Delegation versus Authority[*]

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Abstract

The paper studies the determinants of delegation and authority within a principal-agent relation in which a non-contractible action has to be taken that affects both the principal and the agent. In contrast to previous literature we assume transferable utility and contractibility of messages. Under authority the principal uses the best message-contingent contract to elicit information from the agent and then chooses an action. Under delegation the agent chooses an action. We investigate when delegation outperforms authority. Furthermore, the impact of monetary transfers on the informativeness of communication is scrutinized. The model is relevant to the theory of firm boundaries.

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1 Introduction

A major conflict of interests between a principal and an agent arises when the agent has private knowledge relevant for the principal's best policy but at the same time has policy preferences different from the principal.

Examples abound. A worker generally knows the task he can perform at lowest effort but this task is often not the best task from the boss' perspective. A producer may be specialized in a particular product but this need not be the product the buyer wishes. A legislative committee may know the best policy in a particular situation but this policy oftentimes is not the policy preferred by the commitee members. Financial advisers are informed about promising portfolios but may be biased towards recommending different portfolios. A competition authority generally has interests different from firms who want to merge but whether the merger is socially desirable usually depends on information which is held privately by the firms. Leaders of unions and employers' associations may know the state of the economy and thus the best policy for reducing unemployment but this need not be in the interests of their members. Further examples are patient-doctor, client-lawyer, or lender-borrower relations.

More generally the problem is one of communication. Agents within a social relation need not necessarily communicate their private information truthfully but may be unwilling to reveal relevant information because they want to prevent the principal from pursuing a policy against their private interests. This is particularily so when the principal cannot credibly pre-commit not to take an action detrimental to an agent.

The paper studies how an appropriate allocation of decision rights can mitigate this communication problem when the principal is imperfectly commited due to contractual incompleteness. When the prinicipal has the decision right we shall talk of authority, when the agent has that right we shall talk of delegation. In particular we consider the case with non-verifiable action and transferable utility.[1]

With imperfect commitment the communication problem under authority has been extensively studied in the cheap talk literature (notably in the seminal work of Crawford/Sobel (1982)[2]). Though some information may be communicated under cheap talk, the commitment problem generally prevents

[1] With perfect commitment the classical revelation principle implies that the outcome of delegation can be implemented through a complete incentive compatible contract in which the principal has control over the action. Thus, delegation cannot improve authority. The seminal paper with perfect commitment is Holmström (1984). For a recent account of the problem with endogenous information acquisition see Szalay (2001).

[2] For a review of the cheap talk literature see Farrell/Rabin (1996). Two recent contributions that extend the original Crawford/Sobel model are Krishna/Morgan (2000) and Battaglini (2001). Krishna/Morgan consider the case with two agents, Battaglini additionally allows for a multi-dimensional action space.

the principal form making a decision in which all of the agent's information is used.

In contrast, delegating the decision to the agent leads to an informed decision and can therefore be seen as a means to overcome the principal's commitment problem. However, as delegation is accompanied with loss of control, the principal may be hurt by the agent's action if preferences are sufficiently disaligned. This observation is the basis for an extensive discussion of authority and delegation in the political science literature. Starting with the seminal work of Gilligan/Krehbiel (1987, 1989) this literature asks whether a legislature should adopt an open rule (authority) or a closed rule (delegation) when it consults specialized commitees in the legislation process (see also Austin-Smith (1990, 1993), Epstein (1998), Krishna/Morgan (2001)[3].)

Also recent work in economics investigates the trade-off between information and control under contractual incompleteness. If differences in policy preferences are not too large, informational benefits can explain delegation in economic organizations like firms, investor-advisor relations, or unions (Aghion/Tirole (1997), Garidel-Thoron/Ottaviani (2000), Dessein (2000), Goerke/Hefeker (2000)).

Common to these approaches is the assumption that utility is non-transferable (with the partial exception of Garidel-Thoron/Ottaviani). However, particularly in economic situations, for instance in buyer-seller or boss-worker relations, the principal has in general the possibility to use monetary transfers so as to provide explicit incentives for information revelation.

We therefore extend the existing literature and consider the case with transferable utility. Particularly, we shall assume that messages from the agent to the principal are contractible. Accordingly, in contrast to pure cheap talk, message-contingent payment contracts can be written and explicit incentives can be provided at least to some extent. Indeed, we shall identify authority with the best message-contingent payment contract for the principal.

To the best of our knowledge we are the first to analyse the question as to authority versus delegation in the context of contractual incompleteness and transferable utility. In order to find what authority in this situation can achieve we use the generalized revelation principle as developed in Bester/Strausz (2001). Bester/Strausz show that for a principal with imperfect commitment the best contract, as with the classical revelation principle, is still a direct contract, that is, the message space coincides with the state space. But, as opposed to the classical revelation principle, it may be optimal for the principal to induce the agent to lie with positive probability.

Model and Results

[3] Krishna/Morgan (2001) re-consider and challenge the results derived in Gilligan/Krehbiel (1987, 1989). They contend that Gilligan/Krehbiel use an inconsistent equilibrium selection criterion when they compare different legislative rules.

We use a variant of the Crawford/Sobel (1982) cheap talk model. In our model there are two states. The agent knows the true state, while the principal does not. Both principal's and agent's most preferred actions depend on the state of nature, but most preferred actions are different. The difference in most preferred actions is called the agent's bias. Deviations from most preferred actions are accompanied with quadratic loss. In addition, one of the parties may be more interested in the decision. We capture this by scaling the principal's loss with a constant which is called the principal's interest relative to the agent's.

The analysis focuses on two points. On the one hand we are interested in the determinants of delegation both with and without transferable utility. On the other hand we are interested in the extent to which explicit monetary incentives can alleviate the communication problem as compared to pure cheap talk.

As regards the determinants of delegation, we find, first, that with non-transferable utility authority always dominates delegation irrespectively of the agent's bias and the principal's interest. This is because for small bias cheap talk will be fully informative and hence delegation has no informational advantage. For large bias cheap talk is not informative at all but the informational benefit of delegation is outweighed by the agent's abuse of power.

Second, with transferable utility, delegation dominates authority if the principal's interest is smaller than that of the agent, irrespectively of the agent's bias. Conversely, if the interest of the principal is sufficiently large, authority dominates delegation irrespectively of the agent's bias. In this limited sense, with monetary transfers decision rights are optimally allocated such that the party with the higher stakes in the decision should make the decision.

The previous result does however not hold if the principal's interest in the decision is only moderately larger than that of the agent. This is because, due to imperfect commitment, the provision of incentives is costly. If the principal's interest is not too large, incentive costs may be larger than the principal's loss under delegation. Thus, in this case delegation proves to be a means to overcome the principal's commitment problem.

As regards the informativeness of communication under authority, in our model cheap talk is either fully informative (for small bias) or there are only babbling equilibria (for large bias). By contrast we find that with message-contingent transfers the principal optimally induces the agent to report always truthfully, that is, in both states and irrespectively of bias and interest. Thus, for large bias the amount of information that is communicated considerably increases with transferable utility as compared to pure cheap talk.

Related Literature

We are aware of only two papers that consider monetary transfer, Baron (2000) and in part Garidel-Thoron/Ottaviani (2000). However, neither of these derive the optimal contract for the principal. Garidel-Thoron/Ottaviani restrict attention to linear payment-contracts but do not show that they are optimal. Baron uses the quadratic version of the original Crawford/Sobel model with a continuum of types. Baron's notion of authority (or "open rule" in his context) and delegation (or "closed rule") is however different from ours. It rather draws the distinction between non-commitment and commitment. In fact, in Baron's model the principal (or the legislative authority as the so-called "floor") can commit to an action under closed rule whereas she cannot under open rule. Consequently he concludes that closed rule always dominates open rule. Moreover, he derives the contract under open rule by using the classical revelation principle. Accordingly, as open rule corresponds to non-commitment, it is not clear if this indeed the optimal contract.

