{1+\lambda}+\nu(1-\xi)\right\}\Phi(e_4^{CP})$$

A comparison of CP and CF reveals that $W_{CF}^{*}\geq W_{CP}^{*}$: indeed, for a given e_4 we have,

$$W_{CF}(e_4)=W_{CP}(e_4)+\frac{\xi\nu}{1+\lambda}\Phi(e_4) \tag{10}$$

From (10) we get that the cost of collusive supervision is $\frac{\xi\nu}{1+\lambda}\Phi(e_4)$.

3. CONDITIONAL SUPERVISION–CS

3.1. An intuitive Explanation

We now consider the conditional supervision mechanism (CS) as an alternative to the collusion proof mechanism. We will show that our mechanism improves on the collusion proof mechanism, and in fact is able to restore the collusion free outcome. We will present this in two ways. First, we will provide an intuition for our mechanism: it is useful to revisit the payoffs to S and F under collusion proofness (CP) and collusion free supervision (CF). When F is efficient, payoffs to F (U) and S (V), contingent on the probability of receiving an informative signal (ξ), are represented by a matrix:

	state	*prob.*	U	V
Collusion proof contract CP	1	ξ	0	$\frac{1}{1+\lambda}\Phi(e_4)$
	3	$1-\xi$	$\Phi(e_4)$	0

	state	*prob.*	U	V
Collusion free contract CF	1	ξ	0	0
	3	$1-\xi$	$\Phi(e_4)$	0

A couple of aspects are worth noticing. First, note that in expectation the efficient F earns a rent of $(1-\xi)\,\Phi(e_4)$ in both regimes, whereas S earns a rent of $\frac{\xi}{1+\lambda}\Phi(e_4)$ in CP but of 0 in CF. Second, under CP, both F and P have reasons to dislike state 1. F dislikes it because it earns zero rents; P dislikes it because it must pay out S.

In conditional supervision, P can exploit this mutual dislike of state 1: when the efficient F accepts this fast contract, P guarantees a rent of $(1-\xi)\,\Phi(e_4)$, and no supervision. If F instead reveals to be inefficient, P then calls in S, a grand contract is implemented, and the game is played as in CP.

The outcome of the game is as follows: all efficient F choose to adopt the fast contract, under no supervision, and earn rents of $(1-\xi)\,\Phi(e_4)$, whereas S is paid its outside option. All inefficient F choose instead to enter a CP contract with supervision. We have then a separating equilibrium.

To show that there are no profitable deviations, suppose that an efficient F chooses not to enter a fast contract. Then, it will receive supervision, and with a probability of $1-\xi$ it will get caught and receive zero rents. Note that, since the lottery CP is collusion-proof, F cannot hope to collude with S.

Furthermore, it must be the case that inefficient F choose not to sign the fast contract. This is clearly the case in our model. A sufficient proof is that the inefficient F never chooses the efficient contract when this contract provides rents of $\Phi(e_4)$ to the efficient F. Therefore, this inefficient F will never choose a fast contract that provides even smaller rents of $(1-\xi)\,\Phi(e_4)$.

A final aspect is worth noticing: if F happens to be risk averse, conditional supervision brings about a further gain with respect to both CP and CF mechanisms. Indeed, CS provides full insurance to the efficient F which would otherwise face the supervision-lottery: as a consequence, the efficient type is willing to surrender some of its rent in the fast contracting stage. P has to guarantee a reduced rent of

$$(1-\xi)\,\Phi(e_4)-j(.)$$

where $j(.)$ denotes the risk premium. It is easy to notice that CS implements an outcome which is even better then the CF one: it follows that CS should be implemented even in the absence of collusion.

3.2. A Formal Model

3.2.1. The contract

P introduces two contracts: a fast contract between itself and F, and a grand contract which also involves S. In the fast contract, P makes a take-it-or-leave-it offer to F (C_0, t_0) that does not depend on any input of either F or S[4].

