Transfer of Authority within Hierarchy[1]

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April 13, 2010

[1]I'd like to thank the helpful comments from Guillaume Haeringer, Sjaak Hurkens, Hannes Mueller, Nathanael Vellekoop, as well as the attendants in the workshops in UAB, Tilburg, and ENTER Jamboree. E-mail address: Pinghan.Liang@uab.es.

Abstract

Bureaucracy is featured by vertical hierarchical structure in which the decision maker usually lacks direct access to the informed agent, and the span of discretionary authority decreases top down. In this paper we analyze the performance of delegation mechanism in three-level hierarchies. The decision maker delegates authority to a biased mediator, then the mediator makes further delegation decision. We provide a full characterization of the implemented delegation set. It's shown that the efficiency is attained if and only if the mediator's bias lies between the DM and the sender. On the other hand, given the bias of the mediator, the optimal sender should lie between the mediator and the DM. We also show that under certain conditions that the loyal agent doesn't get promotion, and complete delegation to the mediator may be beneficial if the DM is uncertain about the bias of the sender. We then compare the performance of delegation with communication (mediator cheap talk), and reverse the conclusion in Dessein (2002) that delegation ex ante dominates informative cheap talk and show that the inability to access informed party restrict the attractiveness of delegation to the DM.

Key words: Delegation, Cheap Talk, Bureaucracy, Mediator, Hierarchy

JEL classification codes: D72, D78, D82

> The principles of office hierarchy and of levels of graded authority mean a firmly ordered system of super- and subordination in which there is a supervision of the lower offices by the higher ones.
>
> ——— Max Weber (1946, p. 214)

1 Introduction

It is well known that the person who has the right to make decison usually is not the one with the relevant expertise. A key issue in organization design thus is how to design a mechanism that efficiently uses the knowledge of strategic expert. Mechanism design approach suggests that when information is non-contractable, the decision maker could still gain information by allocating some control right to the informed agent (Holmstrom 1977). However, in spite of the common implicit assumption that the DM directly interacts with experts, e.g., talk with any expert and can make arbitrary allocation, in many circumstance there is a chain of intermediaries between the informed party and the decision maker, thus neither can the expert communicate directly with the DM, nor may the DM command arbitrary subordinates. For example, the minister keeps the control on policy decision and leaves the senior bureaucrats, e.g, undersecretaries, with the authority over administrative decisions. And the latter would further assign executive power over more specific affair to the junior officers, e.g., deputy secretaries. It's noteworthy that the span of discretionary authority is decreasing top down, and in many cases the minister is unable to circumvent the senior bureaucrats to authorize the juniors. In parliament the floor selects a specified committee to hear information from the lobbyists. In army, between divisions and battalions, regiments control information flow from below and pass authorization from above. International organizations usually have to deliver the aid to local community via the authorization of national government. Even the man with the most power, an emperor or a king, is restricted by the inheritance law in the sense that he cannot bypass his son to assign the crown to the grandson he favors. These examples share the same feature that due to physical, social and institutional constraints, the decision maker has to rely on a specified network to gain information and allocate authority. The question this paper addresses thus is: how does the lack of access to informed agent affect the allocation of control rights.

To answer this question, using the classical Crawford and Sobel (1982, henceforth, CS) cheap-talk model, we analyze organizational design in a three-layer DM/mediator/sender hierarchies. Only the sender is informed about the true state. The agents (the mediator and the sender) strategically

manipulate information, the DM (principal, receiver) chooses between delegating noncontractable decision right to the mediator and keeping control rights when the sender communicates his information via "mediator cheap talk" (Goltsman et al, 2009, henceforth, GHPS). All players want to adapt to the underlying state, though they also gain different private benefit (bias). Differ from previous works, we use hierarchical delegation to refer to the situation that the DM not only assigns some controls to the mediator, but also allows him to further delegate the decision right to the sender within his authority.

Under hierarchical delegation the mediator can further reduce, but is unable to increase, the list of available actions of the sender. Without loss of generality, we restrict attention to the *implemented delegation set,* i.e., the set of alternatives available to the sender, because only the sender is informed about true state and has the expertise to make right decision. We completely characterize the implemented delegation set, and show that it is truncated at either the top or bottom, conditional on the degree of conflict of interest between the sender and the mediator. It's shown that if the authority is allowed to be transferred, namely the mediator is allowed to further delegate decision right to the sender, then the information efficiency increases. We show that given the hierarchical structure, the hiring policy and job design, i.e. who becomes the mediator, who becomes the sender, and the role of mediator, are interrelated.

The *efficient delegation set* obtained in DM-sender direct interaction (Holmstrom 1977, Alonso and Matouschek 2008, henceforth AM), i.e., the second-best optimal outcome, is implementable if and only if the mediator's bias lies between the DM and the sender, e.g., conservative senior bureaucrat and more conservative juniors. The intuition is that the intermediately biased mediator prefers to delegate more authority to the sender, thus the DM can implement his optimum by truncating the delegation set to the mediator at the top. However, if the mediator is opposite-biased, e.g., more conservative senior vs. radical junior, he prefers lower cap on the action set of the sender, so efficient delegation set is not implementable. Therefore in contrast with the welfare-improving role of opposite biased mediator in communication (Ivanov, 2009, Ambrus et al, 2009), considerable loss in delegation chain occurs. Moreover, if the mediator is more biased than the sender, e.g., more conservative senior vs. conservative junior, he would like to truncate the menu of actions at the bottom, which is in contrast with the interest of DM. Therefore a direct implication for the hiring policy is that in organization the "like-minded" or "loyal" agent should be promoted to higher level position, and this middle level agent should be given control over a limited set of action and allowed to further delegate. In other words, if the minister

can only choose whoever to be undersecretary, then the bureaucrat with the closest preference should be appointed and given authority, since he helps the minister to control the deputy secretaries indirectly. However, if the minister can reorganize the whole department, namely the senior and the junior is determined simultaneously, then the benefits of loyal senior may not hold if the other agent's bias is not too far, since the loyal agent can directly reduce the loss of control more in the informed junior position.

Moreover, we examine the optimal choice of the expert if the DM cannot change the mediator but has some voices in choosing the sender. In the minister/senior/junior example we show that the optimal selection of junior bureaucrat will be the outcome of compromise between the minister and the senior, in the sense that the optimal junior lies in middle between these two parties will be chosen. Thus we also cast lights on the hiring decision of bureaucratic organization. Furthermore, we also investigate the delegation scheme when the minister is uncertain about the intensity of conflict of interest of the junior, and show that complete delegation to the senior may arise as the optimization outcome of the minister.

Then we compare the performance of delegation and communication in hierarchy. By communication we mean that the DM keeps decision right and hear the sender via a strategic mediator. The mediator can improve efficiency, which may be of his own interest, by filtering information flow, i.e., using a specific garbling of information to relax incentive compatibility constraint (Mitusch and Strausz, 2005). We are led to reverse the influential conclusion in Dessein (2002) that delegation dominates cheap talk whenever there exists an informative communication equilibrium. It's shown that for some range of values of preference misalignment, delegation strictly *underperforms* cheap talk in the sense that communication is *ex ante* better. The logic uses the fact that delegation is equivalent to that the DM commits to a particular decision rule (rubberstamp the recommendation from subordinates). The inability of direct interaction limits the available decision rules that the DM could select since the implementation has to be subject to the incentive of the mediator. This restriction varies with respect to the preference of the mediator, thus when the available action rules via hierarchical delegation are worse than those under communication, the DM may entirely get rid of delegation. Therefore, we provide a new reason for the absence of commitment: inability to access informed party directly.

The contribution of this paper is two-fold. For the strand of mechanism design, following Renou and Tomala (2008), we show that network structure matters in the allocation of control. The lack of direct access and the existence of strategic intermediaries may restrict the implemented outcome considerably. In particular, we demonstrate that the DM may deliberately

choose communication over delegation, in spite of GHPS (2009) that delegation mechanism can achieve the best outcome attainable in any mechanism. This thus sheds new light on the formal conflict resolution through arbitration or mediation in GHPS (2009). When the arbitrator and mediator are no longer neutral, which is quite plausible in those less-developed countries where the legal environment is poor, the party involved in conflict may engage in mediation instead of arbitration. For the research of organizational economics, our work contributes to the understanding of bureaucracy, in particular those government and army organization which is characterized by strict hierarchy and the absence of contingent contract. We show that job design and promotion policy are interrelated: the top-level DM will delegate control to the direct subordinate if she can choose the person, and given the biased middle-level agent, the top-level DM may keep control rights and restrict his role to conveying information. So when the bureaucrats cannot be removed, the minister may discretionarily controlling the decision right and change the job specification of that senior. The choice between keeping control and delegating discretionary authority depends on the preference of *all* members within hierarchy. On the other hand, if the minister can affect the hiring decision of the juniors, she will seek compromise with the senior. The appointed junior will lie between the minister and the senior.

This paper is organized as follows. In the following section we lay out the basic model, and investigate the benchmark case of direct communication and delegation, which serves as the efficiency criterion. Section 3 highlights the hierarchical delegation, and characterizes the implemented delegation set, then sheds lights on hiring policy of the sender. In Section 4 we compare hierarchical delegation with mediator cheap talk. We review the related literature in Section 5. Section 6 discusses and concludes. All proofs are relegated in Appendix.

2 Model

An organization is composed of three players: a DM (she, denote as player DM), a mediator, and a sender (he, denote as agent m and s, respectively). The utility of each player is of quadratic form in line with the classical CS model:

$$U(\theta, y, b_i) = -(\theta - y + b_i)^2, i = DM, m, s \tag{1}$$

Thus their payoffs depend on the true state $\theta \in \Theta = [0, 1]$, the action undertaken $y \in Y = \mathbb{R}$, and their private benefits b_i. Each player wants to adapt to the true state though to different extent, i.e., the ideal action

is $\theta + b_i$. Without loss of generality, we normalize $b_{DM} = 0$ and use b_s, b_m to measure the discrepancy of interest between agents and the DM. For the sake of simplificity, we use $U_i(\theta, y)$ to refer the utility of player i.

