博士論文

# Essays on decision making and strategic communication in organization

(組織における意思決定と
戦略的コミュニケーションに関する論考)

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# Contents

# Chapter 1.
# Introduction

Good decision-making requires good communication. In organizations, it is typical that relevant information is dispersed for decision-making (Hayek (1945)). While effective communication is necessary to make informed decisions, there may exist various constraints that make communication costly and incomplete. It is crucial to take these constraints into account when we discuss about what an organization should be from the perspective of efficiency. The first attempt to understand decision-making under dispersed information in organizations began with studies of a model under exogenous communication quality. Marschak and Radner (1972) construct the team theoretic model, in which decisions are needed to be coordinated but communication is costly due to physical reasons. Building on their work, Crémer (1980) and Dessein and Santos (2006) discuss how multiple tasks are bundled from the perspective of reducing coordination loss led by limited communication, and Aoki (1986) compares the efficiency of vertical and horizontal information structures.

However, we know little about decision-making under strategic situations in which constraints can arise endogenously, in particular, in situations where people strategically transmit information in organizations. Recent studies of organizational economics teach us that consideration of endogenous communication quality involves many significant implications for designing an organization. A trade-off between effort provision and informative communication is a good example for clarifying this aspect clear; optimal contracts from the perspective of eliciting effort often create conflict between agents over decisions made in organizations, and serious conflict generally lowers the amount of information provided by agents, as shown by Crawford and Sobel (1982). To understand this, let's consider a situation in which an organization introduces a comparative measure in evaluating agents' performance. While comparative performance evaluation can enhance agents' incentives for providing effort by mitigating the free-rider problem or eliminating the common measurement error in performance evaluation (Holmstrőm(1982)), it makes agents act in their personal interest, rather than in the interest of the organization. For example, agents are inclined to disagree with implementing projects that may cause their own performance to decline but improves the other agents' performance, despite the fact that the project yields a large benefit for the entire organization.[1] Then, even if agents become aware of such a beneficial project, they have incentives to conceal or misrepresent it to manipulate the organizational decision for their personal interest, thereby making a wrong decision in organizations. Dessein, Garicano, and Gertner (2010) study the trade-off between effort provision and high quality of communication in the synergy-creation problem, and Friebel and Raith (2010) discuss the boundary of the firm from the perspective of this tradeoff.

A few researches study the issue of authority allocation in organization under strategic communication. Dessein (2002) studies the value of delegation in the traditional cheap talk model presented in Crawford and Sobel(1982). He shows that higher organizational performance can be achieved when the person (”sender” in the terminology of cheap talk) who possesses complete knowledge regarding an underlying state, but whose objective is biased makes a decision, than when the person (”receiver” in the terminology of cheap talk) who possess no information regarding the state but whose objective is not biased makes a decision, if communication is strategic. Similarly, building on the team theoretic model, Alonso, Dessein and Matouschek (2008) and Rantakari (2008) study the optimal authority allocation in a multi-agents(senders) situation: centralization or decentralization. However, many issues regarding decision-making in organization under strategic communication still remain to be explored.[2]

The main purpose of this thesis is to study decision-making with endogenous communication quality by investigating how effective leadership improve the quality of decision-making under strategic communication. Specifically, we develop the model of strategic information transmission and answer the following questions: (i) how does a leader's belief regarding the value of her own and/or followers' information affect the amount of information provided from followers through cheap talk, and (ii) when should a leader adopt communication-based decision-making process under strategic-communication constraints?

In Chapter 2, we answer the first question of the relation between a leader's belief on the value of leader's and/or followers' information and quality of communication. We construct a primitive strategic information transmission game between one leader (receiver) and two followers (senders). In this game, the followers have independent and heterogeneous preferences with regard to the

[1] Athey and Roberts (2001) study this fundamental trade-off between effort provision and creating conflict under comparative performance evaluation.

[2] As an approach to model endogenous communication quality in organization other than cheap talk, Gibbons (2005) develops the model of signal jamming.

organizational decision, but this is private information. The leader listens to the followers regarding their preferences through cheap talk and makes an organizational decision to maximize overall welfare. Contrary to prevailing knowledge, we show that the leader who overestimates the value of her own information (or underestimates the value of followers' information) can extract more precise information from followers as compared to leaders who rationally estimate or underestimate such information (or overestimate the value of followers' information), if followers are likely to have a significantly different preference.

The results of Chapter 2 also involve a theoretical contribution to the literature of studies on a receiver's sensitivity in strategic information transmission. Early studies in the literature focus on the situations in which one sender who has an irrational belief on the value of his own information communicates with one receiver. Admati and Pfleiderer (2004) argue that a sender's overconfidence in his skill of observing an underlying state may improve the quality of communication and the receiver's welfare. Kawamura (2013) also shows that a slight overconfidence on the part of the sender can always increase information transmission and the receiver's welfare whenever the sender has a different preference from the receiver's decision, whereas underconfidence does not. This study offers a novel theoretical insight regarding how a receiver's confidence on two senders' information affects information transmission, depending on the level of conflict between two senders. We find that the amount of information provided by one sender depends on two factors: the receiver's sensitivity to that sender's opinion in making a decision and the collective opinion, which is formed as the expected sum of the opinions of the receiver and the other sender weighted by the sensitivity to each opinion. We show that a sensitive receiver can improves the senders' information transmission through the first factor if the conflict between the two senders is not severe but can decline it through the second factor otherwise.

In Chapter 3, we construct a team theoretic model and answer the second question of decision-making process under strategic-communication constraints. In the model, each follower's performance is maximized when his decision is adapted to each environment and is coordinated with the organizational decision. Each environment is private information for each follower. The leader makes an organizational decision to maximize the organizational performance, which is defined as the sum of both followers' performance. We compare two decision-making processes in the chapter. In one process, which is associated with the leader's initiative, the leader collects information on each environment through cheap talk from the followers and makes an organizational decision, before the followers make decisions. In another process, the leader postpones her decision until the followers make their decisions, observes the followers' decisions, and thereafter makes an organizational decision. We show that the former process has an advantages over the latter process when the importance of coordination is relatively greater than the importance of adaptation, and the opposite is true otherwise. We also discuss that one strong point of communication-based decision-making lies in aligning followers' decisions with the interest of the organization.

A few empirical studies on leadership indicate that leadership style has a considerable effect on the decisions of the organizations (Bertrand and Schoar (2003)) and which traits of the leader are positively or negatively related the organizational success (Kaplan, Klebanov, and Sorensen (2012)).[3] Although the early studies on leadership by economists focus on the role of leadership in eliciting efforts from followers (Hermalin (1998), Rotemberg and Saloner (1993, 2000)), researchers recently investigate the role of leadership in coordinating followers decisions under communication limited due to exogenous reasons by developing team theoretical models. Brunnermeier, Bolton, and Veldkamp (2013) emphasize the value of a leader's resoluteness in her decision-making for achieving better coordination in the team when direct communication is impossible. Dewan and Myatt (2008) study the situation in which only leaders have information, and they emphasize the value of the leader's speaking skills in communication, rather than the skill in accurately observing the environment. The role of leadership in decision-making under endogenous communication quality, however, remains to be explored in the literature, and we provide significant attempts to understand it in Chapter 2 and 3 of this thesis.

In chapter 4, we consider a task assignment problem from the perspective of behavioral economics.[4] Task allocation is one of central issues in the literature on communication and organizations. In real organizations, the prevalent practice is that a single task is always assigned to a single agent, even if the other agents can potentially implement the task in a better manner in certain situations. Although studies in communication-and-organization literature explain why multiple tasks are assigned to a single agent from the perspective of mitigating coordination failure caused by costly communication ( Crémer (1980) and Dessein and Santos (2006) ), it can not explain why such a simple form of assignment prevails. In Chapter 4, we attempt to understand this issue from

[3] In management literature, researchers believe that the value of a leader's traits or behaviors is determined by the underlying situation or environment (for example, Fiedler(1967) and Finkelstein, Hambrick, and Cannella (2009)).

[4] Chapter 4 is a joint work with Kohei Daido, Kimiyuki Morita, and Takeshi Murooka. My contribution is constructing the theoretical model and deriving the propositions.

a prominent behavioral aspect: expectation-based loss aversion developed by Kőszegi and Rabin (2006, 2007). We analyze the simple task-assignment model, in which a principal assigns a task to one of two agents depending on future states and the productivity of one agent is higher than the others in a state but lower in another state. We show that if the agents are loss averse, assigning the task to a single agent in all states can be optimal, even when the principal can write a contingent contract at no cost.

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# Chapter 2.
# A Good Lister and a Bad Listener

## 1 Introduction

> ”Listening is the first priority for managers.” - Konosuke Matsushita (Founder of Panasonic)
>
> ”Don’t let the noise of others’ opinions drown out your own inner voice.”
>
> - Steve Jobs (CEO of Apple)

It is critical that a leader listens to the opinions of her followers in making decisions. However, it is often challenging to elicit full information from them, because self-interested followers may have an incentive to provide misleading information to influence the leader’s decision in favor of themselves. For example, suppose the CEO of a firm needs to design a new product. Whereas the CEO may have in mind an ideal design that is optimal from the perspective of cost saving because of the production technology of the firm, she may have less information about the needs of consumers in each local market. Because sales managers in local markets know the needs better than the CEO, their opinions help to identify the product that will maximize total sales in a whole market. However, if the sales managers prefer the product that would be sold mostly in their own markets, they may exaggerate the needs in their respective markets (e.g., ”our consumers need a more functional product”) even if the extent of the needs is not so extreme, because manager know that the CEO will consider their opinions as well as those of the other managers, who may send conflicting messages to the CEO. In such a situation, it is important for the leader to be able to elicit as much information as possible.

Although excellence in listening is considered as a key factor in efficient leadership, we know little about what type of leaders can actually elicit a large amount of information. In this paper, our main focus is on leaders’ sensitivity toward others’ opinions in listening. Specifically, we focus on two types of leaders: a good listener and a bad listener. An example of the first type is Konosuke Matsushita, the founder of Panasonic; he incorporates followers’ opinions into own decision giving them a lot of weight, and does not persist in his own opinion. We call a Matsushita-like leader a good listener, because such a leader gives more importance on followers' opinions and is intensely interested in listening to them. An example of the second type of leader is Steve Jobs, the former charismatic CEO of Apple, who tended to persist in his own opinion rather than incorporate the opinions of others. We call a Jobs-like leader a bad listener, because such a leader tends not to listen and learn from other people. These observations lead us to the questions we attempt to answer in this paper. How does leaders' sensitivity affect the amount of information followers provide? Which type of leaders able to elicit more information from followers? How should leaders communicate their opinions with followers in order to elicit plenty of information?

Here, we construct a model of a strategic information-transmission game between a leader and two followers. The followers may have different preferences concerning organizational decisions, and these are private information. The leader makes an organizational decision to maximize organizational welfare, but the followers are assumed to be self-interested. The leader and the followers can communicate what decision they prefer via cheap talk before the decision is made. Even truthful communication is not strategy proof because the leader do not incorporate each follower's opinion fully into the decision. Only partially informative communication can be achieved as Crawford and Sobel (1982), which partitions the type space into some intervals so that the follower reveals only that the information belong to a certain interval; thus, the followers' messages contain some noise in the equilibrium.

Somewhat counter-intuitively, a leader's sensitivity may hurt the quality of communication with the followers. It is true that if there is only one follower, a good listener can elicit more information than a bad listener. If a leader is a good listener, a follower will be more willing to reveal information because such a leader does not persist in her opinion, rather carefully considering and incorporating followers' opinions. However, if there is even one more follower, the negative side of being a good listener arises. Because a good listener is also sensitive to other followers' opinions, the leader's decision may also be easily influenced by their opinions. If followers believe that their rivals hold opposite opinions from them, they may exaggerate their information in order to change the leader's mind.

More precisely, when followers communicate their opinions with the leader, they take two factors into accounts: first, how will the leader incorporate their opinions into the decision? If the leader gives followers' opinions substantial weight, the incentive to misrepresent information becomes weak, and followers are inclined to provide more information. Second, what is the collective opinion in the organization (which is formed as the expected weighted sum of the opinions of the leader and the other followers)? If a given follower believes that the other organizational members have similar opinions, that follower does not feel the need to misrepresent information. Conversely, if the follower believes that others have different opinions and that the collective opinion differs from his ideal decision, there is a larger incentive to exaggerate information to change the leader's mind. Such a conflict of opinions over organizational decisions results in the follower's providing less information. Thus, a sensitive attitude of a leader may exacerbate misrepresentation from the followers when their opinions are likely to be in conflict.

A distortion in leaders' sensitivity toward followers' opinions may actually improve an organizational performance. If a distortion in leaders' decision policies from the ex-post efficient level is slight, we can neglect all direct effect from the distortion, and only the strategic effect matters as it captures how the distortion affects the quality of communication with the followers. Therefore, a slight increase or decrease in leaders' sensitivity can improve the organizational performance whenever it facilitates communication.

In the discussion section, we address two issues. The first concerns the value of being a good listener when there is some biases in the side of the leader. We show that the value of being a good listener is more likely to be high when leaders have biased opinions. This is likely because leaders' extreme opinions give followers an incentive to exaggerate their information; in such a scenario, leaders can elicit more information by giving up their own extreme opinions. Another form of distortion in sensitivity is leader favoritism, in which leaders show different sensitivities toward each follower. We demonstrate that it is preferable for organizations to employ the leader who is biased in terms of showing high sensitivity toward the follower whose information is most volatile.

The second issue relates to leaders' confidence in their communication skill. We also show that irrational self-confidence in the leader's own communication skill can explain a distortion in the leader sensitivity. We argue that leaders who are overconfident in their communication skills and irrationally underestimate the probability of communication failure incorporate followers' opinions more into organizational decisions, whereas an underconfident leader, who irrationally overestimates the probability of failure, incorporates them less.

We further examine a bilateral communication setting, in which a leader can send a one-time costless message to the followers concerning her opinion before the followers send messages. We find that leader's equilibrium strategy can take only two forms; binary strategy and babbling strategy despite the leader's type space being a continuum and more than three messages available. Although there may be an infinite number of binary equilibrium, all equilibrium can be Pareto ranked, and the amount of information provided from the followers and the organizational performance is better in babbling equilibrium than in any binary equilibrium. The results imply that a leader should intentionally obfuscate her own opinion before she listens to followers.

## 2 Related Literature

### Leadership

To our knowledge, no theoretical model has been constructed to discuss what a type of leaders improves the quality of communication itself in a strategic communication setting. Some papers on leadership have studied the role of leaders in eliciting followers' efforts. Rotemberg and Saloner (1993, 2000) considered the situation in which a follower exerts effort in finding improvements and the leader decides whether to adopt the follower's idea or not. They show that if the leader is open to a follower's suggestion for improvement, the followers' efforts are enhanced. Hermalin (1998) considers the free-rider problem in a team, and he shows that a leader can moderate the problem with leading by example. However, the researchers do not address the aspect of the quality of communication.

Some researchers have studied the role of leadership and non-strategic communication in coordination games. Although our model does not address coordination issues, the messages in this paper are similar to those from Brunnermeier et.al (2012), who emphasize the value of leader resoluteness in listening to followers in a coordination game. They argue that leader resoluteness helps to mitigate coordination difficulty, which arises from a time-consistency problem. Our work differs from theirs in two senses, though we emphasize similar traits. First, they do not allow communication among organizational members in terms of private information before decision-making. Second, even if communication is possible, there is no reason to provoke intentional communication noise because there is no ex-post conflict among organizational members in their model. Dewan and Myatt (2008) also depict a situation in which followers' actions need to be adapted to the environment and coordinated to the other followers' actions. Only leaders can observe signals concerning the environment and can transmit the signals to the followers. They emphasize the importance of not only skillful observation but also speaking skills in efficient coordination. A novel contribution of our paper is to point out that communication difficulty arises from ex-post conflict if communication is possible and that leadership may help to mitigate such a difficulty.

Researchers have also examined leader overconfidence in the literature. Gervais and Goldstein (2007), Van Den Steen (2005), Vidal and Mollar (2007), and Brunnermeier et.al (2012) emphasize the positive sides of a leader's overconfidence, and Goel and Thakor (2008) address why a leader might be overconfident. Our work points out not only the positive side of leader overconfidence, but also the negative side that may exist in terms of efficiency in communication. Furthermore, little research has considered leaders' irrational confidence in communication skills.

As considered in the management literature, different attitudes in listening to followers are interpreted as arising from differences in leaders' traits, such as openness. It is plausible that if leaders have a high degree of openness, they tend to listen to others and to incorporates others' opinions flexibly into their decisions. In the management literature, some studies support this view. Finkelstein, Hambrick, and Cannella (2009) denote CEOs openness as a composite of such facets of her personality as awareness of multiple perspectives, valuing discourse and debate, and openness to new ideas. Using quantitative coding of the biographies of CEOs, Peterson et.al.(2003) also argue that a leader with high openness shows high flexiblity in decision-making. Researchers in the contingency school -for example, Fiedler(1967)- also believe that the value of a leader's traits or behaviors is determined by the underlying situation or environment. Our study contributes to an understanding of how the value of leader openness varies by situations in a strategic communication setting.

A few economists have done empirical studies on leadership. Bertrand and Schoar (2003) find empirical evidence that a CEO has a considerable effect on the decisions of a firm. Kaplan, Klebanov, and Sorensen (2012) did the first empirical study by economists on the relation between a leader's traits and organizational success. The implication of this paper is consistent with the part of their findings showing that the interpersonal aspects of a leader become less important and the execution aspect becomes more important as a firm matures, at which time the organizational members are more likely to become in conflict.

