Credibility, efficiency and the structure of authority

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Abstract

We study the optimal allocation of authority in a setup with endogeneous information and different information acquisition abilities. In our principal-agent setting with two-sided information acquisition and no transfers, the players only disagree when uninformed. We show that a sufficiently efficient principal does not lose any authority when delegating to a less efficient agent plus gains from the additional information the agent may have. As information acquisition efforts are substitutes, a relatively more efficient principal finds it easier to persuade an agent and provides a recommendation that the agent follows when uninformed. A less efficient principal centralizes fearing that the agent will not follow his advice and follows the agent's recommendation if unable to obtain information herself.

Keywords: organizational design, cheap talk, two-sided information acquisition
JEL codes: D82, M52.

1 Introduction

Consulting experts is a crucial component of a good organizational decision-making. Often, both the manager and her subordinates invest time and effort in obtaining decision-relevant information. How does the allocation of authority affect incentives to obtain and share information, and how does it depend on the players' abilities regarding obtaining information?

We study these questions in a principal-agent setup with limited commitment and two-sided information acquisition in which the players disagree on the action only in the absence of conclusive information. In other words, there is a conflict ex-ante which is resolved upon the arrival of information. The lack of commitment is reflected in communication being modeled as cheap talk. The principal can, however, either credibly delegate a decision or retain the

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authority (centralization). In this setup, there is both moral hazard in terms of information acquisition efforts and strategic communication.

We show a surprising result that if the principal is sufficiently efficient, by delegating, *the principal maintains the actual decision making power in form of a recommendation* while the agent exerts higher effort than under centralization. The principal always makes a recommendation whether if she is informed or uninformed. As long as the principal is sufficiently efficient, the recommendation is persuasive for the agent: it means the agent rubber-stamps it whenever his own information acquisition is not successful. In other words, we show that the principal need not face any trade-off when deciding over the authority structure: under delegation, she might both achieve her preferred action and incentivize the agent to invest in learning.

To explain the intuitions more precise and to describe our main results, we, first, sketch the model.

An organization consists of a principal (she) and an agent (he). There is a decision to be made regarding the choice over one of the two projects. Each project is optimal for both players in one of the two unobserved states of nature. The players simultaneously exert effort to obtain a perfectly revealing signal about the state where a higher effort results in a higher likelihood of obtaining an informative signal. When uninformed, the players disagree over the best project. We assume that the players share a common prior and the disagreement comes solely from the preferences. The principal can either credibly delegate the formal authority over the project choice to the agent or retain the decision-making power. In particular, under *centralization* the players first separately exert effort and the agent shares his finding with the principal who, then, chooses a project. Under *delegation*, first, the players exert efforts and then the principal communicates with the agent who, then, chooses one of the projects. Communication is modeled as cheap talk (Crawford and Sobel, 1982).

In our setup, there is no incentive to lie upon successful information acquisition. However, there may be incentives to lie upon the lack of success in information acquisition. Since the principal is unable to commit to transfers or choices based on reports (i.e., communication is cheap talk), it is not clear ex-ante how the authority allocation affects the principal's payoffs. On the one hand, delegation can raise the informational value for the agent who exerts more effort compared to centralization. On the other hand, under delegation the uninformed agent may take his ex-ante preferred action, meaning the principal loses control. We show that this tension does not always arise. Our first main result shows the existence of rubberstamp equilibria under both delegation and centralization where the actual decision maker follows a *credible* recommendation of the other player when uninformed, given that this player exerts sufficiently high effort. Additionally, the decision-maker exerts effort to obtain information and follows his own signal whenever he has successfully learned the state, in which case again he chooses the mutually optimal project.

To understand the mechanism, consider the case of delegation. If the principal exerts effort, she receives one of the three signals – either that the optimal project is the one preferred by the agent ex ante (say, project a), or the optimal project is the one preferred by the principal ex ante (say, project b), or the signal is uninformative. Suppose that the principal reveals if the optimal project is a and sends a different message otherwise. Upon receiving the latter, the agent is uncertain of whether the principal obtained information that the optimal project is b (in which case the players agree), or if she is uninformed. In the latter case, if the agent himself is uninformed, the players disagree on the project choice ex-ante. However, whenever the principal is sufficiently efficient in information acquisition, the recommendation will be credible enough to influence the agent's action. In this case, the agent assigns a sufficiently high posterior belief to the principal being informed. It turns out that in that case the principal retains real authority in form of a recommendation. As efforts are substitutes in this setup, the more inefficient the agent is, the more effort the principal exerts, and the more likely that this outcome arises.

The existence of a rubberstamp equilibrium under centralization is similar: if the agent is sufficiently efficient (and the principal is sufficiently inefficient, relative to the agent), he makes a recommendation which the principal follows whenever uninformed. Similarly, when the principal is indeed informed, she makes the mutually optimal choice.

Our second group of main results refers to the optimality of the organizational structure. We show that as long as the principal is sufficiently efficient to make a persuasive recommendation under delegation and the agent is sufficiently inefficient and so unable to produce a credible recommendation under centralization, the principal delegates. The key ingredients are the relative efficiencies of the players. Even if the agent is inefficient (relative to the principal), he exerts some effort under delegation and no effort under centralization. This happens because an inefficient agent cannot credibly communicate under centralization and therefore cannot affect the principal's decision. As a result, not only does the agent rubberstamp the principal's most preferred action but he also works harder under delegation compared to centralization. The reason for the agent's effort under delegation is that sometimes the principal will recommend project b even though she is uninformed: in this case the agent would have preferred to choose a were he able to observe the principal's signal. The chance of hearing a recommendation from the uninformed principal pushes the agent towards exerting effort even though he follows the principal's recommendation if he is unable to obtain an informative signal.

Similarly, under delegation the inefficient principal anticipates that her recommendation is not credible and therefore does not exert any effort. This shows that, indeed, it enhances overall effort if the inefficient party holds decision making power. In addition, that for there to be effective communication, the two sides have to be sufficiently different in terms of their efficiencies in information acquisition.

We further show that our setting does not allow for truthful communication under any organizational form. Intuitively, after the efforts have been exerted, an uninformed player who does not decide over the final action will try to persuade the other player to choose his most preferred action, anticipating that his recommendation will be followed if and only if no information is acquired. As a result, the only influential communication (it means, communication which affects the decision-maker's posterior) has to involve pooling resulting in a noisy recommendation.

In an extension, we study a setting with sequential information acquisition where a player exerts effort and communicates to the decision-maker who, then, exerts effort and chooses a project. The communication incentives change allowing for truthful communication. This happens if the decision maker (in terms of effort provision) is sufficiently efficient. Then, there is an incentive to reveal the absence of a signal by the first-mover in order to incentivize effort by the follower. As we show, under sequential information acquisition (and communication) both delegation and centralization with rubberstamp exist, and are optimal under the conditions which qualitatively coincide with the case of simultaneous information acquisition. The additional dimension here is that the first-mover will shift some of the effort burden to the follower. However, free-riding in terms of effort is limited since the first-mover also anticipates that the second mover may also not successfully acquire information and therefore exert sufficient effort. Similar to the case of simultaneous effort provision, the first-mover has to be sufficiently efficient to make a persuasive recommendation. The additional dimension is that, the first-mover is more likely to be truthful to a more efficient second mover who he trusts will exert sufficient effort into information acquisition.

Our paper is related to Aghion and Tirole (1997) where the transfer of the actual decision-power to the agent motivates the latter to exert more effort in obtaining decision-relevant information. The conflict of interest in our model is modeled differently. In Aghion and Tirole (1997) the informed players disagree on the optimal project choice whereas in our paper the players disagree only if they are uninformed. Naturally, in Aghion and Tirole (1997) the agent works harder under delegation as he can overrule the principal to choose his preferred action which increases the value of information. In our case, however, the agent works harder under delegation with rubberstamp than under centralization *despite* the fact that the principal maintains the actual decision-making authority. The agent realizes that otherwise she might make her least preferred choice based upon the principal's recommendation. Thus, at the effort stage the agent is motivated to work "against" the principal's recommendation, even though if he obtains no information, his best response is to follow the principal's recommendation. Different to Aghion and Tirole (1997) our setup is one of communication and there is no truthful communication in our setting and a persuasive recommendation is necessarily "noisy" as the uninformed principal pools with the informed one.

While in Aghion and Tirole (1997) the principal would benefit from the lack of a conflict, the presence of the conflict can be beneficial for the principal in Rantakari (2012) and Che and Kartik (2009). In Rantakari (2012), under delegation the agent diverts valuable effort from the tasks important for the principal to the task important for the agent himself. Che and Kartik (2009) consider a disclosure setup where the agent and the principal have different priors over the distribution of the state variable, but conditional the state their preferences are aligned.

The agent is the only one who may, by exerting effort, acquire an imperfectly revealing signal and it may be optimal for the biased agent to hide a signal. This means, no disclosure makes the principal skeptical the more biased the agent is, which in return motivates a more biased agent to exert higher effort in order to find evidence. Plus, there is communication through cheap talk as opposed to disclosure. While in their setup it may happen that the agent hides signals that do not confirm his bias, in our setup it is possible to send a biased recommendation when uninformed. Che and Kartik (2009) find that a more biased agent may be better, as this agent exerts more effort given that upon no disclosure the principal is more skeptical. A similar assumption in our setup is that the two parties agree on the optimal project conditional on the state, with the difference that the signals in our setup are perfectly informative plus there is two sided information acquisition. In terms of organizational structure, Che and Kartik (2009) find that, in congruence with the literature, the principal would only delegate to a sufficiently congruent agent, and centralises when the agent is sufficiently biased. Our results are different in that in our setup of two sided information acquisition, the principal finds it optimal to delegate whenever he is sufficiently efficient in comparison to the agent. This is because given that the principal is expected to exert sufficient effort, the agent finds it optimal to follow her recommendation, in return the principal does exert effort given communication happens. The agent works harder than under centralization as he anticipates that whenever he gets information, he will rather act upon his own information rather than follow a possibly biased recommendation. Under centralization, only a sufficiently efficient agent can convince the principal to follow a recommendation which is against the principal's prior, and in return, such an agent does exert sufficient effort to make the principal believe that the recommendation is based on information. Given efforts are substitutes, this type of equilibrium arises when the agent expects the principal to put in low effort in which case he himself puts in sufficient effort. Thus, the forces in our paper are very different to the above mentioned papers.

There is a rich literature exploring the rationale for delegation within organizations.[1] The key assumption is that contracts are incomplete (Grossman and Hart, 1986; Hart and Moore, 1990) as otherwise the allocation of authority is irrelevant.[2]

Some of the literature assumes that the employees are already endowed with information and explores the trade-off between the quality of communication and the loss of decision power (Dessein, 2002; Harris and Raviv, 2005). If the information is dispersed between multiple employees, the setting of coordinated adaptation with exogenous information (Alonso, Dessein, and Matouschek, 2008; Rantakari, 2008) suggests that the principal prefers to centralize whenever the conflict of interest within an organization is substantial and the coordination is sufficiently important. In a similar framework, Liu and Migrow (2018) show that a large coordination motive can support delegation if the information is endogenous and the principal

[1]See Gibbons, Matouschek, and Roberts (2013) and Garicano and Rayo (2016) for excellent overviews of the literature.

[2]In the setting where the allocation of authority is irrelevant, Holmström (1984) and Alonso and Matouschek (2008) explore which decisions are attainable via constrained delegation.

is unable to commit to decision rules. Different to our paper, in the above papers the principal is unable to obtain information directly and has to rely on her subordinates. Moreover, the conflict of interest is very different - in the above papers, conditional on being informed, the players pursue different goals. In contrast, in our framework the players disagree ex ante.