If the contract is rejected by F, then the grand contract is offered. At this point, S receives the signal $\sigma \in \{\varnothing, \beta\}$ which is also known by F, and makes a report $r \in \{\varnothing, \beta\}$. The signal-contingent contract specifies a set of payments $\{C(r), t(r), s(r)\}$. If either F or S rejects this grand contract, we have shutdown of production. The timing of the subsequent steps is as before. Picture below summarizes.

[4] In practice, we do not think that the contract involves the supervisor at all. Technically, the supervisor can accept or reject the contract. If the supervisor rejects the contract, our model requires shutdown of production.

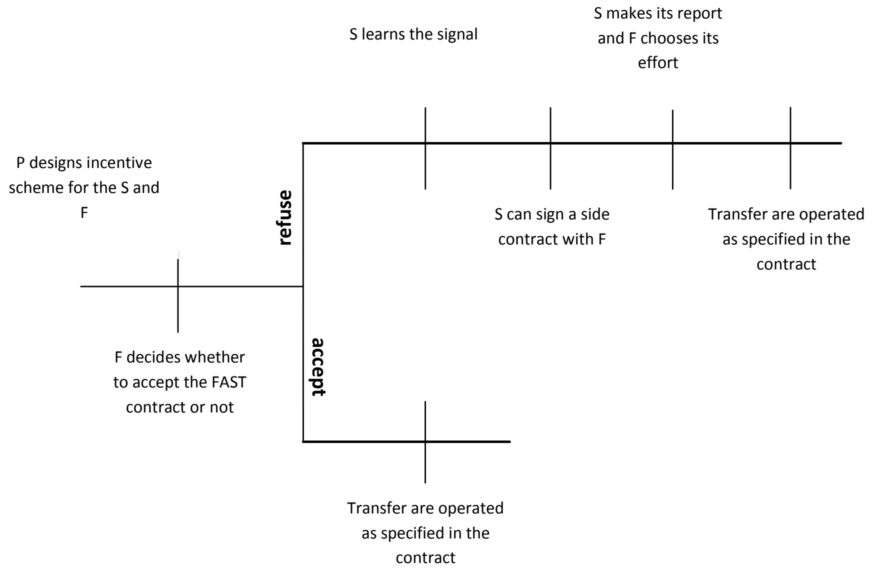

Figure 2: Timing of the Game.

We stress the importance of timing here: the two contracts are drawn together, before the realization of the signal and before F agrees or rejects the fast contract. In the later section, we show what happens when this timing assumption is violated, and the two contracts are drawn sequentially.

With this setup, the state space has now expanded to 8 possible states and is represented by a triplet $\{\beta, \sigma, \kappa\}$, where $\kappa = \{0, 1\}$ denotes whether F accepts (1) or rejects (0) the fast contract.

In practice, there are only 5 relevant states of the world; the other states are off of equilibrium paths. These 5 states are:

$$\begin{aligned}
0 &= \{\underline{\beta}, \varnothing, 1\} \\
1 &= \{\underline{\beta}, \underline{\beta}, 0\} \\
2 &= \{\overline{\beta}, \overline{\beta}, 0\} \\
3 &= \{\underline{\beta}, \varnothing, 0\} \\
4 &= \{\overline{\beta}, \varnothing, 0\}
\end{aligned}$$

The 2 states where $\kappa = 1$ and the signal is informative are excluded from our equilibrium because when $\kappa = 1$ P proposes to not involve a S; this leads to the impossibility by S to report a signal $\sigma \neq \varnothing$ to P[5]. The other restriction, in which inefficient F chooses self reporting, arises out of equilibrium: P formulates the problem in such a way that only low types want to report $\kappa = 1$. The incentive constraint that ensures this will be shown later in the section. Let $\delta \in [0, 1]$ be the probability that such efficient F accepts the fast contract.

3.2.2. The constraints

Grand contract stage Our model is a slight modification of LT, since all of the constraints in LT hold true in our model. The first set of constraints then apply in the grand contracting stage of the game, where F has chosen to reject the fast contract. As before, the participation constraints (2) and (3) are

$$\begin{aligned}
PC &: \quad t_i - \psi(e_i) \geq 0, \ \forall i \\
PC_s &: \quad s_i \geq 0, \forall i
\end{aligned}$$

[5] This assumption would also hold in equilibrium: the government would prefer to ignore the signal σ if $\kappa = 1$.