### Cheap talk

This paper has some contributions to the literature on cheap talk. Using the terminology in the literature, this paper considers the situation in which multiple senders exist and they have independent preferences on the receiver's decision. Crawford and Sobel(1982) is a seminal work in this field. They consider the situation in which only a sender can observe the true state, but only a receiver can make a decision that affects both utilities. They show that there is a Perfect Bayesian equilibrium such that state spaces are divided by finite numbers of partitions, and the sender reveals only the partition in which the true state is as long as the parties never have the same preference in the decision. Some researchers examine multi-sender situations, where senders have correlated preference on a receiver's decision, for example, Gilligan and Krehbiel (1987), Krishna and Morgan (2001), and Battaglini (2002).

Some researchers have studied a multi-sender situation in which senders have independent preferences on the receiver's decision. The closest model is the individually biased-agents case studied in Kawamura (2011), who considers a problem in which a decision maker gathers information via cheap talk about members' preferences on a level of public goods provision that affects all members' welfare. Austen-Smith (1993) makes the comparison between simultaneous and sequential reporting when senders have independent preference. The problem under the centralization case, as treated by Alonso, Dessein, and Matoushek (2008) and Rantakari (2008, 2013), is also close to the one in our model. This paper differs from theirs in the sense that our model studies how heterogeneity in the distributions of senders' preferences affects the quality of communication as well as what a type of distortions in the receiver's decision policy help to elicit information. Furthermore, our paper also investigate a situation in which a receiver (the leader in this paper) also have private information and can communicate it.

The situation this paper considers is similar to that examined by Dessein, Garicano, and Gertner (2005). In their model, the CEO listens to managers, whether they are implementing a suggested project or choosing a status quo. They show that in the condition of a high-powered incentive contact, managers will exaggerate the merit (resp. a demerit) of the quality of a suggested project when it brings a positive (resp. negative) return to their own divisions but a negative return to other divisions. Although our paper neglects the possibility of designing incentive contracts for followers, we thoroughly investigate the issue as it relates to communication and leadership.

Some researchers study how the players' self-confidence on the precision of the sender's signal affect the quality of communication and welfare in one-receiver and one-sender information transmission games. Admati and Pfleiderer (2004) argue that the sender's overconfidence in his observing skill may improve the quality of communication and the receiver's welfare. Kawamura (2013) also shows that a slight overconfidence on the part of the sender can always increase information transmission and the receiver's welfare whenever the sender has a different preference from the receiver's decision, whereas underconfidence does not. We derive the clear welfare result that the value of overconfidence on the receiver's side is likely to be negative as conflict on the receiver's decision among senders becomes severe in a multi-sender setting.

The analysis in the bilateral communication setting contributes to the issue concerning whether disclosing conflict before communication is beneficial or not. Li and Madarasz (2008) consider the information transmission game and show that mandatory disclosure about the extent of conflict between the sender and the receiver is not beneficial. While this paper shares a similar result to them in the sense that revealing information about differences in preferences among the players before communication hurts the quality of communication, no informative message is transmitted via cheap talk in their model, whereas informative communication is feasible even via cheap talk in the model presented here.

# 3 Model

We consider an organization in which there is one leader (she) and two followers (he) indexed by $i = 1, 2$. The leader and the followers have their preferences concerning an organizational decision. Specifically, we assume that follower $i$'s profit is given by

$$\pi_i = -(d - \theta_i - b_i)^2,$$

where $d \in \mathbb{R}$ is an organizational decision (e.g., product design), and $\theta_i + b_i$ is follower $i$'s ideal decision (e.g., the consumers' needs in the local market managed by manager $i$). $\theta_i$ is follower $i$'s private information and is uniformly distributed in $[-s_i, s_i]$ where $s_i \in \mathbb{R}_+$, and $b_i \in \mathbb{R}$ is public information. We assume $-b_1 = b_2 = b > 0$, that is, the expected followers' ideal decision is symmetrical around zero. Then, $b$ represents the extent of ex-ante conflict concerning the organizational decisions between the followers. Each follower's objective is to maximize only his own profit.[1]

[1] In organizations, it is typically to undesirable to fully align a member's incentives from the viewpoint of preventing a free-rider problem, even if a misalignment in their incentives creates communication difficulty. Athey and Roberts (2001), Dessein, Garicano, and Gertner (2010), and Friebel and Raith (2010) address this issue.

We assume that organizational performance is given by

$$\Pi = -\alpha_L(d-\theta_L)^2 - \sum_{i=1,2} \alpha_i(d-\theta_i-b_i)^2.$$

$\theta_L$ is what the leader considers as the ideal decision (e.g., the production technology of the firm), and it is her private information. $\theta_L$ follows a density function $f_L$ and a cumulative function $F_L$, and let the mean and the variance be $\mu_L$ and $\sigma_L^2$ respectively. $\alpha_L$ represents the importance of the leader's information on the organizational performance (e.g., the importance of cost saving), and $\alpha_i$ represents the importance of follower $i$'s information on the organizational performance (e.g., the importance of success in each local market).

Our key assumption is that the leader has an irrational belief in the value of $\alpha_L$. The leader believes the importance of her own information to be higher or lower than $\alpha_L$. The leader's belief is denoted as $\bar{\alpha}_L$. We assume that the leader decides $d$ to maximize

$$\bar{\Pi} = -\bar{\alpha}_L(d-\theta_L)^2 - \sum_{i=1,2} \alpha_i(d-\theta_i-b_i)^2.$$

We say that the leader is a good listener when $\bar{\alpha}_L < \alpha_L$ and a bad listener when $\bar{\alpha}_L > \alpha_L$. As we show in the next section, if the leader underestimates the importance of her information, she places a smaller weight on her information and a larger weight on the followers' opinions in making the decision than what is optimal in terms of ex-post organizational efficiency. On the other hand, if the leader overestimates the importance of her information, she makes a decision with a larger weight on her own information and a smaller weight on the followers' opinions.[2]

The followers can communicate their own information before the leader makes an organizational decision. Each follower sends a one-time costless message $r_i \in [-s_i, s_i]$ to the leader.[3] We suppose that the leader can not commit any mechanism and monetary transfer contingent on the messages, that is, any communication is cheap talk. We denote a rationally up-dated belief after communication as $m_i \equiv E[\theta_i|r_i]$ for $i = 1, 2$.

Finally, in order to make our model tractable, we put the following assumption.

**Assumption 1.** *(i)* $b \leq \min\left\{\frac{s_1}{2}, \frac{s_2}{2}\right\}$, *and (ii)* $|\mu_L| \leq \min\left\{\frac{s_1}{2}, \frac{s_2}{2}\right\}$.

[2] In the product-design example illustrated in Introduction, a biased weight may be explained by a biased compensation contract for the CEO, without assuming the irrational belief on the importance of information. If the shareholders of a firm can offer a compensation contract to the CEO contingent on the profit of each local market, they can arbitrarily design the values of $\alpha_L$ and $\alpha_i$ for $i = 1, 2$.

[3] In discussion section, we examine a bilateral communication in which the leader can also send a one-time, costless, and publicly-observable message to the followers before the followers send messages.

In words, (i) suggests that the extent of the conflict between the followers is not too large, and (ii) suggests that the expected value of the leader's information is not extremely biased.

The game proceeds as follows:

1. The leader and the followers privately observe $\theta_L$ and $\theta_i$ for $i = 1, 2$.

2. The followers send their messages to the leader (they are not necessarily truthful).

3. The leader decides $d$.

# 4 Decision making

## 4.1 Organizational decision

The problem is solved backwards. From the first order condition, the leader's decision is given by

$$d(\theta_L, r_1, r_2) \quad = \quad \frac{\bar{\alpha}_L}{\bar{\alpha}_L + \alpha_1 + \alpha_2}\theta_L + \frac{\alpha_1}{\bar{\alpha}_L + \alpha_1 + \alpha_2}(m_1 + b_1) + \frac{\alpha_2}{\bar{\alpha}_L + \alpha_1 + \alpha_2}(m_2 + b_2).$$

Note that the equilibrium decisions take the form $d = z_L\theta_L + z_1(m_1 + b_1) + z_2(m_2 + b_2)$ with $z_L + z_1 + z_2 = 1$. $z_i$ represents the degree of the leader's sensitivity toward follower $i$'s opinion in the decision-making. We refer to a vector $\mathbf{z} = (z_L, z_1, z_2)$ as the leader's decision policy. The decision policy of the leader who has the correct belief on $\alpha_L$ should be given by $\mathbf{z}^* = (z_L^*, z_1^*, z_2^*) = \left(\frac{\alpha_L}{\alpha_L+\alpha_1+\alpha_2}, \frac{\alpha_1}{\alpha_L+\alpha_1+\alpha_2}, \frac{\alpha_2}{\alpha_L+\alpha_1+\alpha_2}\right)$. If the leader is a good listener, $z_i > z_i^*$ for $i = 1, 2$, that is, a good listener shows a highly sensitive attitude toward both followers' opinions. On the other hand, if the leader is a bad listener, $z_i < z_i^*$ for $i = 1, 2$, that is, a bad listener shows a low sensitive attitude toward both followers' opinions.

## 4.2 Communication strategy

Before we consider the followers' communication strategy, we show that the followers have incentives to misrepresent the information they possess. Suppose that follower 1 can credibly misrepresent his information, that is, he can arbitrarily choose the leader's posterior belief about the information. For a given decision policy of the leader, the optimal posterior, denoted by $m_1^*$, satisfies $E[d|m_1 = m_1^*] = \theta_1 + b_1$, or equivalently,

$$m_1^* = \frac{\theta_1 + b_1 - z_L\mu_L - z_2E[m_2 + b_2]}{z_1} - b_1.$$

Define functions $B_1$ as

$$B_1(\theta_1, \mathbf{z}) \equiv m_1^* - \theta_1 = \frac{(1-z_1)(\theta_1+b_1) - z_L\mu_L - z_2E[m_2+b_2]}{z_1}$$

and $q_1$ as

$$q_1(\mathbf{z}) \quad \equiv \tfrac{z_L\mu_L+z_2E[m_2+b_2]}{1-z_1} - b_1.$$

$B_1(\theta_1, \mathbf{z})$ represents the difference between what follower 1 wants the leader to believe and his true information. The first term of $q_1(\mathbf{z})$ is interpreted as an expected collective opinion of the other organizational members from 1's viewpoint weighted by $\mathbf{z}$, and it is straightforward to show $B_1(q_1(\mathbf{z}), \mathbf{z}) = 0$. Intuitively, if $\theta_1 = q_1(\mathbf{z})$, follower 1's ideal decision is identical to the expected collective opinion, then he has no incentive to misrepresent his information. However, he has the incentive to exaggerate his information whenever $\theta_1 \neq q_1(\mathbf{z})$. Follower 1 induces a higher posterior belief than his true information when $\theta_1$ is higher than $q_1(\mathbf{z})$ and a lower posterior belief when $\theta_1$ is lower than $q_1(\mathbf{z})$. Moreover, $|B_1(\theta_1, \mathbf{z})|$ increases as $\theta_1$ is further away from $q_1(\mathbf{z})$. Thus, the greater the difference between follower 1's ideal decision and the expected collective opinion, the stronger the incentive for misrepresentation.

We define functions $B_2$ as

$$B_2(\theta_2, \mathbf{z}) \equiv m_2^* - \theta_2 = \frac{(1-z_2)(\theta_2+b_2) - z_Lm_L - z_1E[m_1+b_1]}{z_2}$$

and $q_2$ as

$$q_2(\mathbf{z}) \quad \equiv \tfrac{z_Lm_L+z_1E[m_1+b_1]}{1-z_2} - b_2.$$

Follower 2 also has no incentive to reveal his information truthfully but rather an incentive to exaggerate his information whenever $\theta_2 \neq q_2(\mathbf{z})$. The incentive for misrepresentation becomes larger as the difference between $\theta_2$ and $q_2(\mathbf{z})$ increases in the same manner as follower 1.

While truth-telling equilibrium does not exist, partially informative communication may still be achieved as shown by Crawford and Sobel (1982). It is achieved by partitioning the type space so that any message $r_i$ reveals only that $\theta_i$ belongs to some interval. Divide follower $i$'s type space into $N_i$ intervals and name cutoff points from left as $a_{ij}$ for $j = 0, ..., N_i$, which satisfies boundary conditions $a_{i0} = -s_i$ and $a_{iN_i} = s_i$ and order constraints $a_{ij} < a_{ij+1}$. In equilibrium, follower $i$ sends a randomized message that is drawn from the uniform distribution supported on $[a_{ij-1}, a_{ij})$

if $\theta_i \in [a_{ij-1}, a_{ij})$. If the receipt message is in $[a_{ij-1}, a_{ij})$, the leader's posterior belief is given by $m_{ij} = \frac{a_{ij-1}+a_{ij}}{2}$. On each cutoff point, follower $i$ is indifferent between reporting that $\theta_i$ belongs to either one of the two intervals around that cutoff point. That is, any cutoff $a_{ij}$ for $j = 1, ...N_i - 1$ must satisfy the following indifferent condition,

$$E_i[\pi|\theta_i = a_{ij}, m_i = m_{ij}] = E_i[\pi|\theta_i = a_{ij}, m_i = m_{ij+1}]. \tag{1}$$

Solving and arranging (1), we obtain the second order difference equation as follows; for $j = 1, ..., N_i - 1$,

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} + 4B_i(a_{ij}, \mathbf{z}). \tag{2}$$

Cutoffs in an equilibrium are depicted in Figure 1. In figure 1, we put $s_1 = 1$, $z_1 = z_2 = 1/3$, and $b = 1/3$. From the second order difference equation (2), we can see how $B_i(a_{ij}, \mathbf{z})$ determines the size of each interval. At any cutoff $a_{ij}$ such that $a_{ij} < q_i(\mathbf{z}) = 1/2$, the size of the interval $a_{ij+1} - a_{ij}$ is smaller than the size of the preceding intervals $a_{ij} - a_{ij-1}$ by $4|B_i(a_{ij}, \mathbf{z})|$, and the changes in the sizes of intervals decrease as $j$ increases. The change in the size of the intervals becomes quite small when $a_{ij}$ is near $q_i(\mathbf{z})$. In turn, at any cutoff $a_{ij}$ such that $a_{ij} > q_i(\mathbf{z})$, the size of the interval $a_{ij+1} - a_{ij}$ is larger than the size of the preceding intervals $a_{ij} - a_{ij-1}$ by $4|B_i(a_{ij}, \mathbf{z})|$, and the changes in the sizes of intervals increase as $j$ increases.

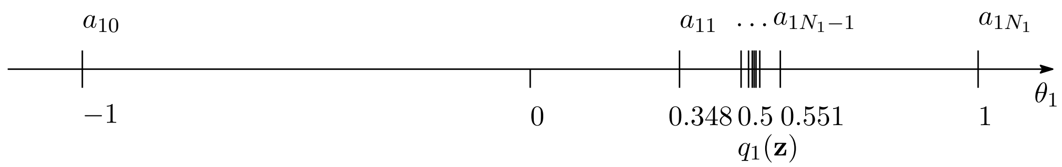


Figure 1: Communication strategy

There is no upper bound for the number of equilibrium cutoffs except for the case where $q_i(\mathbf{z})$ is extremely high or low. The following lemma identifies a sufficient condition to ensure that $N_i$ is not limited.

**Lemma 1.** *For $i = 1, 2$, the upper bound of $N_i$ does not exist if $q_i(\mathbf{z}) \in [-s_i, s_i]$.*

The proof is in Appendix. In words, the limit disappears when the follower possibly has an information that is identical to the expected collective opinion, in terms of 1's expectation, with strict positive probability. Intuitively, if $q_i(\mathbf{z}) \in [-s_i, s_i]$, we can find the equilibrium, in which an infinite number of intervals exist around $q_i(\mathbf{z})$ with negligibly small size. We remark that Assumption 1 ensures that $q_i(\mathbf{z}) \in [-s_i, s_i]$ for any $\mathbf{z}$.

To summarize the results so far, we present the following proposition.

**Proposition 1.** *Suppose Assumption 1 holds. Given the leader's decision policy* $\mathbf{z}$*, for* $i = 1, 2$ *for any positive integer* $N_i$ *there exists at least one equilibrium such that*

1. *follower* $i$ *sends the randomized message* $r_i$*, which is drawn from the uniform distribution supported on* $[a_{ij-1}, a_{ij})$ *if* $\theta_i \in [a_{ij-1}, a_{ij})$ *for* $j = 1, ...N_i - 1$ *and on* $[a_{iN_i-1}, a_{iN_i}]$ *if* $\theta_i \in [a_{iN_i-1}, a_{iN_i}]$*,*

2. *the leader makes her belief* $m_i$ *as* $\frac{a_{ij-1}+a_{ij}}{2}$ *if* $r_i$ *is in* $[a_{ij-1}, a_{ij})$ *for* $j = 1, ...N_i - 1$ *and* $\frac{a_{iN_i-1}+a_{iN_i}}{2}$ *if the receipt message* $r_i$ *is in* $[a_{iN_i-1}, a_{iN_i}]$*, and*

3. *for* $j = 1, ..., N_i - 1$*,* $a_{ij}$ *follows* (2)*, and* $a_{i0} = -s_i$ *and* $a_{iN_i} = s_i$*.*

The proof is in Appendix.