Further rationales for delegation explored in the literature include learning about the agent's type (Aghion, Dewatripont, and Rey, 2002, 2004) or motivating the agent through the actual implementation of the final decision (Bester and Krähmer, 2008).

Finally, we relate to the literature on credibility of delegation. As the principal is the ultimate stakeholder, granting authority might not be credible and can be revoked if it goes against the principal's interest (Baker, Gibbons, and Murphy, 1999). In our setting, however, under delegation with rubberstamp the principal cannot benefit from revoking authority from the agent as the agent follows the principal's recommendation whenever he isn't informed and if he is informed then he is taking the optimal decision for the principal.

2 Model

An organization consists of a principal (she, P) and an agent (he, A). Each player wants to match a project $\theta \in \{a, b\}$ with an unobserved state $\omega \in \{1, 2\}$. The players' payoffs are shown in the following matrix where the first entry in each cell is the agent's payoff:

	$\theta = a$	$\theta = b$
$\omega = 1$	$\beta w,\ (1-\beta)w$	$0, 0$
$\omega = 2$	$0, 0$	$(1-\beta)w,\ \beta w$

with $\beta \in (1/2, 1]$ and $w > 0$. Hence, β defines the ex-ante bias. The common prior assigns probability $p > 0$ to $\omega = 1$. We are interested in situations where the players disagree on the optimal project ex-ante and therefore we assume $1 - \beta < p < \beta$.[3]

Each player can acquire a costly state-dependent signal. We assume success-enhancing effort (Green and Stokey, 1980) where exerting effort $e_i \in [0, 1]$ for $i = P, A$ results in a perfectly revealing signal $s_i = \omega$ arriving with probability e_i at a cost $\frac{e_i^2}{2} c_i$. The signal is non-verifiable.

We follow the incomplete contract approach (Grossman and Hart, 1986; Hart and Moore, 1990) and assume that the principal is unable to commit to transfers (or choice functions) based on reports. However, at the beginning of the game the principal can choose (and commit to) an allocation of decision rights. The principal either chooses centralization or delegation. Under centralization, first, both players simultaneously exert efforts to acquire signals. Then, the agent sends a cheap talk message to the principal who chooses a project. Under delegation,

[3]The ex ante conflict of interest means that for a given β the uninformed agent (weakly) prefers project a to b: $p\beta w \geq (1-p)(1-\beta)w$, and the uninformed principal (weakly) prefers project b to a: $(1-p)\beta w \geq p(1-\beta)w$.

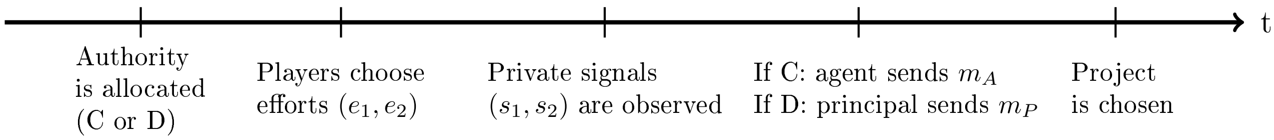


Figure 1: Timing of Events

first, both players exert efforts. Then, the principal sends a cheap talk message to the agent who, then, chooses a project. The timing of the game is summarized in Figure 1.

We model communication as cheap talk highlighting the lack of the principal's commitment power when it comes to decisions based on agent's reports. The message space M available to each player is countable and arbitrarily large, and we denote by $m_i \in M$ a message sent by player $i \in \{A, P\}$.

3 The outcomes of the game

Throughout the paper we maintain the following assumption on the costs of information acquisition that ensures that both player's efforts are less than 1:

Assumption 1 The following has to hold for c_P and c_a:

$$c_A \geq (1-p)(1-\beta)w \text{ and } c_P \geq p(1-\beta)w.$$

The next proposition shows that the players never reveal all of their information, whatever the allocation of authority.

Proposition 1: *There is no truthful communication equilibrium under centralization or delegation.*

To understand why a player does not reveal his signal truthfully to the decision-maker, realise that this player may only influence the decision if the decision maker is indeed not informed. Hence, when uninformed, he conditions his strategy on the state in which the decision maker is also uninformed. Consider the case of delegation and assume by contradiction that there is a truth telling equilibrium. Then, whenever the agent expects the principal to be truthful, the uninformed principal will deviate to misreport his signal to recommend the agent to choose project b. In this case, the principal influences the agent's decision whenever the agent is uninformed, and it remains unchanged whenever the agent is indeed informed, making it a profitable deviation. Since we assumed that $1-\beta < p < \beta$ in order to generate the conflict of interest from the ex ante perspective, truthful communication cannot happen in equilibrium under delegation. The logic is the same under centralization: the uninformed agent benefits from misreporting recommending the principal choosing project a whenever uninformed, were the principal to believe that the agent is truthful.

3.1 Delegation

As we show below, there are two possible equilibria under delegation: one in which the principal exerts effort and the agent rubberstamps whenever he himself is uninformed. This happens if and only if the principal is sufficiently more efficient compared to the agent. Otherwise, if the agent doesn't rubberstamp the principal's recommendation, the principal exerts no effort as she is unable to change the agent's decision in any case. Hence, there is a discontinuity in the principal's effort just at the point where the rubberstamp equilibrium is no longer attainable.

3.1.1 Rubberstamp by the agent

Consider a strategy profile in which the principal exerts effort and, after observing her signal, sends a recommendation to the agent who follows it if uninformed.

The principal's communication strategy consists of sending one of the two signal-contingent messages in equilibrium. If she receives the signal indicating that the optimal project is a, she always sends a truthful message to the agent, who then follows her recommendation: we denote this message by $m(a)$. For the two other signal realizations she sends a message $m(b)$. Thus, upon receiving $m(b)$ the agent does not know whether the principal is uninformed or genuinely informed that the optimal project is b. The agent, then, exerts effort and, if uninformed, follows the principal's recommendation and chooses b.

To understand the incentives behind this strategy profile, we start with the agent's optimal choices. First, whenever the agent receives $m(b)$, he assigns a posterior probability $\tilde{p} = \frac{1-p}{1-e_P p}$ to the principal being uninformed and, thus, the posterior

$$1 - \tilde{p} = \frac{p(1-e_P)}{1-pe_P} \tag{3.1}$$

to the optimal project being b. Therefore, the uninformed agent follows the recommendation if

$$(1-\tilde{p})(1-\beta)w \geq \tilde{p}\beta w$$

or

$$e_P \geq \frac{\beta + p - 1}{\beta p} \tag{3.2}$$

meaning that the principal should be expected to exert enough effort to induce a sufficiently high posterior belief of the agent that the recommendation is based on an informative signal rather than her preference. Notice that the RHS of (3.2) increases in β and p. This is because a higher β and/or p increase the attractiveness of choosing an ex ante preferred project a by the uninformed agent. Then, the recommendation more persuasive only for higher effort expected from the principal.

Anticipating his own best response to the principal's cheap talk message, at the effort stage the agent chooses e_A to maximize

$$e_A[p\beta w + (1-p)(1-\beta)w] + (1-e_A)[e_P p\beta w + (1-e_P p)(1-\tilde{p})(1-\beta)w] - \frac{e_A^2}{2}c_A.$$

The above expected payoff reflects the fact that, conditional on obtaining an informative signal – which happens with probability e_A – the agent chooses the optimal project. With the complementary probability $1-e_A$ the agent is uninformed. In this case he either receives a truthful recommendation from the principal to choose project a, or a "noisy" recommendation (which the agent follows) to choose project b which yields the conditional expected payoff $(1-\beta)(1-p)w$. As the above objective is concave in the agent's effort, the first-order approach yields the agent's best response

$$e_A = \frac{(1-e_P)p\beta w}{c_A}.$$

The principal's problem at the effort stage is to choose e_P maximizing

$$e_P[(1-p)\beta w + p(1-\beta)w] + (1-e_P)[e_A((1-p)\beta w + p(1-\beta)w) + (1-e_A)(1-p)\beta w] - \frac{e_P^2}{2}c_P$$

which results in

$$e_P = \frac{(1-e_A)(1-\beta)pw}{c_P}.$$

Solving both player's best responses at the effort stage, we obtain

$$e_A = \frac{p\beta w(c_P - (1-\beta)pw)}{c_A c_P - (1-\beta)p^2 w^2 \beta}$$

and

$$e_P = \frac{p(1-\beta)w(c_A - p\beta w)}{c_A c_P - (1-\beta)p^2 w^2 \beta}.$$

Using the principal's optimal effort we can rewrite the condition (3.2) to get the condition for the existence of a persuasive recommendation (and therefore of a rubberstamp equilibrium) in terms of the principal and agent's cost:

$$\frac{p^2(1-\beta)\beta w}{p+\beta-1}\Big(1-\frac{(1-p)(1-\beta)w}{c_A}\Big) := \hat{c}_P \tag{3.3}$$

Intuitively, the principal has to be sufficiently efficient, and therefore exert sufficient equilibrium effort in order to persuade the uninformed agent to rubberstamp her recommendation. Given that (3.3) is satisfied, the agent assigns a sufficient posterior to the principal being informed.

Notice that the constraint (3.3) gets more relaxed as c_A increases. This is due to the strategic substitutability of the effort levels, and a less efficient agent exerts less equilibrium effort which induces the principal to exert more effort for any given level of the principal's efficiency. Therefore, for the principal to be able to persuade an agent, it must be that the principal is sufficiently more efficient than the agent!

Finally, notice that the RHS of (3.3) converges continuously to the limit

$$\bar{c}_P = \frac{p^2(1-\beta)\beta w}{p+\beta-1}$$

as $c_A \to \infty$. Intuitively, even if an agent gets very inefficient, there is some finite bound on the principal's efficiency to make her recommendation persuasive. As a result, for a very inefficient agent, if his inefficiency rises, the principal's constraint (3.3) can only be relaxed by a small amount. In addition, if we replace the minimum value of c_P which is $(1-\beta)pw$ into $\hat{c}_P$, we get the minimum c_A for which this type of equilibrium can exist:

$$c_A \geq \beta p w$$

3.2 No rubberstamp by the agent

Suppose, next, that $c_P > \hat{c}_P$ meaning that the principal is sufficiently inefficient to not being able to make a persuasive recommendation under delegation: i.e. make the agent choose project b when uninformed himself. Although the principal's recommendation will be credible when he sends message m'(a), this is what the uninformed agent going to choose anyway even without information. Finally, if the agent is indeed informed there is no further gain from the principal's information. Hence, given that the principal can never affect the agent's decision, and given costly effort, she would exert no effort at all. Therefore in this equilibrium $e_P = 0$. The agent therefore maximizes

$$p(1-\beta)w + e_A(1-p)\beta w - \frac{e_A^2}{2}c_P$$

over his effort choice leading to

$$e_A = \frac{(1-\beta)(1-p)w}{c_A}.$$

Thus, the agent exerts more effort the higher is the possibility of information changing his decision and the payoff from that and the lower is his cost c_A. We call this equilibrium, babbling under delegation. As typical of a cheap talk game, this equilibrium exists for all parameter values (c_A, c_P) under delegation. Importantly, for $c_P > \hat{c}_P$ this is the unique equilibrium.

3.3 Centralization

We now consider the case in which the principal keeps decision making power. Similar to delegation, there are two possible outcomes: one in which the principal rubberstamps the agent's recommendation and the other where the principal dismisses the agent's message as babbling.