The DM has the right to take action, and only the sender would be informed about the true state θ, but he could not communicate directly with the DM, neither the DM can allocate the authority directly to the sender. In other words, the mediator has full control of the information transmission between the DM and the sender. The mediator and the DM have uniform prior on Θ.

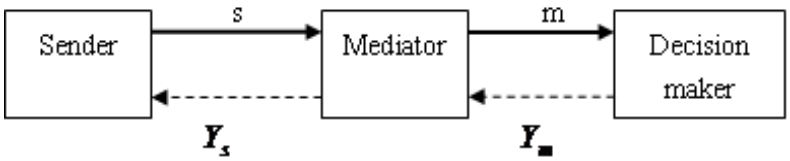

Figure 0 Timeline under communication and delegation (The solid and dashed line represents communication and delegation, respectively)

Now we specify the timing of this game under delegation and communication, which is described in Figure 0. The DM first assigns two agents to the mediator and the sender positions, and only the sender learns the true state. With a little abuse of notation, here we also use m and s to denote the message sent by the mediator and the sender, respectively. If the DM engages in mediator communication, as the solid line in Figure 0, the sender first delivers message from the signal space S to the mediator, and the mediator in turn chooses m from the message space M and send to the DM. The strategy for the sender thus is $\mu_s : \Theta \to \Delta S$, and for the mediator is $\mu_m : S \to \Delta M$. The DM forms a posterior about the true state conditional on the message received from the mediator, and chooses his ideal action $y : M \to Y$. The optimal response thus is $y = E[\theta \,|M]$. To get rid of multiple equilibria problem common in cheap talk game[1], we would focus on the most informative equilibrium, i.e., the Pareto-dominance one.

Alternatively, if the DM chooses delegation, then she gives the mediator full control over the subset $Y_m \subset Y$, from which he can choose any action. However, the mediator is uninformed and he can ask the sender to send message from the signal space S, and implement his best response $y_m = \arg\max_{y \in Y_m} -(E[\theta \,|S] - y + b_m)^2$. Otherwise, the mediator can subcontract, i.e.,

[1]Babbling equilibrium (Uninformative communication equilibrium) always exists in cheap talk game, in which the DM would always implement the *ex ante* optimal action $E[\theta] = \frac{1}{2}$

delegate decision right, with the sender by granting him the list of actions $Y_s \subset Y_m$, as the dashed line in Figure 0.

2.1 Benchmark: direct communication

We start from the benchmark case that the sender conveys messages to the DM directly, who then updates belief about the true state and makes decision. Thus we return to the classical CS model, as Lemma 1 summarizes

Lemma 1 (CS 1982) *If the informed party could talk with the decision maker directly, then informative communication occurs if* $|b_s| \leq \frac{1}{4}$*, and in equilibrium the induced set of actions consists of finite elements.*

This pessimistic result obtains due to the DM's inability to commit, which means that the DM would update his belief and selects ex post best adaption action upon receiving message. The DM gains by keep the flexibility to take action, and loses in motivating the sender to provide information. The information loss is significant since only finite action would be undertaken despite the fact that the state space is a continuum. The communication is informative if the DM would have finer partition about the state after hearing messages. It naturally leads to questioning whether and how the DM could improve the efficiency. In a well-cited paper Dessein (2002) shows that complete delegation in which the informed party chooses whatever action he prefers dominates direct communication whenever informative communication equilibrium exists. In other words, the minister should delegate control rights to the informed bureaucrat to improve information transmission.

By delegating authority to the informed party, the DM allows the agent to implement his preferred action from a prescribed set (finite or infinite), thus this is in effect equivalent to making commitment to a decision rule. The DM forges the flexibility to make decision and gains in information transmission. Under complete delegation, since the preferred action of informed party could be always selected, there is full information transmission on the expense of loss of the control rights. GHPS (2009) establish the second-best optimal outcome, and demonstrate that it can be attained by the optimal delegation scheme which is featured by that the informed party is given control over an interval of Y.

Lemma 2 (GHPS 2009) *If the decision maker can delegate authority to the informed party, then outcome would be better than ex ante optimal action*

if $0 \leq b_s \leq \frac{1}{2}$. *The optimal delegation set is* $[0, 1 - b_s]$, *and the action chosen is*

$$y(\theta) = \begin{cases} \theta + b_s, if\ \theta \in [0, 1 - 2b_s] \\ 1 - b_s, \ otherwise \end{cases}$$

Therefore, the optimal delegation set of action is an interval $Y^* = [0, 1 - b_i]$, which is determined by the degree of conflict of interest between the decision maker and the informed party. The optimal delegation set would be truncated on the top. Optimal delegation seeks the balance between the loss of control right and the gain of information. In low state the latter effect outweighs, thus the informed party is allowed to act according to his interest. In high state the former effect dominates and the decision maker keeps *de facto* control by setting up an upper bound $(1 - b_s)$. Thus the information is perfectly revealed in the lower interval, whose length is decreasing with respect to the preference misalignment. In effect, there is an one-to-one mapping from the bias b_s to this truncated set. This optimal delegation would serve as the *efficient delegation set* for our analysis on hierarchical delegation, which corresponds to that the DM delegates to the sender directly. The expected utility for the DM under second-best thus is:

$$EU_{DM} = -\int_0^{1-2b_s} b_s^2 d\theta - \int_{1-2b_s}^{1} \left[\theta - (1 - b_s)\right]^2 d\theta = (\frac{4}{3}b_s - 1)b_s^2 \qquad (2)$$

It's routine to find out that the expected utility is strictly decreasing with respect to the intensity of conflict b_s, given that $b_s \in \left[0, \frac{1}{2}\right]$. One straightforward implication is under direct interaction, if the DM could choose agent from a large pool, then she should assign the least biased agent to the position which gains information.

On the other hand, the utility of the agent turns out to be:

$$U_s = \begin{cases} 0, & \text{if } \theta \in [0, 1 - 2b_s] \\ -\left(\theta - (1 - b_s) + b_s\right)^2, & \text{otherwise} \end{cases} \qquad (3)$$

Therefore, the agent's *ex ante* expected utility before being assigned to the sender position would be $EU_s = -\frac{8}{3}b_s^3$.

Alternative ways to implement this optimal outcome are suggested by various authors, such as using arbitration to resolve dispute (Melumad and Shibano, 1991), veto-power of the decision maker (Mylovanov, 2008), and stochastic delegation (Kovac and Mylovanov, 2009)

The previous work by AM (2008) establishes the conditions for allowing the informed party to choose action from an interval in more general environment. Formally, they specify the property of optimal delegation set, which is restated in current environment as the following:

Lemma 3 (AM 2008) *The optimal delegation set from the DM to informed agent is a connected set.*

This lemma states that if two discrete actions are given to the agent, then the DM would find out that EU_{DM} increases by adding the actions between these two to the delegation set. This is could be understood from the DM's risk aversion. Therefore, the DM would either authorize the informed agent to choose from an interval of actions, or restrict the delegation set to only one action[2]. With this lemma, we can extend Lemma 2 to characterize the optimal delegation set when the bias is negative. This result is useful for further analysis however methodological trivial. It's shown that the optimal delegation set is truncated on the bottom in the sense that the informed party would be given control when $\theta \in [-2b_s, 1]$, as long as the action lies into Y.

Proposition 4 *If* $-\frac{1}{2} \leq b_s < 0$*, then efficient delegation set is* $Y^* = [-b_s, 1]$.

3 Hierarchical Delegation

In this section we provide a complete characterization about the performance of delegation scheme in hierarchy. We show that the efficient outcome defined in (2) is attainable only when the mediator is intermediately biased between the DM and the sender. We further use this result to analyze the promotion and hiring policy within government. The DM should promote the like-minded agent to higher position. If the DM cannot choose the mediator but can affect the selection of the sender from a pool of candidates, then the DM may flatter the mediator in the sense that the agent closed to him will be selected by the DM. The optimal sender should lie between the DM and the mediator.

[2]This would be the ex ante optimal response $E_{DM}[\theta] = \frac{1}{2}$.

3.1 Preliminaries

Under hierarchical delegation, there is no direct interaction between the DM and the informed sender, e.g., the minister usually cannot directly contact with the junior bureaucrats[3]. The procedure is the DM delegates control over Y_m to the uninformed mediator, and the latter not only can talk with the sender, but could delegate the sender with the authority over a subset $Y_s \subseteq Y_m$. In other words, the scope of authority to the junior bureaucrat is restricted within the delegation set available to the senior. Because it has already established that meaningful delegation, which means that there are more than one action in delegation set, requires that $b_s \leq \frac{1}{2}$. We would focus on the case that $|b_m|, |b_s| \leq \frac{1}{2}$.

We would use $\Delta \equiv b_s - b_m$ to represent the divergence of conflict between sender and mediator. As a useful benchmark, we first examine the situation that the delegation is not allowed to transfer. In other words, the mediator is allowed to select action from a set of alternatives, but he is not allowed, or lack the necessary commitment power, to further delegate this authority to the sender. Therefore the standard CS cheap talk applies between mediator and sender, and the results are the same as Lemma 1 except that now Δ, rather than b_i, determines the equilibrium outcome.

Then we check the performance when subcontract (further delegation to the sender) is possible. We define the *implementable delegation set* as

Definition 5 *A set of action Y' is implementable if $Y' \subseteq Y_s \subseteq Y_m$ and every element $y_s \in Y'$ results from the parties' optimizing behavior given that the authority is allowed to transferred and the hierarchical structure.*

The implemented delegation set is also the final delegation set of the sender, in the sense that only the sender has the relevant expertise to choose proper action. It's noteworthy that in concept implemented set is the set of action of the sender, and implementable set is from the perspective of the DM, a set implemented through hierarchical delegation.