Rather than on delegation Mitusch/Strausz (1999, 2000) focus on mediation. In a framework similar to ours but with more general utilities they consider a mediator who communicates with the agent and afterwards makes a policy proposal to the principal. The proposal rule is optimally designed by the principal. As opposed to us, they assume that messages are non-contractible. Mediation can improve pure cheap talk provided that the agent's incenctive to lie under cheap talk is not too large. Clearly, it would be interesting to make the comparison between delegation and mediation.

Related to our paper is also the literature in which delegation serves as a means to stimulate the initiative and participation of an agent. The main conceptual difference of this literature to our paper is that we do not endogenize effort choice of the agent. In Aghion/Tirole (1997) delegation both stimulates the effort and weakens the participation constraint of the agent but is accompanied with loss of control for the principal. If the latter is not too large, delegation dominates authority. Finally, we mention a rationale for delegation as pointed out by social psychologists and as modelled in Benabou/Tirole (2000). There delegating decisions to the agent may boost the agent's self-confidence and thereby stimulate effort.

Relation to the Theory of the Firm

Our model is also relevant to the theory of the firm. For we can interprete the principal as a buyer and the agent as a seller who produces an intermediate good and delivers it to the buyer. The agent comes in two types (states) which refer to his specialization. The action concerns the implementation of a production technology to produce the good. The principal's utility may be state-dependent because the agent's type may affect the quality of the product.

Under authority the buyer installs the technology and hires the seller as a worker to produce the good. The utility transfer from the principal to the agent, depending on the latter's report on his type, corresponds then to the worker's wage. This is suggestive of an integrated firm. Under delegation the seller is an independent contractor who decides on the technology, then produces the good and delivers it to the buyer. The utility transfer corresponds then to the product's price. This is suggestive of a market relation. (In the parlance of the theory of the firm authority corresponds to "make", whereas delegation corresponds to "buy".)

As in transaction cost economics (Coase (1937), Williamson (1985)) and in the property rights approach (Grossman/Hart (1986), Hart/Moore (1990), Hart (1995)) in our model the key element to make the distinction between firms and markets is incompleteness of contracts. In fact, analogous to the property rights view in our agency view the notion of vertical integration is one of control rights. However, as opposed to the property rights theory in our model it is asymmetric information rather than relation-specificity of investments which is the source of inefficiencies. Notice also the differences between our and the transaction cost approach.[4] Transaction cost economics starts from asking "Why do firms exist?". For it maintains that in a world without transaction costs "buy" always dominates "make". By contrast, our model rather provides an answer to the question "Why do markets exist?". For in a world of complete contracts in our model "make" would always dominate "buy" and we could not explain the existence of markets. In this sense our theory can be seen as dual to transaction cost economics.

The paper is organized as follows. Section 2 describes the model. Sections 3 analyses the model. Section 4 discusses the robustness of our results and some possible extensions of the model, particularly how information acquisition can be endogenized. Section 5 concludes. All proofs are in the appendix.

2 The Model

There is a principal, P (she), and an agent, A (he). There are two states of the world, t_0, and t_1. Without loss of generality, $t_0 = 0; t_1 = 1$. The ex-ante probability of state t_0 is γ_0, and that of state t_1 is γ_1. There is an action space $Y = \mathbb{R}$.

We distinguish two different regimes regarding the control of the action $y \in Y$, authority and delegation. Under authority the principal has the right to take an action $y \in Y$. Under delegation the agent has the right to take an action $y \in Y$.

Pay-offs from actions are state-dependent. If in state t action $y \in Y$ is taken, the principal's and

[4] For a discussion of the differences between transaction cost and property rights approach see Whinston (2000).

the agent's utility—gross of potential transfers—are respectively given as[5]

$$v(y;t) = -\lambda(y-t)^2; \tag{1}$$

$$u(y;t) = -(y-(t+b))^2: \tag{2}$$

The parameter $b \geq 0$ measures the extent to which incentives are disaligned and is called bias. The larger is b, the more differ the parties' preferences as to the implementation of action $y \in Y$. The parameter $\lambda > 0$ captures the idea that a wrong decision may affect players differently and is called the principal's interest relative to the agent's. If $\lambda > 1$, deviations from a player's most preferred action entail more serious losses for the principal than for the agent. In this sense, $\lambda > 1$ means that the principal has a stronger interest in the decision than the agent. If $\lambda < 1$, the reverse holds. Which case is the relevant one depends on the application in question.

The agent has perfect private information as to the true state of the world. By contrast, the principal is entirely ignorant. In this sense, the agent can be viewed as an expert. We identify the state of the world with an agent's type and denote an agent of type t by A_t.

Most preferred actions

The principal's most preferred action in state t is $y^P = t$, and the most preferred action of agent A_t is $y_t^A = t + b$. Notice that agent A_1 prefers the principal's most preferred action in state 1, that is, $y_1^P = 1$, to the action most preferred by the principal in state 0, that is, $y_0^P = 0$. This implies that if the principal was naive and believed any reports sent by the agents about their types, agent A_1 would not have an incentive to lie. We call an agent with this property compatible[6]. Formally:

Definition 1 Agent A_t is called compatible if and only if

$$u\left(y_t^P;t\right) \geq u\left(y_s^P;t\right) \quad \text{for } t \neq s. \tag{3}$$

Note that agent A_0 may or may not be compatible depending on the size of b. The following observation is immediate:

Lemma 2 Agent A_0 is compatible if and only if $b \leq 1/2$.

Rules of the Game

Under delegation the agent chooses an action. Under authority the principal and the agent play a

[5] In the sequel we shall denote the principal's and the agent's expected utility by the corresponding capitals, that is, V and U.

[6] This term is introduced in Mitusch/Strausz (1999).

message game, and the principal chooses an action upon receiving the agent's message. Our main focus is on the case with non-contractible actions, contractible messages and transferable utility. Yet, for purposes of comparison we shall also consider other cases. Particularly, we distinguish the case with and without transferable utility. In all cases we assume that the decision right and messages are contractible.

With transferable utility parties write an explicit contract. Thus, we have to specify what happens if an agreement is not reached. We assume that the agent's reservation utility is 0, and the principal's reservation utility is $-\infty$. The latter rules out that the principal may want to use the contract to screen among agents. It also captures the idea that the principal benefits from the relationship irrespectively of the agent's type, that is, there are always benefits of trade. A further interpretaton is that the agent's expertise is indispensable for the principal to go ahead with the decision, or that the agent has veto-power.

By contrast, as is usual in the cheap talk literature, we assume that under non-transferable utility the principal does not have to respect a participation constraint. Therefore comparisons of the principal's utilities in the cases with and without transferable utility are meaningless. Nevertheless we can compare the two situations with respect the incentives of information revelation and the extent to which information is transmitted.

3 Analysis of the Model: Delegation and Authority

3.1 Delegation

Under delegation the agent chooses an action. With transferable utility the principal additionally pays the agent a transfer w^δ so as to satisfy the agent's participation constraint. By backward induction, the agent implements his most preferred action. That is, he chooses action $y = t + b$ in state t. This leaves the agent with an overall utility of 0 in either state. Therefore, if utility is transferable, the principal optimally chooses $w^\delta = 0$. Moreover, the principal receives a utility of $-\lambda b^2$ in either state. Thus:

Proposition 3 Both with and without transferable utility the principal's expected utility under delegation is

$$V_\delta^{TU} = V_\delta^{NTU} = -\lambda b^2. \quad (4)$$

3.2 Authority

Under authority the principal and the agent play a message game. That is, the principal designs a message space M, the agent sends a message $m \in M$ to the principal, and finally the principal chooses an action $y \in Y$. With transferable utility the principal offers the agent a contract which specifies message-contingent transfers. We look for the Perfect Bayesian Nash equilibria of the message games.