The efficient F must still be discouraged from mimiking an inefficient F by meeting the incentive constraint (5)

$$IC_f : t_3 - \psi(e_3) \geq t_4 - \psi(e_4 - \triangle\beta)$$

And finally, S must be discouraged from entering into side agreements with F (constraint 8)

$$s_1 \geq s_3 + \frac{1}{1+\lambda} b$$

where the bribe is at most the information rent of F in state 3.

The fast contract The second set of constraints apply in the fast contract stage of the game. In order for the efficient F to choose the fast contract, the rents gained should at least equal to those under the grand contract in expectation.

$$IC_0 : t_0 - \psi(e_0) \geq \xi\,(t_1 - \psi(e_1)) + (1 - \xi)(t_3 - \psi(e_3)) \tag{11}$$

Note that what we call IC_0 could be considered as a participation constraint: as long as participation constraints (2) and (3) bind, the outside option for F with respect to the fast contract is not to pull out of the market entirely but to pursue a strategy of hiding its own type and move into the grand-contract stage. Furthermore, in order for a fraction $1 - \delta$ of low type F to choose not to self report, it must be the case that IC_0 binds with equality. The incentive constraint for the high type F is indicated here, ensures that high type F never report $\kappa = 1$, and is always met.

$$\overline{IC}_0 : t_0 - \psi(e_0) \leq \xi(t_2 - \psi(e_2)) + (1 - \xi)(t_4 - \psi(e_4))$$

3.2.3. The maximization program

We are now ready to introduce the welfare function:

$$\begin{aligned}
\max_{\{e_i\}_{i=1,\ldots,4}} W &= G - \delta\nu\left\{t_0 + s_0 + \underline{\beta} - e_0\right\} - \xi\nu(1-\delta)\left\{t_1 + s_1 + \underline{\beta} - e_1\right\} \\
&\quad -(1-\nu)\xi\left\{t_2 + s_2 + \bar{\beta} - e_2\right\} - \nu(1-\xi)(1-\delta)\{t_3 + s_3 + \underline{\beta} - e_3\} \\
&\quad -(1-\nu)(1-\xi)\{t_4 + s_4 + \bar{\beta} - e_4\}
\end{aligned} \tag{12}$$

Subject to constraints (2), (3),(5), (8) and (11).

The solution to the problem involves determining which participation constraints and incentive constraints bind. First off, participation constraints (2) for states $i = 1, 2, 4$ bind with equality: not only reducing t_i increases welfare, but it also makes it easier to facilitate IC_0. For similar reasons, the solution involves $s_0 = s_2 = s_3 = s_4 = 0$. Furthermore, IC_f binds with equality. This implies that rents to the efficient F in state 3 of the world are

$$IC_f : t_3 - \psi(e_3) = \Phi(e_4)$$

and the incentive pay paid to S in state 1 of the world is

$$s_1 = \frac{1}{1+\lambda}\Phi(e_4)$$

Thus, the rents for F and S remain unchanged under the grand contract from the CP equilibrium. What is new now is that IC_0 also binds with equality:

$$t_0 - \psi(e_0) = (1-\xi)\Phi(e_4) \tag{13}$$

Welfare is now reduced to a function of e_i only:

$$
\begin{aligned}
\max_{\{e_i\}_{i=1,\ldots,4}} W &= G - \delta\nu\left\{\psi(e_0) + (1-\xi)\Phi(e_4) + \underline{\beta} - e_0\right\} \\
&\quad -\xi\nu(1-\delta)\left\{\psi(e_1) + \frac{1}{1+\lambda}\Phi(e_4) + \underline{\beta} - e_1\right\} \\
&\quad -(1-\nu)\xi\left\{\psi(e_2) + \bar{\beta} - e_2\right\} \\
&\quad -\nu(1-\xi)(1-\delta)\{\psi(e_3) + \underline{\beta} - e_3 + \Phi(e_4)\} \\
&\quad -(1-\nu)(1-\xi)\{\psi(e_4) + \bar{\beta} - e_4\}
\end{aligned}
$$