3.3.1 Rubberstamp by the principal

Consider a strategy profile in which an agent provides a recommendation to the principal, and the principal follows it if and only if she does not obtain an informative signal. The agent's communication strategy consists of two signal-contingent messages. If the agent receives a signal indicating that the optimal project is b, he discloses his finding to the principal sending a message $m(b)$. In all other instances he sends a different message, say, $m(a)$, recommending the principal to choose project a. Thus, upon receiving the second message the principal cannot distinguish whether the agent is uninformed or is genuinely informed that the optimal project is a. When will the principal follow the recommendation, it means, choose $\theta = a$ if she does not receive any informative signal?

To see this, first, notice that given the effort choice of the agent, e_A, the principal's posterior upon receiving $m = a$ assigns probability $\bar{p} = \frac{p}{1-e_A(1-p)}$ to the agent being informed. Thus, the principal rubber-stamps the agent's recommendation if

$$\bar{p}(1-\beta)w \geq (1-\bar{p})\beta w$$

resulting in

$$e_A \geq \frac{\beta - p}{(1-p)\beta}. \tag{3.4}$$

Intuitively, the principal rubberstamps if she expects the agent to exert sufficient effort, and therefore the principal assigns a sufficient posterior to the agent being informed, compared to him have failed to obtain a signal. Notice the parallel to (3.2): in both cases the communicating player must be expected to exert high enough effort for the decision-maker believe that the recommendation is more likely to be based on information rather than preference.

At the effort stage the agent chooses e_A to maximize

$$e_A[(1-p)(1-\beta)w+p\beta w]+(1-e_A)e_P[(1-p)(1-\beta)w+p\beta w]+(1-e_A)(1-e_P)p\beta w-\frac{e_A^2}{2}c_A$$

resulting in

$$e_A = \frac{(1-p)(1-\beta)w(1-e_P)}{c_A}.$$

Similarly, the principal chooses e_P to maximize her expected payoff

$$e_P[(1-p)\beta w + p(1-\beta)w] + (1-e_P)[e_A(1-p)\beta w + (1-e_A(1-p))\bar{p}(1-\beta)w] - \frac{e_P^2}{2}c_P$$

resulting in

$$e_P = \frac{(1-p)\beta w(1-e_A)}{c_P}.$$

Using the players' best responses at the effort stage, we obtain the optimal effort choices:

$$e_P = \frac{(1-p)\beta w[c_A - (1-p)(1-\beta)w]}{c_A c_P - (1-p)^2\beta(1-\beta)w^2}, \text{ and}$$

$$e_A = \frac{(1-p)(1-\beta)w(c_P - (1-p)\beta w)}{c_A c_P - (1-p)^2\beta(1-\beta)w^2}.$$

Finally, for the agent to be persuasive (3.4) has to be satisfied. Using the optimal efforts, (3.4) becomes equivalent to

$$c_A \leq \frac{(1-p)^2(1-\beta)\beta w}{(\beta-p)}\left(1-\frac{pw(1-\beta)}{c_P}\right) = \hat{c}_A \tag{3.5}$$

Thus, for the agent to appear credible, his cost of information acquisition has to be sufficiently low, in particular, he has to be sufficiently more efficient compared to the principal. As equilibrium efforts are substitutes, a less efficient principal induces the agent to exert more effort in equilibrium which in turn makes him more credible. As $c_P \to \infty$, we get the maximum c_A for which rubberstamp can exist which is:

$$\bar{c}_A = \frac{(1-p)^2(1-\beta)\beta w}{\beta-p}.$$

Thus, even if the principal is very inefficient, there is an upper bound on the agent's efficiency to appear credible.

On the other hand, when we replace the minimum value of c_A which is $(1-\beta)(1-p)w$ into $\hat{c}_A$, we get the minimum c_P for which this type of equilibrium can exist:

$$c_P \geq \beta(1-p)w$$

3.3.2 No rubberstamp by the principal

When $c_A > \hat{c}_A$, the principal no longer rubberstamps as she believes that it is highly unlikely that the agent's recommendation is based on an informative signal. In this case, the agent cannot affect the principal's decision. To see this, realise the only case where agent's communication may be influential is when the principal isn't informed. In that case, the principal would choose project b no matter the message sent by the agent. As a result, the agent chooses 0 effort and the principal chooses e_P to maximize

$$e_P[(1-p)\beta w + p(1-\beta)w] + (1-e_P)(1-p)\beta w - \frac{e_P^2}{2}c_P$$

leading to:

$$e_P = \frac{p(1-\beta)w}{c_P}.$$

Parallel to the case of babbling under delegation, here the principal exerts more effort the higher is the benefit of acquiring information which changes her decision, $(1-\beta)pw$, and the lower is the principal's cost c_P.

It is easy to show that in case of equilibrium multiplicity under centralization, the principal's preferred equilibrium features agent's recommendation. The principal cannot be worse-off by getting a recommendation: if it were the case, she would simply ignore it resulting in payoffs of the babbling equilibrium.

4 Optimal organizational form

First, it is straightforward to verify that $\hat{c}_A$ is increasing and concave in c_P, while $\hat{c}_P$ is increasing and concave in c_A. Using Assumption 1, the minimum values of both functions are 0, when $c_P = c_P^{min} = \beta(1-p)w$ and when $c_A = c_A^{min} = \beta pw$, respectively.

Assuming the rubber stamp regions do not overlap, we will focus respectively on three regions. Realise that under certain parameter conditions, these regions might indeed overlap. First, we compare the babbling outcome under centralization to the principal's optimal equilibrium under delegation (to remind, in the rubberstamp case we have equilibrium multiplicity given that a babbling equilibrium always exists). Second, we compare the babbling equilibrium under delegation to the principal's optimal equilibrium under centralization.

The following proposition focuses on the region where only babbling equilibria exist and compares both organization forms.

Proposition 2: In the region where no communication at all is possible, ($c_A > \hat{c}_A$ and $c_P > \hat{c}_P$), *the principal will prefer to delegate for sufficiently low c_a, namely*

$$c_A \leq \frac{2(1-\beta)\beta c_P(1-p)^2 w}{2c_P(\beta - p) + (1-\beta)^2 p^2 w} \tag{4.1}$$

and centralise otherwise.

The region in which $c_A > \hat{c}_A$ and $c_P > \hat{c}_P$ is such that, under either organizational structure, given that no communication can take place the decision maker exerts positive effort. Intuitively, the principal delegates only if the agent is sufficiently efficient relatively (c_P versus c_A), resulting in a high likelihood of the agent being informed under delegation.

It is easy to show that the RHS of 4.1 is concave and increasing in c_P. Hence, for higher c_P, the constraint for delegation to be optimal is more relaxed, though in a diminishing way.

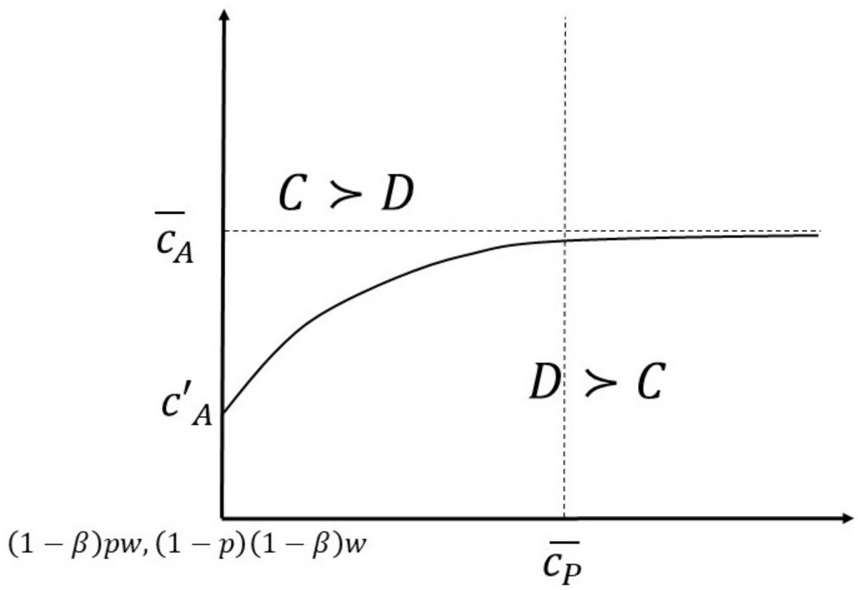
Notice that the RHS of 4.1 converges monotonically to $\bar{c}_a$ as c_p goes to infinity. Moreover, for c_P^{min}, the RHS is

$$c_A' := \frac{2\beta(1-p)^2(1-\beta)w}{2\beta - \beta p - p} < \bar{c}_A.$$

Finally, since

$$c_A' - (1-\beta)(1-p)w = \frac{(1-\beta)^2(1-p)pw}{2\beta - \beta p - p} > 0,$$

we have $c_A^{min} < c_A' < \bar{c}_A$, and therefore the RHS of 4.1 starts at c_A' in $(c_A^{min}, \bar{c}_A)$ and converges monotonically, in a concave way, to $\bar{c}_A$ as c_P goes to infinity. Given the condition in Proposition 2, for the region $c_A > \bar{c}_A$ we have that centralization without rubberstamp dominates delegation without rubberstamp. The corresponding areas are shown in figure below. This picture is drawn excluding the possibility of rubber-stamp equilibria.



The region in which $c_A > \hat{c}_A$ and $c_P > \hat{c}_P$, is such that, under either organizational structure, no communication takes place as only the decision maker exerts positive effort. Intuitively, the principal delegates if the agent is sufficiently efficient relative to c_P, resulting in a high likelihood of the agent being informed under delegation.

It is easy to show that the RHS of 4.1 is concave and increasing in c_P. Hence, for higher c_P, the constraint for delegation to be optimal is more relaxed, though in a diminishing way.

Hence, in this region where communication completely breaks down, delegation to a very efficient agent is optimal, which is in congruence with Aghion and Tirole (1997). We will show that, when persuasive equilibrium exists, the effect is *reversed* in that it is more profitable to delegate to an inefficient agent while centralising when the agent is very efficient.

Next, we study the regions in which a persuasive equilibrium exists. Firs, we focus on the region $c_P \leq \hat{c}_P$ and $c_A > \hat{c}_A$: only the principal can be persuasive in terms of her recommendation under delegation while the agent is inefficient and therefore cannot convince the principal under centralization. As a result, the only equilibrium under centralization involves no effort by the agent.

Proposition 3: *In the region where $c_P \leq \hat{c}_P$ and $c_A > \hat{c}_A$, where rubberstamp equilibrium exists under delegation while babbling is the unique outcome under centralisation, it is always optimal for the principal to delegate decision making power.*

The idea of the proof is very intuitive. Under centralization, the agent does not exert any effort and the principal's payoff is:

$$\beta(1-p)w + (1-\beta)pwe_P - \frac{e_P^2}{2}c_P$$

reflecting the fact that the uninformed principal chooses project b. In this case the principal's optimal effort is $e_P = \frac{(1-\beta)pw}{c_P}$. Now, the payoff under delegation with rubberstamp can be written as:

$$\beta(1-p)w + (1-\beta)pwe_P + (1-e_P)e_A p(1-\beta)w - \frac{e_P^2}{2}c_P.$$

If, under delegation, the principal deviates from the equilibrium effort and exerts the effort $e_P = \frac{(1-\beta)pw}{c_P}$ while the agent still maintains equilibrium expectations of the principal's effort, the principal does strictly better than under centralization. Comparing both expected payoffs above, we see that by deviation the principal's payoff has an additional component $(1-e_P)e_A p(1-\beta)w$ which is, in general, strictly positive. With other words, the principal could work as hard under delegation as under centralization, while still benefiting from agent's effort and not losing the actual decision power thanks to her persuasive recommendation.