Consider first non-transferable utility, that is, cheap talk.

3.2.1 Non-transferable utility: Cheap Talk

As is usual in the cheap talk literature we consider the cheap talk equilibria which are best from the principal's perspective. To find these equilibria we can apply the generalized version of the revelation principle of Bester/Strausz (2001). As shown there without loss of generality one can assume that the message space coincides with the type space, that is, $M = \{0;1\}$. A (mixed) strategy of an agent is then a probability distribution over $\{0;1\}$. For $s;t \in \{0;1\}$ denote by σ_{st} the probability that agent A_t sends message $m = s$, that is,

$$\sigma_{st} = P[m = s | A_t]. \tag{5}$$

The principal's strategy is a function that maps messages into actions. For $s \in \{0;1\}$ denote by $y_s \in Y$ the principal's action contingent on having received message $m = s$. Moreover, the principal holds a belief about the state of nature conditional on the message received. Denote by μ_{ts} the principal's belief that the agent is of type t, conditional on having received message $m = s$, that is,

$$\mu_{ts} = P[A_t | m = s]. \tag{6}$$

The equilibria which are best for the principal are then given as the solution to the following program.

$$\max_{\sigma;y} \sum_{t;s \in \{0;1\}} -(y_s - t)^2 \gamma_t \sigma_{st} \tag{7}$$

s.t.

$$IC_t : \quad -(y_t - (t+b))^2 \geq -(y_s - (t+b))^2 \quad \text{for } t \neq s \tag{8}$$

$$IND : \quad \left[-(y_t - (t+b))^2 - \left(-(y_s - (t+b))^2 \right) \right] \sigma_{st} = 0 \quad \text{for } \sigma_{st} \in (0;1) \tag{9}$$

$$OPT : \quad y_t \in \arg\max_y -\mu_{0t}(y - 0)^2 - \mu_{1t}(y - 1)^2 \tag{10}$$

$$BayR : \quad \mu_{ts} = \frac{\sigma_{st}\gamma_t}{\sigma_{st}\gamma_t + \sigma_{ss}\gamma_s} \tag{11}$$

Conditions IC are the usual incentive compatibility constraints. IND says that an agent has to be indifferent between messages if he actively mixes between messages. Finally, in a Perfect Bayesian equilibrium the principal must choose an optimal action given her beliefs, and these beliefs must be consistent with Bayes' rule. These are conditions OPT and BayR.

The following proposition gives the solution to the program.

Proposition 4 (i) If $b \leq 1/2$, that is, if both agents are compatible, the equilibrium is fully revealing, that is, both agents report truthfully and the principal chooses the action according to the message received. Formally

$$y_0 = 0, y_1 = 1; \tag{12}$$

$$\sigma_{00} = 1, \sigma_{11} = 1; \tag{13}$$

$$\mu_{00} = 1, \mu_{11} = 1. \tag{14}$$

(ii) If $b > 1/2$, then the equilibrium is a babbling equilibrium, that is, the principal chooses an action irrespectively of messages received. We have

$$y_0 = \gamma_1, y_1 = \gamma_1; \tag{15}$$

$$\sigma_{00} = 1 - \sigma_{11}, \sigma_{11} \in [0, 1]; \tag{16}$$

$$\mu_{00} = \gamma_0, \mu_{11} = \gamma_1. \tag{17}$$

Notice that the equilibrium which is best for the principal is also the most informative equilibrium, that is, the equilibrium in which most information is transmitted.

Corollary 5 If $b \leq 1/2$, then the most informative cheap talk equilibrium is fully informative. If $b > 1/2$, then there is no information transmission at all.[7]

This result does not obtain with a continuum of types, as e.g. in the original Crawford/Sobel (1982) model. There, if the bias is not too large, the most informative equilibrium is neither fully informative nor is not informative at all. Rather it exhibits some intermediate degree of information transmission. For large bias however, as in our discrete types model, there are only babbling equilibria.[8]

Players' expected utilites are now easily computed.

[7] Notice that this discontinuity results from our equilibrium selection. For $b \in (\gamma_1/2, 1/2)$, there is an additional equilibrium with $\sigma_{11} = 1$, and $\sigma_{00} = (2b - \gamma_1)/(2b\gamma_0)$. If we make the assumption that agent A_1 always reports truthfully, that is, also for $b > 1/2$, then agent A_0's equilibrium strategy σ_{00} is continuous and Z-shaped.

[8] In a discrete model with an additional type $t = 1/2$ it can be easily seen that in the most informative equilibrium intermediate information transmission takes place provided $b \in (1/4, 1/2)$. Notice however that in any discrete model there is a bias below which all agents are compatible such that cheap talk is fully revealing.

Proposition 6 The principal's expected utility in the most informative equilibrium is given by

$$V_{\alpha}^{NTU} = \begin{cases} 0 & \text{if } b \leq 1/2 \\ -\lambda \gamma_0 \gamma_1 & \text{if } b > 1/2. \end{cases} \tag{18}$$

Agent A_t receives

$$U_{\alpha}^{NTU} = \begin{cases} -b^2 & \text{if } b \leq 1/2 \\ -(\gamma_1 - (t+b))^2 & \text{if } b > 1/2. \end{cases} \tag{19}$$

If we now compare the principal's utility under delegation and under authority, we see that delegation is always dominated by authority. Formally

Proposition 7 $V_{\delta}^{NTU} \leq V_{\alpha}^{NTU}$ for all b and λ.

The intuition is straightforward. For small bias cheap talk is fully informative since interests are sufficiently aligned. The informational benefit of delegation does therefore not matter in comparison. Rather only the cost of delegation which is loss of control matters. For large bias differences in interests lead to large costs of delegation. In our case these costs are in fact so large that they are not outweighed by the informational benefits of delegation.

The result follows directly from the informational properties of our cheap talk equilibrium. In fact, in a model with a continuum of types delegation may be superior to authority (see Garidel-Thoron/Ottaviani (2000), Dessein (2000)). This is because in the continuum model cheap talk is not fully but only partially informative for small bias. As opposed to our discrete model, delegation is therefore in fact strictly better than authority from an informational view. And if the bias is small, this advantage is not offset by the loss of control accompanied. For large bias however our result is confirmed that loss of control weighs heavier than informational benefits.

3.2.2 Transferable Utility: Message-Contingent Contracts

We shall now come to the case with transferable utility in which message-contingent payments from the principal to the agent are possible. We shall first consider two benchmark cases. With complete information and with contractible actions.

Benchmark 1: Complete Information Under complete information the principal knows the type of the agent, that is, $\gamma_0 = 1$ or $\gamma_1 = 1$. Thus, under authority the principal chooses her most preferred action $y_t = t$ and receives gross utility 0. Therefore the agent obtains gross utility $-b^2$, and thus the principal has to pay a wage of b^2 to induce participation of the agent. Hence

Proposition 8 With complete information the principal's utility under authority is

$$V_{\alpha}^{TU;CI} = -b^2. \tag{20}$$

Proposition 9 With complete information delegation dominates authority if and only if $\lambda \leq 1$.

This simply says that under complete information and with transferable utility the party with the higher stake in the decision should be given the decision right. Though simple, this result is not completely trivial. For it illustrates that with transferable utility delegation does not only serve informational purposes but it also facilitates the participation of the agent.[9]

Benchmark 2: The Complete Contract With Perfect Commitment and Transferable Utility If the action is contractible, the principal can perfectly commit to a mechanism and we can apply the classical revelation principle to find the optimal contract for the principal. The principal's problem writes

$$\max_{y,w} \sum_{t \in \{0,1\}} \left[-\lambda (y_t - t)^2 - w_t \right] \gamma_t \tag{21}$$

s.t.

$$IC_t \;:\; -(y_t - (t+b))^2 + w_t \geq -(y_s - (t+b))^2 + w_s \quad \text{for } t \neq s \tag{22}$$

$$IR_t \;:\; -(y_t - (t+b))^2 + w_t \geq 0. \tag{23}$$

Here, y_t and w_t denote message-contingent actions and transfers (wages) respectively. The solution of the program is as follows.