We are now able to solve for the optimal contract. First order conditions are:

$$
\begin{aligned}
\psi'(e_i) &= 1,\ i = 0,1,2,3 \\
\nu(1-\xi)\Phi'(e_4) + \nu\frac{(1-\delta)\xi}{1+\lambda}\Phi'(e_4) + (1-\nu)(1-\xi)\psi(e_4) &= (1-\nu)(1-\xi) \qquad (14)
\end{aligned}
$$

We are now able to derive the main point of the paper.

PROPOSITION 1. *With Conditional Supervision the collusion-free supervision outcome is feasible.*

Proof. When $\delta = 1$ the FOC (14) becomes

$$
\nu(1-\xi)\Phi'(e_4) + (1-\nu)(1-\xi)\psi'(e_4) = (1-\nu)(1-\xi)
$$

Note that this FOC is perfectly identical to the FOC (6) in the CF program: that is, any additional cost associated with corruption is eliminated, and the optimal level of effort is e_4^{CF}. ∎

All this implies that self-reporting makes it possible for P to reach the *second-best outcome.*

PROPOSITION 2. *With Conditional Supervision the collusion-free outcome is the best outcome achievable.*

The proof is offered in Appendix 1.

With this proposition, we know that $\delta^* = 1$: it is best for P to induce the efficient F to sign the fast contract with probability 1. Note that this validates the example we saw in the previous section.

To conclude this section, we write again the Conditional Supervision outcome, which corresponds to the Collusion Free welfare.

$$W_{CF}^* = S - \sum_{i=1}^{3} p_i \left\{ \psi(e_i^*) + \beta_i - e_i^* \right\} - p_4 \left\{ \psi(e_4^{CF}) + \beta_i - e_4^{CF} \right\} - \nu(1-\xi)\Phi(e_4^{CF})$$

We summarize the findings in the following proposition:

PROPOSITION 3. *By adopting the conditional supervision mechanism with fast contract and grand contract:*

1. *All efficient F choose the fast contract*
2. *All inefficient F decline the fast contract and accept the grand contract*
3. *The agency receives zero rents in all realized states.*
4. *Principal fully eliminates the costs of collusion, and $W_{CS} = W_{CF} > W_{CP}$*
5. *The inefficient F (in state 4) is given a high-powered incentive scheme with respect to the case in which conditional supervision is not allowed ($e_4^{CF} > e_4^{CP}$).*

4. SEQUENTIAL CONTRACTING–SC

A problem with the self reporting equilibrium shown here is that it is not interim-efficient. The introduction of a fast contract allows the govenment to naturally and costlessly separate efficient F from inefficient F: once F has chosen to reject the fast contract, it is obvious to everyone that this F must be of the inefficient kind, and therefore the obvious contract that should be offered in the second stage is the first best contract. Therefore, the equilibrium grand contract is suboptimal, and P will be tempted to renegotiate the contract. The ability of P to renegotiate (or, conversely, the inability to commit to the original grand contract) causes the outcome visited above to unravel: the efficient F suspects that renegotiation may happen, and thus require higher rents.

This problem arises if the contracting is sequential in nature. To see how sequential contracting may modify the model above, suppose that P offers two alternatives to F: a fast contract (C_0, t_0, s_0) which is independent of the signal, or the possibilty to negotiate a grand contract. Since the negotiation of a grand contract is conditional on a rejection by F to the fast contract, P will make use of the additional information to update its own beliefs regarding the type of F[6].