Furthermore, in this delegation with rubber stamp region, we have that: $c_A \in [\beta pw, \infty]$ and $c_p \in [(1-\beta)pw, \bar{c}_p]$.

Proposition 2 concludes that whenever rubber stamp equilibrium under delegation exists, delegation is the optimal organizational structure. However, there is always the possibility of a babbling equilibrium under delegation. Thus, whenever the conditions of the proposition 3 are satisfied, meaning that the principal is sufficiently efficient to persuade the uninformed agent to follow her recommendation, there is an equilibrium multiplicity under delegation. We adopt the idea that the principal's preferred equilibrium is played. Next Corollary is a direct consequence of Propositions 2 and 3 and finds a condition under which rubber stamp always outperforms babbling equilibrium under delegation.

Corollary 1: *If* $\frac{2(1-\beta)\beta c_P(1-p)^2 w}{2c_P(\beta-p)+(1-\beta)^2p^2w} \leq \hat{c}_p$ *for all* $c_p \in [(1-\beta)pw, \bar{c}_p]$*, then we know that, in the region defined in proposition 3 where delegation is the optimal organizational structure, a babbling equilibrium dominates the rubber stamp equilibrium for the principal, hence multiplicity has no bite and rubberstamp equilibrium is the unique optimal equilibrium.* The corollary uses proposition 2 and 3 in order to eliminate the possibility of multiplicity in the rubber stamp region for delegation. This does not affect the optimality of delegation but the equilibrium selection under delegation, which we assume as the principal-optimal one.

Finally, we consider the region where centralisation and rubber stamp arises. Suppose, next, that $c_A \leq \hat{c}_A$ and $c_P > \hat{c}_P$: thus, the only equilibrium under delegation is a babbling one, whereas the agent is efficient enough to support a rubber stamp (or persuasive) equilibrium under centralization. The next proposition shows that the principal prefers to delegate whenever the agent is sufficiently efficient.

Proposition 4: *Assume* $c_P > \hat{c}_P$ *and* $c_A \leq \hat{c}_A$*. Then, delegation without rubberstamp dominates centralization with rubberstamp whenever* $c_A < 2(1-\beta)(1-p)w$*, and whenever*

$c_A \in [2(1-\beta)(1-p)w, 3(1-\beta)(1-p)w]$, *and:*

$$c_P > \frac{2(1-\beta)^2\beta(1-p)^3w^3}{c_A(3(1-\beta)(1-p)w - c_A)}, \tag{4.2}$$

and otherwise centralization with rubberstamp dominates.

Indeed, when $b - 2p + bp > 0$, then we have $2(1-\beta)(1-p)w > \bar{c}_A$ and hence centralisation is optimal in all of the region in proposition 4.

Even though under centralization the agent exerts enough effort to make a convincing recommendation, the principal may prefer to delegate. This is only because by delegating, the principal cuts off the possibility that she will exert effort, which in turn increases the agent's incentives to exert effort. The comparison of the principal's expected payoffs under both regimes reveals that she prefers centralisation if:

$$\frac{(1-p)(1-\beta)w}{c_A}(3 - e_p) < 1$$

First, delegation is optimal if the agent is very efficient, no matter what c_p is ($c_A < 2(1-\beta)(1-p)w$). Second, if the agent is not so efficient, delegation is still optimal for high enough c_p. The benefit of decentralisation is to increase the agent's effort, while the cost of decentralisation is that the principal no longer has the option to influence the decision which would increase her payoff in the event that agent didn't have information.

In terms of the comparative statics, the derivative of the RHS of 4.2 with respect to c_A is

$$\frac{2(1-\beta)^2\beta(1-p)^3w^2(2c_A - 3(1-\beta)(1-p)w)}{c_A^2(c_A - 3(1-\beta)(1-p)w)^2}.$$

It is easy to see that the derivative is positive if and only if $c_A > \frac{3}{2}(1-\beta)(1-p)w$. Hence, the threshold for c_P below which the principal prefers to delegate increases in c_A when $c_A > \frac{3}{2}(1-\beta)(1-p)w$. Indeed, this threshold is defined for $c_A > 2(1-p)(1-\beta)w$: as otherwise the agent is so efficient that the principal prefers to delegate no matter what is c_p, we see that the threshold has to increase in c_A. To understand the intuition, consider an increase in c_A. As the agent becomes less efficient (while still maintaining the necessary level to provide a persuasive recommendation to the principal), a slight decrease in the efficiency of the principal can still rationalize centralization.

5 Extensions

5.1 Generalizing preferences

Consider the following state- and project-contingent payoff matrix where the first entry is the agent's payoff:

	$\theta = a$	$\theta = b$
$\omega = 1$	u_1, v_1	u_2, v_2
$\omega = 2$	u_3, v_3	u_4, v_4

As before, we assume a common prior on the state space where each player assigns probability p to the state $\omega = 1$. Whenever:

$$u_1 > u_2, v_1 > v_2, \text{ and } u_4 > u_3, v_4 > v_3$$

the condition for the uninformed agent to prefer a over b is

$$pu_1 + (1-p)u_3 > pu_2 + (1-p)u_4,$$

and the condition for the uninformed principal to prefer b over a is

$$(1-p)v_4 + pv_2 > (1-p)v_3 + pv_1.$$

Hence, the agent has a threshold $\hat{p}$ below which he will choose project b and the principal has a threshold $\tilde{p}$ above which he will choose project a. We have: $\tilde{p} > \hat{p}$, and $p \in [\hat{p}, \tilde{p}]$ in which case, given the prior beliefs, the players disagree on the optimal project.

The principal benefits from agent's effort, if there is a possibility that the agent affects the final decision. Also with those general preferences, whenever the agent inefficient, his messages are not credible and the principal ignores the agent's recommendations under centralization. Thus, the only way to induce agent's effort is to delegate the decision. As the next proposition shows, delegating the decision does not need to lead to the loss of principal's control as the principal retains the real authority under delegation.

Proposition 6: *If the principal is sufficiently efficient, namely:*

$$c_P < \frac{p^2(u_1-u_2)(v_1-v_2)}{c_A(p(u_1-u_2)-(1-p)(u_4-u_3))}(c_A-(1-p)(u_4-u_3)),$$

then there exists an equilibrium with rubberstamp under delegation in which the agent exerts effort $e_A = \frac{p(u_1-u_2)(c_P-p(v_1-v_2))}{c_Ac_P-p^2(u_1-u_2)(v_1-v_2)}$ *and follows the principal's recommendation if unable to obtain an informative signal.*

We have the following observations. First, for any given efficiency of the agent, the principal's constraint is relaxed, the larger is $v_1 - v_2$. To see why, notice, first, that the players' best response functions at the effort stage are

$$e_A(e_P) = \frac{(1-e_P)p(u_1-u_2)}{c_A}, \; e_P(e_A) = \frac{(1-e_A)p(v_1-v_2)}{c_P}.$$

Thus, the higher is $(v_1 - v_2)$, the larger is the principal's effort to obtain an informative signal. Intuitively, the principal's default option, is uninformed, is to choose project b. Thus, the costs of being uninformed are increasing in $v_1 - v_2$. Therefore, the value of principal's information increases in payoff from project a relative to project b is state $\omega = 1$. Given this incentive, even for a larger c_P the agent can be still persuaded to follow the recommendation if $v_1 - 2v_2$ is sufficiently high.

The second observation is that, given that $c_A > (1-p)(u_4 - u_3)$, the threshold for c_P in $(u_1 - u_2)$. To see this, note that

$$\frac{\partial \frac{p^2(u_1-u_2)(v_1-v_2)}{c_A(p(u_1-u_2)-(1-p)(u_4-u_3))}}{\partial(u_1-u_2)} = -\frac{(1-p)p^2(u_4-u_3)(v_1-v_2)}{c_A(p(u_4-u_3+u_1-u_2)-(u_4-u_3))^2} < 0.$$

Having fixed the principal's payoff function, the increase in $(u_1 - u_2)$ means that the default option of the uninformed agent, namely to choose project a, gets more attractive. In order for the principal to persuade the uninformed agent with her recommendation, the principal has to exert higher effort which happens if the principal's efficiency is sufficiently high. Thus, the principal's threshold in terms of c_P decreases as $(u_1 - u_2)$ increases.

5.2 Sequential information acquisition

We now extend our model to sequential information acquisition and communication. Under centralization the principal chooses which project to implement. Prior to the principal's project choice, the agent can acquire a signal and communicate to the principal using cheap talk messages. Then, the principal decides whether to exert effort and subsequently chooses a project. Under delegation the agent has authority over the project choice, and the sequence of moves is reversed relative to centralization: under delegation, first, the principal exerts effort and communicates her research findings to the agent using cheap-talk messages. Then, the agent decides whether to exert effort and subsequently chooses one of the projects.

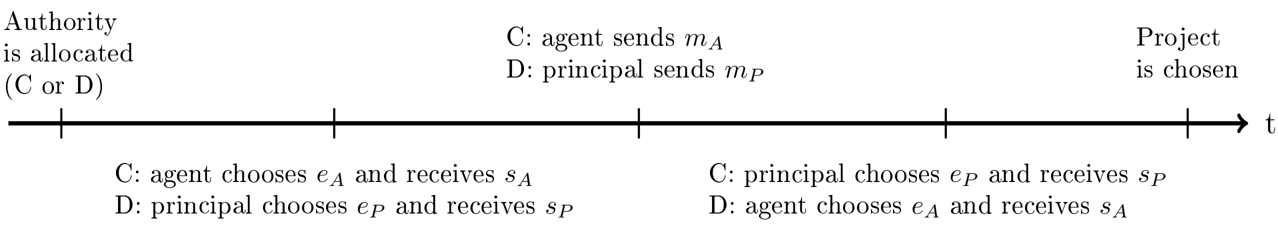


Figure 2: Timing of Events

We noted in the description of the main model that the simultaneous effort assumption is justified in a particular institutional setting where, for example, research has to be completed simultaneously. Relaxing this assumption, sequentiality becomes a feature of equilibrium: when the principal holds decision making power, given that effort is unobservable, it is optimal for her to wait before the agent communicates and reversely, when the agent holds decision making power it is optimal for him to wait for the principal's communication before deciding on effort himself.

The next proposition shows that there exists a truthful equilibrium under both organizational forms.

Proposition 7: *There exists an equilibrium in which the principal reveals his signal under delegation if*

$$c_P \leq \frac{pw(1-\beta)}{1-\frac{(1-\beta)(1-p)}{\beta p}} := \bar{c}_p.$$

Further, there exists an equilibrium where the agent reveals his signal under centralization if

$$c_a \leq \frac{(1-\beta)\beta(1-p)^2 w}{\beta - p} := \bar{c}_a.$$

To understand the proposition, notice that the sender could only have an incentive to misinform the receiver if the sender is uninformed. Thus, the rationale to reveal the absence of the informative signal is to incentivize high effort by the receiver – who is the actual decision-maker under the respective organizational form – in order to obtain an informative signal. This motive, of course, is absent if the efforts are exerted simultaneously, and therefore complete truthtelling is non-existent with simultaneous efforts, as Proposition 1 showed.

The next proposition shows conditions for the existence of rubberstamp equilibria under both organizational forms. The communication strategy of a sender in rubberstamp equilibria is the same as before - the sender wither informs the decision-maker whether the signal indicates that the optimal project is the receiver's most preferred project, or sends a recommendation to pick the sender's ex ante preferred project otherwise. Denote by $(e_A^{d,r}, e_A^{d,r})$ the agent's and principal's efforts in the rubberstamp equilibrium under delegation and by $(e_A^{c,r}, e_P^{c,r})$ the agent's and principal's efforts in the rubberstamp equilibrium under centralization.