Proposition 10 Define

$$\hat{b} = \frac{1+\lambda}{2\lambda}; \quad \tilde{b} = \frac{2+\gamma_1(\lambda - 1)}{2\gamma_1 \lambda}. \tag{24}$$

Then with perfect commitment optimal actions are given by

$$y_0 = \frac{b}{1+\lambda}; \tag{25}$$

$$y_1 = \begin{cases} 1 + \frac{b}{1+\lambda} & \text{if } b \leq \hat{b} \\ \frac{1}{2} + b & \text{if } \hat{b} < b \leq \tilde{b} \\ \frac{\gamma_1 \lambda + 1}{\gamma_1(1+\lambda)} + \frac{b}{1+\lambda} & \text{if } b > \tilde{b}. \end{cases} \tag{26}$$

[9] That delegation facilitates participation is also pointed out in Aghion/Tirole (1997), section IV.B.

Furthermore, A_1 gets just his reservation utility and A_0 gets an information rent if b is sufficiently large, that is,

$$w_0 = \begin{cases} (y_0 - b)^2 & \text{if } b \leq \hat{b} \\ (y_0 - b)^2 + 1 + 2b - 2y_1 & \text{if } b > \hat{b}, \end{cases} \tag{27}$$

$$w_1 = (y_1 - (1 + b))^2 : \tag{28}$$

Unsurprisingly, the results exhibits familiar features of standard adverse selection models. There is no distortion at the top. That is, y_0 equals the efficient action under complete information. Also, the compatible agent is kept at his reservation utility. Notice however, that for small bias ($b \leq \hat{b}$) also y_1 equals the efficient action under complete information, and also A_0 only gets his reservation utility. Particularly, since the principal is risk-neutral, agency costs are 0. As b increases however, it is no longer optimal to implement the efficient action in state 1 since this can only be done at the price of a large w_0 so as to ensure incentive compatibility for A_0. Rather it is cheaper to provide incentives for A_0 by deviating from the efficient action in state 1 and thus to pay agent A_0 a smaller information rent.

We shall now come to the main part of the paper and analyze the authority contract with imperfect commitment and transferable utility.

The Incomplete Message-Contingent Contract with Imperfect Commitment If the principal cannot perfectly commit to an action ex-ante, the classical revelation principle fails. To find the optimal contract, as under cheap talk, we therefore again apply the generalized revelation principle of Bester/Strausz (2001). Particularly, we can assume that the message space M coincides with the type space $\{0; 1\}$. However, as opposed to pure cheap talk, the principal can now commit to message-contigent transfers. Thus, additionally she has to design an optimal message-contingent transfer scheme $(w_0; w_1)$. We use the same notation for strategies and beliefs as under cheap talk. The principal's problem then writes as follows.

$$\max_{\sigma;y;w} \sum_{t;s \in \{0;1\}} \left[-\lambda (y_s - t)^2 - w_s \right] \gamma_t \sigma_{st} \tag{29}$$

s:t:

$$IC_t : \quad -(y_t - (t + b))^2 + w_t \geq -(y_s - (t + b))^2 + w_s \qquad \text{for } t \neq s \tag{30}$$

$$IR_t : \quad -(y_t - (t + b))^2 + w_t \geq 0 \tag{31}$$

$$IND : \quad \left[-(y_t - (t + b))^2 + w_t - \left(-(y_s - (t + b))^2 + w_s \right) \right] \sigma_{st} = 0 \quad \text{for } \sigma_{st} \in (0; 1) \tag{32}$$

$$\text{OPT} : \quad y_t \in \arg\max_y \; -\mu_{0t}(y-0)^2 - \mu_{1t}(y-1)^2 \tag{33}$$

$$\text{BayR} : \quad \mu_{ts} = \frac{\sigma_{st}\gamma_t}{\sigma_{st}\gamma_t + \sigma_{ss}\gamma_s} \tag{34}$$

In addition to cheap talk the principal has to respect an interim individual rationality constraint.[10] The optimal contract is as follows.

Proposition 11 Irrespectively of b and λ it is optimal to induce agents to report truthfully and to choose the corresponding action, that is,

$$\sigma_{00} = 1; \sigma_{11} = 1 \tag{35}$$

$$y_0 = 0; y_1 = 1. \tag{36}$$

Optimal wages are such that agent A_1 is kept at his reservation utility and agent A_0 gets an information rent if $b > 1/2$, that is,

$$w_1 = b^2; \tag{37}$$

$$w_0 = \begin{cases} b^2 & \text{if } b \leq 1/2 \\ b^2 + 2b - 1 & \text{if } b > 1/2. \end{cases} \tag{38}$$

The principal's expected utility is given by

$$V_\alpha^{TU;IC} = \begin{cases} -b^2 & \text{if } b \leq 1/2 \\ -b^2 - \gamma_0(2b-1) & \text{if } b > 1/2. \end{cases} \tag{39}$$

There are two points to notice. First, it is always optimal to induce perfect revelation. Thus, if $b > 1/2$, the amount of information that is communicated under authority considerably increases with transferable utility as compared to pure cheap talk.

As a consequence, the principal's expected utility does not depend on λ, since the principal always implements her most preferred action. This results from our quadratic specification. In this case the objective that remains to be maximized after consideration of all constraints turns out to be linear. Therefore, the optimal solutions are corner solutions which correspond to truthful revelation. In general, three effects determine how much truthtelling the principal wishes to induce. Suppose that it is optimal to induce agent A_1, the compatible agent, to report truthfully, particularly $y_0 = 0$.

[10] Following Garidel-Thoron/Ottaviani (2000), the interim individual rationality constraint can be interpreted as limited liability of the agent. The case with an ex-ante individual rationality constraint, or unlimited liability, is similarly dealt with.

Then determination of agent A_0's truthtelling probablity σ_{00} involves the following trade-off. If σ_{00} is increased then, on the one hand y_1 becomes more precise in the sense that it moves closer to 1. Thus, expected loss declines. And this decline is faster the larger is λ and the more convex is the loss function. Furthermore, the rise in y_1 facilitates participation of agent A_1, thus w_1 declines. On the other hand however, the information rent $w_0 - w_1$ for agent A_0 has to be increased to ensure incentive compatibility. As it turns out, with quadratic loss, the first two effects outweigh the third effect and it is always optimal to increase σ_{00} up to 1.[11]

Second, one may expect that the principal's expected utility $V_\alpha^{TU,IC}$ converges to the utility $V_\alpha^{TU,CI} = -b^2$ under complete information as $\gamma_0 \to 1$. However, this is not the case. This results from the assumption that both agent types have to participate in the mechanism. Suppose that $\gamma_0 = 1$, then it is optimal for P to choose action $y_0 = y_1 = 0$ irrespectively of messages, and to pay a wage of b^2. This would satisfy individual rationality for agent A_0 (which seems to be enough since there is only this agent if $\gamma_0 = 1$). However, it would violate individual rationality for agent A_1.For to induce participation of A_1, given action $y_1 = 0$, the principal has to pay $w_0 = (0 - (1 + b))^2$. Thus, if the principal is required to make sure participation also of the (fairly) unlikely agent A_1, this mechanism would give him $-(1 + b)^2$. This is however dominated by $V_\alpha^{TU,IC}$ as derived above.