The mediator acts as if a mechanism designer whose set of available actions is restricted to Y_m, and make delegation decision based on the relative

[3]The senior bureaucrats may actively prevent the direct link between his subordination and supervision. The behavior of Sir Humphrey Appleby, the permanent undersecretary in the fictional Department of Administrative Affairs in the BBC series *Yes, Minister*, vividly illuminates this point.

difference of bias Δ. We could employ the powerful *revelation principle* (Myerson, 1982) to restrict attention to the decision rule whereby the sender sends a single message to the mediator, which in equilibrium would be the truthful announcement about the state of world. Therefore we could define a *delegation rule* to be $(p(\cdot|\theta))_{\theta\in\Theta}$, a family of probability distribution on Y_m, formally $p(\cdot|\theta) : \Theta \to \Delta Y_m$. Therefore we could write the subcontract as the optimization problem constrained by Y_m:

$$\max_{(p(\cdot|\theta))_{\theta\in\Theta}} -\int_{Y_m}\int_{\Theta} (y-\theta)^2 \, dp(y|\theta)\, d\theta \tag{4}$$

subject to

$$\theta = \arg\max_{\widehat{\theta}\in\Theta} \left[-\int_{Y_m} (y-(\theta+\Delta))^2 \, dp\left(y\left|\widehat{\theta}\right.\right) \right], \forall\theta\in\Theta$$

Any implementable delegation set has to be a subset of the set of solution to the optimization problem above. Hence, the delegation set to the sender Y_s has to be given by the optimizing behavior of mediator, in other words the mediator chooses Y_s.

Due to the existence of mediator, the delegation rule available to the DM thus is subject to the incentive compatibility of mediator. So the DM is unable to commit to whatever decision rule.

Lemma 3 immediately leads to that if Y_m is a connected set, so is Y_s. Therefore, the mediator chooses Y_s as an interval or a point, unless Y_m itself consists of discrete actions or contains unconnected intervals. For the latter situation, Lemma 3 would implies that Y_s also contains unconnected intervals. However, Lemma 18 in Appendix shows that if Y_s contains more than one interval, then it's in the best interest of the DM to add actions between them via the mediator, thus Y_s would be a connected set, as well as Y_m. In other words, Y_s with unconnected intervals would not be outcomes of optimizing behavior of the DM.

For the former case, suppose more than two elements of Y_m is delegated to the sender, then the DM would again find it's in her interest to add actions between these two into Y_s. And if $|\Delta| \leq \frac{1}{2}$, the mediator would also voluntarily pass this new delegation set to the sender. If $|\Delta| > \frac{1}{2}$, then the

mediator would only allow the sender to choose his ex ante preferred action, $\frac{1}{2} + b_m$, given that $\frac{1}{2} + b_m \in Y_m$.

Readers may conjecture that the DM may preclude $\frac{1}{2} + b_m$ from delegation set to force the strong biased mediator to delegate other actions in her interest, like Szalay (2005) shows. However, this intuition is wrong here since the strong biased mediator would only leave one action to the informed sender. This is formally summarized in the following lemma.

Lemma 6 *If the intensity of conflict between agents is large, i.e.,* $|\Delta| > \frac{1}{2}$*, then only one action would be selected by the mediator from his delegation set, regardless of the size of* Y_m*.*

Therefore, the above analysis suggests that the property that the optimal delegation set is a connected set also holds in hierarchies, namely the implemented delegation set Y_s is connected. In other words, Y_s would be a continuum of choices or just one action, and the DM will just limit the menu of actions by imposing upper- and lower-bound.

3.2 Implemented delegation set

Now we turn to characterize the implemented delegation set of the sender.

Proposition 7 *If* $\Delta > 0$*, the highest available alternative to the sender* $\overline{y_s} = \min\{1 - \Delta, \sup\{y \,|y \in Y_m\}\}$

This proposition demonstrates the impact of conflict of interest between the DM and the mediator. If the mediator is granted with large discretion power, then he would act in his own interest, and the delegation set implemented ($[0, 1 - \Delta]$) differs from the efficient one ($[0, 1 - b_s]$), as shown in Figure 1. However, it also suggests that the DM could control the loss from this divergence of ideal actions by truncating the delegation set, i.e., imposing upper-bound $1 - b_s$ on Y_m. The efficient delegation set would be implemented in hierarchical structure.

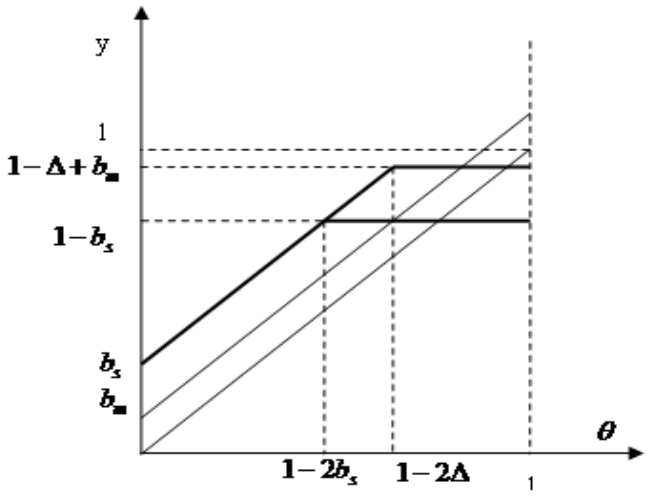

Figure 1. Property of optimal delegation set from DM and the mediator standpoint, respectively. The bold line depicts the action chosen as function of state θ.

Corollary 8 *If two agents are both positive biased and the mediator is less biased, i.e.,* $b_s > b_m > 0$*, then the efficient delegation set* Y^* *is implemented by imposing* $\sup\{y \,|y \in Y_m\} = 1 - b_s$

It's routine to check that if these two agents are negatively biased and $b_s < b_m$, then the efficient delegation set is still implementable, though now the device to get it is to truncate delegation set Y_m at the bottom.

Therefore, even though the mediator is biased, the DM still can implement her optimal outcome by appointing a less biased mediator and truncating the delegation set. In other words, given the conflict of interest among the bottom-level workers, the agent with less intensity should be assigned to higher level in hierarchies. The expected utility of the DM thus would be the one in (2), the second-best outcome. Obviously, it significantly increases the payoff to the DM relative to the case that the authority is not allowed to be transferred. The implication to promotion decision thus is the minister should fill the undersecretary position with the person whose preference is aligned, e.g. more "loyal" or "like-minded". Based on direct interaction between principal and agent, Marino et al (2006) derive the similar result for hiring policy that preference alignment is important if decisions must be delegated. We extend it to three-layer hierarchy and demonstrate more flexible span for the preference alignment of the mediator. The prediction

that the DM would like to assign the loyal agent to important position also receives some empirical support from Iyer and Mani (2009), who find out that in India the elected politician (Chief Minister) will award the loyal professional bureaucrats with important positions.

However, this results crucially depends on that the mediator is intermediately biased. If the mediator is more biased, or two agents are of opposite direction of bias, then this implementation of efficient outcome fails.

Proposition 9 *If two agents are opposite biased or the mediator is more biased than the sender, then the efficient delegation set would never be implementable, i.e.,* $Y_s \neq Y^*$.

We demonstrate the failure of implementable efficient delegation set in the following figures. In Figure 2(a), when two agents are of opposite direction of bias, the elements of efficient delegation set are everywhere higher than those in Y_s, so $Y_s \subset Y^*$ if $Y^* \subset Y_m$. Thus the DM has no way to force the mediator to authorize the sender to take any higher action than $1 - \Delta$. In particular, for meaningful delegation we need these two agents are not too extremely biased when they have opposite interest, namely $\Delta < \frac{1}{2}$. On the other hand, as shown in Figure 2(b) when the mediator is more biased, though the DM prefers to truncate the sender's behavior in high state, the mediator is inclined to restrict the sender's discretion in low state. Thus any action lower than $-\Delta$ would not be authorized by the mediator. Thus the DM and the mediator differ in the direction in controlling the informed party.

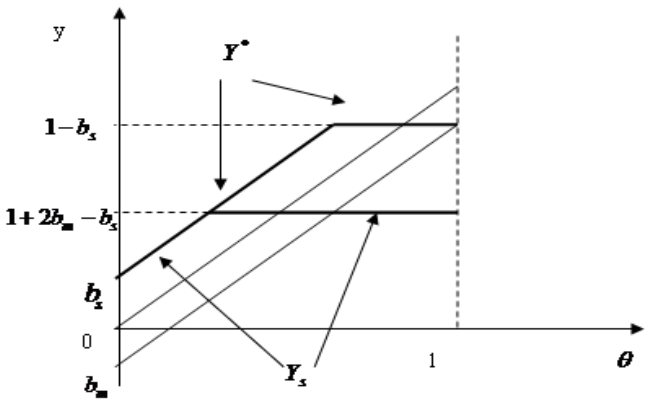

Figure 2(a). The delegation set with opposite biased agents

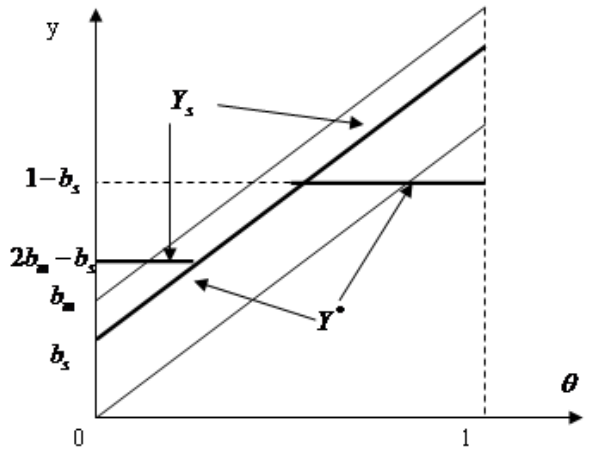

Figure 2(b). The delegation set with extremely biased mediator

Finally, we fully characterize the optimal implemented delegation set under different bias of agents and the expected payoff to the DM. We should keep in mind that when either $|\Delta| \leq 1/2$ or $|b_i| \leq 1/2$ fail, the DM prefers to take ex ante optimal action $\frac{1}{2}$ and there is no information gain from delegation, the expected payoff thus would be $-\frac{1}{12}$. To focus on the issue of interest and for the sake of simplicity, we assume that $\frac{1}{2} \geq b_s \geq 0$ (the case of $b_s < 0$ is perfectly symmetric), and there is no limitation on b_m.