Note that when $N_i$ is large enough any cutoffs can be approximately represented by the following explicit form; for the $j$-th cutoff from the left edge,

$$a_{ij} \quad = -\tfrac{1}{x(z_i)^j} s_i + \left(1 - \tfrac{1}{x(z_i)^j}\right) q_i(\mathbf{z}), \tag{3}$$

and for the $j$-th cutoff from the right edge,

$$a_{iN_i-j} \quad = \tfrac{1}{x(z_i)^j} s_i + \left(1 - \tfrac{1}{x(z_i)^j}\right) q_i(\mathbf{z}). \tag{4}$$

where $x(z_i) = \frac{-\left(2-\frac{4}{z_i}\right)+\sqrt{\left(2-\frac{4}{z_i}\right)^2-4}}{2} > 1$. The derivations are in Appendix. Then, $j$-th cutoff from the left (resp. right) edge is represented as an internally divided point between the left (resp. right) edge and $q_i(\mathbf{z})$ in the ratio $\frac{1}{x(z_i)^j} : 1 - \frac{1}{x(z_i)^j}$.

### 4.3 Quality of communication

A residual variance $E[(\theta_i - m_i)^2]$ indicates how the information that follower $i$ provides is precise. If the updated posterior belief of the leader about $i$'s information is close to (resp. far from) his true one, it becomes small (resp. large). By applying the law of iterated expectation, we obtain $E[(\theta_i - m_i)^2] = E[\theta_i^2] - E[m_i^2]$. Because $E[\theta_i^2]$ is independent of the equilibrium profile and the residual variance decrease as $E[m_i^2]$ goes up, we refer to $E[m_i^2]$as the quality of communication with follower $i$.

The quality of communication with follower $i$ increases as $N_i$ goes up, that is, the more intervals, the more precise the communication.

**Lemma 2.** *$E[m_i^2]$ is increasing in $N_i$.*

Proof is in Appendix. As we see in the next section, a high quality of communication also improves the organizational performance, except for some extreme cases. Therefore, the following section focuses on the equilibrium with an infinite partitioned communication strategy, in which the organizational performance is maximized within any partitioned communication strategy. In the infinitely partitioned equilibrium, the residual variance is simply given by

$$\lim_{N_i \to \infty} E[(\theta_i - m_i)^2] = \frac{1 - z_i}{4 - z_i} \left( \frac{s_i^2}{3} + q_i(\mathbf{z})^2 \right)$$

and the quality of communication with $i$ is given by

$$\lim_{N_i \to \infty} E[m_i^2] = \frac{1}{4 - z_i} s_i^2 - \frac{1 - z_i}{4 - z_i} q_i(\mathbf{z})^2. \tag{5}$$

We denote $\lim_{N_i \to \infty} E[m_i^2]$ by $M_i(z_i, q_i(\mathbf{z}))$. If Assumption 1 holds $M_i(z_i, q_i(\mathbf{z}))$ is well-defined.

Two key parameters, $z_i$ and $q_i(\mathbf{z})$, characterize the quality of communication with follower $i$. From (5), it is straightforward to observe that the following property exists.

**Lemma 3.** *(i) $\frac{\partial M_i}{\partial z_i}(z_i, q)\Big|_{q=q_i(\mathbf{z})} > 0$. (ii) $\frac{\partial M_i}{\partial q_i}(z_i, 0) = 0$ and $\frac{\partial^2 M_i}{\partial q_i^2}(z_i, q) < 0$.*

Figure 2 depicts a change in cutoffs as $z_1$ increases, for fixed $q_1$. In figure 2, we put $s_1 = 1$ and $z_1 = 1/2$ and fix $q_1 = 1/2$. Because $\frac{1}{x(z_i)^j}$ increases as $z_1$ increases for any $j$, according to (3) and (4), any cutoffs to the left (resp. right) of $q_1$ shift toward left (resp. right) edge. Thus, the equilibrium partitions on both sides become "fine", and the quality of communication is improved as $z_1$ increases, for a given fixed $q_1$. Comparing with the case in figure 1, $a_{11}$ shifts to 0.243 from 0.348 and $a_{1N_1-1}$ shifts to 0.586 from 0.551, and the quality of communication is improved to 1/4 from 5/22.

Lemma 3 (ii) means that $M_i$ is single peaked at $q_i = 0$. Figure 3 depicts a change in cutoffs as $q_1 (> 0)$ increases, for a given fixed $z_1$. In figure 3, we put $s_1 = 1$ and $q_1 = 0.75$ and fix $z_1 = 1/3$. According to (3) and (4), any cutoffs shift toward the right as $q_1$ increases, then the equilibrium partitions to the right of $q_1$ become "fine", but ones to the left of $q_1$ become "coarse". Comparing

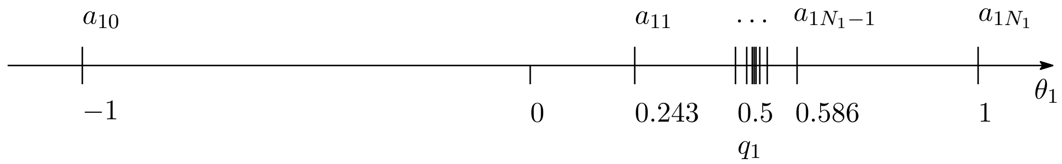


Figure 2: Communication strategy with $z_1 = 1/2$, given fixed $q_1$

with the case in figure 1, $a_{11}$ shifts to 0.573 from 0.348 and $a_{1N_1-1}$ shifts to 0.775 from 0.551, and the quality of communication declines to 15/88 from 5/22. Note that the residual variance becomes large as the sizes of larger intervals increase even if the sizes of smaller intervals decrease. In contrast, the residual variance becomes small when the sizes of larger intervals decrease even if the sizes of smaller intervals increase. Then, the residual variance is minimized when the equilibrium partitions are symmetric around zero, that is, when $q_1 = 0$.

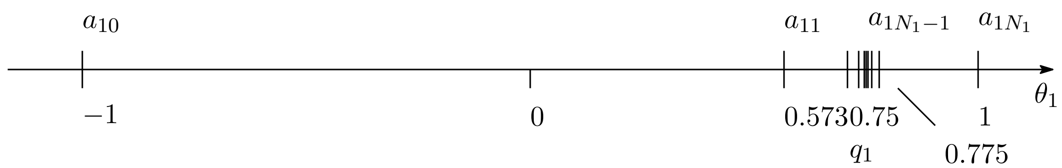


Figure 3: Communication strategy with $q_1 = 3/4$, given fixed $z_1$

# 5 The leader's belief about the importance of information, the quality of communication, and the organizational performance

Here, we examine how distortions in $\bar{\alpha}_L$ affect the quality of communication and the organizational performance. To make intuition of the results clear, we put $\alpha_1 = \alpha_2 = \alpha > 0$ and $\mu_L = 0$ in the following sections unless otherwise noted.

## 5.1 The leader's belief about the importance of information and the quality of communication

We consider how a decrease in $\bar{\alpha}_L$ affect the quality of communication with follower $i$. The marginal effect can be represented as follows;

$$-\frac{\partial M_i}{\partial \bar{\alpha}}(z_i, q_i(\mathbf{z})) = \frac{\partial M_i}{\partial z_i}(z_i, q)\bigg|_{q=q_i(\mathbf{z})} \left(-\frac{\partial z_i}{\partial \bar{\alpha}_L}\right) + \frac{\partial M_i}{\partial q_i}(z_i, q_i)\left(-\frac{\partial q_i}{\partial \bar{\alpha}_L}(\mathbf{z})\right). \tag{6}$$

Note that $\frac{\partial M_i}{\partial z_i}(z_i, q)\Big|_{q=q_i(\mathbf{z})} > 0$ from Lemma 3 (i). Because $-\frac{\partial z_i}{\partial \bar{\alpha}_L} > 0$, the first term of (6) is always positive. The first term of (6) is interpreted as the positive side of a good listener, which is coming from the notion that follower $i$'s incentive to misrepresent information becomes weaker according to the leader's willingness to incorporate $i$'s opinions into organizational decisions.

On the other hand, the second term of (6) represents the negative side of a good listener. To see this, we focus on the quality of communication with follower 1. Because

$$\begin{aligned} q_1(\mathbf{z}) &= \frac{z_L\mu_L + z_2 E[m_2 + b_2]}{1 - z_1} - b_1 && (7) \\ &= \frac{\bar{\alpha}_L + 2\alpha}{\bar{\alpha}_L + \alpha} b > 0, && (8) \end{aligned}$$

we obtain $-\frac{\partial q_1}{\partial \bar{\alpha}_L}(\mathbf{z}) > 0$. In the same manner, since

$$\begin{aligned} q_2(\mathbf{z}) &= \frac{z_L\mu_L + z_1 E[m_1 + b_1]}{1 - z_2} - b_2 && (9) \\ &= -\frac{\bar{\alpha}_L + 2\alpha}{\bar{\alpha}_L + \alpha} b < 0, && (10) \end{aligned}$$

we obtain $-\frac{\partial q_2}{\partial \bar{\alpha}_L}(\mathbf{z}) < 0$. Note that, for $i = 1, 2$, $\frac{\partial M_i}{\partial q_i}(z_i, q_i) > 0$ if $q_i < 0$ and $\frac{\partial M_i}{\partial q_i}(z_i, q_i) < 0$ if $q_i > 0$ from Lemma 3 (ii). Those imply that the second term of (6) is always negative. The result above is interpreted as follows. While a good listener gives follower 1's opinion significant weight in the decision, she also gives follower 2's opinion a significant weight. This implies that from follower 1's view point, the voice of the rival becomes more influential, and the collective opinion becomes biased toward the rival's ideal decision. If follower 1 believes that the rival has a greatly different ideal decision from his, follower 1's incentive to exaggerate his information becomes strong in order to change the leader's mind against the rival's voice.

Even though the negative side of a good listener may exist, however, it can be negligible when $b$ is quite small. As $b$ decreases, $q_i$ become less sensitive to the change in $\bar{\alpha}_L$. Therefore, we arrive at the next proposition, which identifies the situation in which the leader's overestimation of the importance improves the quality of communication with the followers.

**Proposition 2.** *Suppose Assumption 1 (i) holds. $M_i$ is increased as $\bar{\alpha}_L$ decreases if and only if*

$$b^2 < \frac{(\bar{\alpha}_L + \alpha)^2}{(\bar{\alpha}_L + 2\alpha)(5\bar{\alpha}_L + 8\alpha)} s_i^2. \tag{11}$$

In Appendix, we provide the proof and confirm the existence of the threshold within the area restricted by Assumption 1. Proposition 2 claims that when the conflict between the followers is not severe, a good listener is more likely to improve the quality of communication because the negative side of a good listener is quite small and the only positive side arises in that case. However, if the conflict is severe, the negative side is no longer negligible and a bad listener can elicit more information than a good listener.

## 5.2 Performance

Next, we consider how a decrease in $\bar{\alpha}_L$ affect the organizational performance. The ex-ante expected organizational performance is represented as

$$\begin{aligned} E[\Pi] &= -\alpha_L E[(d(\theta_L, r_1, r_2) - \theta_L)^2] - \sum_{i=1,2} \alpha E[(d(\theta_L, r_1, r_2) - \theta_i - b_i)^2] \\ &= -(\alpha_L(1-z_L)^2 + 2\alpha z_L^2)\sigma_L^2 - \alpha\frac{s_1^2}{3} - \alpha\frac{s_2^2}{3} \\ &\quad -z_1(z_1(\alpha_L + 2\alpha) - 2\alpha)E[m_1^2] - z_2(z_2(\alpha_L + 2\alpha) - 2\alpha)E[m_2^2] \\ &\quad -\alpha_L((1-z_L)\mu_L - z_1 b_1 - z_2 b_2)^2 \\ &\quad -\alpha((1-z_1)b_1 - z_L\mu_L - z_2 b_2)^2 - \alpha((1-z_2)b_2 - z_L\mu_L - z_1 b_1)^2. \end{aligned} \tag{12}$$

Then the marginal effect of a decrease in $\bar{\alpha}_L$ on the organizational performance is represented by

$$\begin{aligned} -\frac{\partial E[\Pi]}{\partial \bar{\alpha}_L} &= -\left.\frac{\partial E[\Pi]}{\partial \bar{\alpha}_L}\right|_{M_1 = M_1(z_1, q_1(\mathbf{z})), M_2 = M_2(z_2, q_2(\mathbf{z}))} \\ &\quad + \frac{\partial E[\Pi]}{\partial M_1}\left(-\frac{\partial M_1}{\partial \bar{\alpha}_L}(z_1, q_1(\mathbf{z}))\right) + \frac{\partial E[\Pi]}{\partial M_2}\left(-\frac{\partial M_2}{\partial \bar{\alpha}_L}(z_i, q_i(\mathbf{z}))\right). \end{aligned} \tag{13}$$

The first term of (13) represents the direct effect of a decrease in $\bar{\alpha}$ on the organizational performance. The second and third terms of (13) represent the strategic effect of a decrease in $\bar{\alpha}$ on the quality of communication.[4] We can further separate the strategic effect into two. The first effect is how $\bar{\alpha}$ affects the quality of communication, and the second effect is how the quality of communication affects the organizational performance.

We focus on a slight distortion of $\bar{\alpha}_L$ from $\alpha_L$. By doing so, we can neglect any direct effect by applying the envelope theorem. It is straightforward to show that $\frac{\partial E[\Pi]}{\partial M_i} > 0$ at $\bar{\alpha}_L = \alpha_L$, that is, the organizational performance is improved as the quality of communication is improved. Then, using proposition 2, we may identify one case where a good listener can improves the organizational performance.

[4] If communication is not strategic, because the strategic effect should be zero, it immediately follows that the optimal decision policy should be $\mathbf{z}^*$.

**Proposition 3.** *Suppose Assumption 1 (i) holds. A slight decrease in $\bar{\alpha}_L$ at $\bar{\alpha}_L = \alpha_L$ improves the organizational performance if*

$$b^2 < \frac{(\alpha_L + \alpha)^2}{2(\alpha_L + 2\alpha)(5\alpha_L + 8\alpha)}(s_1^2 + s_2^2).$$

*Otherwise, a slight increase in $\bar{\alpha}_L$ at $\bar{\alpha}_L = \alpha_L$ improves the organizational performance.*

Proposition 3 claims that a good listener can achieves a better performance if the conflict between the followers is not severe, and otherwise a bad listener can achieves better performance.

### 5.3 One leader and one follower case

A good listener always improves the quality of communication in the case of one leader and one follower. To treat that case in the same framework, we assume that $\alpha_1 = \alpha$ and $\alpha_2 = 0$. If $\alpha_2 = 0$, follower 2's information does not matter for the organizational performance and follower 2's opinion is never incorporated into the organizational decision. Thus, the problem under the the assumption is identical to one in the organization in which the leader and only follower 1 exist. In this case, from (7), $q_1(\mathbf{z}) = -b_1$ then $q_1(\mathbf{z})$ is independent of $\alpha_L$. It implies that the negative side of a good listener disappears in this case, though the positive side exists. Then, the next proposition immediately follows.

**Proposition 4.** *If one leader and only follower 1 exist in the organization, $M_1$ is always increased as $\bar{\alpha}_L$ decreases. A slight increase in $\bar{\alpha}_L$ at $\bar{\alpha}_L = \alpha_L$ always improves the organizational performance.*

## 6 Discussion

### 6.1 A Biased opinion of the leader

The value of being a good listener is also dependent on the opinion of the leader. The negative side of a good listener disappears if the leader's opinion is extremely biased. To demonstrate this, we assume $\mu_L \neq 0$ and focus on the quality of communication with follower 1. Note that

$$\frac{\partial M_1(z_1, q_1)}{\partial q_1}\left(-\frac{\partial q_1(\mathbf{z})}{\partial \bar{\alpha}_L}\right) = \frac{2\alpha(\mu_L - b)(\bar{\alpha}_L\mu_L + (\bar{\alpha}_L + 2\alpha)b)}{(\bar{\alpha}_L + \alpha)^2(4\bar{\alpha} + 7\alpha)}. \tag{14}$$

From (14), if $\mu_L \leq -\frac{\bar{\alpha}_L + 2\alpha}{\bar{\alpha}_L}b$ then the negative side does not exist. Intuitively, if the leader has an extremely biased opinion in a negative direction, the collective opinion is also extremely biased in a negative direction. In this case, $q_1(\mathbf{z})$ goes toward zero as the voice of follower 2 become slightly influential, because follower 2's ideal decision is biased in a positive direction. Nor does the negative side exist if $b \leq \mu_L$. Intuitively, the collective opinion is extremely biased in a positive direction and $q_1(\mathbf{z})$ is larger than $b_2$ in this case. Then, since the bias of follower 2's ideal decision is more moderate than that of the leader's opinion in the sense of expectation, the collective opinion goes toward zero as the voice of follower 2 becomes more influential.

The negative side of a good listener remains if the bias of the leader's opinion is moderate, that is, $-\frac{\bar{\alpha}_L+2\alpha}{\bar{\alpha}_L}b < \mu_L < b$. Because $q_1(\mathbf{z}) > 0$ and $-\frac{\partial q_1(\mathbf{z})}{\partial \bar{\alpha}_L} > 0$ in this case, Lemma 3 suggests that the negative side exists. The seriousness of the negative side is dependent on $\mu_L$. Note that

$$\frac{\partial}{\partial \mu_L}\left(\frac{\partial M_1(z_1, q_1)}{\partial q_1}\left(-\frac{\partial q_1(\mathbf{z})}{\partial \bar{\alpha}_L}\right)\right) = \frac{4\alpha(\bar{\alpha}_L \mu_L + \alpha b)}{(\bar{\alpha}_L + \alpha)^2(4\bar{\alpha} + 7\alpha)}. \tag{15}$$

From (15), we derive that the negative side is the most serious when $\mu_L = -\frac{\alpha}{\bar{\alpha}_L}b$. We can show that the negative side on the quality of communication with follower 2 disappears if $\mu_L \leq -b$ or $\frac{\bar{\alpha}_L+\alpha}{\bar{\alpha}_L}b \leq \mu_L$, the negative side exists if $-b < \mu_L < \frac{\bar{\alpha}_L+\alpha}{\bar{\alpha}_L}b$, and it is the most serious when $\mu_L = \frac{\alpha}{\bar{\alpha}_L}b$ in the same manner.