Proposition 8: *There exists an equilibrium with rubberstamp under delegation if*

$$c_P \leq \frac{p^2(1-\beta)(1-e_A^{d,r})\beta w}{\beta + p - 1} := \hat{c}_p$$

where $e_A^{d,r} = \frac{\beta \bar{p}_A w}{c_A}$ *where* $\bar{p}_A = \frac{p(1-e_P)}{1-pe_P}$ *is the agent's posterior that the principal is informed when recommending her ex ante preferred project, and* $e_P^{d,r} = \frac{(1-\beta)pw(1-e_A^{d,r})}{c_P}$. *Further, there exists an equilibrium with rubberstamp under centralization if*

$$c_a \leq \frac{w(1-p)(1-\beta)(1-e_P^{c,r})}{1-\frac{p(1-\beta)}{(1-p)\beta}} := \hat{c}_a$$

where $e_P^{d,r} = \frac{(1-\bar{p})\beta w}{c_P}$ *where* $\bar{p} = \frac{p}{pe_A + (1-e_A)}$ *is the principal's posterior that the agent is informed when recommending her ex ante preferred project, and* $e_A^{c,r} = \frac{(1-\beta)(1-p)w(1-e_P^{c,r})}{c_A}$.

Intuitively, a sender who exerts effort prior to sending a recommendation has to be efficient enough to persuade the decision-maker to follow their recommendation in case the decision-maker remains uninformed. We next characterize the optimal allocation of authority in the region $c_A \leq c_A \leq \bar{c}_A$, which is the truthful region for both sides. The next proposition shows that within this truthful region $[(1-\beta)pw, \bar{c}_p] \times [(1-p)(1-\beta)w, \bar{c}_a]$ there is a continuous and convex function lying between the "corners" of the truthful region $((1-\beta)pw, \bar{c}_a)$ and $((1-p)(1-\beta)w, \bar{c}_p)$ such that above this curve centralization with truthful communication dominates decentralization with truthful communication.

Proposition 9: *In case of truth-telling arising under both regimes, centralization dominates delegation whenever either* c_A, c_P, *or both, are sufficiently high, namely if*

$$c_p\Big[c_a(\beta - p) + (1-\beta)\beta(2p-1)w\Big] \geq (1-\beta)^2\beta w^2 p^3.$$

Moreover, when $c_A = c_A^{min}$ *or* $c^P = c_P^{min}$ *delegation dominates centralization, while when either* $c^A = \bar{c}^A$ *and* $c^p > c_P^{min}$ *or* $c^P = \bar{c}^P$ *and* $c_A > c_A^{min}$ *centralization dominates delegation.*[4]

Since truthful communication can be sustained under both regimes, the principal's choice of the authority allocation is affected by the effort provision. If the agent is very efficient, it means his cost are very close to the lowest possible costs, c_A^{min}, then the principal wants to delegate as she assigns a high likelihood to the agent obtaining a signal if the principal fails

[4]As shown in the proof, this is a sufficient condition although not necessary. Hence, there is possibly a larger set of parameters for which centralization dominates delegation.

to do so. In case the agent remains uninformed, he chooses his best action which is different to the principal's best choice. However, for a very efficient agent, the high effort provided under delegation outweighs the losses from loosing the decision-making authority. This result clearly resonates with the main insight from the literature following Aghion and Tirole (1997) where being in charge motivates effort. On the other hand, if the agent gets less efficient, the principal better centralizes – which is exactly the sufficient condition in Proposition 2. In this case, the effect coming from the loss of authority dominates the higher effort of the agent under delegation.

Notice that Proposition 9 does not fully answer the question of optimality of authority allocation – this is because rubberstamp equilibria might exist in the truthful region. In the next step we show the existence conditions of the rubberstamp equilibria under both regimes within the truthful region. Notice that the necessary conditions for these regions to exist are $\beta - p > 0$ and $\beta + p - 1 > 0$ (since otherwise $\bar{c}_A \leq 0$ and $\bar{c}_P \leq 0$) and are indeed satisfied by our initial assumptions.

Proposition 10: *Rubberstamp equilibria exist under following conditions:*

1. *The rubberstamp equilibrium under delegation exists if for* $c_P \leq \hat{c}_P$

$$c_a(\beta p^2(1-\beta)w - c_p(\beta + p - 1)) \geq (1-\beta)^2\beta^2 p^2 w^2.$$

2. *Moreover, the rubberstamp equilibrium under centralization exists if for* $c_A \leq \hat{c}_A$

$$c_p((1-\beta)\beta(1-p)^2 w - (\beta - p)c_a) \geq (1-\beta)^2\beta^2(1-p)^2 w^2.$$

In addition, from the above we can find a minimum c_a for delegation with rubberstamp to exist, which is $c_a(min) = \frac{\beta^2 wp}{(1-p)}$, while the minimum c_p above which centralization with rubberstamp exists is given by $c_p(min) = \frac{\beta^2(1-p)w}{p}$. This means, if $c_a(min) > \bar{c}_a$, then the region of delegation with rubberstamp is outside the truth-telling region, and similarly if $c_p(min) > \bar{c}_p$, the region of centralization with rubberstamp is outside the truth-telling region.

The result in Proposition 10 is intuitive. Consider, for example, the region where delegation with rubberstamp exists. There, the condition is that the principal has to be very efficient. As a result, once the agent receives principal's recommendation to follow the principal's preferred project, he must assign a sufficiently high posterior to the principal being informed in order to follow the recommendation. If the principal is less efficient, she is not able to persuade the agent. The logic is similar for the region where the rubberstamp exists under centralization.

Proposition 10 only establishes the existence of rubberstamp equilibria. We now turn to the optimality of equilibria. The next proposition characterizes the condition under which decentralization with rubberstamp dominates centralization with truthful communication.

Proposition 11: *Decentralization with rubberstamp dominates centralization with truth-telling if and only if for all* $c_p \leq \bar{c}_p$

$$c_a \leq \frac{pw(\beta(3-2p)+p-1)}{2(1-p)}.$$

Once both equilibria exist, Proposition 11 reveals the sufficient condition for the decentralization wit rubberstamp to outperform centralization with truthful communication: the agent has to be sufficiently efficient. The existence condition in Proposition 10 has already established the prerequisite for the principal who has to be sufficiently efficient; Proposition 11 highlights that the agent has to be sufficiently efficient as well. Then, the principal can both be able to incentivize the agent to exert high effort and to persuade the agent to follow her recommendation in case he does not receive an informative signal.

6 Conclusions

This paper shows how the differences in ability to access information within an organization affects the allocation of authority. In general, our results suggest that a less efficient party should be endowed with decision making power while a more efficient party can maintain real authority in form of a persuasive recommendation. The latter comes in form of a recommendation which the less efficient party rubberstamps, if uninformed. Crucially, the disagreement between the parties exists only in the absence of decision-relevant information. As a result, a sufficiently efficient principal optimally delegates to a less efficient agent, providing stronger incentives for the agent to work harder while still being able to persuade the agent to take the principal's most preferred action.

As we show, the idea that the presence of soft information favors delegation (Dessein, 2002) need not be true even if a conflict of interest is substantial. In fact, we show that it is precisely the presence of soft information that encourages centralization when the agent is sufficiently efficient and provides a principal with a credible recommendation. The recommendation leaves the principal unsure as to whether the agent is informed. An efficient agent is able to provide a credible recommendation meaning that the principal is sufficiently convinced that it is based on information rather than purely on the agent's preference.

Our results also suggest that some communication only happens between a principal and agent who are sufficiently different in terms of their ability to get information. This is because, given the substitutability of efforts, when the two parties are sufficiently similar in their efficiencies, neither of the two alone is exerting sufficiently high effort to make a persuasive recommendation. Hence, in that case, we have that the principal decentralises whenever the agent is sufficiently efficient and centralises when the agent is inefficient.

Our results have important implications for the design of organizations in sectors where multiple members of management are actively involved in obtaining decision-relevant information. Further, this is likely to happen in smaller firms where the managerial attention is not absorbed by managing complex organizational processes so that the manager is involved in information production.

It will be interesting to empirically test our main predictions. There is an emerging literature emphasizing a positive relation between the quality of the organizational human capital and delegation (e.g. Bloom, Sadun, and Van Reenen (2012)). Our results suggest to have a closer look at the relative qualifications within manager-subordinate relationships. We hypothesize that if the manager is sufficiently qualified and invests time in research, she is able to provide a credible recommendation to her subordinates and is therefore more likely to delegate decisions.

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7 Appendix

Proof Proposition 1: Suppose, first, that the agent chooses θ and the principal's signal is $s_p = \emptyset$. First, consider her deviation to $m = a$. Then, conditional on $\omega = a$ the principal does not strictly benefit as the agent would have chosen a anyway. Conditional on $\omega = b$, the principal does not deviate either since the project and the state would be mismatched.

Suppose, next, deviation to $m = b$. Conditional on $\omega = a$, the deviation payoff is 0 whereas conditional on $\omega = b$, the deviation payoff is βw instead of 0. Thus, the incentive constraint preventing deviation from the principal's truthful communication is

$$p(1-e_A)(1-\beta)w + (1-p)(1-e_A)0 \geq p(1-e_A)0 + (1-p)(1-e_A)\beta w$$

implying

$$p \geq \beta.$$

However, since per assumption $\beta > p$, there cannot be truthtelling equilibrium under delegation. The case for centralization is similar.
Q.E.D.

Proof of Proposition 2: First, the delegation payoff of the principal is given by:

$$\frac{(1-p)(1-\beta)w}{c_A}\Big(p(1-\beta)w + (1-p)\beta w\Big) + \Big(1 - \frac{(1-p)(1-\beta)w}{c_A}\Big)p(1-\beta)w$$

which simplifies to:

$$\frac{(1-p)^2(1-\beta)\beta w^2}{c_A} + p(1-\beta)w = X$$

The centralization payoff of the principal is given by:

$$\frac{(1-\beta)pw}{c_P}\Big(p(1-\beta)w\Big) + \beta(1-p)w - \frac{((1-\beta)pw)^2}{2c_P}$$

which simplifies to:

$$\frac{(1-\beta)^2p^2w^2}{2c^p} + \beta(1-p)w = Y$$

Now, the difference between delegation and centralization payoff X_Y is:

$$2c_Ac_P(-\beta+p) + (1-\beta)(2\beta c_P(p-1)^2 - (1-\beta)c_Ap^2)w$$

we check that the above is decreasing in c_A, and it is increasing in c_P for small enough c_A, but it is decreasing in c_P for high enough c_A.

The condition for delegation to dominate is:

$$c_A \leq \frac{2(1-\beta)\beta c_P(1-p)^2 w}{2c_P(\beta-p) + (1-\beta)^2p^2w}.$$

Q.E.D.

Proof of Proposition 3: Let's check the principal's payoff in centralization in the delegation with rubberstamp area when the agent doesn't exert any effort:

$$\beta(1-p)w + (1-\beta)pwe_P - \frac{e_P^2}{2}c_P$$

where $e_P = \frac{(1-\beta)pw}{c_P}$.

The principal's payoff under delegation with rubberstamp is:

$$(1-p)\beta w + (e_P + (1-e_P)e_A)p(1-\beta)w - \frac{e_P^2}{2}c_P$$

Now, we see that the only difference in the payoff functions is $(1-e_P)e_A p(1-\beta)w$ which is added in the delegation with rubberstamp. As the principal could replicate the same effort in delegation with rubberstamp as in centralization, it is easy to see that delegation with rubberstamp is strictly better than centralization.