Theorem 10 *The optimal implemented delegation set prescribes the alternatives available to the informed sender. Formally, it satisfies:*

$$Y_s = \begin{cases} [0, 1-b_s], & \text{if } \frac{1}{2} \geq b_s > b_m \geq 0 \\ [0, 1+2b_m-b_s], & \text{if } b_s > 0 > b_m \text{ and } \Delta \in \left[0, \frac{1}{2}\right] \\ [2b_m-b_s, 1-b_s], & \text{if } b_m > b_s > 0 \text{ and } |\Delta| \in \left[0, \frac{1}{2}\right] \\ \frac{1}{2}, & \text{otherwise} \end{cases} \tag{5}$$

and the DM's expected utility is

$$EU_{DM}^{HD} = \begin{cases} (\frac{4}{3}b_s - 1)b_s^2, & \text{if } \frac{1}{2} \geq b_s > b_m \geq 0 \\ -b_s^2 + \frac{8}{3}b_m^3 - 4b_m^2 b_s + \frac{4}{3}b_s^3, & \text{if } b_s > 0 > b_m \text{ and } \Delta \in \left[0, \frac{1}{2}\right] \\ -\frac{8}{3}b_m^3 + 4b_s b_m^2 - b_s^2, & \text{if } b_m > b_s > 0 \text{ and } |\Delta| \in \left[0, \frac{1}{2}\right] \\ -\frac{1}{12}, & \text{otherwise} \end{cases} \tag{6}$$

This theorem shows that the discrepancy of interest of the mediator is irrelevant to the implementation of optimal delegation scheme as long as it lies between the DM and the sender, e.g., a compromised senior bureaucrat

will not affect the allocation of control. Otherwise, the span of discretionary authority of the sender, i.e., the implemented delegation set, would be increasing (decreasing) with respect to the bias of the mediator if it's negative (positive). Moreover, $\frac{\partial EU_{DM}^{HD}}{\partial b_m} < 0$ if $b_m > b_s$, and $\frac{\partial EU_{DM}^{HD}}{\partial b_m} > 0$ if $b_m < 0$. Thus in general the more closed the preference of the mediator to the DM, the larger gain in delegation. Thus for the minister only the absolute difference in interest matters in selecting senior officers.

An intrigue question is given the conflict of interest of two agents and the hierarchy, which agent should be assigned to higher position. It differs from promoting the loyal agent because it involves entire reassignment of jobs, instead of promote someone while leave the bottom line unchanged. To deal with this question, we assume that both agents are of positive bias[4], i.e., $b_2 > b_1 > 0$. The DM thus needs to tradeoff between using the more biased sender 2, in which the optimal delegation set is implementable, and using the less biased sender 1, where the DM may gain in high state but lose in low state. We find out that the more biased agent will be assigned to the sender position only if his bias is sufficiently far from the other agent.

Corollary 11 *The more biased agent 2 will be assigned to the sender position if* $b_2 > \frac{1+\sqrt{1+16b_1}}{8}$.

Therefore, a moderately biased mediator can help controlling the more biased sender, but the DM can also find out that it may be beneficial to assign this moderately biased agent to the bottom line and promote the more biased guy, in order to enlarge the range of implemented delegation set. While the loyalty in mediator position provides the DM with better control of the informed party indirectly, the loyalty in the informed position reduce the loss of control directly. The indirect gain in control due to loyalty cannot compensate the direct loss if the other agent is not very biased. It's not necessarily that the mediator is more like-minded to the DM, even if the DM has the full power to organize the hierarchy and assign the jobs.

Lastly, we calculate the ex ante expected payoff to agents and present in the following corollary

Corollary 12 *The ex ante expected payoff to the sender, before he is informed, is*

[4]When they are of the opposite bias, the delegation scheme may not even be chosen by the DM, see Section 4 for the discussion.

$$EU_s^{HD} = \begin{cases} -\frac{8}{3}b_s^3, & if\ \frac{1}{2} \geq b_s > b_m\ \geq 0 \\ -\frac{8}{3}\Delta^3, & if\ b_s > 0 > b_m\ and\ \Delta \in \left[0, \frac{1}{2}\right] \\ \frac{8}{3}\left(\Delta^3 - b_s^3\right), & if\ b_m > b_s > 0\ and\ |\Delta| \in \left[0, \frac{1}{2}\right] \\ -\frac{1}{12} - b_s^2, & otherwise \end{cases} \tag{7}$$

and the expected payoff to the mediator is

$$EU_m^{HD} = \begin{cases} -\Delta^2\left(1 - 2b_s\right) - \frac{2b_s}{3}\left(b_s^2 + 3b_m^2\right), & if\ \frac{1}{2} \geq b_s > b_m\ \geq 0 \\ -\Delta^2 + \frac{4}{3}\Delta^3, & if\ b_s > 0 > b_m\ and\ \Delta \in \left[0, \frac{1}{2}\right] \\ \frac{\Delta^3}{3} - \Delta^2\left(1 - 2b_m\right) - \frac{\left(b_s + b_m\right)^3}{3}, & if\ b_m > b_s > 0\ and\ |\Delta| \in \left[0, \frac{1}{2}\right] \\ -\frac{1}{12} - b_m^2, & otherwise \end{cases} \tag{8}$$

3.3 Selecting the sender

We have studied the choice of the mediator for the DM, given the bias of the sender. It corresponds to the promotion policy of bureaucratic organization, and we show that the more loyal bureaucrat should be placed into senior position.

In real world, however, usually the minister cannot remove the senior officer. For example, in UK government the permanent undersecretary is the non-political civil service head of a government department, they report and advise the Secretary of State, and are answerable to Parliament. However, the minister may have some voices in screening the entry-level (junior) bureaucrat. In this subsection we explore the selection of the junior given the preference of the senior and the DM.

We undertake some comparative statics about the expected payoff of the DM. First, $\frac{\partial EU_{DM}^{HD}}{\partial b_s} \leq 0$ for almost all cases[5], which means that the DM is harmed by the conflict of interest between the DM and the informed sender. Second, there exists complementarity between the bias of the sender and the mediator ($\frac{\partial EU_{DM}^{HD2}}{\partial b_s \partial b_m} \geq 0$).

To understand the implications of these comparative statics, we should think about the hiring policy of bureaucratic organization. Given the preference of the senior officer and a pool of candidates for the junior position, which one should be selected as the junior bureaucrat? Suppose the senior is conservative ($b_m > 0$), then if the neutral DM chooses a more conservative junior ($b_s > b_m$), then the efficient delegation set is implementable (the first

[5]If $b_m > b_s > 0$, then $\frac{\partial EU_{DM}^{HD}}{\partial b_s} \leq 0 \Leftrightarrow b_m^2 \leq \frac{b_s}{2}$. If $b_m < 0 < b_s$, then $\frac{\partial EU_{DM}^{HD}}{\partial b_s} \leq 0$ holds for any $b_s \in \left[0, \frac{1}{2}\right]$.

part of (5)), and the expected payoff of the DM (the first part of (6)) is decreasing with with respect to the conflict of interest of the junior. Therefore, the DM would like to appoint a bureaucrat no more conservative than the senior. On the other hand, if the DM selects a liberal junior ($b_s < 0$), then the senior wants to impose more restriction on the discretionary of the junior than the DM, thus the DM again gains by appointing a less liberal junior. Therefore the DM would not like to appoint a liberal junior.

Hence to check the increasingly conservative senior bureaucrat, the minister should either select the less radical one if all candidates are liberal, or choose optimally conservative one[6] if all just differ in the degree of conservatism. But in general, the DM would like to appoint a compromise junior ($b_m > b_s > 0$). The general implication is the DM will check the conflict of interest of the mediator by deliberating selecting the sender. Iyer and Mani (2009) also examine the Chief Minister/District Politician/Bureaucrat hierarchy in India, and find out that when the Chief Minister and the District Politician are elected from the different parties, then the Chief Minister is more likely to change bureaucrat. In broad sense our implication is consistent with their results.

More interesting results can be obtained if the minister (DM) and the senior (mediator) have joint control over the selection of junior (sender). To focus on issue of interest, we assume that $b_s, b_m \in \left(0, \frac{1}{2}\right)$, i.e., the bureaucrats have the same direction of bias, like conservatism, but differ in the extent. Therefore, the selection of junior will depend on the total expected welfare of the minister and the senior.

Suppose the expected payoff of the minister and the senior enter the total welfare equally. By adding (6) and (8) together we will have

$$W = \begin{cases} \frac{8}{3}b_s^3 - 2b_s^2 + 2b_s b_m - b_m^2 - 4b_s^2 b_m, \text{ if } b_s \geq b_m \\ -\frac{4}{3}b_m^3 - 2b_s^2 + 2b_s b_m - b_m^2, \text{ if } b_m > b_s \end{cases} \tag{9}$$

Take derivatives of W with respect to b_s, we have $b_s^* = \frac{b_m}{2}$ if $b_m > b_s$, and $b_s^* = b_m$ if $b_s \geq b_m$. Furthermore, $W\left(b_s = \frac{b_m}{2}\right) = -\frac{4}{3}b_m^3 - \frac{b_m^2}{2} > W\left(b_s = b_m\right)$. Therefore, the neutral minister and the conservative senior will jointly select less conservative candidate for junior position.