From the discussion above, we can show that the negative side of a good listener is weak or diminished when the leader's opinion is somewhat biased, that is, when $\mu_L < -\frac{\alpha}{\bar{\alpha}_L}b$ and $\frac{\alpha}{\bar{\alpha}_L}b < \mu_L$. If $-\frac{\alpha}{\bar{\alpha}_L}b < \mu_L < \frac{\alpha}{\bar{\alpha}_L}b$, the trade-off is such that the negative side on the quality of communication with follower 1 becomes weak but that with follower 2 becomes strong as $\mu_L$ increases. In this case, although a decrease in $\bar{\alpha}_L$ affects the quality of communication with each follower heterogeneously, the sum of them is more likely to be improved as $\bar{\alpha}_L$ decreases. The following proposition holds.

**Proposition 5.** *Suppose Assumption 1 holds. A good listener is more likely to improve the quality of communication with both followers when the leader has a biased opinion.*

Proof in Appendix.

### 6.2 Heterogeneous sensitivity

In this subsection, we consider a case in which the leader shows heterogeneous sensitivity toward each follower's opinion. Our concern here is to examine whether heterogeneous sensitivity is attractive or not, and if so, when it is attractive. Thus, we suppose here that, although the leader has a rational belief in the importance of her own information, the importance of either follower's information is overestimated, that is, $\bar{\alpha}_1 = \alpha_1 + \epsilon$ and $\bar{\alpha}_2 = \alpha_2 - \epsilon$ where $\epsilon \in \mathbb{R}$.The leader's objective is given by

$$\bar{\Pi} = -\alpha_L(d - \theta_L)^2 - \sum_{i=1,2} \bar{\alpha}_i(d - \theta_i - b_i)^2. \tag{16}$$

Then, the leader's decision policy, denoted by $\mathbf{z}^\epsilon$, is given by

$$z_L^\epsilon = \frac{\alpha_L}{\alpha_L + 2\alpha}, \quad z_1^\epsilon = \frac{\alpha + \epsilon}{\alpha_L + 2\alpha}, \quad \textit{and} \quad z_2^\epsilon = \frac{\alpha - \epsilon}{\alpha_L + 2\alpha}.$$

Because $z_1^\epsilon$ is increasing in $\epsilon$, the leader becomes more sensitive to follower 1's opinion and gives it a large weight in the decision as $\epsilon$ increases. Similarly, because $z_2^\epsilon$ is decreasing in $\epsilon$, the leader becomes less sensitive to follower 2's opinion giving a small weight in the decision as $\epsilon$ increases. Thus, we can interpret $\epsilon$ as the degree of favoritism toward follower 1.

As $\epsilon$ increases, the quality of communication with follower 1 always improves, but that with follower 2 always declines. Note that

$$\begin{aligned} q_1(\mathbf{z}^\epsilon) &= \frac{\alpha_L + 2\alpha - 2\epsilon}{\alpha_L + \alpha - \epsilon} b > 0 \\ q_2(\mathbf{z}^\epsilon) &= -\frac{\alpha_L + 2\alpha + 2\epsilon}{\alpha_L + \alpha + \epsilon} b < 0, \end{aligned}$$

and it is straightforward to show that $\frac{\partial q_1}{\partial \epsilon}(\mathbf{z}^\epsilon) < 0$ and $\frac{\partial q_2}{\partial \epsilon}(\mathbf{z}^\epsilon) < 0$. Then, from Lemma 3, we obtain that $\frac{\partial M_1}{\partial \epsilon}(z_1^\epsilon, q_1(\mathbf{z}^\epsilon)) > 0$ and $\frac{\partial M_2}{\partial \epsilon}(z_2^\epsilon, q_2(\mathbf{z}^\epsilon)) < 0$. This suggests that heterogeneity in the leader's sensitivity has a trade-off effect on the quality of communication with each follower. The following proposition identifies a situation in which the heterogeneity improves the organizational performance.

**Proposition 6.** *Suppose Assumption 1 holds. Some small $\epsilon$ improves the organizational performance if $s_1 > s_2$.*

Proposition 6 claims that the leader should be sensitive to the opinion of the follower whose information varies widely from that of the other. To make the intuition clear, we suppose an extreme example in which $s_2$ is near zero. Though the information of both followers is equivalently important for the organizational performance, the leader does not need to extract information from follower 2 because without communication almost accurate information can be extrapolated. In such case, it is effective to be sensitive toward follower 1's opinion in order to extract more information from him, even if the quality of communication with follower 2 declines.

In figures 4 and 5, we compare the communication strategies under decision policy $\mathbf{z}^*$ and that under decision policy $\mathbf{z}^\epsilon$ when $s_1 > s_2$. Figure 4 illustrates the partitions of type spaces in the equilibrium when the decision policy is $\mathbf{z}^*$. The leader can know which grid the followers' private information lies in. Under $\mathbf{z}^*$, follower 1's type space is divided by relatively coarser partitions than follower 2's type space. Figure 5 illustrates the partitions of type spaces in the equilibrium when the decision policy is $\mathbf{z}^\epsilon$ with $\epsilon > 0$. As $\epsilon$ increases, the size of the partitions in follower 1's type space becomes "finer" and that of the partitions in follower 2's type space becomes "coarser". In this case, the grids become more balanced, whereupon the sum of residual variances $E[(\theta_1 - m_1)^2] + E[(\theta_2 - m_2)^2]$ decreases and the leader can infer the ideal decisions of both followers more precisely on average.

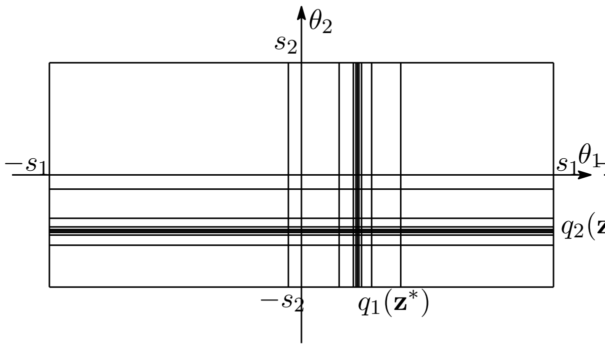


Figure 4: The partitions of type spaces under decision policy $\mathbf{z}^*$.

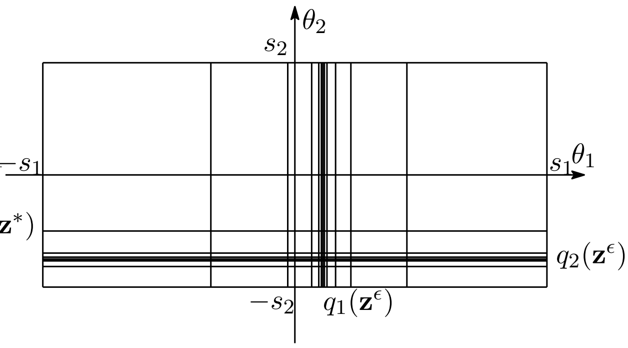


Figure 5: The partitions of type spaces under decision policy $\mathbf{z}^\epsilon$ with $\epsilon > 0$.

### 6.3 The leader's confidence in communication skills

In this subsection, we attempt to give another explanation for why the leader's decision policy is distorted, from the viewpoint of the leader's confidence in her own communication skill. Although we suppose that the leader has the correct belief on the importance of her own information here, we introduce two alternative assumptions regarding her skill level in interpreting followers' messages correctly. First, the leader misinterprets a follower's message with probability $\lambda$ and unconsciously forms a wrong posterior which is independent of the message. Formally, when follower $i$ sends message $r_i$ to the leader, she receives it with probability $1 - \lambda$ but receives an independent random message, denoted by $\bar{r}_j$, with probability $\lambda$, and she is unaware of misinterpreting it.[5] Second,

[5]Here we employ the same framework as that for communication noise, which was introduced by Blume et al. (2007).

the leader may have a wrong belief in her own communication skill. Let $\bar{\lambda}$ be her belief on the probability of misinterpretation. We say that the leader is overconfident if $\bar{\lambda} < \lambda$ and underconfident if $\bar{\lambda} > \lambda$.

The leader's posterior belief after communication is then represented as

$$\begin{aligned} E_L[\theta_i \mid r_i] &= (1-\bar{\lambda})m_i + \bar{\lambda}E[E[\theta_i \mid \bar{r}_i]] \\ &= (1-\bar{\lambda})m_i, \end{aligned} \tag{17}$$

and the leader's decision policy, denoted by $\mathbf{z}^{\lambda}$ is given by

$$z_L^{\lambda} = \frac{\alpha_L}{\alpha_L + 2\alpha}, \quad z_1^{\lambda} = \frac{(1-\bar{\lambda})\alpha}{\alpha_L + 2\alpha} \quad z_2^{\lambda} = \frac{(1-\bar{\lambda})\alpha}{\alpha_L + 2\alpha}.$$

We remark that the decision policy is determined by the leader's belief in her communication skill, not by the skill itself. Because the leader believes that she has not formed a correct assessment of one follower's message with probability $\bar{\lambda}$, the probability of misinterpretation is taken into account optimally discounting the weight on the followers' opinions in decision-making. The overconfident (resp. underconfident) leader puts an excessively large (resp. small) weight on followers' opinion and a small (resp. large) weight on her own information. We can then discuss how self-confidence affects the quality of communication in almost the same manner as we considered the leader's overestimation, and we then obtain a similar claim to Proposition 2 and 3 without qualitative differences as follows.

**Proposition 7.** *Suppose Assumption 1 (i) holds. The overconfident leader in her communication skill improves the quality of communication with i if*

$$b^2 < \frac{\alpha_L + (1-\bar{\lambda})\alpha}{(\alpha_L + 2\alpha)(5\alpha_L + (8 + 2\bar{\lambda})\alpha)} s_i^2.$$

*Furthermore, a leader's slight overconfidence in her communication skill improves the organizational performance if*

$$b^2 < \frac{\alpha_L + (1-\lambda)\alpha}{2(\alpha_L + 2\alpha)(5\alpha_L + (8 + 2\lambda)\alpha)} (s_1^2 + s_2^2).$$

Proof in Appendix.

# 7 Bilateral communication

In this section, we consider a bilateral-communication situation whereby the leader can sends a one-time costless message concerning her own information to the followers. We suppose that the message of the leader is publicly observable and that the followers send messages after receiving and observing the leader's message. [6] Denote the leader's message as $r_L \in \mathbb{R}$ and posterior beliefs about the leader's information after communication as $m_L \equiv E[\theta_L | r_L]$.

While the leader's message does not affect the decision policy and the organizational performance directly, it can affect the amount of information the followers provide to the leader. Given the leader's message $r_L$ and decision policy $\mathbf{z}$, the followers communication strategy is derived by the following indifferent condition;

$$E_i[\pi_i | \theta_i = a_{ij}, m_i = m_{ij}, r_L] = E_i[\pi_i | \theta_i = a_{ij}, m_i = m_{ij+1}, r_L]. \tag{18}$$

Solving and arranging (18), we obtain the second order difference equation that is same as (2). The difference from the unilateral-communication situation is that $B_i$ and $q_i$ is the function of $m_L$ such that

$$\begin{aligned} B_1(\theta_1, \mathbf{z}) &= \tfrac{(1-z_1)(\theta_1+b_1)-z_L m_L - z_2 E[m_2+b_2]}{z_1} \\ B_2(\theta_1, \mathbf{z}) &= \tfrac{(1-z_2)(\theta_2+b_2)-z_L m_L - z_1 E[m_1+b_1]}{z_2}, \end{aligned}$$

and

$$\begin{aligned} q_1(\mathbf{z}) &= \tfrac{z_L m_L + z_2 E[m_2+b_2]}{1-z_1} - b_1 \\ q_2(\mathbf{z}) &= \tfrac{z_L m_L + z_1 E[m_1+b_1]}{1-z_2} - b_2. \end{aligned}$$

Thus, the collective opinion can be dependent on the leader's message in the context of bilateral-communication.

As we considered the followers' communication strategy in unilateral-communication, likewise we may first consider the leader's incentive to misrepresent her information. Suppose that the leader can credibly misrepresent her information, that is, she can arbitrarily choose the followers' posterior beliefs. The optimal posterior, denoted by $m_L^*$, maximizes the leader's objective for given $\theta_L$:

$$m_L^* = \text{argmax}_{m_L} E_L[\bar{\Pi} | \theta_L, m_L]. \tag{19}$$

From (12), because the leader's message affect the organizational performance only through changes in $M_i$, the problem can be represented as

$$\max_{m_L} P(M_1, M_2) \equiv z_1(z_1(\alpha_L + 2\alpha) - 2\alpha)M_1 + z_2(z_2(\alpha_L + 2\alpha) - 2\alpha)M_2. \tag{20}$$

[6] Even if the message is not public but private, the results can hold.

Under the assumption that $\alpha_1 = \alpha_2$, the first order condition gives that $m_L^* = 0$, then the leader has an incentive to misrepresent her information unless $\theta_L = 0$. Furthermore, since $\frac{\partial^2 P(M_1,M_2)}{\partial m_L^2} < 0$, the leader's objective is single peaked and symmetric around zero with regard to $m_L$.

Given $\frac{\partial^2 P(M_1,M_2)}{\partial m_L^2} < 0$, the number of the posteriors induced in equilibrium is two at most. We refer to an equilibrium where the leader induces two different posteriors as binary equilibrium. Then, the following proposition holds.

**Proposition 8.** *In equilibrium, the leader's communication strategy may take only two forms; babbling strategy or binary strategy.*

Proof in Appendix. Only in binary equilibrium, the leader sends an informative message to the followers.

The posteriors induced in binary equilibrium are not uniquely determined. For example, $\theta_L$ is a random variable drawn from a uniform distribution on $[-1, 1]$. Consider the following communication strategy. If $\theta_L < 0$ the leader sends message "$A$" with probability $p$ and "B" with probability $1-p$, and if $\theta_L \geq 0$ she sends message "B" with probability $p$ and "A" with probability $1-p$ where $1/2 < p \leq 1$. Given that, the posterior of the followers after observing each message is represented as $E[\theta_L|r_L = A] = -p/2+(1-p)/2 = -(2p-1)/2$ and $E[\theta_L|r_L = B] = -(1-p)/2+p/2 = (2p-1)/2$ respectively. Since the leader's objective is symmetric around zero regardless of the information she possess, the two posteriors are indifferent for the leader then she does not have an incentive to deviate from such a communication strategy. Then, an infinite number of binary equilibrium may exist, in which the two different posteriors characterized by $p \in (1/2, 1]$ are induced in each equilibrium.[7]

Although an infinite number of binary equilibrium may exist, all equilibrium can be Pareto ranked. Let us denote $k$ as an absolute value of the posteriors induced in each of the binary equilibrium, that is, $k = |m_L^A| = |m_L^B|$ where $m_L^A$ and $m_L^B$ are posteriors induced in equilibrium. Then, each of the binary equilibrium can be characterized by $k$ and $k$-binary equilibrium is defined, in which the absolute value of the posteriors equals $k$. To make a countably infinite partition strategy of the followers feasible, we offer the following assumption.

**Assumption 2.** *$\theta_L$ is distributed within $\left[-\frac{s}{2}, \frac{s}{2}\right]$, where $s = \min\{s_1, s_2\}$.*

[7]If we focus only on a binary partition strategy, binary equilibrium is unique.

Assumption 2 ensures that $k \leq \min\left\{\frac{s_1}{2}, \frac{s_2}{2}\right\}$, no matter what communication strategy the leader follows. Then, the following proposition holds.

**Proposition 9.** *Suppose Assumption 1 (i) and Assumption 2 hold. The quality of communication and the organizational performance in babbling equilibrium are higher than those in binary equilibrium. The quality of communication and the organizational performance in $k$-binary equilibrium are higher than those in $k'$-binary equilibrium for any $k' > k$.*

Proof in Appendix. The first claim follows from the fact that $k > |E[\mu_L]|$ has to hold, and the second claim follows from the single peakedness of $P(M_1, M_2)$ with regard to $m_L$. Furthermore, the following claim immediately follows from Proposition 5.

**Corollary 1.** *Being a good listener is more likely to be valuable in any binary equilibrium than the babbling equilibrium. Being a good listener is more likely to be valuable in $k'$-binary equilibrium than $k$-binary equilibrium for any $k < k'$.*

# 8 Concluding remarks

This article examines how a leader's sensitivity toward followers' opinions affects the amount of information the followers provide. A good listener is more likely to facilitate communication with followers when (i) conflict between the followers is not severe and/or (ii) there is one leader and one follower. Otherwise, it actually may hurt the quality of communication with the followers, and a less sensitive leader, a bad listener, would be required. If the leader improves the quality of communication, the organizational performance can be improved. The value of being a good listener is enhanced when the followers believe that the leader has a biased opinion. The leader's favoritism in decision-making can improve the organizational performance by means of balancing the bias in the quality of communication. The degree of sensitivity is dependent on the leader's irrational estimation on the importance of information and the leader's self-confidence in her communication skill. We also show that it is valuable for the leader to obfuscate her information, even if she can communicates it with the followers, in order to elicit more information from them.

A few empirical implications arise from this study. One testable implication is that a sensitive leader is not needed in matured organizations, because the members are more likely to be in conflict in those organizations. This is consistent with the finding of Kaplan, Klebanov, and Sorensen

(2012), who found that CEO's persistence is critical factor for the success in matured firms.[8] Another implication is that a sensitive leader is not required in a firm that adopts diversification strategy. In such a firm, it is feasible for each of the division managers to have different opinions about the organizational direction.