To see how our result is modified, suppose that there is a proportion δ of low type that choose to self report, while the remaining $1-\delta$ choose not to[7]. With this restriction in mind, note that the grand contract is changed because the probabilities of each state of the world are now changed. Denote by p_i' the ex-post distribution of types, after the fast contract was rejected. For a given δ, we have the following ex-post probabilities:

$$\begin{aligned}
p_1' &= \frac{\nu\xi(1-\delta)}{(1-\delta)\nu + (1-\nu)} < p_1 \\
p_2' &= \frac{(1-\nu)\xi}{(1-\delta)\nu + (1-\nu)} > p_2 \\
p_3' &= \frac{\nu(1-\xi)(1-\delta)}{(1-\delta)\nu + (1-\nu)} < p_3 \\
p_4' &= \frac{(1-\nu)(1-\xi)}{(1-\delta)\nu + (1-\nu)} > p_4
\end{aligned}$$

[6] Throughout this paper, we maintain the assumption that P can commit to the grand contract once that has been drawn. Our results would be a little weaker if this assumption is removed, but the advantage of our model remains. See LM 1998 for an explanation of the renegotiation-proof mechanism in the standard model.

[7] This can happen, for example, if efficient firms are heterogeneous in their risk aversion.

These are the probabilities of each state of the world occurring conditional on F not self reporting its behavior.

The interim welfare function is the same as in LT, with the new set of probabilities p'_i:

$$\max_{\{e_i,t_i,s_i\}_{i=1,\dots,4}} W^{interim}(\delta) = G - \sum_{i=1}^{4}(t_i + C_i + s_i)p'_i$$

Subject to the same restrictions as in the LT model. Without going to all the steps, we simply state the collusion-proof interim welfare function:

$$\begin{aligned}\max_{\{e_i\}_{i=1,\dots,4}} W^{interim}(\delta) &= G - p'_1\left\{\psi(e_1) + \frac{1}{1+\lambda}\Phi(e_4) + \underline{\beta} - e_1\right\} - p'_2\left\{\psi(e_2) + \overline{\beta} - e_2\right\} \\ &\quad - p'_3\{\psi(e_3) + \underline{\beta} - e_3 + \Phi(e_4)\} - p'_4\{\psi(e_4) + \overline{\beta} - e_4\}\end{aligned}$$

The first order conditions for e_i, $i = 0, 1, 2, 3$ are, as usual, the optimal level e^*. The level of effort in state 4, $e_4(\delta)$, is now determined by the following:

$$\nu\omega_\delta\Phi'(e_4(\delta)) + (1-\nu)(1-\xi)\psi'(e_4(\delta)) = (1-\nu)(1-\xi) + \nu\delta(1-\xi)\Phi'(e_4(\delta)) \qquad (15)$$

where $\omega_\delta = \left(1 - \xi + \frac{(1-\delta)\xi}{1+\lambda}\right)$.

Condition (15) defines the minimum effort $e_4(\delta)$ to the inefficient F: any contract chosen by P in the first stage needs to involve $e_4 \geq e_4(\delta)$ in order for this contract to be renegotiation proof. Denote by $e_4^{SC}(\delta)$ the effort that meets this condition, where SC stands for "sequential contracting". It is easy to notice that $e_4(\delta)$ is an increasing function of δ. Moreover if $\delta = 0$ condition (15) turns out to be identical to (9): in this case $e_4^{SC}(0) = e_4^{CP}$. This establishes that, at its worst, sequential contracting is no more distortionary than the collusion-proof contract. On the other hand, for any $\delta > 0$ we have $e_4^{SC}(\delta) > e_4^{CP}$. If $\delta = 1$ condition (15) reduces to $\psi'(e_4) = 1$, i.e. $e_4^{SC} = e_4^*$.