We are now in the position to compare delegation and authority. Straightforward algebra yields

Proposition 12 For given bias, authority dominates delegation if the principal's interest is sufficiently large, that is, $V_\delta^{TU} \leq V_\alpha^{TU,IC} \iff \lambda \leq \hat{\lambda}(b)$, where

$$\hat{\lambda}(b) = \begin{cases} 1 & \text{if } b \leq \frac{1}{2} \\ 1 + \gamma_0 \left(\frac{2}{b} - \frac{1}{b^2} \right) & \text{if } b > \frac{1}{2}. \end{cases} \tag{40}$$

The intuition is as follows. If b is small ($b \leq \frac{1}{2}$), then there is no incentive problem and delegation is motivated exclusively by participation considerations. If $\lambda \leq 1$, then delegating the decision is cheaper than paying a participation transfer.

As b increases ($b > \frac{1}{2}$), in addition to participation considerations an incentive problem arises because interests are increasingly disaligned. The agent anticipates that under authority the principal will, due to imperfect commitment, choose an action detrimental to the agent. Accordingly, he will demand an appropriate compensation so as to reveal information. That is, the provision of incentives

[11] Of course, it would be desirable to avoid this peculiarity of the quadratic specification and consider more general loss functions. However, the problem then quickly becomes analytically untractible. In fact, with $|\cdot|$ there is a problem of differentiability, with $(\cdot)^4$ the first order condition is a cubic equation,

becomes costly and the agent has to be paid an information rent in expectation. Moreover, since the agent cares only about his own interest in the decision, the compensation does not depend on the principal's interest, that is, λ. On the other hand, the cost of delegation is moderate if λ and b are not too large. Therefore, if λ and b are not too large, the provision of incentives may be more costly for the principal than the loss she incurs when delegating the decision. In this sense, delegation helps to overcome the principal's commitment problem.

As b becomes very large however, the large difference between the principal's and the agent's most preferred actions together with a sufficiently large λ makes delegation costly relative to the provision of incentives. Then the principal does better if she keeps the right to control the action.

4 Discussion and Extensions

We shall now briefly discuss the robustness of our results and how the model can possibly be extended. Model assumptions which limit the generality of our results are the quadratic loss specification, the restriction to only two agent types, and the assumption that the principal's reservation utility is $-\infty$.

The quadratic specification leads to the result that under authority with transferable utility the principal optimally induces truthful revelation. This is because under the quadratic specification the objective of the principal after consideration of all constraints is linear. For general loss function this is not the case. However, the insight that monetary transfers improve information transmission holds also for general loss functions. This is the main driving force behind Proposition 11, and therefore we do expect that our main results qualitatively carry over to general loss. But we cannot say anything about detailed comparative statics properties of the general case.

The two-type assumption leads to the result that cheap talk is either fully informative or results in pure babbling. As mentioned in Section 2 this does not hold for more types, particularly for a continuum of types. Clearly, it would be desirable to extend our model along these lines. However, it is not clear how the generalized revelation principle in Bester/Strausz (2001) carries over to a continuum of types. As opposed to this more conceptual problem, the difficulty with a higher number of discrete types is that the computational effort quickly increases in the number of types. For to find the optimal contract under imperfect commitment one generally has to consider two cases for each agent, one in which incentive compatibility holds with strict inequality, and one in which it holds with equality. Afterwards on has to check which case is best for the principal. The number of cases that need to be considered in general is therefore 2 to the power of the number of types. Nevertheless, it might be worthwile to solve the model for three types. This might give a hint as to how the general case may look like.

Finally, as mentioned in section 2 the assumption that the principal's reservation utility is $-\infty$ is made to avoid interference with screening effects. Consider a contract offer by the principal which is accepted by one agent type and rejected by the other agent type. Then the agent's decision is informative, and the principal learns the state of the world already before the message game is played. If reservation utility is bounded, we can, a priori, not rule out that such a strategic contract offer is optimal for the principal.

The model can be extended along several lines and raises a series of questions for future research. First of all, it would be interesting how delegation and authority affect incentives for information acquisition or specialization. To illustrate this case suppose that at the beginning of the game the principal commits either to delegation or authority. Then the initially uninformed agent exerts unobservable effort e at cost $g(e)$ to gain perfect information with probability e.

In the political science literature it is usually assumed that it is verifiable whether the agent has become informed or not. We shall briefly sketch this case. It essentially amounts to adding to our game an initial information acquisition stage. In fact, the contract of our original delegation or authority game is then extended by a transfer z_k^I which the agent receives if he is informed and a transfer $z_k^{\neg I}$ which the agent receives if he is not informed. (Here $k \in \{\delta, \alpha\}$ stands for delegation or authority.) Because the agent is informed with probability e, the return to effort is just the product of e and the expected gain from being informed. It is easy to see that the latter depends additively on $z^I - z^{\neg I}$ such that the marginal return to effort depends additively on $z^I - z^{\neg I}$. As a consequence the principal can induce all effort levels under both delegation and authority by varying $z^I - z^{\neg I}$ appropriately. The latter is a general fact for quasi-linear utility. More specifically, it turns out that in our model the effort levels optimally induced by the principal are the same under delegation and authority. Therefore, provided it is verifiable that the agent is informed, delegation and authority do not affect information acquisition incentives differently.

More in the economics tradition one would assume that the principal can not observe whether the agent is informed or not. In this case the principal faces a moral hazard problem on part of the agent. Under authority the principal can provide explicit information acquisition incentives by an appropriate use of message-contingent payments. By contrast, under delegation explicit incentives can not be provided since transfers can not be conditioned on whether the agent is informed or not. Nevertheless, delegation may be a cheap way to motivate the agent as he can use the information gained according to his own preference. Notice however that a thorough analysis of this case amounts to solving our model for the case with three agent types. For the uninformed agent corresponds to an agent of type $t = \gamma_1 + b$ with most preferred action $y = \gamma_1 + b$.

A further extension concerns the number of agents. The Crawford/Sobel model has only recently been extended to the case with two agents (Krishna/Morgan (2000), Battaglini (2001)), and the comparison with delegation under non-transferable utility is investigated in Krishna/Morgan (2001). As for transferable utility however the extension is not straightforward as it is not clear whether and how the generalized revelation principle under imperfect commitment carries over to multiple agents.

5 Conclusion

The paper aims to shed light on the relation between delegation and authority in a context of contractual incompleteness and transferable utility. The analysis of the case with transferable utility has not been thoroughly done in the literature and is therefore our main contribution.

Under transferable utility delegation serves two purposes. First, it facilitates participation of the agent. Therefore the principal always delegates the decision when she is less interested in the decision than the agent. Second, as with non-transferable utility delegation has beneficial informational properties in that it mitigates the principal's commitment problem. Therefore delegation may be advantageous for the principal despite having a stronger interest in the decision than the agent.

In addition the paper shows that monetary transfers can considerably improve the transmission of information between the agent and the principal as compared to cheap talk.

We have illustrated the relevance of our model to the theory of firm boundaries and discussed some extensions for future research, particularly how the acquisition of information can possibly be endogenized.

Appendix

Proof of Proposition 4: Notice first that OPT implies that the principal's optimal action upon receiving message s is $y_s = \mu_{1s}$. Particularily, $y_s \in [0,1]$.

Suppose first that $b > 1/2$. Then only message-independent actions $y_0 = y_1$ are feasible. For suppose that $y_0 \neq y_1$, and particularily that $y_0 < y_1$: (The other case is symmetric and amounts only to a relabeling of messages.) Then IC_1 holds with strict inequality. By IND it thus follows that $\sigma_{11} = 1$, which implies by OPT that $y_0 = 0$. Therefore IC_0 writes $-b^2 \geq -(y_1 - b)^2$, which is equivalent to $y_1 \geq 2b$. Since $b > 1/2$, this contradicts $y_1 \leq 1$. Thus, $y_0 = y_1$.