This is a compromise choice between the preferred choice of the minister and that of the senior. To see this, note that if $b_m > b_s$, then $\frac{\partial EU_{DM}^{HD}}{\partial b_s} = 0$ if $b_s = 2b_m^2$. Moreover, $EU_{DM}^{HD}\left(b_s = 2b_m^2\right) > EU_{DM}^{HD}\left(b_s = b_m\right)$. Therefore the minister prefers to choose the junior with the intensity of conflict as $2b_m^2$. On the other hand, the senior's preferred choice is the junior with $b_s = b_m - 2b_m^2$. The analysis above is summarized in the following remark.

[6] As we derive in footnote 4, it should be $b_s = 2b_m^2$ if $b_m \leq \frac{1}{2}$

Remark 13 *The DM and the mediator has different ideal sender. The sender that maximizes the joint welfare will be in exact middle position between the DM and the mediator.*

It's interesting to look at the intuition underlying the preferred choice of each side. The minister has to tradeoff the efficiency loss from the limitation in low state imposed by the senior, and the gain in more information in high state. When the senior bureaucrat is modest conservative, i.e., $b_m \leq \frac{1}{4}$, then the minister prefers to appoint a junior with the preference close to herself. The minister knows that though the senior will impose more restriction on the low state, she gains even more since the like-minded junior can improve efficiency in high state. When the senior bureaucrat is very conservative, i.e., $b_m > \frac{1}{4}$, for the minister the loss due to this extreme senior outweighs the gain in loyallty from the junior, thus she wants to flatter the senior by appointing a junior closely related to him. This logic reverses for the senior. As the result of compromise, these two parties will reach an exactly middle junior.

3.4 Uncertainty about the preference

In real world it's usually that the highest-level leader doesn't know the true preference of the bottom-level workers due to the limited information processing ability or lack of direct access. On the other hand, the middle-level manager may have more precise knowledge about the direct subordinates. This bounded rationality argument usually provides a rationale for hierarchy (Radner 1993, Bolton and Dewatripont 1994). In this subsection we explore the design of delegation scheme when the player just knows the intensity of preference misalignment of the direct subordinates, and the information about preference cannot be conveyed to the supervisor. In other words, when the DM designs the delegation schedule, she just knows the conflict of interest of the mediator and the fact that the mediator knows the sender.

We assume that the DM knows b_m and the direction of the bias of the sender, e.g., whether conservative or liberal, but doesn't know the exact intensity of bias. Without loss of generality, we assume $b_m \in [0, \frac{1}{2}]$ and $b_s \sim U[0,1]$, the DM has a uniform prior about the bias of the sender. Because both agents are of the positive bias, the DM will only choose the cap on the delegation set to the mediator Y_m. The strategy for the DM thus turns out to be imposing a fixed upper bound $\overline{y}$ on Y_m, then letting the mediator to decide Y_s. Therefore, using the logic leading to (5), we have that when the sender is more biased:

$$EU_{DM} = \begin{cases} -b_s^2 (\overline{y} - b_s) - \frac{1}{3}\left[(1-\overline{y})^3 + b_s^3\right], \text{ if } 1 + 2b_m - \overline{y} > b_s \geq b_m \\ -b_s^2 (1 + 2b_m - 2b_s) - \frac{1}{3}\left[(b_s - 2b_m)^3 + b_s^3\right], \text{ if } b_m + \frac{1}{2} > b_s > 1 + 2b_m - \overline{y} \end{cases} \tag{10}$$

Similarly as the intuition underlying Corollary 8 and Proposition 9, when the sender is more biased than the mediator, the mediator prefers to give the sender more freedom of action than the DM. Thus if his best cap is lower than $\overline{y}$, the mediator can completely implement his preferred delegation set by choosing the upper bound $1 + 2b_m - b_s$, as the second line in (10) shows. On the other hand, if his preferred cap is higher than $\overline{y}$, the implemented delegation set will also end in $\overline{y}$, as the first line in (10) suggests.

When the mediator is more biased, he would like to impose the additional lower bound on the span of control to the sender, thus the expected payoff to the DM becomes

$$EU_{DM}(\overline{y}) = -\frac{1}{3}\left[(1-\overline{y})^3 + (2b_m - b_s)^3\right] - b_s^2 (\overline{y} + b_s - 2b_m), \text{ if } b_m > b_s$$

Finally, if the discrepancy between the mediator and the sender is too large, e.g., $\frac{1}{2}$, then the sender's action set will include only one action: either the ex ante best action to the mediator, or the highest possible action in Y_m, thus we have

$$EU_{DM}(\overline{y}) = -\int_0^1 \left(\min\{\overline{y}, \tfrac{1}{2} + b_m\} - \theta\right)^2 d\theta, \text{ if } b_s \geq b_m + \tfrac{1}{2}$$

The DM gains from the cap if the sender is more biased than the mediator, since it restricts the tendency of the mediator to delegate more authority. However, the uniformly cap leads to efficiency loss when the sender is like-minded, since it prohibit some possible beneficial action in high state. Which effect dominates depends on the range of the preference of the informed sender. If the mediator is closed to the DM, it's more likely that the DM will get a more biased sender, for which the DM needs to restrict the conflict of interest of the mediator in high state, this favors low cap. However, the like-minded mediator also enables the DM to control the informed sender, thus the DM can trust the mediator and give him more freedom of action. It's ambiguous which is more important. On the other hand, if the mediator is very biased, then it's more likely that the sender is between them, thus high cap is favored. We calculate the expected payoff to the DM with uncertainty about the sender's bias, and found out that in this specification it's optimal for the DM to completely delegate to the mediator. Formally:

Proposition 14 *If the DM has uniform prior about the bias of the sender, then she will completely delegate the authority to the mediator, i.e., the optimally cap on* Y_m *is* $\overline{y} = 1$.

This result provides a rationale for the exclusive concentration on full delegation: when the DM is uncertain about the conflict of interest of the informed party, it will be beneficial to delegate all decision right to the mediator who has the relevant knowledge about the intensity of conflict. The complete delegation scheme thus arises as the optimization outcome of the DM. It's noteworthy that this is obtained conditional on the prior distribution of the bias of the sender. For example, if the DM thinks that the bias of the sender is drawn from $\left[0, \frac{1}{2}\right]$, then complete delegation may not be optimal for more biased mediator.

4 Comparison with Hierarchical Communication

We have established the relationship between the performance of delegation and the preference of agents, and shown that it's ideal for the DM to appoint a mediator with close preference. In real world, however, usually the selection of the mediator is not made by the DM. For example, in the U.S. system of separate powers, the executive (the President) appoints the administrative agency managers, e.g., FDA, while the Congress dictates policy and oversees its implementation. In terms of our model, the DM (Congress) can choose neither the mediator (FDA) nor the informed sender (the pharmaceutical company). Alternatively, she would respond by varying the level of oversights (Warren, 2008).

In this section we cast delegation scheme into a more general environment and ask the specific question: if the DM cannot select the agents, under what condition the delegation scheme will be chosen? In particular, we compare delegation with communication given hierarchies and the preference of agents. This investigation involves job design in hierarchy: should the mediator be given control, or just act as a gate-keeper in communication process? This theoretical exploration also has real-world implications, usually the elected politician (minister) cannot arbitrarily remove bureaucrats, neither change the structure of government, thus the minister has to decide the allocation of control within bureaucratic hierarchy to achieve the goal. We find out that the inability to interact with informed party significantly reverses the conclusion in previous study that the DM is better off by choosing delegation over communication.

In hierarchical communication, the mediator serves only as information intermediary. Specifically, the perfect Bayesian-Nash equilibrium is a pair of strategies and beliefs (μ_s, μ_m, y, F, G), in which $F(\theta|s)$ denote the belief of the mediator and $G(\theta|m)$ assigns a probability distribution over states θ for the DM, given the message m sent by the mediator. The equilibrium requires that upon receiving any message m, the DM maximizes his expected utility EU_{DM}^{HC} given his belief function G. For any signal s, the mediator maximizes EU_m^{HC} given belief F and the action rule of the DM $y(m)$. And the sender also maximizes his expected utility EU_s^{HC} given μ_m and $y(m)$. Moreover, both F and G are derived from μ_s and μ_m by Bayesian Law. Therefore, hierarchical communication shares with hierarchical delegation with the same structure: vertical hierarchy, but differs in whether the DM delegates the authority to the mediator.

As Mitusch and Strausz (2005) note, the uninformed mediator can improve information transmission upon direct cheap talk by using mixed strategy equilibrium, i.e., mix or conceal some messages. The intuition is fully explored by Blume et al (2007), in which noise in communication invalids the monotonicity condition of action with respect to message, thus the DM gains by relaxing incentive compatibility constraint of the sender, which outweighs the loss in information. GHPS (2009) further characterize the best outcome attainable in any mechanism in the context of cheap talk, and show that it could be implemented by a neutral mediator who takes mixed strategy by randomizing in each state between at most two actions. The highest payoff in hierarchical communication to the DM thus is

$$EU_{DM}^{HC} = -\frac{1}{3} b_s (1 - b_s)$$

Ivanov (2009) extends this result to the situation of strategic mediator and shows that by appointing a mediator with properly opposite bias, the DM could implement the optimal cheap talk outcome. Furthermore, the intermediately biased mediator ($0 < b_m < b_s$) could not improve efficiency upon direct talk.