# Appendix

## Derivation of (2), (3), and (4)

Note that

$$E_1[d|m_1 = m] = z_L\mu_L + z_1(m + b_1) + z_2(E[m_2] + b_2).$$

Substituting this into (1), we obtain

$$\begin{aligned}
&z_1^2((m_{1j+1} + b_1)^2 - (m_{1j} + b_1)^2) - 2z_1(m_{1j+1} - m_{1j})(a_{1j} + b_1) + 2z_1z_L(m_{1j+1} - m_{1j})\mu_L \\
&+2z_1z_2(m_{1j+1} - m_{1j})E[m_2 + b_2] = 0 \\
&\rightarrow m_{1j+1} + m_{1j} + 2b_1 - 2\frac{1}{z_1}(a_{1j} + b_1) + 2\frac{z_L}{z_1}m_L + 2\frac{z_2}{z_1}(E[m_2] + b_2) = 0 \\
&\rightarrow a_{1j+1} - a_{1j} = a_{1j} - a_{1j-1} + 4\frac{(1 - z_1)(\theta_1 + b_1) - z_L\mu_L - z_2E[m_2 + b_2]}{z_1} \\
&\rightarrow a_{1j+1} - a_{1j} = a_{1j} - a_{1j-1} + 4B_1(a_{1j}, \mathbf{z}).
\end{aligned}$$

We can obtain follower 2's communication strategy in the same manner. Together with the boundary conditions $a_{i0} = -s_i$ and $a_{iN_i} = s_i$, (2) yields a following explicit form of equilibrium cutoffs as follows;

$$a_{ij} = \frac{x(z_i)^j - y(z_i)^j}{x(z_i)^{N_i} - y(z_i)^{N_i}}(s_i - q_i(\mathbf{z})) + \frac{x(z_i)^{N_i-j} - y(z_i)^{N_i-j}}{x(z_i)^{N_i} - y(z_i)^{N_i}}(-s_i - q_i(\mathbf{z})) + q_i(\mathbf{z}) \tag{21}$$

where $x(z_i) = \frac{-\left(2-\frac{4}{z_i}\right)+\sqrt{\left(2-\frac{4}{z_i}\right)^2-4}}{2}$ and $y(z_i) = \frac{-\left(2-\frac{4}{z_i}\right)-\sqrt{\left(2-\frac{4}{z_i}\right)^2-4}}{2}$. Since $2 - \frac{4}{z_i} < -2$ for any $z_i \in (0, 1)$, $x(z_i) > 1$ and $y(z_i) < 1$. Then, if $N_i$ is large enough, $j$-th cutoff from the left edge can be approximately represented as (3), and $j$-th cutoff from the right edge can be approximately represented as (4).

[8] However, Kaplan, Klebanov, and Sorensen (2012) did not find significant positive or negative effects on firms' success in several traits related to a good listener, such as respect (values others, treating them fairly and showing concern for their views and feelings), listening skill (lets others speak and seeks to understand their viewpoints), and open to critic (often solicits feedback and reacts calmly to receiving criticism). One reason for the weak inconsistency of their results to this study is that the current model does not capture other activities than communication for efficient leadership. For example, Brunnermeier et al.(2012) emphasizes the importance of less sensitivity (in their terminology, resoluteness) when organizational members' actions must be coordinated. Then, it is plausible that the value of being a good listener can be canceled out if the needs for coordination is large.

## Proof of Lemma 1

It is straight forward to check that $\{a_{ij}\}_{j=0,1,\ldots N_i}$ satisfy boundary constraints $a_{i0} = -s_i$ and $a_{iN_i} = s_i$ for any $N_i$. Next, we show that $\{a_{ij}\}_{j=0,1,\ldots N_i}$ satisfy the order constraints. For any $N_i$, the first term of (21) is not decreasing in $j$ if $s_i \geq q_i(\mathbf{z})$ and strictly increasing in $j$ if $s_i > q_i(\mathbf{z})$. For any $N_i$, the second term of (21) is not decreasing in $j$ if $-s_i \leq q_i(\mathbf{z})$ and strictly increasing in $j$ if $-s_i < q_i(\mathbf{z})$. Thus, if $-s_i \leq q_i(\mathbf{z}) \leq s_i$, $a_{ij}$ is strictly increasing in $j$. $\square$

## Proof of Proposition 1

What remains to show is that the number of partitions is not limited if Assumption 1 holds. Because $q_1(\mathbf{z}) + b_1$ is a convex combination of $\mu_L$ and $E[m_2] + b_2$, $\mu_L \leq q_1(\mathbf{z}) + b_1 \leq E[m_2] + b_2$. Using fact that $E[m_2] = 0$, $\mu_L - b_1 \leq q_1(\mathbf{z}) \leq b_2 - b_1$. Then, Assumption 1 immediately suggest that $-s \leq q_1(\mathbf{z}) \leq s$, where $s = \min\{s_1, s_2\}$. In the same manner, we can show that $q_2(\mathbf{z})$ is in $[-s, s]$. Applying Lemma 1, we thus complete the proof. $\square$

## Proof of Lemma 2

After some lengthy calculation, we obtain

$$
\begin{aligned}
E[m_i^2] &= \sum_{j=0}^{N_i-1} \int_{a_{ij}}^{a_{ij+1}} \left(\frac{a_{ij+1}+a_{ij}}{2}\right)^2 \frac{1}{2s_i} d\theta_i \\
&= \frac{1}{8s_i} \sum_{j=0}^{N_i-1} (a_{ij+1}^3 + a_{ij+1}^2 a_{ij} - a_{ij+1} a_{ij}^2 - a_{ij}^3) \\
&= \frac{1}{4} \frac{x(z_i)^2 + 2x(z_i) + 1}{x(z_i)^2 + x(z_i) + 1} s_i^2 - \frac{1}{4} \frac{x(z_i)^2 - 2x(z_i) + 1}{x(z_i)^2 + x(z_i) + 1} q_i(\mathbf{z})^2 \\
&\quad - \frac{1}{4} \frac{(x(z_i)^2 - 1)^2 (x(z_i)^{N_i}(x(z_i)^{N_i} - 1)^2 (s_i^2 - q_i(\mathbf{z})^2) + 4x(z_i)^{2N_i} s_i^2)}{x(z_i)(x(z_i)^2 + x(z_i) + 1)(x(z_i)^{N_i} + 1)^2 (x(z_i)^{N_i} - 1)^2}
\end{aligned} \tag{22}
$$

Because the third term is strictly positive and decreasing in $N_i$, $E[m_i^2]$ is increase in $N_i$. (5) can be derived by substituting $x(z_i)$ into (5) and taking the limit of $N_i$. $\square$

## Proof of Proposition 2

For $i = 1$, the first term and the second term of (6) are given as follows;

$$
\left.\frac{\partial M_1}{\partial z_1}(z_1, q)\right|_{q=q_1(\mathbf{z})} \left(-\frac{\partial z_1}{\partial \bar{\alpha}_L}\right) = \frac{\alpha(\bar{\alpha}_L + \alpha)^2 s_1^2 + 3(\bar{\alpha}_L \mu_L + b(\bar{\alpha}_L + 2\alpha))^2}{(\bar{\alpha}_L + \alpha)^2 (4\bar{\alpha}_L + 7\alpha)^2},
$$

and

$$\frac{\partial M_1}{\partial q_1}(z_1, q_1)\left(-\frac{\partial q_1}{\partial \bar{\alpha}_L}(\mathbf{z})\right) = \frac{\alpha(\mu_L - b)(\bar{\alpha}_L \mu_L + b(\bar{\alpha}_L + 2\alpha)}{(\bar{\alpha}_L + \alpha)^2(4\bar{\alpha}_L + 7\alpha)}.$$

Then, $-\frac{\partial M_i(z_i, q_i(\mathbf{z}))}{\partial \bar{\alpha}_L} \geq 0$ if and only if

$$(\bar{\alpha}_L + \alpha)^2 s_1^2 + (\bar{\alpha}_L \mu_L + b(\bar{\alpha}_L + 2\alpha))(\mu_L(11\bar{\alpha}_L + 14\alpha) - b(5\bar{\alpha}_L + 8\alpha)) \geq 0. \quad (23)$$

Substituting $\mu_L = 0$ into (23), we obtain proposition 2. In the same manner, we can derivate the condition for $i = 2$.

Finally, we confirm the condition that the threshold of $b^2$ specified in proposition 2 exist in $\left[0, \min\left\{\frac{s_1^2}{4}, \frac{s_2^2}{4}\right\}\right]$. Note that $\min_{\{\bar{\alpha}_L, \alpha\}} \frac{(\bar{\alpha}_L+\alpha)^2}{(\bar{\alpha}_L+2\alpha)(5\bar{\alpha}_L+8\alpha)} = \frac{1}{16}$. Then, for $i = 1, 2$ , the threshold that satisfies (11) exists in that area for any $(\bar{\alpha}_L, \alpha)$ as long as $|s_1 - s_2|$ is not extremely large. □

## Proof of Proposition 5

Note that

$$\begin{aligned}
&-\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \bar{\alpha}_L} - \frac{\partial M_2(z_2, q_2(\mathbf{z}))}{\partial \bar{\alpha}_L} \\
&= \alpha \frac{(\bar{\alpha}_L + \alpha)^2(s_1^2 + s_2^2) - (\bar{\alpha}_L + 2\alpha)(5\bar{\alpha}_L + 8\alpha)b^2 + \bar{\alpha}_L(11\bar{\alpha}_L + 14\alpha)m_L^2}{(\bar{\alpha}_L + \alpha)^2(4\bar{\alpha}_L + 7\alpha)^2}.
\end{aligned}$$

Then, $-\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \bar{\alpha}_L} - \frac{\partial M_2(z_2, q_2(\mathbf{z}))}{\partial \bar{\alpha}_L}$ is more likely to be positive as $|\mu_L|$ increases. Applying envelop theorem, we can show that the organizational performance can be improved if $M_1 + M_2$ is increased as $\bar{\alpha}_L$ decrease at $\bar{\alpha}_L = \alpha_L$ in the same manner as Proposition 3. □

## Proof of Proposition 6

We show that a slight increase in $\epsilon$ at $\epsilon = 0$ makes the organizational performance better. At first, we derive the marginal effect of an increase in $\epsilon$ on the quality of communication. Note that

$$\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \epsilon} = \frac{\alpha_L + 2\alpha}{(4\alpha_L + 7\alpha - \epsilon)^2} s_1^2 + \frac{\alpha^2(\alpha_L + 2\alpha - 2\epsilon)(11\alpha_L^2 + 26\alpha_L + 12\alpha^2 - (8\alpha_L + 12\alpha)\epsilon)}{(\alpha_L + \alpha - e)^2(4\alpha_L + 7\alpha - \epsilon)^2} b^2$$

and

$$\frac{\partial M_2(z_2, q_2(\mathbf{z}))}{\partial \epsilon} = -\frac{\alpha_L + 2\alpha}{(4\alpha_L + 7\alpha + \epsilon)^2} s_2^2 - \frac{\alpha^2(\alpha_L + 2\alpha + 2\epsilon)(11\alpha_L^2 + 26\alpha_L + 12\alpha^2 + (8\alpha_L + 12\alpha)\epsilon)}{(\alpha_L + \alpha + e)^2(4\alpha_L + 7\alpha - \epsilon)^2} b^2.$$

Next, we derive the marginal effect of an increase in $\epsilon$ on the organizational performance at $\epsilon = 0$. Using envelop theorem, we obtain

$$\left.\frac{\partial E[\Pi]}{\partial \epsilon}\right|_{\epsilon=0} = \frac{\partial E[\Pi]}{\partial M_1} \left.\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \epsilon}\right|_{\epsilon=0} + \frac{\partial E[\Pi]}{\partial M_1} \left.\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \epsilon}\right|_{\epsilon=0}.$$

At $\epsilon = 0$, $\frac{\partial E[\Pi]}{\partial M_1} = \frac{\partial E[\Pi]}{\partial M_2} > 0$ from (12), and

$$\frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \epsilon}\bigg|_{\epsilon=0} + \frac{\partial M_1(z_1, q_1(\mathbf{z}))}{\partial \epsilon}\bigg|_{\epsilon=0} = \frac{\alpha_L + 2\alpha}{(4\alpha_L + 7\alpha)^2}(s_1^2 - s_2^2).$$

This completes the proof. □

## Proof of Proposition 7

Applying the same procedure as Proposition 1, we can show that the following equilibrium exist. When Assumption 1 holds, given the leader's decision policy $\mathbf{z}^\lambda$, for $i = 1, 2$, for any positive integer $N_i$ there exists at least one equilibrium such that

1. follower i sends the randomized message $r_i$, which is drawn from the uniform distribution supported on $[a_{ij-1}, a_{ij})$ if $\theta_i \in [a_{ij-1}, a_{ij})$ for $j = 1, ...N_i - 1$ and on $[a_{iN_i-1}, a_{iN_i}]$ if $\theta_i \in [a_{iN_i-1}, a_{iN_i}]$,
2. the leader makes her belief $m_i$ as $(1-\bar{\lambda})\frac{a_{ij-1}+a_{ij}}{2}$ if $r_i$ is in $[a_{ij-1}, a_{ij})$ for $j = 1, ...N_i - 1$ and $(1-\bar{\lambda})\frac{a_{iN_i-1}+a_{iN_i}}{2}$ if the receipt message $r_i$ is in $[a_{iN_i-1}, a_{iN_i}]$, and
3. for $j = 1, ..., N_i$, $a_{ij}$ follows

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} + 4B_i(a_{ij}, \mathbf{z}^\lambda), \tag{24}$$

   and $a_{i0} = -s_i$ and $a_{iN_i} = s_i$

Then, the quality of communication with $i$ is given by $M_i(z_i^\lambda, q_i(\mathbf{z}^\lambda))$. It is straightforward to show

$$\begin{aligned} \frac{\partial M_i}{\partial \bar{\lambda}}(z_i^\lambda, q_i(\mathbf{z}^\lambda)) &= \frac{\partial M_i}{\partial z_i^\lambda}(z_i^\lambda, q)\mid_{q=q_i(\mathbf{z}^\lambda)} \frac{\partial z_i^\lambda}{\partial \bar{\lambda}} + \frac{\partial M_i}{\partial q_i}(z_i^\lambda, q_i)\frac{\partial q_i}{\partial \bar{\lambda}}(\mathbf{z}^\lambda) && (25) \\ &= -\frac{\alpha(\alpha_L + 2\alpha)}{(4\alpha_L + (7+\lambda)\alpha)^2}s_i^2 + \frac{\alpha(\alpha_L + 2\alpha)^2(5\alpha_L + (8+2\lambda)\alpha}{(4\alpha_L + (7+\lambda)\alpha)^2(\alpha_+ L(1+\lambda)\alpha)^2}b^2. && (26) \end{aligned}$$

The first statement of the proposition immediately follows from (26).

Applying the envelope theorem, we obtain

$$\frac{\partial E[\Pi^\lambda]}{\partial \bar{\lambda}}\bigg|_{\bar{\lambda}=\lambda} = \frac{\partial E[\Pi^\lambda]}{\partial M_1}\frac{\partial M_1}{\partial \bar{\lambda}}(z_1^\lambda, q_1(\mathbf{z}^\lambda))\bigg|_{\bar{\lambda}=\lambda} + \frac{\partial E[\Pi^\lambda]}{\partial M_2}\frac{\partial M_2}{\partial \bar{\lambda}}(z_2^\lambda, q_2(\mathbf{z}^\lambda))\bigg|_{\bar{\lambda}=\lambda}. \tag{27}$$

Note that $\frac{\partial E[\Pi^\lambda]}{\partial M_1}\Big|_{\bar{\lambda}=\lambda} = \frac{\partial E[\Pi^\lambda]}{\partial M_2}\Big|_{\bar{\lambda}=\lambda} > 0$, because the expected organizational performance is given by

$$\begin{aligned} E[\Pi^\lambda] &= -(1-\lambda)^2(\alpha_L E[(d(\theta_L, r_1, r_2)-\theta_L)^2] + \sum_{i=1,2} \alpha E[(d(\theta_L, r_1, r_2)-\theta_i-b_i)^2]) \\ &\quad -(1-\lambda)\lambda(\alpha_L E[(d(\theta_L, r_1, \bar{r}_2)-\theta_L)^2] + \sum_{i=1,2} \alpha E[(d(\theta_L, r_1, \bar{r}_2)-\theta_i-b_i)^2]) \\ &\quad -\lambda(1-\lambda)(\alpha_L E[(d(\theta_L, \bar{r}_1, r_2)-\theta_L)^2] + \sum_{i=1,2} \alpha E[(d(\theta_L, \bar{r}_1, r_2)-\theta_i-b_i)^2]) \\ &\quad -\lambda^2(\alpha_L E[(d(\theta_L, \bar{r}_1, \bar{r}_2)-\theta_L)^2] + \sum_{i=1,2} \alpha E[(d(\theta_L, \bar{r}_1, \bar{r}_2)-\theta_i-b_i)^2]) \\ &= -(\alpha_L(1-z_L)^2 + 2\alpha z_L^2)\sigma_L^2 - \alpha\frac{s_1^2}{3} - \alpha\frac{s_2^2}{3} \\ &\quad -z_1(z_1(\alpha_L+2\alpha) - 2\alpha(1-\lambda))E[m_1^2] - z_2(z_2(\alpha_L+2\alpha) - 2\alpha(1-\lambda))E[m_2^2] \\ &\quad -\alpha_L((1-z_L)\mu_L - z_1 b_1 - z_2 b_2)^2 \\ &\quad -\alpha((1-z_1)b_1 - z_L\mu_L - z_2 b_2)^2 - \alpha((1-z_2)b_2 - z_L\mu_L - z_1 b_1)^2. \end{aligned}$$

Thus, the second statement of the proposition holds. □

## Proof of Proposition 8

First, we show that $P(M_1, M_2)$ is single peaked at $m_L = 0$. Substituting $M_i$ into (20), the first order condition gives

$$m_L^* = \frac{(1-z_1+z_2)(4-z_2)(1-z_2) + (-1-z_1+z_2)(4-z_1)(1-z_1)}{z_L((1-z_1)(4-z_1) + (1-z_2)(4-z_2))} b. \tag{28}$$

If $\alpha_1 = \alpha_2$, $z_1 = z_2$ then $m_L^* = 0$. Note that

$$\frac{\partial^2 P(M_1, M_2)}{\partial m_L^2} = -\frac{2z_L^2}{(4-z_1)(1-z_1)} - \frac{2z_L^2}{(4-z_2)(1-z_2)} < 0. \tag{29}$$

Next, we show that the number of the posterior the leader induces is two at most. Suppose that the leader induces more than three posteriors in equilibrium. Then, two some posteriors $m_L^A$ and $m_L^B$ exist, which satisfy $|m_L^A| > |m_L^B| > 0$. Because the leader's objective is single peaked at $m_L = 0$, the leader always strictly prefer to induce $m_L^B$ than $m_L^A$. This is contradiction. □

## Proof of Proposition 9

First, we prove the first statement. Let the posterior induced in binary equilibrium be $m_L^A$ and $m_L^B$ where $m_L^A < m_L^B$. Because $P(M_1, M_2)$ is symmetric around zero, those have to satisfy $m_L^A < 0$ and

$m_L^B > 0$. Let $p$ be the probability with which the leader induces $m_L^A$ and $1-p$ be the probability with which the leader induces $m_L^B$. Note that

$$E[\theta_L] = pm_L^A + (1-p)m_L^B.$$

Then, either $m_L^A < 0 \leq \mu_L < m_L^B$ or $m_L^A < \mu_L \leq 0 < m_L^B$ has to hold. Thus, the first statement follows from the fact that $P(M_1, M_2)$ is single peaked at $m_L = 0$. The second statement is also immediately follows from the single peakedness of $P(M_1, M_2)$. □

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# Chapter 3.