From $y_0 = y_1$ it follows by BayR that $\mu_{10} = \mu_{11}$, that is,

$$\frac{\sigma_{01}\gamma_1}{\sigma_{01}\gamma_1 + \sigma_{00}\gamma_0} = \frac{\sigma_{11}\gamma_1}{\sigma_{11}\gamma_1 + \sigma_{10}\gamma_0}. \tag{41}$$

This is equivalent to $\sigma_{00} = 1 - \sigma_{11} = \sigma_{01}$. Hence

$$\begin{aligned} y_0 &= \mu_{10} && (42)\\ &= \frac{\sigma_{01}\gamma_1}{\sigma_{01}\gamma_1 + \sigma_{00}\gamma_0} && (43)\\ &= \gamma_1. && (44) \end{aligned}$$

Thus, (ii) follows.

Suppose second that $b \le 1/2$. From the previous paragraphs it follows that actions with $y_0 < y_1$ are feasible if and only if $\sigma_{11} = 1$, $y_0 = 0$ and $y_1 \ge 2b$. The principal's problem is thus to choose σ_{00} so as to maximize

$$-\gamma_0(1 - \sigma_{00})\lambda(y_1 - 0)^2 - \gamma_1\lambda(y_1 - 1)^2 \tag{45}$$

s.t.

$$y_1 = \frac{\gamma_1}{\gamma_1 + (1 - \sigma_{00})\gamma_0} \ge 2b. \tag{46}$$

It is easier to write this as an optimization problem over y_1. Then the first equality in the constraint yields $(1 - \sigma_{00}) = \gamma_1(1 - y_1)/(\gamma_0 y_1)$ and the principal's objective becomes

$$-\gamma_1\lambda(1 - y_1). \tag{47}$$

Thus, it is optimal to choose y_1 as large as possible, that is, $y_1 = 1$.

Notice finally that the still feasible action combination $y_0 = y_1 = \gamma_1$ yields lower utility than $y_0 = 0, y_1 = 1$. This shows (i). ∎

Proof of Proposition 7: Let $b \le 1/2$. Then $U_P^d - U_P^{ct} = -\lambda b^2 - 0 \le 0$.
Let $b > 1/2$. Then $U_P^d - U_P^{ct} = -\lambda\left(b^2 - \gamma_0(1 - \gamma_0)\right) \le -\lambda\left(b^2 - 1/4\right) \le 0$. ∎

Proof of Proposition 10: We show first that IR_1 is always binding. Notice that it cannot be optimal for the principal to have both IR constraints hold with strict inequality. For whether the IC constraints are satisfied depends only on the wage differential $\Delta w = w_0 - w_1$. Hence, both wages could be reduced without violating the IC constraints.

Suppose now that IR_1 is not binding. This implies that IR_0 is binding, thus $w_0 = (y_0 - b)^2$. Assume for a moment that $y_0 \le 1/2 + b$ in the optimum. Then, the right hand side of IC_1 writes

$$
\begin{aligned}
-\left(y_0 - (1+b)\right)^2 + (y_0 - b)^2 &= 2y_0 - 1 - 2b && (48)\\
&\le 1 + 2b - 1 - 2b && (49)\\
&= 0. && (50)
\end{aligned}
$$

Hence, w_1 can be reduced until IR_1 binds without violating IC_1.

We show now that indeed $y_0 \le 1/2 + b$. Suppose the contrary. Then

$$
\begin{aligned}
-\left(y_1 - (1+b)\right)^2 + w_1 &\ge -\left(y_0 - (1+b)\right)^2 + w_0 && (51)\\
&\ge -\left(y_0 - (1+b)\right)^2 + (y_0 - b)^2 && (52)\\
&= 2y_0 - 2b - 1 && (53)\\
&> 0, && (54)
\end{aligned}
$$

where the first inequality follows by IC_1 and the second by IR_0. Hence, IR_0 holds with strict inequality which implies that IR_0 must be binding, that is, $w_0 = (y_0 - b)^2$. However, P can improve by replacing y_0 by $\hat{y}_0 := 2b - y_0$ and setting $\hat{w}_0 = (\hat{y}_0 - b)^2$. For notice that for A_0 nothing changes as $(y_0 - b)^2 = (\hat{y}_0 - b)^2$. Furthermore, IC_1 still holds as

$$-(\hat{y}_0 - (1+b))^2 + w_0 = 2b - 1 - 2y_0 \le 0. \qquad (55)$$

However, $\hat{y}_0$ is closer to 0 than is y_0, and therefore P's utility increases. Thus, IR_1 is binding.

Since IR_1 is binding it follows that $w_1 = (y_1 - (1+b))^2$. Moreover, IC_0, IC_1, and IR_0 imply that Δw must satisfy

$$
\begin{aligned}
& y_0^2 - y_1^2 - 2b(y_0 - y_1) + \max\{0, 2y_1 - (1+2b)\} && (56)\\
\le\ & \Delta w && (57)\\
\le\ & y_0^2 - y_1^2 - 2(1+b)(y_0 - y_1). && (58)
\end{aligned}
$$

Thus the principal's problem is to choose $y_0, y_1, \Delta w$ so as to maximize

$$-\gamma_0 \lambda y_0^2 - \gamma_1 \lambda (y_1 - 1)^2 - (y_1 - (1+b))^2 - \gamma_0 \Delta w \qquad (59)$$

subject to (57). Since Δw enters negatively in the objective, it must be that in the optimum $\Delta w = y_0^2 - y_1^2 - 2b(y_0 - y_1) + \max\{0, 2y_1 - (1+2b)\}$. Thus, the objective becomes

$$
\begin{aligned}
& -\gamma_0 \lambda y_0^2 - \gamma_1 \lambda (y_1 - 1)^2 - (y_1 - (1+b))^2 && (60)\\
& -\gamma_0 \left[y_0^2 - y_1^2 - 2b(y_0 - y_1) + \max\{0, 2y_1 - (1+b)\} \right]. && (61)
\end{aligned}
$$

The first order condition with respect to y_0 yields

$$y_0 = \frac{b}{1+\lambda}, \tag{62}$$

as was claimed.

For y_1, since the objective has a kink in $y_1 = b + 1/2$, we need to distinguish the case $y_1 < b + 1/2$ (case A) and the reverse $y_1 \geq b + 1/2$ (case B). In case A the first order condition yields

$$y_1^A = \frac{\gamma_1(\lambda + b) + 1}{\gamma_1(1+\lambda)}. \tag{63}$$

Notice that $y_1^A < b + 1/2$ if and only if $b > (2 + \gamma_1(\lambda - 1))/(2\gamma_1\lambda) = \bar{b}$. Thus, the optimal y_1 under the constraint $y_1 < b + 1/2$ is given as

$$y_1^A 1_{\{b > \bar{b}\}} + (b + 1/2 - \varepsilon) 1_{\{b \leq \bar{b}\}}, \tag{64}$$

where ε is thought to be arbitrarily small. In case B the first order condition yields

$$y_1^B = 1 + \frac{b}{(1+\lambda)}. \tag{65}$$

Notice that $y_1^B \geq b + 1/2$ if and only if $b \leq (1+\lambda)/(2\lambda) = \hat{b}$. Thus, the optimal y_1 under the constraint $y_1 \geq b + 1/2$ is given as

$$y_1^B 1_{\{b \leq \hat{b}\}} + (b + 1/2) 1_{\{b > \hat{b}\}}. \tag{66}$$

Observe now that $\hat{b} < \bar{b}$. This implies that, if $b \leq \hat{b}$, then y_1^B is optimal. If $\hat{b} < b \leq \bar{b}$, then the kink point $b + 1/2$ is optimal. And if $b > \bar{b}$, then y_1^A is optimal. Hence, the claimed optimality of actions is shown.