We now consider the global problem in which the contract is chosen ex-ante and is renegotiation proof. As before, the problem involves maximizing the welfare function (12) subject to all prior constraints (2), (3),(5), (8) and (11), plus the renegotiation constraint (15). Notice that (15) must also be binding in order to ensure the optimality of $e_4(\delta)$. The resultant welfare equation is a function of δ.

$$\begin{aligned}\max_{\delta\in[0,1]} W_{SC}(\delta) &= G-\nu\left\{\psi(e^*)+\underline{\beta}-e^*\right\}-(1-\nu)\xi\left\{\psi(e^*)+\overline{\beta}-e^*\right\}\\ &\quad -(1-\nu)(1-\xi)\{\psi(e_4(\delta))+\underline{\beta}-e_4(\delta)\}-\nu\omega_\delta\Phi(e_4(\delta))\end{aligned}$$

where $e_4(\delta)$ solves (15). Given our assumptions on the disutility function $\psi(.)$, the welfare function is a concave function in δ. There is a level of $\delta\in[0,1]$ that would uniquely maximize this function. Next, we derive the condition for this δ^*.

By taking first order conditions with respect to δ, we get:

$$\begin{aligned}&\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta))+(1-\nu)(1-\xi)\frac{\partial e_4(\delta)}{\partial\delta}= \\ &\nu\omega_\delta\Phi'(e_4(\delta))\frac{\partial e_4(\delta)}{\partial\delta}+(1-\nu)(1-\xi)\psi(e_4(\delta))\frac{\partial e_4(\delta)}{\partial\delta}\end{aligned} \tag{16}$$

We can then substitute (15) into the right hand side of this Euler equation, rearrange, and (16) becomes

$$\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta))-v\delta\Phi'(e_4(\delta))\frac{\partial e_4(\delta)}{\partial\delta}=0 \tag{17}$$

Condition (17) determines the optimal δ^*. Note that it is possible that the LHS is equal to 0, depending on the shape of the function $\psi(e)$ and of λ. When that is the case, we have an interior solution. It is also possible that for all values of δ, the LHS remains greater than zero. In that case, we have that $\delta^*=1$, a condition that we explore below.

4.1. What happens when the efficient F chooses the fast contract with probabilty 1?

Suppose that $\delta^* = 1$. Then, clearly, (15) reduces to

$$\psi'(e_4) = 1$$

and the optimal level of effort is always maximal: $e_4 = e^*$. Social welfare then becomes:

$$W^*_{SC}(\delta^* = 1) = G - \nu \left\{\psi(e^*) + \underline{\beta} - e^*\right\} - (1-\nu)\left\{\psi(e^*) + \overline{\beta} - e^*\right\} - \nu(1-\xi)\Phi(e^*)$$

This is the same expected utility for P as in CF, provided that e_4^{CF} is replaced with the sub-optimal level e^*. SC is, therefore, less advantageous than CF and, in some cases, less advantageous than CP.

4.2. On the attainabilty of welfare-improving Sequential Contracting

The role of deadweight losses We have seen in the prior sub-section that when sequential contracting leads to full separation, the fast contract leads to welfare inferior allocation. When the fast contract is never chosen, then sequential contracting reduces to CP. Thus, in order for SC to be welfare-improving, it is necessary that $\delta \in (0, 1)$. Even at its (interior) optimum, it is not necessary true that SC dominates CP, since selecting the first over the second type of contract leads to a tradeoff: a reduction of rents to S in exchange of an increase of rents to F (but also higher efficiency). SC may still be the better policy if deadweight losses from collusion are small (λ is small). When transfers from F to S are efficient, supervisory payouts are a large source of allocative inefficiency. Selecting a sequential contract eliminates this source of inefficiency. On the other hand, under a system where side contracting is cumbersome – say, due to high transparency requirements for F and the supervising agency, or because of aggressive auditing practices implemented by P –

payouts to S are small enough to make sequential contracting a 'fourth-best' policy. This result enhances the applicability of Sequential Contracting in environments where the fight against corruption and collusion is difficult, such as in many developing countries.

5. CONCLUSIONS

This paper analyzes a simple modification of Laffont and Tirole's (1993) standard mechanism in hierarchical structures where an agent (a firm F) and his supervisor (S) can collude at the expense of the principal (P). By letting F choose between a regime free of supervision over a regime of supervision, our model yields results that are superior to the standard model. In fact, our mechanism allows P to eliminate all the costs associated with the threat of collusion.