Lemma 15 (Ivanov 2009) *For any $b_s \in [0, \frac{1}{2}]$, there exists a mediator with bias $b_m \in (-2b_s, 0]$ and an equilibrium in the game with this mediator that provides $EU_{DM}^{HC} = -\frac{1}{3} b_s (1 - b_s)$. However, if $b_m \in [0, b)$, the mediator communication could not improve upon direct talk.*

Thus we could compare the maximum efficiency in communication EU_{DM}^{HC} with the outcome of hierarchical delegation. Since $\frac{\partial EU_P^{HD}}{\partial b_m} \geq 0$ when $b_m < 0$, if there is a b'_m such that $EU_{DM}^{HD}(b'_m) = -\frac{1}{3}b_s(1-b_s)$, then we could conclude that for any $b_m > b'_m$, hierarchical delegation strongly dominates mediator talk in the sense it can achieve higher payoff than the maximal payoff attainable in mediator talk. The resulted b'_m turns out to be a nonlinear function of b_s, which is formally defined by the following equation:

$$-b_s^2(1+2b'_m) + \frac{(2b'_m - b_s)^3}{3} + \frac{5b_s^3}{3} = -\frac{1}{3}b_s(1-b_s) \tag{11}$$

The higher dashed line in Figure 3 describes this indifference line.

However, as Ambrus et al (2009) show, there is non-monotonic relationship between the existence k-interval mixed equilibrium and the bias of mediator. For example, though two-action mixed equilibria requires that b_m is "sufficiently" far below zero, 3-action mixed equilibria can exist when both b_s and b_m are close to 0. In other words, in spite of the outcome in direct talk, there exists situation in which k-action equilibrium is possible, but $k-1$-action equilibrium fails to exist. Hence there is no one-to-one mapping between the biases of agents and the best final outcome. This non-monotonicity in hierarchical communication limits complete characterization about the relative efficiency of two organization modes. In fact, we have to do case-by-case comparison of the efficiency in delegation and communication.

However, we still obtain the striking finding that informative communication may dominates delegation. To illustrate this, we compare the range of values of b_m for the existence of two-interval equilibrium in HC mode and meaningful HD mode (the DM would find out optimal to delegate more than one action). We relegate in Appendix C the construction of two-action mixed equilibria under HC, and note that any non-trivial (informative) HD requires the following inequality being satisfied:

$$-b_s^2(1+2b_m) + \frac{(2b_m - b_s)^3}{3} + \frac{5b_s^3}{3} \geq -\frac{1}{12} \tag{12}$$

Namely for the DM delegating more than one action is better than taking ex ante optimal action.

Figure 3 demonstrates this comparison. The dashed lines represents (11) and (12), respectively. Thus the delegation is informative only if b_m lies above the lower dashed line. The shadow area specifies the range of values of b_m for

which the two-interval equilibrium exists[7]. For slightly biased mediator (b_m higher than the higher dashed curve), delegation generates higher expected payoff than communication. For large biased mediator ($b_m \leq -\frac{1}{4}$ but $\Delta \leq \frac{1}{2}$), again delegation dominates. However, for some intermediate value of b_m, like those points lower than the dashed line but still lie in shadow area, communication would be informative, but delegation is worse than acting based on prior.

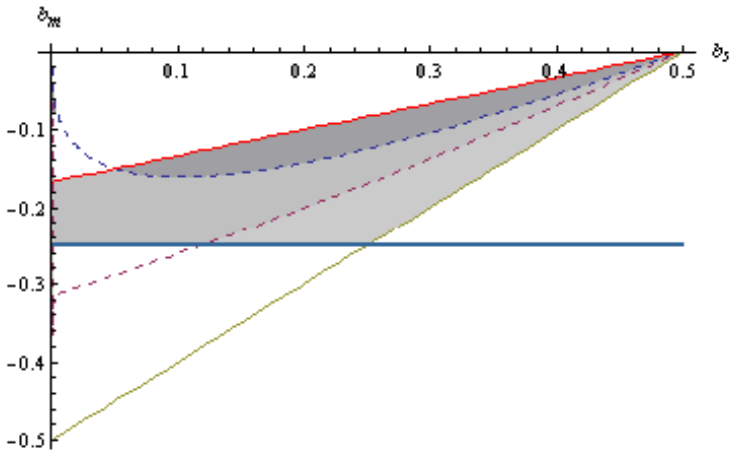

Figure 3. The comparison of expected payoff under HD and HC modes.

Therefore, if the two agents are of same direction of bias and given hierarchy, then the DM should assign the less biased agent to the mediator position and give him limited discretion power, as hierarchical delegation scheme prescribes. On the other hand, if two agents are of opposite interest, the choice of organization may be ambiguous. It's possible for the given b_m, the delegation set would by trivial since it consist of only one action, $\frac{1}{2}$, the ex ante best response of the DM, but communication could induce informative talk. The following numerical example elaborates this claim:

Example 16 *Suppose $b_s = \frac{1}{3}$, the upper-bound of communication efficiency is $-\frac{2}{27}$, which could be achieved by choosing $b_m = -\frac{1}{9}$. On the other hand, by (11), if $b_m \geq -0.089$, then delegation strongly dominates communication. Hence, for some range of value of the mediator's bias, for instance, $b_m = -\frac{1}{9}$, communication generates higher expected payoff than delegation.*

[7]It's defined by $0 \geq b_m \geq -\frac{1}{4}$ and $b_s - \frac{1}{2} \leq b_m \leq \frac{b_s}{3} - \frac{1}{6}$.

Put it into our example of government department. If the department consists of a neutral minister, a radical liberal junior deputy secretary and a conservative undersecretary, and the senior bureaucrat is protected from the removal by the minister, then the minister may keep control rights and restrict the role of the undersecretary to information processing, instead of delegate decision rights.

Therefore we revise the central conclusion in Dessein (2002) regarding the efficiency of delegation, in which whenever there is informative communication in cheap talk, delegation dominates communication. The basic intuition in terms of mechanism design is with commitment power, which is equivalent to delegation, the DM could do no worse than without (cheap talk). Hence the DM should engage in delegation instead of communication. However, we show that this result would not hold when the DM cannot access informed sender. As we have already show in Figure 3 and the example above, it's possible that for some range of bias there is gain in mediator talk but no meaningful delegation scheme.

The possibility that the DM chooses to engage in communication rather than delegation results from the DM's inability to interact with informed agent directly. Because the DM cannot access the sender, i.e., she cannot observe message s, she has to take the incentive of mediator into account when making decision based on m. Moreover, any decision rule she commits to has to be in the best interest of mediator. In other words, due to the fact that the mediator controls information flow, there are only limited action rules available to the DM.

In mechanism design literature the DM can choose whatever decision rule, thus the researchers could restrict attention to incentive-compatible mechanism to implement the action rule. However, this is not the case in hierarchy. When the DM finds out that under the available decision rules the loss of control is too costly, she may forgo commitment and engage in communication, in which the gain in keeping decision right outweighs the loss in information transmission. The absence of commitment in our hierarchy is not due to commitment cost or *ex post* temptation to renege, as previous works suggest. Instead, there is a new reason for giving away commitment: inability to interact with informed party directly. As consequence, the possible solution to this commitment problem would not be providing with commitment device or reputation concerns. Instead, organization design, in particular the layers in organization, matters in solving commitment problem and providing proper incentives for real informed agent.

This result sheds lights on job design, more specifically, what's the role of middle-level agent? Should he be assigned with some discretionary authority, or just act as a bottleneck in information flow? We show that when the two

agents are opposite biased, the decision maker may optimally retain control rights and limit the role of mediator to information garbling. Moreover, job design is inevitably related to hiring policy since the preference alignment of mediator determines what the mediator could do. In our example about internal form of government, the minister delegates discretionary authority to the senior if she can fill the senior position with whatever person. However, the elected politician would like to retain control over decision if she cannot replace the bureaucrats. Thus even though the hierarchy as a structural feature of bureaucracy is well defined, the job content of each position depends on the ability of top-level DM to replace agents. And if the authority over hiring and promotion is restricted, the top-level DM then engage in specifying the content of job.

5 Related Literature

There is a large body of literature in organizational economics which address the benefits of hierarchy. Largely motivated by bounded rationality, the works by Radner (1993), Bolton and Dewatripont (1994), and Geankoplos and Milgrom (1991) are concerned with the role of hierarchy in facilitating information processing, and stress the information aggregation within vertical structure. Based on heterogeneity among agents, another related strand of literature since Garicano (2000) develops "knowledge-based" hierarchy. As complementary, we take hierarchy as given structural characteristic, and address the strategic behavior of agents, analyze the selection of agents and choice between communication and delegation. Therefore our work pays more attention to the issues in personal economics such as job design and hiring policy[8].

Tirole (1986) explicitly introduces supervisor into principal-agent relationship to study multiple-layer hierarchies. However, in his paper the supervisor holds private information about the type of agent, and the focus is the collusion between supervisor and agent. He establishes the equivalence between coalition-proof contract and giving ownership to supervisor, who subcontract with an agent further. In our model the existence of mediator is given, and he is uninformed. Further we show that without monetary transfer, the equivalence fails and subcontract cannot implement the optimal delegation scheme.

Some recent works including Alonso et al (2008) and Calvo-Armengol and de Marti (2007, 2009) study organization form and delegation decision

[8]See Gibbons and Waldman (1999) for a accessible survey on this field.

in the light of network structure. Our work differs from theirs in that the decision right, though transferable, is not divisible, thus there is no issue about decentralization of decision-making. Besides, there is no coordination motivation among players in our work. Though these two points may limit the application of our model, there are some advantages in our approach in that we address the multiple-level, instead of direct interaction, and we study optimal delegation, rather than unconditional delegation in theirs. This paper is related to the literature on the optimal assignment of authority (Aghion and Tirole, 1997, Aghion et al, 2004), in which the information role in determining the "real" authority is concerned. We contribute to this line of literature in that we stress the presence of hierarchy, thus an agent not only could receive authority, but also can transfer it to another agent.