Q.E.D.

Proposition 4: First, let us calculate the principal's payoff under centralization with rubberstamp:

$$p(1-\beta)w + (e_P + (1-e_P)e_A)(1-p)\beta w - \frac{e_P^2}{2}c_P \tag{7.1}$$

where

$$\tilde{p} = \frac{p}{1-e_A(1-p)}$$

Then we get the principal's effort:

$$e_P = \frac{(1-p)\beta w(1-e_A)}{c_P} \tag{7.2}$$

Now, making use of these, the payoff simplifies to:

$$p(1-\beta)w + (1-p)\beta w(e_A + \frac{e_P(1-e_A)}{2}) \tag{7.3}$$

The payoff of principal under delegation and no rubberstamp:

$$p(1-\beta)w + e_A(1-p)\beta w \tag{7.4}$$

where:

$$e_A = \frac{(1-p)(1-e_P)(1-\beta)w}{c_A}$$

Now the condition for centralization with rubberstamp to dominate delegation becomes:

$$e_A^c r + \frac{e_P^c r(1-e_A^c r)}{2} \geq e_A^d \tag{7.5}$$

which further simplifies to:

$$\frac{(1-p)(1-\beta)w(1-e_P)}{c_A}(1-\frac{e_P}{2}) + \frac{e_P}{2} \geq \frac{(1-p)(1-\beta)w}{c_A}$$

where now e_P denotes the effort in centralization. This further simplifies to:

$$\frac{e_P}{2} - \frac{(1-p)(1-\beta)w}{c_A}(\frac{3}{2}e_P - \frac{e_P^2}{2}) \geq 0$$

simplified by e_P and $1/2$, we get:

$$\frac{(1-p)(1-\beta)w}{c_A}(3-e_P) \leq 1$$

this is going to be satisfied for e_P and c_A large enough, which is equivalent to large enough c_A and low enough c_P. This condition is equivalent to:

$$e_P \geq 3 - \frac{c_A}{(1-p)(1-\beta)w}$$

When $c_A > 3(1-\beta)(1-p)w$, then for any c_P, centralization with rubberstamp dominates delegation. Realize that in this case, the above is satisfied for any $e_P \geq 0$.

Plus whenever $c_A < 2(1-p)(1-\beta)w$, the condition can never be satisfied, given that $e_P \leq 1$, and in that case, Delegation is optimal for any c_P.

Now, we find the threshold for c_P for $2(1-p)(1-\beta)w \leq c_A \leq 3(1-p)(1-\beta)w$.

When we replace the e_P in centralization rubberstamp, we get:

$$c_P \leq \frac{2(1-\beta)^2\beta(1-p)^3w^3}{c_A(3(1-\beta)(1-p)w - c_A)} \tag{7.6}$$

for the centralization with rubberstamp to dominate delegation with no rubberstamp.

In addition, given that we are not in the delegation with rubberstamp region, we have:

$$c_P > \frac{p^2(1-\beta)\beta w(c_A - (1-p)(1-\beta)w)}{c_A(p+\beta-1)} = \frac{p^2(1-\beta)\beta w}{p+\beta-1}\Big(1 - \frac{(1-p)(1-\beta)w}{c_A}\Big) := \hat{c}_P \tag{7.7}$$

Hence, it must be that:

$$\hat{c}_P < c_P < \frac{2(1-\beta)^2\beta(1-p)^3w^3}{c_A(3(1-\beta)(1-p)w - c_A)} \tag{7.8}$$

or:

$$c_A > 3(1-\beta)(1-p)w \tag{7.9}$$

For centralization with rubberstamp to be optimal and delegation is optimal otherwise.

Q.E.D.

Proof of Proposition 5: Suppose that in equilibrium with rubberstamp the principal deviates at the effort stage and exerts the same effort as under centralization without rubberstamp, while the agent still maintains his equilibrium beliefs about the principal's beliefs and choices. Then, the rubberstamp case dominates the case without rubberstamp if

$$e_A(1-p)\beta w + (1 - e_A(1-p))\bar{p}(1-\beta)w > (1-p)\beta w,$$

where e_A is the agent's effort under centralization with rubberstamp. Given the definition of $\bar{p}$ from 3.3.1, the above inequality can be rewritten as

$$e_A > \frac{\beta - p}{\beta(1-p)}$$

which is exactly the condition for the rubberstamp equilibrium to exist. Thus, the principal's equilibrium payoff without rubberstamp can never dominate her equilibrium payoff with rubberstamp.

Q.E.D.

Proof of Proposition 6: Denote by (e_P, e_A) the principal's and agent's efforts under delegation with rubberstamp. In the rubberstamp equilibrium, the principal's communication strategy is either to reveal $\omega = 1$ to the agent, or to recommend the agent to choose project b.

Upon receiving the latter, the agent assigns probability $\bar{p} = \frac{1-p}{1-e_p p}$ to the principal being informed that $\omega = 2$. At the effort stage, the agent chooses e_A to maximize

$$e_A(pu_1 + (1-p)u_4) + (1-e_A)(e_P p u_1 + (1 - e_P p)(\bar{p}u_4 + (1-\bar{p})u_2)) - c_A\frac{e_A^2}{2},$$

and the principal chooses e_P to maximize

$$e_P(pv_1 + (1-p)v_4) + (1-e_P)(e_A(pv_1 + (1-p)v_4) + (1-e_A)((1-p)v_4 + pv_2)) - c_a\frac{e_P^2}{c_P}.$$

The equilibrium efforts are

$$e_P^* = \frac{p(c_A - p(u_1 - u_2))(v_1 - v_2)}{c_A c_P - p^2(u_1 - u_2)(v_1 - v_2)}, \; e_A^* = \frac{p(u_1 - u_2)(c_P - p(v_1 - v_2))}{c_A c_P - p^2(u_1 - u_2)(v_1 - v_2)}.$$

The condition for a persuasive recommendation is

$$\bar{p}u_4 + (1 - \bar{p})u_2 \geq \bar{p}u_3 + (1 - \bar{p})u_1.$$

Using e_P^*, this condition can be written as

$$c_P < \frac{p^2(u_1 - u_2)(v_1 - v_2)}{c_A(p(u_1 - u_2) - (1 - p)(u_4 - u_3))}(c_A - (1 - p)(u_4 - u_3)).$$

Proof of Proposition 7: Consider, first, the truthful communication under delegation. In particular, consider a strategy profile in which the principal truthfully reveals her signal to the agent before the agent exerts effort and chooses which project to implement. Given the congruence of players' interests conditional on information received, the agent follows principal's recommendation. If the principal is uninformed, then the agent chooses effort to maximize his expected payoff

$$e_A\Big[p\beta w + (1 - p)(1 - \beta)w\Big] + (1 - e_A)p\beta w - \frac{(e_A)^2}{2}c_A$$

resulting in

$$e_A^{d,t} = \frac{(1 - \beta)(1 - p)w}{c_A}. \tag{7.10}$$

The level of the optimal effort is intuitive. Without any information the agent chooses project a and receives the payoff $p\beta w$. If the agent were perfectly informed, the expected payoff (without information acquisition costs) is $p\beta w + (1 - p)(1 - \beta)w$. Thus, the higher is the payoff difference, $(1 - p)(1 - \beta)w$, the higher is the value of information and therefore the higher is the optimal level of effort for any given costs of effort.

The principal anticipates the agent's best response (3.6) and chooses her effort to maximize

$$e_P\Big[p(1 - \beta)w + (1 - p)\beta w\Big] + (1 - e_P)\Big[p(1 - \beta)w + (1 - p)e_A^{d,t}\beta w\Big] - \frac{(e_P)^2}{2}c_P,$$

resulting in

$$e_P^{d,t} = \frac{\beta(1 - e_A^{d,t})(1 - p)w}{c_P}.$$

Consider, now, the principal's incentives at the communication stage in case she receives an uninformative signal. If she reveals her signal truthfully, her expected payoff is

$$e_A^{d,t}\Big[p(1-\beta)w+(1-p)\beta w\Big]+(1-e_A^{d,t})p(1-\beta)w.$$

If she deviates and informs the agent that her signal is b (which is her best deviation conditional on being uninformed), and the agent believes that communication is truthful, she expects the agent to choose b resulting in her expected payoff $(1-p)\beta w$. Thus, the does not deviate for

$$c_a \leq \frac{(1-\beta)\beta(1-p)^2 w}{\beta-p} := \overline{c}_a. \tag{7.11}$$

Intuitively, the agent has to be sufficiently efficient in order to induce truthful revelation by the principal. If this is the case, the principal anticipates that, if uninformed, the agent puts high effort to obtain a signal. Notice that (3.7) is parallel to the condition (3.3): both conditions imply that a player in charge of the final decision, if sufficiently efficient, correctly anticipates that they will receive truthful information from the other player. In this case the principal's expected payoff is

$$p(1-\beta)w+(1-p)\beta w(e_P^{d,t}+(1-e_P^{d,t})e_A^{d,t})-\frac{(e_P^{d,t})^2}{2}c_P. \tag{7.12}$$

Next, consider truthful communication under centralization. In this case, if the agent reveals to the principal that he hasn't obtained an informative signal, the principal chooses effort to maximize

$$e_P[p(1-\beta)w+(1-p)\beta w]+(1-e_P)(1-p)\beta w-\frac{(e_P)^2}{2}c_p, \tag{7.13}$$

where e_P denotes principal's effort. As the objective (3.1) is concave in e_P, we can use the first-order approach to obtain the principal's optimal choice, that is

$$e_P^{c,t}=\frac{(1-\beta)pw}{c_P}. \tag{7.14}$$

Intuitively, the principal's consideration at the effort stage goes as follows. If she does not obtain an informative signal, she chooses $\theta=b$ and her expected payoff is $(1-p)\beta w$. If, however, she obtains a perfectly revealing signal, then her expected payoff is $p(1-\beta)w+(1-p)\beta w$. Thus, the higher is the difference in payoffs, $(1-\beta)pw$, the higher is the value of information for the principal and, therefore, the higher is her effort.

Now, consider the agent's consideration at the communication stage. If the agent does not transmit an informative signal to the principal, then with probability $1-e_P^{c,t}$ the principal remains uninformed and chooses project b whereas the agent prefers a. On the other hand, if the agent misinforms the principal that the optimal project is a, then she prevents the possibility of a principal obtaining a signal valuable in case the optimal project is b. Therefore, conditional on no signal received, the agent truthfully admits that he is uninformed to the principal if

$$p\beta w \leq e_P^{c,t}\Big[p\beta w + (1-p)(1-\beta)w\Big] + (1-e_P^{c,t})\Big[(1-p)(1-\beta)w\Big]$$

that implies

$$c_P \leq \frac{pw(1-\beta)}{1 - \frac{(1-\beta)(1-p)}{\beta p}} := \bar{c}_p. \tag{7.15}$$

Intuitively, the principal should be efficient enough. This ensures that the agent has no interest in misinforming the principal as he assigns a sufficiently high probability to the principal being able to obtain a perfectly revealing signal. Given that the agent truthfully reveals his signal at the communication stage, he chooses the effort e_A that maximizes

$$e_A\Big[p\beta w + (1-p)(1-\beta)w\Big] + (1-e_A)\Big[(1-p)(1-\beta)w + \hat{e}^* p\beta w\Big] - \frac{(e_A)^2}{2}c_A$$

resulting in

$$e_A^{c,t} = \frac{(1-e_P^{c,t})\beta p w}{c_A}. \tag{7.16}$$

The agent's rationale is similar to the principal's characterized above - the higher is $\beta p w$, the higher is the value of information for the agent and therefore the higher is e_A. The principal's expected payoff is then

$$(1-p)\beta w + (e_A^{c,t} + (1-e_A^{c,t})e_P^{c,t})p(1-\beta)w - (1-e_a)\frac{(e_P^{c,t})^2}{2}c_P.$$

Q.E.D.