## The value of a leader's initiative in an adaptation and coordination problem

### 1 Introduction

Organizational economists consider constraints on information transmission a critical determinant of an organizational design. Marschak and Radner (1972) develop a team theoretic model and discuss optimal decision-making processes with dispersed information and constraints on communication. The team theoretic model depicts a typical trade-off problem between adaptation and coordination in organizations. In the model, each divisional activity must be not only adapted to environment but also coordinated to the others' activities. It is difficult to resolve the trade-off problem in an efficient manner, because of members' lack of knowledge for the other divisions' environment and physical or strategic constraints on communication.

Some researchers indicate that leadership helps to resolve the trade-off problem. Dewan and Myatt (2008) and Brunnermeier, Bolton, and Veldkamp (2013) claim that it is important that leaders provide a vision at an early stage. We interpret the leader's decision-making in early stages as the leader's initiative. Through making a vision, followers can foresee future decisions of other members and better coordination is attainable. However, these studies neglect the case in which members' incentives are not aligned to the interest of the organization and followers strategically communicate with each other, despite that such consideration is plausible in actual organizations. How does the leader's initiative affect the followers decisions in a strategic situation within the context of adaptation and coordination problems, and should the leader take an initiative?

To answer these questions, we examine the following adaptation and coordination model in this study. In our model, there exist one leader(headquarter) and two followers(division managers) who make decisions. The follower's objective is characterized by two factors; one is adaptation that requires consistency between each follower's decision and each local environment and another one is coordination that requires consistency between each follower's decision and an organizational decision made by the leader. The organizational performance is defined as the sum of both followers' objectives. Each local environment is independent and private information for each follower. The followers are in conflict ex ante in the sense that their environment follows a heterogeneous distribution. Simultaneous one-time communication is possible. There exist two decision-making processes for the leader. In the first process, that is associated with the leader's initiative, the leader makes an organizational decision by relying on messages from the followers before the followers make decisions. In the second process, the leader postpones her decision after the followers make their own decisions and makes an organizational decision considering the observed followers' decisions.

We shed light on not only the positive side but also the negative side of the leader's initiative. Indeed, if the leader makes an organizational decision before the followers do, there is no room for the followers to manipulate it. The followers' local problems are then separately solved in the most efficient manner for the given organizational decision. In other words, the leader's initiative makes the followers' incentives well-aligned. However, the leader faces the risk of making a wrong organizational decision due to limited knowledge of local environment. The followers attempt to manipulate the leader's decision through wrong reports; the information the leader can access is limited and the organizational decision can be inefficient ex post.

The decision-making process without the leader's initiative can be better than the process with the leader's initiative. If the leader does not take an initiative, she can access correct knowledge regarding which decision is efficient through observing the followers' decisions. Then, the leader always makes an efficient decision in the ex-post sense and communication is unnecessary. Undoubtedly, even though the leader has access to complete knowledge, taking no initiative has a negative influence on the followers' decisions, because the followers try to manipulate an organizational decision via excessive adaptation, that is, the followers make decisions with excessively large weight on their own information. While excessive adaptation does pay for each follower, this cause local decisions to be inefficiently distorted from ex-post efficient levels.

The value of the leader's initiative is dependent on the relative importance of adaptation over coordination. When the importance of coordination is relatively greater than the importance of adaptation, the process with the leader's initiative has an advantage over one without it, because the loss from excessive adaptation is more than the loss that is coming from miscommunication. However, the opposite is true otherwise by the opposite reason.

A remarkable result of the study is that the ex-ante conflict (the extent of heterogeneity of local environment) among the followers affects the value of the leader's initiative in different ways between non-strategic communication case and strategic communication case. Although the quality of communication is independent of the ex-ante conflict in non-strategic communication case, it is dependent in strategic communication case and becomes worse as the ex-ante conflict increases. Then, the relative superiority of the leader's initiative over no initiative is diminished as the ex-ante conflict increases when communication is strategic. This is counterintuitive to the prevailing knowledge that strong leadership is required when members are in serious conflict.

We use the word "coordination" in a different sense from the standard model, in which better coordination implies that followers' decisions are consistent with those of the other followers. To explain these situations, we assume the following example of a multi-divisional firm with one CEO and two local divisional managers. Each divisional manager invests into a certain production technology, which determines the quality of the product of each division. Two factors determine each division's profit. The first one, which is associated with adaptation, is consistency between the quality of the product and the consumers' needs in the local market. If the product meets the consumers' needs, the sales result is maximized. The second is a developing cost from a product that is jointly developed with the other division. The developing cost is minimized when the division's technology is consistent with the design of the joint product. The CEO's task in this regard is making the design of the joint product to maximize the two divisions' profits. However, since each division is likely to face a different market condition, the respective managers are frequently in serious conflict regarding which joint product should be developed.

## 2 Related literature

Many researchers have studied the tradeoff between adaptation and coordination and the optimal decision-making process in organizational economics. Marschak and Radner (1972) construct the team theoretic model, in which decisions are needed to be coordinated but communication is costly due to physical reasons. Building on their work, Crémer (1980) and Dessein and Santos (2006) discuss how multiple tasks are bundled from the perspective of reducing coordination loss led by limited communication, and Aoki (1986) compares the efficiency of vertical and horizontal information structures. Dewan and Myatt (2008) study the role of leadership and leader's communication skills in the standard adaptation and coordination problem. Brunnermeier, Bolton, and Veldkamp (2013) add a new issue related to coordination between members' and leader's decisions to the standard model. However, these studies do not consider the case in which members' incentives are not aligned to maximizing organizational performances and communication is strategic. Furthermore, our paper indicates out that the optimal decision-making process is different between non-strategic and strategic cases when ex-ante conflict is serious.

The extensive literature on strategic communication has analyzed strategic information transmission among self-interested parties with conflicting interest. Crawford and Sobel (1982) is a seminal work in this field. They considered a situation in which only a sender can observe the true state, but only a receiver can make a decision that affects both the sender's and receiver's utilities. They show that there is a Perfect Bayesian equilibrium such that state spaces are divided by finite numbers of partitions, and the sender reveals only the partition in which the true state is as long as the parties never have the same preference in the decision. We model the communication game as more simple and more tractable than the traditional model developed by Craword and Sobel (1982). As done by Alonso, Dessein, and Matouchek (2008), we avoid the integer problem, which is associated with the finite-partition equilibrium in the traditional model, by focusing on the equilibrium with infinite-partition equilibrium. For infinite-partition equilibrium to be feasible, we assume that such ex-ante conflict between two followers is not too strong. This assumption ensures that each follower has an identical preference as the other follower in the sense of his expectation with strictly positive probability.

Some recent papers consider an adaptation and coordination model with strategic communication. Alonso, Dessein, and Matouschek (2008) consider an authority allocation problem in such situation. Rantakari (2008) considers a situation in which heterogeneous importance of adaptation and coordination exists within divisions. We consider a different aspect of coordination, that is, coordination between members' and an organizational decisions, and address the issue on leadership. This study has a similar characteristics with researches on multi-sender situations with independent preference of senders, for example, Kawamura (2011), McGee and Yang (2013), and Ogawa (2013). As studied in Ogawa (2013), this study considers the case in which there exist ex-ante conflict among followers in the sense that expected ideal decisions of theirs is different and also assumes that the ex-ante conflict is not strong to ensure that infinite-partition strategy is feasible.

In leadership literature, taking initiatives is considered as one of the central roles of leaders. Hermalin (1998) considers the free-rider problem in a team and shows that a leader can moderate the problem by being the first to make s decision.

## 3 Model

We study the organization in which there is one leader (she) and two followers (he) indexed by $i$. Follower $i$ has two concerns ; 1) minimizing the difference between his decision $d_i$ and his environment $\theta_i + b_i$ ($i$'s ideal point or ideal decision) and 2) minimizing the difference between $d_i$ and an organizational decision $d$. In particular, we specify that his profit function $\pi_i$ is composed of two quadratic-loss function:

$$\pi_i = -k(d_i - \theta_i - b_i)^2 - \delta(d_i - d)^2,$$

where $k \in \mathbb{R}_+$ indexes the importance of local adaptation and $\delta \in \mathbb{R}_+$ indexes the importance of coordination between local decisions and an organizational direction. Because the relative sizes of $k$ and $\delta$ are of significant, we assume $k + \delta = 1$. The leader decides $d$ to maximizes the organizational performance $\Pi$ defined by the sum of both followers' profits;

$$\Pi = \pi_1 + \pi_2.$$

Each follower's objective is to maximize only his own profit[1] .

$\theta_i$ is follower $i$'s private information and is uniformly distributed in $[-s, s]$ where $s \in \mathbb{R}_+$, and $b_i \in \mathbb{R}$ is public information. We assume $-b_1 = b_2 = b > 0$. This implies that the expected followers' ideal points are symmetrical around zero, and we interpret $b$ as the extent of ex-ante conflict with regard to the organizational decisions among the followers. If $b = 0$, the distributions of both followers' ideal points are identical, and the followers are most likely to have similar preference regarding which organizational decision should be implemented. As $b$ increases, the overlapping ranges between both the distributions decrease and the followers are likely to have different preference regarding the organizational decision.

The followers can communicate their own private information before the leader and the followers make decisions. Each follower privately sends a one-time costless message $r_i \in [-s, s]$ to the leader[2]. We suppose that the leader cannot commit any mechanism and monetary transfer contingent on messages, that is, any communication is cheap talk. We denote the belief on follower $i$'s information after communication as $m_i \equiv E[\theta_i | r_i]$ for $i = 1, 2$. Finally, in order to make our model tractable, we utilize the following assumption.

[1] In organizations, it is typically to undesirable to fully align a member's incentives from the viewpoint of preventing a free-rider problem, even if a misalignment in their incentives creates communication problem. Athey and Roberts (2001), Dessein, Garicano, and Gertner (2010), and Friebel and Raith (2007) address this issue.

[2] We will study the case in which the followers' messages are publicly observable in Discussion section.

**Assumption 1.** $b \leq \frac{s}{2}$.

In words, the assumption suggests that the extent of the conflict between the followers is not too serious. As we see later, this assumption ensures that the partition-strategy with infinite partitions in the communication game is feasible.

### Decision-making process and game flow

The leader can commit the timing of her making an organizational decision ex ante. The first opportunity to make a decision is before followers' decision-making.[3] We term this decision-making process as a "process with the leader's initiative", and we use "I" to index this. The leader does make an organizational decision based on collected information through cheap talk communication. In process I, the game proceeds in the following manner:

1. The followers privately observe $\theta_i$.
2. The followers send their messages to the leader (they are not necessarily truthful).
3. The leader decides $d$.
4. After observing $d$, the followers decide $d_i$.

The second opportunity of making an organizational decision is after decision-makings of the followers. We term this decision-making process as a "process without the leader's initiative", and we use "NI" to index this. The leader can observe the followers' decision and decide an organizational decision based on not only received messages but also observed followers' decisions. In process NI, the game proceeds in the following manner:

1. The followers privately observe $\theta_i$.
2. The followers send their messages to the leader (they are not necessarily truthful).
3. The followers decide $d_i$.
4. After observing $(d_1, d_2)$, the leader decides $d$.

[3] We can show that making an organizational decision before communication yields a lower profit than the one after communication.

# 4 Decision-making and performance under process I

Here, we solve the problem backward. In the last stage, for given $d$, follower $i$'s decision is given by the convex combination of the organizational direction $d$ and his ideal point $\theta_i + b_i$ weighted by $k$ and $\delta$;

$$d_i = k(\theta_i + b_i) + \delta d.$$

It is important to make two remarks regarding the follower's decision policy. First, for each follower, the preference of the other follower is not significant in his decision-making. Then, the observability of the other follower's message does not affect his decision. Second, the followers' decisions are aligned toward maximizing the organizational performance for given $d$. Once $d$ is determined, the decision of each follower also maximizes the organizational performance. This implies that the initiative by the leader makes each followers' incentives aligned toward global optimization, and if she has complete knowledge of followers' information, the leader archives the highest performance by setting $d$ appropriately in process I.

Substituting $d_i$ into $\pi_i$, $\pi_i$ is represented as

$$\pi_i = -k\delta(d - \theta_i - b_i)^2.$$

The product $k\delta$ captures the seriousness of the tradeoff between adaptation and coordination. To see this, suppose $k$ is sufficiently low and $\delta$ is high, that is, the followers have to pay little attention to failures in adaptation and only care about failures in coordination. If the organizational decision is greatly different from their own ideal points, the followers accommodate their decisions to the organizational decision with a large weight and reduces dependency on their own ideal points. As $\delta$ goes to 1, the loss that comes from failures in adaptation becomes trivial then the followers completely accommodate their decisions to the organizational decision. Thus, when $\delta$ is close to one (equivalently $k$ is zero), $k\delta$ is close to zero and the trade-off problem becomes trivial. In contrast, when $delta$ and $k$ are similar values such as 1/2, the trade-off problem becomes most serious. This is also true if we replace $\delta$ with $k$ in the above discussion.

In the third stage, the leader makes the decision $d$ to maximize organizational performance for given the message $(r_1, r_2)$. The leader's problem is represented as

$$\max_d -k\delta \sum_{i=1,2} E[(d - \theta_i - b_i)^2 | r_1, r_2].$$

The optimal decision is given by a mean of $m_1$ and $m_2$;

$$d = \frac{m_1 + m_2}{2}.$$

Using $E[m_i\theta_i] = E[m_i^2]$, the organizational performance is represented as

$$E[\Pi^I] = -k\delta\left[\frac{2}{3}s^2 - \frac{1}{2}E[m_1^2] - \frac{1}{2}E[m_2^2] + 2b^2\right].$$

In the remainder of this section, we identify the communication strategy when followers communicate strategically. While truth-telling equilibrium does not exist, partially informative communication may still be achieved. The followers follow the partition-strategy such that they divide the type-space into some intervals and reveal only the interval their types belong to. Precisely, for $i = 1, 2$, follower $i$ divide his type-space into $N_i$ intervals and name cutoff points from the left as $a_{ij}$, which satisfies boundary conditions $a_{i0} = -s_i$ and $a_{iN_i} = s_i$ and order constraints $a_{ij} < a_{ij+1}$ for $j = 0, ..., N_i$. In equilibrium, follower $i$ sends a randomized message that is drawn from the uniform distribution supported on $[a_{ij-1}, a_{ij})$ if $\theta_i \in [a_{ij-1}, a_{ij})$. If the receipt message is in $[a_{ij-1}, a_{ij})$, the leader forms the posterior belief that $m_{ij} = \frac{a_{ij-1}+a_{ij}}{2}$. On each cutoff point, follower $i$ is indifferent between reporting that $\theta_i$ belongs to either one of the two intervals around that cutoff point. That is, any cutoff $a_{ij}$ for $j = 1, ...N_i - 1$ must satisfy the following indifferent conditions,

$$E[\pi_i|\theta_i = a_{ij}, m_i = m_{ij}] = E[\pi_i|\theta_i = a_{ij}, m_i = m_{ij+1}]. \tag{1}$$

Solving and arranging this, we obtain the second order difference equation in the following manner: for $j = 1, ..., N_i - 1$,

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} + 4a_{ij} - 8b_i. \tag{2}$$

From the second order difference equation (2), we can see how the size of each interval is determined. The change in the size of the intervals becomes quite small when $a_{ij}$ is near $-2b_i$. Intuitively, if $\theta_i = -2b_i$, his ideal decision is $-2b_i + b_i = -b_i = b_{-i}$. That is, his ideal decision equals the expected value of the other follower's ideal decision, and follower $i$ has an incentive to represent correct information. On the other hand, at any cutoff $a_{ij}$ such that $a_{ij} < -2b_i$, the size of the interval $a_{ij+1} - a_{ij}$ is smaller than the size of the preceding intervals $a_{ij} - a_{ij-1}$ by $4|a_{ij} + 2b_i|$, and the changes in the sizes of intervals decrease as $j$ increases. At any cutoff $a_{ij}$ such that $a_{ij} > -2b_i$, the size of the interval $a_{ij+1} - a_{ij}$ is larger than the size of the preceding intervals $a_{ij} - a_{ij-1}$ by $4|a_{ij} + 2b_i|$, and the changes in the sizes of intervals increase as $j$ increases.