Based on CS model, Mitusch and Strausz (2005) and GHPS (2009) establish that by hiring a neutral mediator the DM could achieve optimal mechanism to extract information from informed agent. Ivanov (2009) shows that this result is robust to strategic mediator for some range of parameters. On the other hand, Dessein (2002) and AM (2008) analyze the delegation decision in classical CS model, and demonstrate the dominance of delegation mechanism over cheap talk. The basic intuition follows the insights of mechanism design that by commitment the mechanism designer can do no worse that without. We combine these two strands together to study delegation mechanism via a mediator. To the best of our knowledge, our work is the first to show the possible *ex ante* dominance of communication over delegation. Board and Dragu (2008) consider the communication between one sender and two asymmetric decision makers, in which the second DM serves as vetoer. Thus the communication between the sender and first DM is affected by the interest of vetoer. In our model the mediator acts somehow like the vetoer whose incentive compatibility condition has to be satisfied, but we emphasize the impact on delegation mechanism and choice over communication and authority transfer.

A closely related paper is the recent work by Ambrus et al (2010), who compare the performance of closed rule and open rule in floor-committee-lobbyist hierarchy. In terms of our work, open rule is equivalent to communication, while closed rule is complete delegation to the mediator (committee). Though we ask the similar research questions on the role and choice of the mediator, we have different focus. Moreover, they develop based on Dessein (2002) and stress full delegation, and they don't allow the mediator (committee) to further delegate decision right, i.e., commit to an action rule.

Our work contributes to the growing body of literature on strategic communication embodied in network structure (Hagenbach and Koessler, 2008, Galeotti et al, 2009, Ambrus et al, 2009, Renou and Tomala, 2008, Calvo-

Armengol et al, 2009). In particular, in the sense that implementation of optimal mechanism in network structure is addressed, we are closely related to Renou and Tomala. However, we differ from this line of research in highlighting the choice between delegation and communication, which also corresponds to that the principal could commit to a decision rule in terms of strategic information transmission. Moreover, in our work commitment is endogenous in the sense that mechanism designer (DM) chooses between delegation (commitment) and communication. We add a possibility that due to inability to interact with informed party, rather than inability to make commitment, the mechanism designer may not want to make promise.

We share with Ambrus and Egorov (2009) the same motivation on understanding the role of bureaucracy, though we address different aspect of bureaucracy (Weber, 1946). The current work highlights the structural features like hierarchy and network (strict subordination), instead of procedural paperwork and official activities in their paper.

6 Conclusion

The fact that within hierarchical organization, especially government, the span of discretionary authority decreases top down motivates our research on optimal delegation mechanism under hierarchy. This work contributes to literature by providing a complete characterization of the implemented delegation set, and establishing conditions for attaining efficiency in hierarchy. The results that the optimal intermediary in delegation chain should be moderately biased, and allowing transfer of authority benefits decision maker are intuitive. We also use this framework to show the job design, promotion, and hiring policy within bureaucratic organization.

It worthwhile to note that we take hierarchy as given structural characteristic, thus we don't answer the important question about the rationale of hierarchy. Besides, we study the three-tier hierarchy and ignore the multiple subordinates tree structure, which is a more realistic feature of hierarchy. However, as long as hierarchy is formed based on the consideration beyond strategic information transmission, such as information processing cost (Radner, 1993), heterogenous knowledge (Garicano, 2000) or conflict over hiring and promotion decisions (Friebel and Raith, 2004), our results still hold in multiple subordination structure.

A possibly more important contribution of this paper is to illustrate the possibility that the DM may engage in communication, instead of delegation. Mechanism design literature has demonstrated that the principal could not be worse off by commitment. However, this work shows that given hierarchical

structure and divergence of interest, the set of decision rule available to the DM is limited by the incentive compatibility of mediator, thus the DM may find it's no longer optimal to make a specific commitment: delegation. This result suggests that network structure matters in mechanism design and implementation. The lack of access to informed agent, in addition to commitment cost or ex post temptation to renege, is identified as a reason to the absence of commitment. Delegation is usually considered as an important form of incomplete contract, which works as response to ex post renegotiation or unverifiable information. This work shows that specific network structure can impose stringent limit on the efficiency of incomplete contract, which is to large extent beyond the sights of theorists.

A Appendix A

Proof of Lemma 1: See Lemma 1 and Theorem 1 in CS.

Proof of Lemma 2: See Theorem 1 in GHPS (2009).

Proof of Lemma 3: See Proposition 2 in AM (2008).

Proof of Proposition 4

By Lemma 3 the delegation set is a connected set. Without loss of generality, let this connected set be a closed interval of state $\left[\min\{\underline{\theta}+b_s,0\},\max\{\overline{\theta}+b_s,1\}\right]\in Y$ where the informed party could select any action within this interval, i.e., the informed party can implement his preferred action when $\theta\in\left[\underline{\theta},\overline{\theta}\right]$. For any $\overline{\theta}+b_s\leq 1$ to be optimal from the DM standpoint, we need that she is indifferent between her best response given that $\theta\geq\overline{\theta}$ and delegated action $\overline{\theta}+b_s$. This would lead to $1-2b_s=\overline{\theta}$. Since $b_s<0$, this would be impossible, so $\overline{\theta}=1$ has to be satisfied.

On the other hand, this the lower bound $\underline{\theta}+b_s$ should also be the best response of the DM when she knows that the true state locates within $[0,\underline{\theta}]$, thus this $\underline{\theta}$ should be equal to $-2b_s$. Therefore we reach the desired conclusion.

Proof of Lemma 6

We have already shown that when $|\Delta|>\frac{1}{2}$, $Y_s=\frac{1}{2}+b_m$ if it lies in Y_m. Now we just need to show that there is only one action being selected if $\frac{1}{2}+b_m\notin Y_m$. Without loss of generality, we focus on the constrained optimization problem of the mediator (4). Suppose in contrast, two actions $y_1<y_2$ would be chosen by the sender depending on the state, then we could find out a $\theta'=\frac{y_1+y_2}{2}-\Delta$ such that y_1 is chosen if $\theta\leq\theta'$, and vice versa. Next we turn to see the incentive of the mediator. His expected payoff would be $-\int_0^{\theta'}(y_1-\theta)^2\,d\theta-\int_{\theta'}^1(y_2-\theta)^2\,d\theta$ under this scheme, and $-\int_0^1(y-\theta)\,d\theta$. Therefore, we would get

$$
\begin{aligned}
& -\int_0^1 (y-\theta)\,d\theta - \left[-\int_0^{\theta'} (y_1-\theta)^2\,d\theta - \int_{\theta'}^1 (y_2-\theta)^2\,d\theta\right] \\
= & -\int_{\theta'}^1 (y_1-\theta)^2\,d\theta + \int_{\theta'}^1 (y_2-\theta)^2\,d\theta \\
= & -\int_{\theta'}^1 \left[y_1^2 - y_2^2 - 2(y_1-y_2)\theta\right] d\theta \\
= & (y_1-y_2)(1-\theta')\left[(1+\theta') - (y_1+y_2)\right] \\
= & (y_1-y_2)\left[\left(1-\frac{y_1+y_2}{2}\right)^2 - \Delta^2\right]
\end{aligned}
$$

Because $\theta' \geq 0$, $\frac{y_1+y_2}{2} \geq \Delta \geq \frac{1}{2}$ has to be satisfied. Thus the above inequality would be positive, namely the mediator could increase his expected utility by authorizing only the lower action y_1. Thus we reach the conclusion desired.

Proof of Proposition 7

Since $Y_s \subset Y_m$, the highest action available to the sender $\overline{y_s}$ can not exceed the highest action in Y_m. On the other hand, by Lemma 2 if the mediator could select whatever delegation set in his interest, then the size of delegation set relies only on the relative difference of bias Δ, thus the upper-bound would be $1-\Delta$.

Proof of Corollary 8

Lemma 19 in Appendix B shows that Y_s is connected set if Y_m is connected, thus the the DM can focus only on the upper-bound. Since $\Delta < b_s$, $1-\Delta > \sup\{y\,|y \in Y_m\} = 1-b_s$, thus by truncating delegation set to the mediator with the highest action of efficient delegation set $1-b_s$, the sender would be limited to take any action less than $1-b_s$, which is exactly the contents of efficient delegation set.

Proof of Proposition 9

1. We first study the case of opposite biased agents and show that the efficient delegation set is not implementable. Without loss of generality, assume that $b_s > 0 > b_m$, so $\Delta > b_s > 0$. Suppose in contrast, the efficient delegation set $Y^* = [0, 1-b_s]$ is implementable, then we should have $Y^* \subset Y_m$, namely there is an interval larger than $[0, 1-b_s]$ belongs to the mediator's delegation set.
   Because the relative difference of interest is Δ and $1-\Delta < 1-b_s = \sup\{y\,|y \in Y^*\}$, by Proposition 6 the mediator would like to only delegate $[0, 1-\Delta]$ to the sender, given his delegation set Y_m. Hence we get the contradiction needed.

2. Now we check the case of extremely biased mediator. Still without loss of generality, we assume that $b_m > b_s > 0$. Hence $\Delta < 0$, and according to Proposition 4, the mediator would impose lower bound $-\Delta$ on Y_s, while Y^* prescribes zero lower bound. Since the mediator' prefers to truncate at the bottom, the DM could not implement the efficient delegation set, in which the sender has control in low state.

Proof of Corollary 11

If the agent 2 is assigned as the sender, then as (6) shows, the expected payoff to the DM is $\left(\frac{4}{3}b_2 - 1\right) b_2^2$, while if the agent 1 becomes the sender the expected payoff becomes $-\frac{8}{3}b_2^3 + 4b_1 b_2^2 - b_1^2$. By comparing these two formula it shows that it's beneficial to appoint agent 2 only if $4b_2^3 - (1 + 4b_1) b_2^2 + b_1^2 > 0$. The remaining reasonable root leads to $b_2 > \frac{1+\sqrt{1+16b_1}}{8}$.