Proof of Proposition 8: Consider, first, a situation where the principal exerts effort and then sends a recommendation to the agent who follows it if uninformed. As we show below, the principal's recommendation is persuasive only if she is sufficiently efficient. Moreover, under delegation she can induce the agent to work harder compared to centralization as she uses her first-mover advantage to back-load some effort burden to the agent.

The principal's communication strategy consists of sending one of the two signal-contingent messages in equilibrium. If she receives the signal indicating that the optimal project is a, she perfectly reveals the signal to the agent (who then follows her recommendation): we denote this message by $m'(a)$. For the two other signal realizations she sends a message $m'(b)$. Thus, upon receiving the latter message, the agent does not know whether the principal is uninformed or genuinely informed that the optimal project is b. The agent, then, exerts effort and, if uninformed, follows the principal's recommendation and chooses b.

To understand the incentives behind this strategy profile, we start with the agent's optimal choices. First, whenever the agent receives $m'(b)$, she assigns posterior probability

$$\overline{p}_A = \frac{p(1-e_P)}{1-pe_P} \tag{7.17}$$

to the optimal project being b. The uninformed agent chooses to follow principal's recommendation if $(1-\overline{p}_A)(1-\beta)w \geq \overline{p}_A\beta w$, which implies for the choice of the principal's effort

$$e_P^{d,r} \geq \frac{p-(1-\beta)}{\beta p} \tag{7.18}$$

which means that the principal should have exerted enough effort to induce a sufficiently high agent's belief that the recommendation is based on an informative signal rather than the ex ante preference.

Suppose (3.10) is satisfied. Then, upon receiving the message $m(b)$ the agent chooses his effort optimally, it means to maximize

$$\overline{p}_A\Big[e_A\beta w + (1-e_A)0\Big] + (1-\overline{p}_A)\Big[(1-\beta)w\Big] - \frac{e_A^2}{2}c_A$$

which implies

$$e_A^{d,r} = \frac{\beta\overline{p}_A w}{c_A}.$$

The higher is the agent's payoff from choosing her preferred project, the higher is the value of a signal, and therefore the higher is the agent's effort. Using the agent's posterior (3.9), his effort is

$$e_A^{d,r} = \frac{p(1-e_P)\beta w}{c_A(1-e_P p)}. \tag{7.19}$$

The principal anticipates that if she exerts sufficient effort characterized by (3.10), then the uninformed agent's best-responds with, first, exerting effort to acquire information as specified above. Second, if the agent remains uninformed, he will follow the principal's recommendation. The principal's expected payoff is therefore

$$pe_P(1-\beta)w + p(1-e_P)e_A^{d,r}(1-\beta)w + (1-p)\beta w - \frac{(e_P)^2}{2}c_P.$$

Since her objective is concave in her effort, the unique optimal effort is characterized by

$$e_P^{d,r} = \frac{(1-\beta)(1-e_A^{d,r})pw}{c_P}. \tag{7.20}$$

Since the agent only follows the principal's recommendation if her effort is sufficiently high as shown by (3.10), the prescribed strategy profile is an equilibrium for

$$c_P \leq \frac{p^2(1-\beta)(1-e_A^{d,r})\beta w}{\beta-(1-p)} := \hat{c}_p \tag{7.21}$$

where we combine (3.10) and (3.12). In this case, the principal's expected payoff is

$$(1-p)\beta w + p(1-\beta)w\left[e_P^{d,r} + (1-e_P^{d,r})e_A^{d,r}\right] - \frac{(e_P^{d,r})^2}{2}c_P. \tag{7.22}$$

Consider, second, a strategy profile in which an agent provides a recommendation to the principal, and the principal follows it *if* she does not obtain an informative signal. In other words, the principal rubberstamps the agent's recommendation. Think of an agent's communication strategy that uses one of two signal-contingent messages. If the agent receives a signal indicating that the optimal project is b, he discloses his finding to the principal sending $m = b$. Otherwise he recommends the principal to choose project a: we denote the corresponding message by $m = a$. Thus, upon receiving the second message the principal cannot distinguish whether the agent is uninformed or is genuinely informed that the optimal project is a. When will the principal follow this recommendation, it means, choose $\theta = a$ if she does not receive any informative signal?

To see this, first, notice that given the effort choice of the agent, e_A, the principal's posterior upon receiving $m = a$ assigns probability $\frac{p}{pe_A+(1-e_A)} := \overline{p}$ to the agent being informed that the optimal project is a. Given her posterior $\overline{p}$, the principal chooses effort to maximize

$$e_P\Big(\overline{p}(1-\beta)w + (1-\overline{p})\beta w\Big) + (1-e_P)\overline{p}(1-\beta)w - \frac{(e_P)^2}{2}c_P$$

resulting in

$$e_P^{c,r} = \frac{(1-\overline{p})\beta w}{c_P}. \tag{7.23}$$

Given the specified communication strategy and the principal's best response (3.5), the agent maximizes his expected payoff which results in the following optimal choice of his effort:

$$e_A^{c,r} = \frac{(1-\beta)(1-e_P^{c,r})(1-p)w}{c_A}.$$

The principal rubberstamps after receiving message $m = a$ if $\overline{p}(1-\beta)w \geq (1-\overline{p})\beta w$. This implies that the principal rubberstamps if $e_A^{c,r} \geq 1 - \frac{p}{1-p}\frac{(1-\beta)}{\beta}$, which implies

$$c_a \leq \frac{w(1-p)(1-\beta)(1-e_P^*)}{1-\frac{p(1-\beta)}{(1-p)\beta}} := \hat{c}_a.$$

Intuitively, the principal rubberstamps if the agent is sufficiently efficient as in this case she assigns high enough posterior probability to the optimal project being a conditional on the message $m = a$. Notice that although the principal assigns sufficiently high belief to the agent being informed, she nonetheless exerts effort and tries to obtain an informative signal herself. This is because, conditional on the agent being uninformed, there is a disagreement on the preferred project. If the principal remains uninformed after exerting her effort, her best response is to follow the agent's recommendation. In this case, the principal's expected payoff (given that the probability of the message m_b is $e_a(1-p)$) is:

$$p(1-\beta)w + \beta w(1-p)(e_A^{c,r} + e_P^{c,r}(1-e_A^{c,r})) - (1-e_a(1-p))\frac{(e_P^{c,r})^2}{2}c_P.$$

Q.E.D.

Proof of Proposition 9: Consider the following scenario: the principal centralizes and commits to exert effort $e_p = \frac{(1-\beta)pw}{c_P}$ independent of the agents' message. Think of an equilibrium where the agent reports his signal truthfully. Then, it is easy to show that the agent's effort is $e_A = \frac{(1-e_P)\beta pw}{c_A}$ and therefore the principal's expected payoff is

$$(1-p)\beta w + (e_A + (1-e_A)e_P)p(1-\beta)w - \frac{(e_P)^2}{2}c_P.$$

Notice that the difference to the principal's expected payoff under centralization with truthftelling and without commitment to the case with commitment is that the last term in the former case is $-(1-e_A)\frac{(e_P)^2}{2}c_P$ whereas the last term in the latter case is simply $-\frac{(e_P)^2}{2}c_P$.

In the following we show that in the case with commitment, the principal prefers to centralize instead of decentralize and implement an equilibrium with truthful communication if the following condition is satisfied:

$$c_p\Big[c_a(\beta-p) + (1-\beta)\beta(2p-1)w\Big] \geq (1-\beta)^2\beta w^2 p^3.$$

First, I show that the principal exerts more effort under C with commitment than under D. Using the results of the previous sections we have

$$e_p^d = \frac{\beta w(1-p)(c_a + p + \beta(1-p) - 1)}{c_a c_p},\ e_p^c = \frac{(1-\beta)pw}{c_p}$$

The difference between both efforts is

$$e_p^c - e_p^d = \frac{w(c_A(p-\beta) + (1-\beta)\beta(1-p)^2 w))}{c_A c_P}.$$

which is positive for

$$c_A \leq \frac{(1-\beta)\beta(1-p)^2 w}{\beta - p} = \bar{c}_A$$

and therefore we conclude that $e_p^c \geq e_p^d$. Suppose momentarily that the principal exerts the same effort under C with commitment as under D, and that the agent expects principal's effort to be at the "equilibrium level" as described above. Denote principal's effort under D by $\hat{e}$. Then the difference in principal's payoffs $C - D$ is:

$$(1-p)\beta w\Big[1 - e_a^d(1-\hat{e}) - \hat{e}\Big] - p(1-\beta)w\Big[1 - e_a^c(1-\hat{e}) - \hat{e}\Big]$$

The expression is positive if

$$(\beta - p)(1-\hat{e}) \geq (1-p)\beta e_a^d(1-\hat{e}) - p(1-\beta)e_a^c(1-\hat{e}) \;\Rightarrow$$

$$(\beta - p) \geq (1-p)\beta e_a^d - p(1-\beta)e_a^c \;\Rightarrow$$

$$\beta - p + p\beta e_a^d + p e_a^c \geq \beta e_a^d + p\beta e_a^c \;\Rightarrow$$

$$\beta(1 + p e_a^d - e_a^d) \geq p(1 + \beta e_a^c - e_a^c) \;\Rightarrow$$

$$\beta(1 - e_a^d(1-p)) \geq p(1 - e_a^c(1-\beta))$$

Rewriting the above inequality while using $e_a^c = \frac{\beta p w(c_P - (1-\beta)pw)}{c_a c_p}$ and $e_a^d = \frac{(1-\beta)(1-p)w}{c_a}$, we get:

$$c_a c_p(\beta - p) + (1-\beta)\beta w(c_p(2p-1) - (1-\beta)p^3 w) \geq 0$$

that can be rewritten as

$$c_p\Big[c_a(\beta - p) + (1-\beta)\beta(2p-1)w\Big] - (1-\beta)^2\beta w^2 p^3 \geq 0. \tag{7.24}$$

Since per assumption $\beta \geq p$ (see model section for the explanation why it is necessary to generate an ex ante conflict of interest) the above inequality is maximized for the largest possible c_a. Use the upper bound $\frac{(1-\beta)\beta(1-p)^2 w}{\beta - p}$ (to check if (5.1) can ever be positive). Then, the inequality becomes:

$$(1-\beta)\beta p^2 w(c_p - (1-\beta)pw) \geq 0$$

that is satisfied for $c_p \geq (1-\beta)pw$. To remind, the truthtelling constraint is

$$c_p \leq \frac{(1-\beta)p^2 w\beta}{\beta+p-1}$$

and so (8) can only be satisfied if

$$\frac{(1-\beta)p^2 w\beta}{\beta+p-1} - (1-\beta)pw \geq 0 \tag{7.25}$$

which is true if

$$\frac{(1-\beta)p(\beta+p(1+\beta)-1)w}{\beta+p-1} \geq 0$$

which is true since we assumed $\beta+p-1 \geq 0$ as otherwise the upper bound for c_p that guarantees truth telling is negative. To summarize, the costs of information acquisition have to be sufficiently high.