As Crawford and Sobel (1982) remarked, the finiteness of $N_i$ does not hold if the follower has identical preference (in the term of $i$'s expectation) to the leader with strict positive probability, and Assumption 1 ensures that this condition holds.

**Lemma 1.** *If Assumption 1 holds, there is no upper bound for the number of equilibrium cutoffs.*

The proof is in Appendix. The lemma is further intuitive. From (2), we can obtain the equilibrium at which an infinite number of intervals exist around $-2b_i$ with a negligibly small size. Assumption 1 ensures that $-2b_i \in [-s, s]$, that is, such a type is in the range of $i$'s type space[4].

In summary, we obtain the following proposition.

**Proposition 1.** *Suppose Assumption 1 holds. For $i = 1, 2$, there exists a positive integer $N_i$ and at least one equilibrium such that;*

1. *follower $i$ sends the randomized message $r_i$, which is drawn from the uniform distribution supported on $[a_{ij-1}, a_{ij})$ if $\theta_i \in [a_{ij-1}, a_{ij})$ for $j = 1, ...N_i - 1$ and on $[a_{iN_i-1}, a_{iN_i}]$ if $\theta_i \in [a_{iN_i-1}, a_{iN_i}]$,*

2. *the leader makes her belief $m_i$ as $\frac{a_{ij-1}+a_{ij}}{2}$ if $r_i$ is in $[a_{ij-1}, a_{ij})$ for $j = 1, ...N_i - 1$ and $\frac{a_{iN_i-1}+a_{iN_i}}{2}$ if the receipt message $r_i$ is in $[a_{iN_i-1}, a_{iN_i}]$, and*

3. *for $j = 1, ..., N_i - 1$, $a_{ij}$ follows (2), and $a_{i0} = -s_i$ and $a_{iN_i} = s_i$.*

4. *$d_i^I = k(\theta_i + b_i) + \delta d^I$, and*

5. *$d^I = \frac{m_1+m_2}{2}$.*

It must be noted that, when communication is strategic the leader's decision is almost always inefficient ex post, that is, $d \neq \frac{d_1+d_2}{2}$. In process I, it can be efficient only when $\theta_1 + \theta_2 = m_1 + m_2$ holds. This implies that the leader has incentive to reverse her decision after observing the followers' decisions if possible. We examine the possibility of decision-making after observation in the next section.

A residual variance $E[(\theta_i - m_i)^2]$ indicates how the information that follower $i$ provides is precise on average. If the updated posterior belief of the leader regarding $i$'s information is close to (resp. far from) his actual one, it becomes small (resp. large). By applying the law of iterated expectation,

[4]Then, our model shares a consistent character to the classical Crawford-Sobel model in the sense that the large conflict parameter "b" makes the upper bound of the number of partitions small.

we obtain $E[(\theta_i - m_i)^2] = E[\theta_i^2] - E[m_i^2]$. Because $E[\theta_i^2]$ is independent of the equilibrium profile and the residual variance decreases as $E[m_i^2]$ goes up, we refer to $E[m_i^2]$ as the quality of communication with follower $i$.

The quality of communication with follower $i$ increases as $N_i$ goes up, that is, the more the intervals, the more precise the communication.

**Lemma 2.** *$E[m_i^2]$ is increasing in $N_i$.*

Proof is in Appendix. A higher quality of communication also improves organizational performance. Therefore, in the following section we focus on the equilibrium with an infinite-partition strategy, in which the organizational performance is maximized within any partition-strategy equilibrium. The quality of communication with infinite partitions is given by

$$\lim_{N_i \to \infty} E[m_i^2] = \frac{2}{7}s^2 - \frac{4}{7}b^2.$$

We remark that the quality of communication decreases as $b^2$ increases. The intuition is as follows. For minimizing the residual variance, the size of the largest interval should be decreased even if the size of smaller intervals increase. Since the size of the interval increases as the cutoff is far from $-2b_i$, the size of the largest interval is minimized when $b_i = 0$[5].

When $N_1$ and $N_2$ is sufficiently large, the expected performance is approximately represented as

$$E[\Pi^I] = -\frac{8k\delta}{21}s^2 - \frac{18k\delta}{7}b^2. \tag{3}$$

# 5 Decision-making and performance in process NI

In process NI, the leader pushes off her decision after the followers make decisions. The leader can access not only the messages but also observed followers' decisions in her decision-making.

We solve the problem backward. In the last stage the leader solves the following problem; for given $(d_1, d_2)$ and $(r_1, r_2)$,

$$\max_d \sum_{i=1}^{2} E\left[-k(d_i - \theta_i - b_i)^2 - \delta(d - d_i)^2 | r_1, r_2\right].$$

Clearly, the optimal organizational decision is dependent only on the observed followers' decisions, not on their messages. This implies that communication is no use under process NI and any

[5]For more details, see Lemma 3 in Ogawa(2013).

communication strategy is indifferent.[6] Then, the leader makes the organizational decision as a simple mean of $d_1$ and $d_2$ such as

$$d = \frac{d_1 + d_2}{2}.$$

Substituting $d$ into follower $i$'s objective function and rearranging it, $i$'s problem in the third stage can be represented as

$$\max_{d_i} E\left[-k(d_i - \theta_i - b_i)^2 - \frac{\delta}{4}(d_i - d_{-i})^2\right].$$

Then, if we set $b = 0$, the problem coincides with the standard adaptation and coordination problem, studied by Dessein and Santos (2006), Alonso, Dessein and Matouschek (2008), and Rantakari (2008).

From the first order condition, we obtain

$$d_i = \frac{4k}{1+3k}(\theta_i + b_i) + \frac{\delta}{1+3k}E[d_{-i}].$$

It must be noted that the followers' decisions are distorted from the efficient level in the sense that they place excessive weight on their own ideal points. For the given information set of follower $i$, the first order condition of the total profit maximizing problem shows that $i$'s decision must satisfy

$$d_i^* = \frac{2k}{1+k}(\theta_i + b_i) + \frac{\delta}{1+k}E[d_{-j}].$$

A comparison of efficient decision with equilibrium decision reveals that each follower's local decision is made with excessively high weight on $\theta_i + b_i$ (i.e., $\frac{4k}{1+3k} \geq \frac{2k}{1+k}$) and low weight on $E[d_{-i}]$ (i.e., $\frac{\delta}{1+3k} \leq \frac{\delta}{1+k}$). We call this distortion excessive adaptation. Excessive adaptation does pay for $i$ because the future organizational decision moves toward $\theta_i + b_i$ by one half unit if he moves his decision toward $\theta_i + b_i$ by one unit. It also has to be noted that excessive adaptation can occur even when both followers have identical preferences ex post as long as messages are not publicly observable. The exact decision one follower makes is (almost) always different from the expected decision another follower considers.

After repeated substitution, we obtain

$$d_i^{NI} = \frac{4k}{1+3k}\theta_i + \frac{2k}{1+k}b_i,$$

and

$$E[\Pi^{NI}] = -\frac{2k\delta(1+7k)}{3(1+3k)^2}s^2 - \frac{2k\delta(1+3k)}{(1+k)^2}b^2.$$

[6] Communication is meaningful if messages are observable to the other follower. See Discussion section.

## 6 Performance comparison

In this section, we evaluate the value of the leader's initiative by comparing the performances between processes I and NI. Constraints on information transmission determine the value of the initiative. If the leader has access to adequate information, the leader's initiative is valuable. Taking the initiative, the leader enable the followers to become aligned to maximizing organizational performance, and the leader can achieve the highest performance if there is no asymmetric information. However, if information transmission is restricted, process NI can have an advantage over process I. While taking no initiative makes the followers' decisions distorted, the leader does not need to rely on restricted communication and the leader's decision is optimal in the ex-post sense.

### 6.1 Non-strategic communication case

To describe how constraints on information transmission affect relative performances, we first consider the non-strategic communication case. In this case, followers provide truthful messages but miscommunication occurs with probability $\lambda$ exogenously determined. If miscommunication occurs, the leader unconsciously receives a wrong message $\bar{r}_i$ which is drawn from the uniform distribution on $[-s, s]$ independent of the original message. We use "nsI" to index the no-strategic case and represent the organizational performance in this case as $\Pi^{nsI}$. Process NI is superior to nsI if and only if $\Pi^{NI} - \Pi^{nsI} \geq 0$, or equally,

$$\left[\frac{1-(1-\lambda)^2}{2} + \frac{\delta(9\delta-10)}{2(4-3\delta)^2}\right]\frac{s^2}{3} - \frac{\delta(1-\delta)}{(2-\delta)^2}b^2 \geq 0.$$

We obtain the following relationship from the above condition.

**Proposition 2.** *Suppose communication is not strategic and miscommunication occurs with $\lambda$. The organizational performance without the leader's initiative is larger (smaller) than the organizational performance with it if (i) $\lambda$ is large (small), (ii) $\delta$ is close to zero (one), and (iii) $b^2$ is small (large).*

The proof is in Appendix.

First, process NI is likely to dominate process nsI when $\lambda$ is large. If miscommunication never occurs (i.e., $\lambda = 0$), it is evident that process NI is dominated by process nsI because the leader can achieves the highest performance. However, if some noise can be contained (i.e., $\lambda > 0$), process NI may be superior due to the risk of miscommunication and to making a wrong organizational decision. It is remarkable that even when $\lambda = 1$, it can be the case that process NI may be dominated by process nsI if $\delta$ is sufficiently large. In process nsI, although the leader has no available information and then always sets $d = 0$ when $\lambda = 1$, her initiative relieves the followers' incentives for excessive adaptation. Second, process NI achieves higher performance than process nsI when $\delta$ is small. As $\delta$ become small, the loss from excessive adaptation (it implies worse coordination) in process NI becomes small. Third, large $b^2$ enhances the relative advantage of process nsI. As $b^2$ increases, the extent of the distortion in the followers' decisions becomes large. The marginal loss from miscommunication in process I is not so much as in process NI.

In figure 1, we demonstrate the threshold of $\delta$ with $\lambda = 1/3, 1/2, 1$[7]. In the left area of the threshold, the performance in process NI is higher than the one in process nsI, and vice versa in the right area. Moreover, the area in which NI dominates nsI shrinks as $b^2$ increases and $\lambda$ decreases.

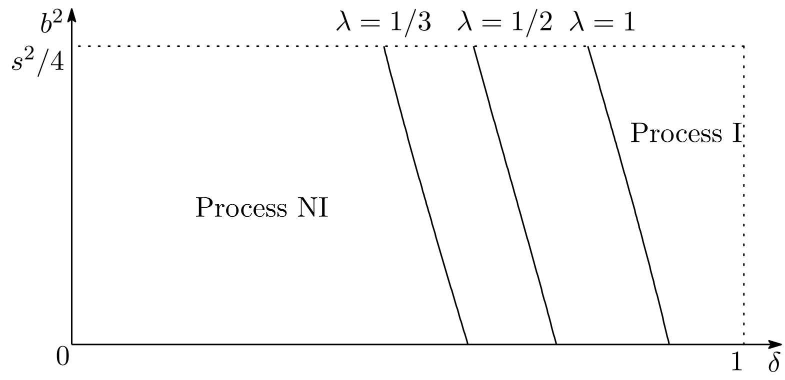


Figure 6: The thresholds when communication is non-strategic

## 6.2 Strategic communication case

Next, we make a comparison of performances under process NI with I in a strategic communication case. In this regard, we make the following proposition.

**Proposition 3.** *Suppose communication is strategic. The organizational performance without the leader's initiative is better (worse) than the performance with it if (i)* $\delta$ *is close to zero (one) and (ii)* $b^2$ *is large (small).*

Proof is in Appendix.

While the result and the intuition of the comparative statics with $\delta$ is the same as in the non-strategic case, we obtain a contrary result in the comparative statics with $b^2$. The relative

[7]Remark that process NI is dominated by process nsI for any $\delta$ and $b^2$ when $\lambda = 0$. This is because the leader archives the highest performance in process I if there exist no constraint on information transmission.

performance of process I over NI is decreasing in $b^2$. This is explained by an interaction between ex-ante conflict and the precision of communication. In the strategic case, the risk of miscommunication is endogenous, and the quality of communication becomes worse as $b^2$ increases. Then, the total marginal loss by increasing $b^2$ in the strategic case is larger than in the non-strategic case, and it is larger than the marginal caused by excessive adaptation.

In figure 2, the curve on the left side is the threshold in the strategic case. Contrary to the non-strategic case, the area in which NI dominates I expands as $b^2$ increases.

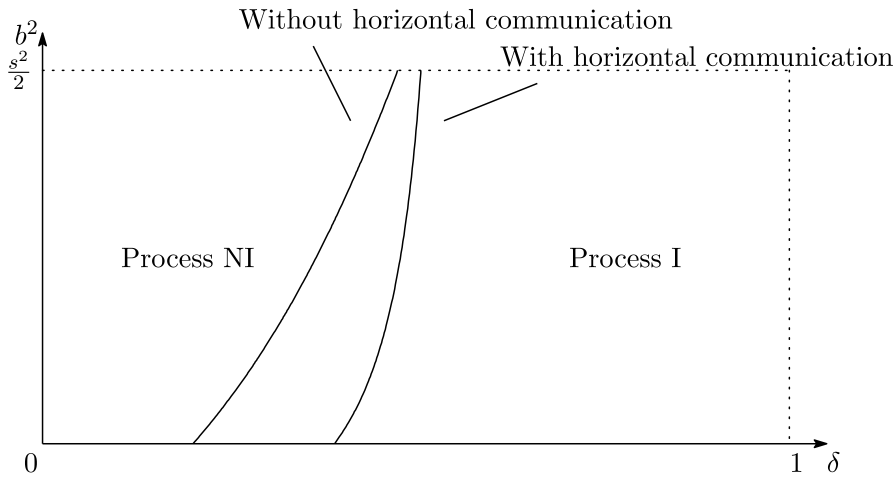


Figure 7: The thresholds when communication is strategic

# 7 Discussion; observability and timing of decision-making

## 7.1 Horizontal communication

In this subsection, we relax the assumption on unobservable messages and assume that followers' messages are publicly observable. We can interpret this scenario to imply that the followers can communicate horizontally, as Alonso, Dessein and Matouschek (2008) and Rantakari (2008) studied in the decentralization case. We index the new process as process NI-HC. While this relaxation does not affect the performance in process I, it makes communication valuable and can improve the performance in process NI because communication enable followers to deduce the others' decisions.

In this scenario, follower $i$'s problem in the third stage in process NI-HC is represented as follows;

$$\max_{d_i} E\left[-k(d_i-\theta_i-b_i)^2-\frac{\delta}{4}(d_i-d_{-i})^2|r_1,r_2\right].$$

From the first order condition, we obtain

$$d_i = \frac{4k}{1+3k}(\theta_j + b_i) + \frac{\delta}{1+3k}E[d_{-j}|r_1, r_2].$$

The follower's decision is dependent on the belief $(m_1, m_2)$ even when the leader does not take initiative. By repeated substitution, we obtain

$$d_i = \frac{4k}{1+3k}\theta_i + \frac{\delta^2}{2(1+k)(1+3k)}m_i + \frac{\delta}{2(1+k)}m_{-i} + \frac{2k}{1+k}b_i.$$

It is also evident that the incentives for excessive adaptation remain. The efficient decision policy for given $(r_1, r_2)$ is

$$d_i^* = \frac{2k}{1+k}(\theta_i + b_i) + \frac{\delta}{1+k}E[d_{-j}|r_1, r_2].$$

Then, the followers also have incentive for excessive adaptation even if messages are publicly observable.

As done in the previous section, we compare organizational performance between the two processes. Then, we obtain the following proposition.

**Proposition 4.** *Suppose messages are publicly observable. The organizational performance without the leader's initiative is better (worse) than the organizational performance with it if $\delta$ is close to zero (one).*

The proof is in Appendix. The threshold is depicted in Figure 2. If messages are publicly observable, the area where process NI is superior should expand. Although the intuition is almost the same as that in propositions 2 and 3, the result of comparative statics with $b$ should be slightly different. Because communication precision becomes worse in both process as $b$ increases, the relative organizational performance in process NI as compared to process I worsen as $b$ becomes large. Nevertheless, we can graphically check that the same property claimed in Proposition 3 is preserved.

### 7.2 Communication vs Observation

There exist two critical differences in between process I and NI. The first one is in the timing of the decision-making and the second one is in the manner how the leader obtain the knowledge of which organizational decision is efficient: through communication or observation. The aim of this subsection is to distinguish between two and study how the difference in the second aspect affects the results.

As long as the leader makes a commitment to not observe followers' decisions, communication is significant even if the leader makes a decision after the followers do. The leader's decision is given by

$$d = \frac{E[d_1|r_1, r_2] + E[d_2|r_1, r_2]}{2}.$$

Then the leader's decision policy is different from the one in processes NI and NI-HC. The leader forms beliefs regarding the decisions of the followers and makes an organizational decision relying on the belief.