Proof of Proposition 13

By (10), we distinguish the discussion into two parts: the binding upper bound $\overline{y}$ or not.

1. First, we study the case that the upper bound is always binding, namely $\overline{y} < 1 + 2b_m - b_s$ whenever $b_m < b_s < b_m + \frac{1}{2}$. This condition translates into $\overline{y} < \frac{1}{2} + b_m$.
   Therefore, the ex ante expected payoff to the DM is

$$\int_0^{b_m} \{-\frac{1}{3}\left[(1-\overline{y})^3 + (2b_m - b_s)^3\right] - b_s^2\left(\overline{y} + b_s - 2b_m\right)\} db_s + \tag{13}$$

$$\int_{b_m}^{b_m+\frac{1}{2}} \{-b_s^2\left(\overline{y} - b_s\right) - \frac{1}{3}\left[(1-\overline{y})^3 + b_s^3\right]\} db_s + \int_{b_m+\frac{1}{2}}^{1} \left[-\int_0^1 \left(\overline{y} - \theta\right)^2 d\theta\right] db_s \tag{14}$$

   The first term is the expected payoff if the sender is less biased than the mediator, where the mediator will set the lower bound on Y_s. The second term represents the expected payoff if the sender is more biased than the mediator, but only modestly. The mediator will further delegate the control rights to the sender p till $\overline{y}$, the cap of his authority. And the third term is the expected payoff when the sender is extremely biased, in which the sender can only take one action prescribed by the mediator and the DM. Because the only strategic choice is $\overline{y}$, we get rid of the constant term and collect the terms relevant to the choices into the "virtual payoff" V

$$V\left(\overline{y}\right) = -\frac{1}{3}\left(1-\overline{y}\right)^3\left(b_m + \frac{1}{2}\right) - \frac{\overline{y}}{3}\left(b_m + \frac{1}{2}\right)^3 - \left(\frac{1}{2} - b_m\right)\left(\overline{y}^2 - \overline{y}\right)$$

Take the derivative of the above virtual payoff and equal it to zero, we have $\overline{y} = \frac{2-2\sqrt{1-\left(b_m+\frac{1}{2}\right)\left[1-\frac{1}{3}\left(b_m+\frac{1}{2}\right)^3\right]}}{2b_m+1}$. Check it with the initial condition $\overline{y} < \frac{1}{2} + b_m$, we need $2\left(b_m+0.5\right)^3 - 6\left(b_m+0.5\right) + 3 < 0$.

2. Second, we study the case that the cap sometimes may not hold, in other words, $\overline{y} > \frac{1}{2} + b_m$, the expected payoff to the DM can be expressed as

$$\int_0^{b_m} \{-\frac{1}{3}\left[(1-\overline{y})^3 + (2b_m - b_s)^3\right] - b_s^2\left(\overline{y} + b_s - 2b_m\right)\} db_s +$$
$$\int_{b_m}^{1+2b_m-\overline{y}} \{-b_s^2\left(\overline{y} - b_s\right) - \frac{1}{3}\left[(1-\overline{y})^3 + b_s^3\right]\} db_s + \int_{1+2b_m-\overline{y}}^{b_m+\frac{1}{2}} \{b_s^2(1+2b_m-2b_s) +$$
$$\frac{1}{3}\left[(b_s-2b_m)^3 + b_s^3\right]\} db_s + \int_{b_m+\frac{1}{2}}^{1} \left[-\int_0^1 \left(\frac{1}{2} + b_m - \theta\right)^2 d\theta\right] db_s$$

The first term is the same as that in (13). The second term establishes that when the sender's preference is not far from the mediator, the cap $\overline{y}$ binds Y_s since the mediator always prefer to delegate more to the sender. The third and fourth terms show that when the sender is further from the mediator, the mediator will impose the cap in his interest, thus $\overline{y}$ no longer binds. Eliminate all terms irrelevant with the choice of $\overline{y}$, we have
$V\left(\overline{y}\right) = -\frac{1}{3}\left(1-\overline{y}\right)^3\left(1+2b_m-\overline{y}\right) - \frac{7}{12}\left(1+2b_m-\overline{y}\right)^4 + \frac{(1-\overline{y})^4}{12}$
The derivative of the above with respect to $\overline{y}$ is always positive, thus the optimal cap is $\overline{y} = 1$. In other words, the DM will completely delegate to the mediator.

Finally, we compare the expected payoff to the DM under these two $\overline{y}$ we find out that $\overline{y} = 1$ is better.

Proof of Lemma 15: See Ivanov (2009) Theorem 1 and Lemma 4.

B Appendix B

Lemma 17 *If the delegation set to the sender Y_s includes an interval of action, then there is no isolated point in Y_s which is also in the interval in Y_m.*

Proof. *Suppose there exists an interval of action $\left[\underline{y_s}, \overline{y_s}\right] \subset Y_s$ and $\left[\underline{y_m}, \overline{y_m}\right]$, we want to show that $\left[\underline{y_m}, \overline{y_m}\right] = \left[\underline{y_s}, \overline{y_s}\right]$.*

By definition of hierarchical delegation, $\left[\underline{y_s}, \overline{y_s}\right] \subset \left[\underline{y_m}, \overline{y_m}\right] \subset Y_m$*, which means that all actions available to the sender are also available to the mediator. Suppose in contrast, there exists a* y'_m *such that* $\underline{y_m} \leq y'_m < \underline{y_s}$*, which means that the mediator could but doesn't allow the sender to select action* $\underline{y_s} - \epsilon, \forall \epsilon > 0$*. For* y'_s *being an element in efficient delegation set to sender, there should be a state* $\theta' < \underline{y_s} - b_s$ *such that when the true state* $\theta \in [\theta', \underline{y_s} - b_s]$*, the sender chooses* $\underline{y_s}$*. Then when the true state* $\theta = \underline{y_s} - b_s - \epsilon$*, the mediator payoff is*

$$-\left[\underline{y_s} - \left(\underline{y}_s - b_s - \epsilon\right) - b_m\right]^2 = -\left(b_s - b_m + \epsilon\right)^2$$

On the other hand, if he allow the mediator to choose his preferred action, the payoff becomes

$$-\left(b_m - b_s\right)^2$$

It's obvious delegation increases the mediator's payoff, hence he would like to include $\underline{y_s} - b_s - \epsilon$ *into* Y_s*, which consists the contradiction we need. Thus we would have* $\underline{y_s} = \underline{y_m}$*.* ■

Lemma 18 *If the delegation set to the sender* Y_s *includes an interval of action, then it's a connected set.*

Proof. *Suppose in contrast that there is a* $y'_s < \underline{y_s}$ *in* Y_s*, and there is no* $y \in \left(y'_s, \underline{y_s}\right)$ *such that* $y \in Y_s$*. By definition,* $y'_s \in Y_s$ *and there is at most finite actions available within interval* $[y'_s, \underline{y_s}]$ *in* Y_s*. In other words, the the DM doesn't allow the mediator to select any action he preferred in this interval. However, then the payoff to the DM would be*

$$-\left[\underline{y_s} - \left(\underline{y}_s - b_s - \epsilon\right)\right]^2 = -\left(b_s + \epsilon\right)^2$$

if $\theta = \underline{y_s} - b_s - \epsilon$*, and delegation generates payoff* $-b_s^2$*. So from the point of DM, she would like that the sender could choose his preferred action around* $\underline{y_s}$*. This delegation is also in the interest of the mediator, so* $\underline{y_s} - \epsilon$ *would also be included into the delegation set* Y_s *and* Y_m*. We iterate this logic and could reach that there is no isolated action* $y'_s < \underline{y_s}$*, and satisfies* $y'_s \in Y_s$*. By the same logic, we get similar result on the upper side. Therefore, we conclude that* Y_s *is connected set if it includes an interval.* ■

Lemma 19 *If* Y_m *is a connected set, so is* Y_s*.*

Proof. *By the reverse of Lemma 18, if* Y_s *is not a connected set, then it has to be a set of finite number of elements. This is in contrast with Lemma 3 which states that the optimal delegation set has to include all actions between any two discrete actions.* ■

C Appendix C

We follow Ambrus et al (2009) closely to construct two-interval mixed strategy equilibrium in vertical communication mode. We focus on the outcome-equivalent perfect Bayesian-Nash equilibrium that the sender reports truthfully on θ, the negatively biased mediator ($b_m < 0$) recommends action m_1 to the DM after receiving message $s \leq x$, and mixes between m_1 (with probability p) and m_2 after getting message $s > x$. Finally the DM acts according to the report sent by mediator, $y_1 = m_1$ and $y_2 = m_2$.

Since the DM understands that $\theta \geq x$ when she hears m_2, we need $m_2 = \frac{1+x}{2}$. Because the mediator must be indifferent between sending m_1 and m_2 when he receives $s = x$, we have $m_1 = \frac{1+x}{2} + 2b_s$. Similarly, the sender has to be indifferent between both actions, so we get $x = 1-2\Delta$. Thus we substitute it into m_1 and m_2, and solve $m_2 = 1-\Delta$ and $m_1 = 1-\Delta+2b_m$. By Bayesian Law, the DM must update her posterior in such way that $E(\theta|m_1) = m_1$, so we have

$$\tfrac{x}{2}\Pr(\theta \in [0,x]\,|m_1) + \tfrac{1+x}{2}\Pr(\theta \in [x,1]\,|m_2) = m_1$$

where $\Pr(\theta \in [0,x]\,|m_1) = \frac{x}{x+(1-x)p}$
Thus we get $p = -\frac{1}{8}\frac{(1-2\Delta)(1+4b_m)}{\Delta b_m}$.
Therefore we get $0 \leq \Delta \leq b_m, b_m \geq -\frac{1}{4}$, and $\Delta \geq \frac{1}{2}(1+4b_m)$.

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