In the next part of the proof we show that the condition goes through the points $[c_p^{min}, \bar{c}_A]$ and $[c_A^{min}, \bar{c}_P]$ and it is a convex function of c_P. If we use c_P^{min} where 5.1) is satisfied with equality, then we have

$$c_A = \bar{c}_A.$$

Moreover, if we use c_A^{min} where (5.1) is satisfied with equality, then we have

$$c_P = \bar{c}_P.$$

Moreover, if we write the condition (5.1) with equality and rearrange for c_A, we get:

$$c_A = \frac{(1-\beta)\beta w(-c_P(2p-1)+(1-\beta)p^3 w)}{c_P(\beta-p)}$$

where the first and second derivatives with respect to c_P are:

$$-\frac{(1-\beta)^2\beta p^3 w^2}{c_P^2(\beta-p)} < 0, \quad \frac{2(1-\beta)^2\beta p^3 w^2}{c_P^3(\beta-p)} > 0$$

and therefore the condition is convex in c_P.

Finally, we show that the case with commitment is dominated by the case without commitment. It is easy to see this as the only difference in the expected payoff of the principal is the last cost term such that in case with commitment the costs are higher than without commitment. As a result, if (7.1) is satisfied, then decentralization with truthtelling is dominated by centralization with truthtelling (and without commitment) if the sufficient condition in Proposition 2 is satisfied. However, as this is a sufficient condition, this gives the minimum region of parameters for which centralization is optimal, although there may exist a larger region in which centralization is optimal.

Q.E.D.

Proof of Proposition 10: Part (1).

From 3.2.2 we know that under delegation with rubberstamp:

$$e_A^d = \frac{p(1-e_P^d)\beta w}{c_A(1-e_P^d p)},\ e_P^d = \frac{(1-\beta)(1-e_A^d)pw}{c_P}.$$

Solving the equation

$$e_A^d = \frac{p\beta w\left(1 - \frac{(1-\beta)(1-e_A^d)pw}{c_P}\right)}{c_A\left(1 - \frac{(1-\beta)(1-e_A^d)pw}{c_P}p\right)}$$

we obtain two roots, where the correct root is

$$\frac{1}{2(\beta-1)c_A p^2 w}(c_A\left((\beta-1)p^2 w + c_P\right) + (\beta-1)bp^2w^2) -$$

$$\frac{\sqrt{(c_A\left((\beta-1)p^2w + c_P\right) + (\beta-1)\beta p^2 w^2)^2 - 4(\beta-1)\beta c_A p^3 w^2((\beta-1)pw + c_P)}}{2(\beta-1)c_A p^2 w}.$$

Since in 3.2.2 we obtained that delegation with rubberstamp exists for

$$c_P \leq \hat{c}_P,$$

using the solution for e_A^d in the above inequality yields

$$c_a \geq \frac{(1-\beta)^2\beta^2 p^2}{\beta p^2(1-\beta) - c_P(\beta + p - 1)}.$$

Part (2):

From 3.2.1 we know that under centralization with rubberstamp

$$e_A^c = \frac{(1-\beta)(1-p)(1-e_P^c)w}{c_A},\ e_P^c = \frac{(1-\bar{p})\beta w}{c_P} = \frac{\beta(1-p)(1-e_A^c)w}{c_P - c_P e_A^c(1-p)}$$

and solving the equation

$$e_P^c = \frac{\beta(1-p)\left(1 - \frac{(1-\beta)(1-p)(1-e_P^c)w}{c_A}\right)w}{c_P\left(1 - \frac{(1-\beta)(1-p)(1-e_P^c)w}{c_A}(1-p)\right)}$$

yields the solution:

$$e_P^c = \frac{1}{2(\beta-1)c_P(p-1)^2 w}(cacp + (-1+\beta)(-1+p)^2 w(c_p + \beta w)) -$$

$$\frac{\sqrt{((\beta-1)(p-1)^2 w(\beta w + c_P) + c_A c_P)^2 - 4(\beta-1)\beta c_P(p-1)^3 w^2((\beta-1)(p-1)w - c_A)}}{2(\beta-1)c_P(p-1)^2 w}.$$

Since in 3.2.1 we obtained that centralization with rubberstamp exists for

$$c_A \leq \hat{c}_A,$$

using the solution for e_P^c we obtain the condition for centralization with rubberstamp to exist that is

$$c_a \leq \frac{(1-\beta)\beta(1-p)^2(c_p - (1-\beta)\beta)}{c_P(\beta-p)}.$$

Q.E.D.

Proof of Proposition 11: We can write the payoff of the principal under centralization with truthful communication:

$$(1-p)\beta w + p(1-\beta)w(e_A^{c,t} + (1-e_A^{c,t})e_P^{c,t}) - (1-e_a)\frac{(e_P^{c,t})^2}{2}c_P,$$

when we replace e_p, we get:

$$(1-p)\beta w + p(1-\beta)we_A^{c,t} + (1-e_A^{c,t})\frac{p^2(1-\beta)^2 w^2}{2c_p},$$

$$(1-p)\beta w + p(1-\beta)w(e_A^{c,t} + (1-e_A^{c,t})\frac{e_P^{c,t}}{2})$$

We can write the payoff of the principal under delegation rubberstamp (delegation with rubberstamp):

$$(1-p)\beta w + p(1-\beta)w\Big[e_P^{d,r} + (1-e_P^{d,r})e_A^{d,r}\Big] - \frac{(e_P^{d,r})^2}{2}c_P.$$

when we replace e_p, we get:

$$(1-p)\beta w + p(1-\beta)e_A^{d,r} + (1-e_A^{d,r})^2\frac{(1-\beta)^2p^2w^2}{2c_P}.$$

$$(1-p)\beta w + p(1-\beta)w(e_A^{d,r} + (1-e_A^{d,r})\frac{e_P^{d,r}}{2}).$$

Now, we can rewrite the difference of the payoffs between delegation with rubberstamp and centralization with truthful communication as:

$$p(1-\beta)w(e_A^{d,r} - e_A^{c,t}) + (1-e_A^{d,r})^2\frac{(1-\beta)^2p^2w^2}{2c_P} - (1-e_A^{c,t})\frac{(1-\beta)^2p^2w^2}{2c_P}$$

$$(e_A^{d,r} - e_A^{c,t}) + (1-e_A^{d,r})^2\frac{(1-\beta)pw}{2c_P} - (1-e_A^{c,t})\frac{(1-\beta)pw}{2c_P}$$

$$(e_A^{d,r} - e_A^{c,t}) + \frac{(1-\beta)pw}{2c_P}(e_A^{d,r2} - 2e_A^{d,r} + e_A^{c,t}).$$

Using the efforts and the notation $k = \frac{1-e_p^d}{1-e_p^dp}$ we obtain the condition that delegation with rubberstamp dominates centralization with truthful communication if

$$\frac{\beta pw}{2c_a^2c_p^2}\Big((1-\beta)\beta c_p(kpw)^2 + c_a((1-\beta)pw - 2c_p(1-k))(c_p - (1-\beta)pw)\Big) \geq 0.$$

where the sufficient condition for delegation with rubberstamp to dominate centralization with truthful communication is

$$(1-\beta)pw \geq 2c_p(1-k). \tag{7.26}$$

To see when (6.3) is satisfied, notice that k decreases in e_p^d since

$$\frac{\partial k}{\partial e_p^d} = -\frac{1-p}{(1-pe_p^d)^2} < 0.$$

We now look for the maximal e_p^d so that wherever (6.3) is satisfied for e_p^d, max, then it will be satisfied for all $e_p^d < e_p^d, max$.

Since $e_p^d = \frac{(1-\beta)pw(1-e_a^d)}{c_p}$ and $c_p \geq (1-\beta)pw$, we have $e_p^d, max = 1 - e_a^d$. Further, using is for the e_a^d expression, we get

$$e_a^d = \frac{p\beta w(1-1-e_a^d)}{c_a(1-p(1-e_a^d))}$$

resulting in

$$e_a^d = 1 - \frac{1}{p} + \frac{\beta w}{c_a},$$

so that

$$e_p^d = \frac{1}{p} - \frac{\beta w}{c_a}. \tag{7.27}$$

To ensure that efforts do not exceed 1, we put the constraint

$$c_a \leq \frac{\beta p w}{1-p}.$$

To make sure that $\frac{\beta p w}{1-p} < \bar{c}_a$ we require $(1-p)^3(1-\beta) - p(1-\beta) < 0$ which can be shown to be satisfied, for example, for all $p \geq 1/2$. For the tractability of the argument, we assume from now on $(1-p)^3(1-\beta) - p(1-\beta) < 0$.

Plugging in (6.4) into k, we get

$$k, max = \frac{1}{p} - \frac{c_a(1-p)}{p^2 \beta w}.$$

Now, consider the lowest possible $c_a = \frac{\beta^2 w p}{1-p}$ required for the existence of delegation with rubberstamp. Then, $k, min = \frac{1-\beta}{p}$ and the condition (6.3) becomes

$$(2\beta - 1)(1-\beta)pw > 0$$

which is true since – given our previous assumptions – we require $\beta \geq \frac{1}{2}$.

Now, take $c_a = \bar{c}_a = \frac{(1-p)^2\beta(1-\beta)w}{\beta - p}$. Take the largest $c_p = \bar{c}_p$. Then, condition (6.3) is equivalent to

$$p - \frac{2\beta(1-p)(1-2(1-p)p - \beta + \beta(1-p)p)}{(\beta-p)(\beta+p-1)} \geq 0$$

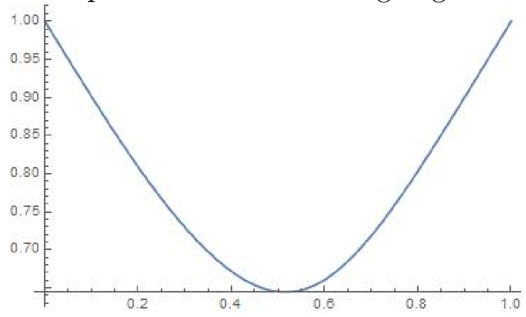
that implies

$$\beta \geq \beta(p)$$

where (obtained with the help of mathematica)

$$\beta(p) = \frac{p(4(p-2)p+5) - \sqrt{(p-2)(p(4p(p(2(p-3)p+7)-5)+9)-2)} - 2}{2p(2(p-2)p+3)-4}$$

and is depicted in the following Figure:



Notice that, as the graph shows, the condition $\beta \geq 1/2$ is satisfied.

What happens if $c_a > \bar{c}_a$? Consider $\bar{c}_p$. Then, the condition (6.3) can be expressed as

$$c_a \leq \hat{c}_a = \frac{pw(\beta(3-2p)+p-1)}{2(1-p)}.$$

To ensure that for $\hat{c}_a > \bar{c}_a$ such that delegation with rubberstamp>centralization with truthful communication is true even when delegation with truthful communication does not exist, we require

$$p(\beta - p)(\beta(3-2p)+p-1) > 2(1-p)^3\beta(1-\beta).$$

But this is exactly the same condition as above, namely

$$\beta(p) = \frac{p(4(p-2)p+5) - \sqrt{(p-2)(p(4p(p(2(p-3)p+7)-5)+9)-2)} - 2}{2p(2(p-2)p+3)-4}. \tag{7.28}$$

Thus, we conclude that if (6.5) is satisfied, then delegation with rubberstamp>centralization with truthful communication for $c_a < \frac{pw(\beta(3-2p)+p-1)}{2(1-p)} > \bar{c}_a$.

Notice that $\beta(p)$ is convex with $\beta(p=0.5) \approx 0.65$ and $\beta(p)=1$. But then, if we draw a line going through the points $[0.5, 0.65]$ and $[1,1]$, then the line has the formula $0.3+0.7p$, and whenever $\beta(p) > 0.3+0.7p$, then the above condition (6.5) is satisfied for $p \geq 1/2$. As a mirror imagine, for $p < 1/2$ the corresponding line is $1-0.7p$.