As for wages, since IR_1 is always binding, $w_1 = (y_1 - (1+b))^2$. As for w_1 notice that for $b \leq \bar{b}$ it holds that $y_1 \geq b + 1/2$, thus $\Delta w = y_0^2 - y_1^2 - 2b(y_0 - y_1) + 2y_1 - (1+2b)$ and IR_0 is binding, that is, $w_0 = (y_0 - b)^2$. If $b > \bar{b}$, then IC_0 holds with equality, thus $\Delta w = y_0^2 - y_1^2 - 2b(y_0 - y_1)$. This yields

$$\begin{aligned} w_0 &= w_1 + \Delta w && (67)\\ &= (y_1 - (1+b))^2 + y_0^2 - y_1^2 - 2b(y_0 - y_1) && (68)\\ &= (y_0 - b)^2 + 1 + 2b - 2y_1. && (69) \end{aligned}$$

This shows the claim. ■

Proof of Proposition 11: Notice first that as in the case with perfect commitment (Prop. 10) it cannot be optimal that both IR constraints hold with strict inequality. Yet, in contrast to standard contracting problems with perfect commitment, under imperfect commitment it is generally not possible to say ex-ante which of the constraints must be binding. Therefore, to find the optimum we have to go through all possible cases and then compare the respective utilities.

A) Suppose first that both IC constraints hold with strict inequality. Then IND implies that both agents report their type with probability 1. Thus, by BayR and OPT it follows $y_0 = 0, y_1 = 1$. Hence, IC implies for the wage differential $\Delta w = w_0 - w_1$ that $2b - 1 < \Delta w < 1 + 2b$. This implies that both IR constraints must bind. For if IC_t did not bind, one could reduce w_t without violating the IC constraints. Therefore $w_t = b^2$ and $\Delta w = 0$. Accordingly, $2b - 1 < 0 < 1 + 2b$, which requires $b < 1/2$. That is, strict inequality of both IC constraints is feasible only if both agents are compatible. The principal's utility in this case is

$$V^A = -b^2 \tag{70}$$

B) Suppose now that IC_0 is binding, and assume w.l.o.g. that $y_0 < y_1$. (The case $y_0 = y_1$ is considered in C), and $y_0 > y_1$ is symmetric.) Then it follows that IC_1 holds with strict inequality. Thus, by IND, $\sigma_{11} = 1$, and hence, by BayR and OPT, $y_0 = 0$. Consequently, $\Delta w = -y_1^2 + 2by_1$.

We shall write P's problem as maximization over y_1 rather than over σ. Notice that with $\sigma_{11} = 1$ BayR and OPT imply

$$\sigma_{10} = \frac{\gamma_1 (1 - y_1)}{\gamma_0 y_1}. \tag{71}$$

With this, P's problem is to choose $w_0, w_1, y_1 \in [\gamma_1, 1]$ so as to maximize the objective

$$\gamma_0 \left[(1 - \sigma_{10}) \left(-\lambda (0 - 0)^2 \right) + \sigma_{10} \left(-\lambda (y_1 - 0)^2 \right) \right] + \gamma_1 \left(-\lambda (y_1 - 1)^2 \right) \tag{72}$$

$$- \gamma_0 (1 - \sigma_{10}) w_0 - \gamma_0 \sigma_{10} w_1 - \gamma_1 w_1$$

s.t.

$$IC_0 : \quad \Delta w = -y_1^2 + 2by_1; \tag{73}$$

$$IR_0 : \quad w_0 \geq b^2; \tag{74}$$

$$IR_1 : \quad w_1 \geq (y_1 - (1 + b))^2; \tag{75}$$

$$\text{BayR, OPT} : \quad \sigma_{10} = \frac{\gamma_1 (1 - y_1)}{\gamma_0 y_1}. \tag{76}$$

Notice that we can re-write the wage bill as follows

$$-\gamma_0 (1 - \sigma_{10}) w_0 - \gamma_0 \sigma_{10} w_1 - \gamma_1 w_1 = -\gamma_0 (1 - \sigma_{10}) \Delta w - w_1.$$

Notice further that $w_1 = w_0 - \Delta w = w_0 + y_1^2 - 2by_1 \geq b^2 + y_1^2 - 2by_1 = (y_1 - b)^2$, where IR_0 was used in the last inequality. Combining this with IR_1 yields

$$w_1 \geq \max\left\{(y_1 - (1+b))^2, (y_1 - b)^2\right\} \tag{77}$$

$$= b^2 + y_1^2 - 2by_1 + \max\{2b + 1 - 2y_1, 0\}. \tag{78}$$

Observe that because of IC_0 this also implies IR_0. Since w_1 enters the objective negatively, (78) must hold with equality. Thus, after plugging in all constraints the objective writes

$$\begin{aligned} &-\gamma_0 \frac{\gamma_1(1-y_1)}{\gamma_0 y_1} \lambda y_1^2 - \gamma_1 \lambda (y_1 - 1)^2 \\ &-\gamma_0 \left(1 - \frac{\gamma_1(1-y_1)}{\gamma_0 y_1}\right)\left(-y_1^2 + 2by_1\right) \\ &-\left(b^2 + y_1^2 - 2by_1\right) - \max\{2b + 1 - 2y_1, 0\}. \end{aligned} \tag{79}$$

Simplifying yields P's problem as

$$\max_{y_1 \in [\gamma_1, 1]} (\gamma_1 \lambda - \gamma_1) y_1 - \gamma_1 \lambda + 2b\gamma_1 - b^2 - \max\{2b + 1 - 2y_1, 0\}. \tag{80}$$

Notice that this is a piecewisely linear function with a kink at $y_1 = 1/2 + b$. For values $y_1 \leq 1/2 + b$ it has slope $2 + \gamma_1\lambda - \gamma_1 > 0$ and for values $y_1 > 1/2 + b$ it has slope $\gamma_1\lambda - \gamma_1$. This implies that for $b \geq 1/2$, since $y_1 \leq 1 \leq 1/2 + b$, the optimum is achieved at $y_1 = 1$.

We shall now show that if $b < 1/2$, the utility in case B) is less than the utility in case A) in which both IC constraints hold with strict inequality. For a moment, allow for values $y_1 \in [0, 1]$. Let $b < 1/2$ and $\lambda < 1$, then the kink is a peak, and the (unconstrained) optimum is achieved at $y_1 = 1/2 + b$. This yields utility $-b^2 + \gamma_1(1+\lambda)(b - 1/2)$. If $\lambda \geq 1$, then the (unconstrained) optimum is achieved at $y_1 = 1$ and yields utility $-b^2 + \gamma_1(2b - 1)$. In either case utility is less than $V^A = -b^2$. Thus, it cannot be optimal to have IC_0 binding if $b < 1/2$.

If $b \geq 1/2$, then P's utility computes to

$$V^B = -b^2 - \gamma_0(2b - 1). \tag{81}$$

In this case IR_1 is binding and wages are $w_0 = b^2 + 2b - 1, w_1 = b^2$.