These results must be mitigated in several ways. First, when P designs contracts sequentially or conditionally on the choices made by F, our mechanism may still bring about better outcomes than centralized supervision alone, but that depends on the parameters of the model. Second, our mechanism devolves into the standard collusion proof mechanism if S and F can collude before the fast contract is accepted or refused. This possibility arises if F can bribe S ex-ante, in exchange for an uninformative ex-post report to P. In order to do so S must be capable to commit to an outcome that is ex-post inferior: this may be reasonable if S and F interact repeatedly. In this case P may still be able to avoid the creation of the cartel by using additional strategies. For instance, job rotation can be used to insure that in the following period S will be moved to a different job with a different contractor. Alternatively, P could avoid to disclose F's identity in the fast contracting stage: this precaution makes it difficult for S to collude in this stage of the game since she faces a potentially vast population of eligible F. Finally, P may decide to hire S only in the second stage of the game while in the first period no supervisor is in charge: for this solution to be effective S should not be able to anticipate that she will be hired for the job in the second stage of the game.

6. APPENDIX

6.1. Proof of proposition 2

We want to show that the self reporting solution necessarily involves $\delta = 1$. To show this, we will show that $\delta = 1$ maximizes the welfare function. First, we rearrange the FOC for e_4 (14):

$$\begin{aligned} \nu\omega_\delta \Phi'(e_4(\delta)) + (1-\nu)(1-\xi)\psi(e_4(\delta)) &= (1-\nu)(1-\xi) \\ where\ \omega_\delta &= \left(1 - \xi + \frac{(1-\delta)\xi}{1+\lambda}\right) \end{aligned}$$

this first order condition defines a level of effort $e_4(\delta)$ which is a function of the probability that a F self reports it being a low type. It is straightforward to show that, as long as $\psi''(.) > 0$, the distortion of the inefficient type is reduced as δ increases: $\frac{\partial e_4(\delta)}{\partial \delta} > 0$.

Second, plug in the optimized levels of e_i in the welfare function, to get a function which depends on δ only:

$$\begin{aligned} \max_{\delta \in [0,1]} W_{sr}(\delta) &= G - \nu\left\{\psi(e^*) + \beta - e^*\right\} - (1-\nu)\xi\left\{\psi(e^*) + \bar{\beta} - e^*\right\} \\ &\quad -(1-\nu)(1-\xi)\{\psi(e_4(\delta)) + \beta - e_4(\delta)\} - \nu\omega_\delta\Phi(e_4(\delta)) \end{aligned}$$

The first order conditions are

$$\underbrace{\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta)}_{loss\ of\ rents\ to\ supervisor} + \underbrace{(1-\nu)(1-\xi)\left[1-\psi'(e_4(\delta)\right]\frac{\partial e_4(\delta)}{\partial \delta}}_{less\ distortion\ to\ the\ inefficient\ F} = \underbrace{\nu\omega_\delta\Phi'(e_4(\delta))\frac{\partial e_4(\delta)}{\partial \delta}}_{increased\ rents\ to\ efficient\ F} \tag{18}$$

We can rewrite these as

$$\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta) + (1-\nu)(1-\xi)\frac{\partial e_4(\delta)}{\partial\delta} = \nu\omega_\delta\Phi'(e_4(\delta))\frac{\partial e_4(\delta)}{\partial\delta} + (1-\nu)(1-\xi)\psi(e_4(\delta))\frac{\partial e_4(\delta)}{\partial\delta}$$

Since these first order conditions hold at the optimal level of effort e_4, it must be the case that (14) binds at the optimum. We can then substitute the right hand side, and (18) becomes

$$\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta) + (1-\nu)(1-\xi)\frac{\partial e_4(\delta)}{\partial\delta} = (1-\nu)(1-\xi)\frac{\partial e_4(\delta)}{\partial\delta}$$

or, $\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta) = 0$

Which cannot be true, since $\frac{\xi\nu}{1+\lambda}\Phi(e_4(\delta)) > 0$ for any level of $\delta \in [0,1]$. Hence, we have a corner solution, and δ is maximal.

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