C) Suppose next that both IC constraints hold with equality. Then

$$y_0^2 - y_1^2 - 2b(y_0 - y_1) = \Delta w = y_0^2 - y_1^2 - 2(1+b)(y_0 - y_1). \tag{82}$$

Thus, it must be that $y_0 = y_1$. As in the proof of Proposition 4 it follows that $y_t = \gamma_1$. Hence, by IR_t, and since $\Delta w = 0$, optimal wages are $w_t = \max\left\{(\gamma_1 - b)^2, (\gamma_1 - (1+b))^2\right\}$. The principal's utility in this case computes to

$$V^C = -b^2 - \lambda\gamma_0\gamma_1 - \gamma_1^2 + 2b\gamma_1 - \max\{0, 2b + 1 - 2\gamma_1\}. \tag{83}$$

We shall now show that $V^C \le V^A$ for $b < 1/2$, and that $V^C \le V^B$ for $b \ge 1/2$. Let $b < 1/2$. Assume first that $1/2 + b \le \gamma_1$, then

$$
\begin{aligned}
V^C &= -b^2 - \lambda\gamma_0\gamma_1 - \gamma_1^2 + 2b\gamma_1 && (84)\\
&\le -b^2 - \lambda\gamma_0\gamma_1 - \gamma_1^2 + 2\gamma_1^2 - \gamma_1 && (85)\\
&\le -b^2 && (86)\\
&= V^A. && (87)
\end{aligned}
$$

Assume next $1/2 + b > \gamma_1$, then

$$
\begin{aligned}
V^B &= -b^2 - \lambda\gamma_0\gamma_1 - \gamma_1^2 + 2b\gamma_1 - 2b - 1 + 2\gamma_1 && (88)\\
&= -b^2 - \lambda\gamma_0\gamma_1 - \gamma_1^2 - 2b\gamma_0 + \gamma_1 - \gamma_0 && (89)\\
&= -b^2 - \lambda\gamma_0\gamma_1 - 2b\gamma_0 - \gamma_0^2 && (90)\\
&\le -b^2. && (91)
\end{aligned}
$$

Thus, for $b < 1/2$ case A) dominates case B).

Let now $b \ge 1/2$. Then $1/2 + b > \gamma_1$, and from equation (90) it follows that $V^B \ge V^C$. Hence, it can never be optimal to have both IC constraints hold with equality.

D) Suppose finally that IC_1 is binding, and assume again that $y_0 < y_1$. Then it follows that IC_0 holds with strict inequality. Thus, by IND, $\sigma_{00} = 1$, and hence, by BayR and OPT, $y_1 = 1$. Consequently, $\Delta w = y_0^2 - 2(1+b)y_0 - 1 + 2(1+b)$.

With the same steps as in B) we can write P's problem as

$$\max_{y_0 \in [0;\gamma_1]} -(1 + \gamma_0\lambda + \gamma_1)y_0 - b^2 + \gamma_1 - 2b\gamma_1 - \max\{2b + 1 - 2y_0; 0\}. \qquad (92)$$

Again, the objective is piecewisely linear with a kink at $y_0 = 1/2 + b$. For values $y_0 \le 1/2 + b$ it has slope $\gamma_0(1 - \lambda)$ and for values $y_0 > 1/2 + b$ it has slope $-(1 + \gamma_0\lambda + \gamma_1) < 0$.

We shall now show that case D) is dominated either by case A) or by case B). Consider first the case $b \ge 1/2$ which implies that $\gamma_1 \le 1/2 + b$. Then, since $y_0 \le \gamma_1$, the optimum is achieved either at $y_0 = 0$ if $\lambda \ge 1$ which yields utility $-b^2 - \gamma_0(2b + 1)$, or at $y_0 = \gamma_1$ if $\lambda < 1$ which yields utility $-b^2 + \gamma_0\gamma_1(1 - \lambda) - \gamma_0(2b + 1)$. In either case utility is less than $-b^2 + \gamma_0\gamma_1 - \gamma_0(2b + 1)$ which is easily seen to be less than $V^C = -b^2 - \gamma_0(2b - 1)$. Thus, for $b \ge 1/2$ it cannot be optimal to have IC_1 binding.

Consider next the case $b < 1/2$. For this, allow for a moment for values $y_0 \ge 0$. Then the (unconstrained) optimum is achieved either at $y_0 = 0$ if $\lambda \ge 1$, or at $y_0 = 1/2 + b$ if $\lambda < 1$. The former yields utility $-b^2 - \gamma_0(2b+1)$ and the latter yields utility $-b^2 - 3b\gamma_1 - b - (1/2)\gamma_0$. In either case this is less than $V^A = -b^2$.

In summary, we have shown, that for $b < 1/2$ case A) is optimal, and that for $b \geq 1/2$ case B) is optimal. This proves the claim. ∎

References

[1] Aghion, P., J. Tirole (1997): "Formal and Real Authority in Organizations," Journal of Political Economy, 105, 1 - 29.

[2] Austin-Smith, D. (1990): "Information Transmission in Debate," American Journal of Political Science, 34, 124 - 152.

[3] Austin-Smith, D. (1993): "Interested Experts and Policy Advice: Multiple Referals under Open Rule," Games and Economic Behavior, 4, 132 - 152.

[4] Baron, D. (2000): "Legislative Organization with Informational Committees," American Journal of Political Science, 44, 485 - 505.

[5] Battaglini, M. (2001): "Multiple Referrals and Multidimensional Cheap Talk," Econometrica, forthcoming.

[6] Benabou, R., J. Tirole (2000): "Self-Confidence and Social Interactions," NBER Working Paper No. 7585.

[7] Bester, H., R. Strausz (2001): "Contracting with Imperfect Commitment and the Revelation Principle: The Single Agent Case," Econometrica, 69, 1077 - 1098.

[8] Coase, R. (1937): "The Nature of the Firm," Economica 4, 386 - 405.

[9] Crawford, V., J. Sobel (1982):"Strategic Information Transmission," Econometrica, 50, 1431 - 4551.

[10] Dessein, W. (2000): "Authority and Communication in Organizations," University of Brussels, mimeo.

[11] Epstein, D. (1998): "Partisan and Bipartisan Signaling in Congress," Journal of Law, Economics & Organization, 14 , 183 - 204.

[12] Farrell, J., M. Rabin (1996): "Cheap Talk," Journal of Economic Perspectives, 10, 103 - 118.

[13] Garidel-Thoron, T., M. Ottaviani (2000): "The Economics of Advice," UCL, mimeo.

[14] Gilligan, T., K. Krehbiel 1987. "Collective Decision Making and Standing Committees: An Informational Rationale for Restrictive Amendment Procedures," Journal of Law, Economics & Organization 3 (2), 459 - 90.

[15] Goerke, L., C. Hefeker (2000): "Delegation and Wage Determination in Trade Unions," Labour, 14, 393 - 416.

[16] Grossman, S., O. Hart (1986): "The Costs and Bene…ts of Ownership," Journal of Political Economy, 94, 691 - 719.

[17] Hart, O. (1995): Firms, Contracts and Financial Structure, Oxford, Oxford University Press.

[18] Hart, O., J. Moore (1990): "Property Rights and the Nature of the Firm," Journal of Political Economy, 98, 1119 - 58.

[19] Holmström, B. (1984) "On the Theory of Delegation," in M. Boyer, R. Kiehlstrom (eds): Bayesian Models in Economic Theory, New York, North-Holland.

[20] Jost, P., S. Weber (2001): "Humankapitalinvestitionen und die Delegation von Entscheidungen," Zeitschrift für Betriebswirtschaft, 71, 183 - 201.

[21] Krishna, V, J. Morgan (2000): "A Model of Expertise", Quarterly Journal of Economics, 116, 747 - 775.

[22] Krishna, V, J. Morgan (2001): "Asymmetric Information and Legislative Rules: Some Amendments," American Political Science Review, 95, 435 - 452.

[23] Mitusch, K., R. Strausz (1999): "Mediators and Mechanism Design: Why Firms Hire Consultants," Free University Berlin, mimeo.

[24] Mitusch, K., R. Strausz (2000): "Mediation in Situations of Con‡ict," Free University Berlin, mimeo.

[25] Szalay, D. (2001): "Optimal Delegation", University of Mannheim, mimeo.

[26] Whinston, M. (2000): "On the Transaction Cost Determinants of Vertical Integration," Northwestern University, mimeo.

[27] Williamson, O. (1985): The Institutions of Capitalism, New York, Free Press.