The leader can eliminate the followers' incentive for excessive adaptation without relying on observation in her decision-making. The followers' decision is represented as

$$d_i = k(\theta_i + b_i) + \delta E[d|r_i].$$

Then, for the given information set of follower $i$, $i$'s decision also maximizes expected organizational performance. On the other hand, also as in process I, the demerit of not relying on observation is that the information the leader can access is limited due to intentional communication noise.

As done in the previous section, we compare the performance between two processes. We obtain the following proposition.

**Proposition 5.** *If the leader makes an organizational decision after the followers, commitment to not observing the followers' decisions improve (worsen) the organizational performance when $\delta$ is close to zero (one).*

The proof is in Appendix. The proposition implies that the positive side of the leader's initiative is associated with communication-based decision-making. The communication-based decision-making process eliminates the followers' self-interested incentives and realizes better coordination than the observation-based decision-making process.

# 8 Concluding remarks

We studied the value of a leader's initiative in the modified adaptation and coordination problem. The merit of the leader's initiative is aligning the followers' incentives to the interest of the organization. Once the leader makes an organizational decision, there is no room for the followers to manipulate the organizational decision in their own favor after that. Indeed, if transmitted information from the followers does not include any noise, the leader's decision is efficient and organizational performance is the best. However, constraints on information transmission reduce the value of the initiative. In particular, the loss from miscommunication becomes serious when the importance of coordination relative to adaptation is large. We showed that organizational performance without the leader's initiative is better than the performance with the leader's initiative when coordination is important. The result is robust even when we change the assumption on observability of messages. We also discuss that the superiority of the leader's initiative originates from the communication-based decision-making process, rather than the timing of decision-making, and we showed that even if the leader makes a decision after the followers, organizational performance can be improved by committing to not observe the followers' decisions.

Some extensions of this study remained to be explored. One important extension is considering the coordination needs between both followers' decisions. If we add that coordination term into the followers' objective function, the extended model is similar to the model studied in Brunnermeier, Bolton, and Veldkamp (2013), excepting the assumption on the local environment followers face.[8] While they study the role of leadership in the extended adaptation and coordination problem when direct communication from a follower to a leader or the other followers is impossible, our result provide a framework that allows us to study their model in a strategic or non-strategic communication case. We conjecture that our result is preserved, that is, the leader's commitment for not observing followers' decisions may improve organizational performance, because the followers potentially have incentives for excessive adaptation as long as the leader observes their decisions.

Introducing biases into the followers' compensation contract is also an important extension. As one follower also takes care of an other follower's profit, not only his own profit, the performance in both decision-making processes would improve. Indeed, it is almost certain that the quality of communication would improve when the leader takes an initiative and the follower's incentive for excessive adaptation becomes mild when the leader does not take an initiative. However, it is not clear whether the relative superiority of the leader's initiative becomes strong or weak as the bias changes.

[8] While local environments are different and independent in our model, it is common in their model.

# Appendix

## Derivation of communication strategy

For the later proofs, we derive the equilibrium communication strategy by a general form. Since follower $i$'s decision can be represented as linear combination of $(\theta_i, m_i, m_{-i}, b_i)$, we can represent follower i's interim expected profit $E[\pi_i|\theta_i, r_i]$ as $E[\pi_i|\theta_i, r_i] = A_i m_i^2 + B_i m_i \theta_i + C_i m_i b_i + F_i$ where $F_i$ is terms independent of $m_i$ (also note that $E[m_{-i}|r_i] = E[\theta_{-i}] = 0$). Then, we can rewrite (1) as follows;

$$\begin{aligned}
&A_i(m_{ij+1}^2 - m_{ij}^2) + B_i(m_{ij+1} - m_{ij})\theta_i + C_i(m_{ij+1} - m_{ij})b_i = 0 \\
&\rightarrow 2(m_{ij+1} + m_{ij}) = -\frac{2B}{A}\theta_i - \frac{2C}{A}b_i.
\end{aligned}$$

Substituting $m_{ij} = \frac{a_{ij+1}+a_{ij}}{2}$ and $\theta_i = a_{ij}$ yields that

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} - \left(\frac{2B_i}{A_i} + 4\right) a_{ij} - \frac{2C_i}{A_i} b_i. \tag{4}$$

For given $N_i$, together with the boundary conditions $a_{i0} = -s$ and $a_{iN_i} = s$, (4) yields a following explicit form of equilibrium cutoffs as follows;

$$a_{ij} = \frac{x_i^j - y_i^j}{x_i^{N_i} - y_i^{N_i}}(s - q(b_i)) + \frac{x_i^{N_i-j} - y_i^{N_i-j}}{x_i^{N_i} - y_i^{N_i}}(-s - q(b_i)) + q(b_i), \tag{5}$$

where

$$\begin{aligned}
x_i &= -1 - \frac{B_i}{A_i} + \sqrt{\left(1 + \frac{B_i}{A_i}\right)^2 - 1} && (6) \\
y_i &= -1 - \frac{B_i}{A_i} - \sqrt{\left(1 + \frac{B_i}{A_i}\right)^2 - 1} && (7) \\
q(b_i) &= -\frac{C_i}{2A_i + B_I} b_i. && (8)
\end{aligned}$$

### Derivation of $E[m_i^2]$

After some lengthy calculation, we obtain

$$\begin{aligned} E[m_i^2] &= \sum_{j=0}^{N_i-1} \int_{a_{ij}}^{a_{ij+1}} \left( \frac{a_{ij+1}+a_{ij}}{2} \right)^2 \frac{1}{2s} d\theta_i \\ &= \frac{1}{8s} \sum_{j=0}^{N_i-1} \left( a_{ij+1}^3 + a_{ij+1}^2 a_{ij} - a_{ij+1} a_{ij}^2 - a_{ij}^3 \right) \\ &= \frac{1}{4} \frac{x_i^2+2x_i+1}{x_i^2+x_i+1} s^2 - \frac{1}{4} \frac{x_i^2-2x_i+1}{x_i^2+x_i+1} q(b_i)^2 \\ &\quad -\frac{1}{4} \frac{(x_i^2-1)^2 (x_i^{N_i}(x_i^{N_i}-1)^2 (s^2-q(b_i)^2) + 4x_i^{2N_i} s^2)}{x_i(x_i^2+x_i+1)(x_i^{N_i}+1)^2(x_i^{N_i}-1)^2} \end{aligned} \tag{9}$$

As $N_i$ goes to infinity, it converges to

$$\lim_{N_i \to \infty} E[m_i^2] = \frac{1}{4} \frac{x_i^2+2x_i+1}{x_i^2+x_i+1} s^2 - \frac{1}{4} \frac{x_i^2-2x_i+1}{x_i^2+x_i+1} q(b_i)^2. \tag{10}$$

### Proof of Lemma 1

We show that $\{a_{ij}\}_{j=0,1,\ldots N_i}$ satisfy the boundary constraint (that is, $a_{i0} = -s$ and $a_{iN_i} = s$) and the order constraint (that is, $a_{ij}$ is strictly increasing in $j$) for any $N_i$ if $-s \le q(b_i) \le s$. It is straight forward to check that $\{a_{ij}\}_{j=0,1,\ldots N_i}$ satisfy the boundary constraints for any $N_i$.

We can show that $\{a_{ij}\}_{j=0,1,\ldots N_i}$ satisfy the order constraints as follows. Since $x_i > 1$ and $0 < y_i < 1$, the coefficient of the first term in (5) is increasing in $j$ and the coefficient of the second term in (5) is decreasing in $j$. For any $N_i$, the first term of (5) is not decreasing in $j$ if $s \ge q(b_i)$ and strictly increasing in $j$ if $s > q(b_i)$. For any $N_i$, the second term of (5) is not decreasing in $j$ if $-s \le q(b_i)$ and strictly increasing in $j$ if $-s < q(b_i)$. Thus, if $-s \le q(b_i) \le s$, $a_{ij}$ is strictly increasing in $j$. □

### Proof of Lemma 2

The third term of (9) is strictly positive and decreasing in $N_i$ if Assumption 1 holds and $x_i > 1$. □

### Proof of Proposition 2

We first derive the performance under I in non-strategic communication case. Because the leader's decision is given by

$$d = (1-\lambda)\frac{r_1+r_2}{2},$$

follower $i$'s expected profit is given by

$$\begin{aligned}
E[\pi_i^{nsI}] &= -(1-\lambda)E\left[k\delta\left((1-\lambda)\frac{\theta_i+\theta_{-i}}{2}-\theta_i-b_i\right)^2\right]-\lambda E\left[k\delta\left((1-\lambda)\frac{\tilde{\theta}_i+\theta_{-i}}{2}-\theta_i-b_i\right)^2\right] \\
&= -(1-\lambda)k\delta\left(\frac{(1+\lambda)^2+(1-\lambda)^2}{4}\frac{s^2}{3}+b^2\right)-\lambda k\delta\left(\left(\frac{(1-\lambda)^2}{2}+1\right)\frac{s^2}{3}+b^2\right)^2 \\
&= -k\delta\left[\left(\frac{(1+\lambda)^2}{2}-\lambda^2\right)\frac{s^2}{3}+b^2\right]
\end{aligned}$$

where $\tilde{\theta}_i$ is independent of $\theta_i$ and uniformly distributed on $[-s,s]$. Then,

$$E[\Pi^{nsI}] = -k\delta\left(\left(\frac{(1+\lambda)^2}{2}-\lambda^2\right)\frac{2s^2}{3}+2b^2\right).$$

Then, NI is superior to nsI if and only if $\Pi^{NI}-\Pi^{nsI}\geq 0$, or equally,

$$\left[\frac{1-(1-\lambda)^2}{2}+\frac{\delta(9\delta-10)}{2(4-3\delta)^2}\right]\frac{2s^2}{3}-2\frac{\delta(1-\delta)}{(2-\delta)^2}b^2\geq 0.$$

The proposition follows from the above condition. □

## Proof of Proposition 3

We first derive the performance in process I in strategic communication case. Follower $i$'s expected profit is given by

$$\begin{aligned}
E[\pi_i^I] &= -E\left[k\delta\left(\frac{m_i+m_{-i}}{2}-\theta_i-b_i\right)^2\right] \\
&= -\left[\frac{s^2}{3}+b^2-\frac{3}{4}E[m_i^2]+\frac{1}{4}E[m_{-i}^2]\right].
\end{aligned}$$

Here we use the fact $E[\theta_i m_i] = E[E[\theta_i m_i|r_i]] = E[m_i^2]$ and $E[m_i] = E[m_{-i}] = 0$. Follower i's interim expected profit is given by

$$E[\pi_i^I|r_i,\theta_i] = -k\delta\left(\theta_i^2+b^2-\frac{1}{4}m_i^2-m_i\theta_i-m_i b\right)+G_i,$$

where $G_i$ is terms independent of $m_i$. Then, substituting $A_i = 1/4$, $B_i = C_i = -1$ into (10), we obtain that

$$\lim_{N_i\to\infty} E[m_i^2] = \frac{2}{7}s^2-\frac{4}{7}b^2.$$

Process NI is superior to process I if and only if $\Pi^{NI}-\Pi^I\geq 0$, or equally,

$$\frac{36\delta^2-47\delta+8}{3(4-3\delta)^2}s^2+\frac{9\delta^2-15\delta+8}{(2-\delta)^2}b^2\geq 0.$$

The proposition follows from the above condition. □

## Proof of Proposition 4

We first derive the performance in process NI when messages are publicly observable. From the first order condition of the follower $i$'s problem and repeated substitution, we obtain

$$d_i^{NI-HC} = \frac{4k}{1+3k}\theta_i + \frac{\delta^2}{2(1+k)(1+3k)}m_i + \frac{\delta}{2(1+k)}m_{-i} + \frac{2k}{1+k}b_i.$$

After some arrangement, we obtain the organizational performance as follows;

$$E[\Pi^{NI-HC}] = \frac{2k\delta(1+7k)}{3(1+3k)^2}s^2 + \frac{2k\delta(1+3k)}{(1+k)^2}b^2 - \frac{k\delta^2(13k^2+10k+1)}{2(1+k)^2(1+3k)^2}(E[m_1^2] + E[m_2^2]).$$

Follower i's interim expected profit is given by

$$E[\pi_i^{NI-HC}|r_i,\theta_i] = -\frac{k\delta^3}{4(1+k)^2(1+3k)}m_i^2 + \frac{k\delta^2}{(1+k)(1+3k)}m_i\theta_i + \frac{k\delta^2}{(1+k)^2}m_i b_i + H_i$$

where $H_i$ is terms independent of $m_i$. Then, substituting $A_i = \frac{k\delta^3}{4(1+k)^2(1+3k)}$, $B_i = -\frac{k\delta^2}{(1+k)(1+3k)}$ $C_i = -\frac{k\delta^2}{(1+k)^2}$ into (10), we obtain that

$$\lim_{N_i\to\infty} E[m_i^2] = \frac{2(1+k)}{7+9k}s^2 - \frac{4(1+3k)}{7+9k}b^2.$$

The equilibrium cutoffs are represented by the following equation.

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} + 4\frac{1+3k}{1-k}a_{ij} + 8\frac{1+3k}{1-k}b_i,$$

Finally, we compare the performance of process NI-HC and process I. $E[\Pi^{NI-HC}] - E[\Pi^I] \geq 0$ if and only if

$$\frac{2(54\delta^2 - 103\delta + 32)}{3}s^2 - \frac{243\delta^3 - 1100\delta + 1456\delta - 512}{2-\delta}b^2 \geq 0.$$

The proposition follows from the above condition. □

## Proof of Proposition 5

We first derive the equilibrium decision in process NI'. Note that $E[d] = \frac{E[d_1]+E[d_2]}{2}$ and $E[d_i] = kb_i + \delta E[d]$. Then, repeated substitution yields that $E[d] = 0$ and $E[d_i] = kb_i$. By the low of iterated expectation, for $i = 1, 2$ we obtain

$$\begin{aligned} E[d|r_i] &= \frac{E[d_1|r_i] + E[d_2|r_i]}{2} \\ &= \frac{E[d_i|r_i] + kb_{-i}}{2}. \end{aligned} \tag{11}$$

Because

$$E[d_i|r_i] = k(m_i + b_i) + \delta E[d|r_i], \tag{12}$$

repeated substitution yields that

$$E[d_i|r_i] = \frac{2k}{1+k} m_i + k b_i.$$

Then, we obtain

$$d_i^{NI'} = k(\theta_i + b_i) + \frac{k\delta}{1+k} m_i.$$

After some arrangement, we obtain the organizational performance as follows;

$$E[\Pi^{NI'}] = -2k\delta \left( \frac{s^2}{3} + b^2 \right) + \frac{k^2\delta}{1+k} (E[m_1^2] + E[m_2^2]).$$

Next, we derive the communication strategy. Follower $i$'s interim expected profit is given by

$$E[\pi_i^{NI'}|r_i, \theta_i] = -\frac{k^3\delta}{(1+k)^2} m_i^2 + \frac{2k^2\delta}{(1+k)} m_i \theta_i + \frac{2k^2\delta}{(1+k)} m_i b_i + I_i$$

where $I_i$ is terms independent of $m_i$. Then, substituting $A_i = \frac{k^3\delta}{(1+k)^2}$, $B_i = -\frac{2k^2\delta}{(1+k)}$, and $C_i = -\frac{2k^2\delta}{(1+k)}$ into (10), we obtain that

$$\lim_{N_i \to \infty} E[m_i^2] = \frac{1+k}{3k+4} s^2 - \frac{(1+k)^2}{3k+4} b^2.$$

The equilibrium cutoffs are represented by the following equation.

$$a_{ij+1} - a_{ij} = a_{ij} - a_{ij-1} + 4\frac{1}{k} a_{ij} + 4\frac{1+k}{k} b_i,$$

Finally, we compare the performance of NI and NI'. $E[\Pi^{NI}] - E[\Pi^{NI'}] \geq 0$ if and only if

$$\frac{8 - 15\delta}{3(4-3\delta)^2} s^2 - \frac{\delta^3 - 9\delta^2 + 19\delta - 8}{(2-\delta)^2} b^2 \geq 0.$$

The proposition follows from the above condition. □

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# Chapter 4.

# Task Assignment under Agent Loss Aversion [1]

## 1 Introduction

Assigning a task to an appropriate employee is a major determinant of firm performance. Such a task assignment can be even more important when the task requires a different skill depending on the situation. According to contract theory, in the absence of asymmetric-information problem, a principal (she) offers a contingent contract where she assigns a task to an agent (he) whose productivity is the highest in each situation. In working environments, however, a task is often assigned to a single agent regardless of the situation even if such a contingent contract is available.

We investigate this issue by incorporating a prominent behavioral aspect, *loss aversion*: people are more sensitive to losses than to same-sized gains. In our model, the principal assigns a task to one of two agents in each state. Each agent's productivity level varies across states, whereas his effort-cost function is the same across states. The principal writes a contract that specifies the wages of the agents, which agent works on the task, and his effort level depending on the state. The agents are expectation-based loss averse à la Kőszegi and Rabin (2006, 2007): the utility of each agent depends not only on intrinsic material payoffs but also on psychological gain-loss payoffs from comparing his realized outcome with his expected outcomes.

If agents are not loss averse, then in each state the principal always assigns the task to the agent with the highest productivity. In contrast, if agents are loss averse, then the principal may assign the task to a single agent in all states based on the trade-off between improving productivity and alleviating expected losses. On one hand, such a contract is less efficient in terms of productivity because a less productive agent works in some state. On the other hand, it reduces the principal's wage payment by alleviating the expected losses of the agent. If the latter effect outweighs the former, assigning the task to a single agent in all states becomes optimal. In addition, when the degree of loss aversion is large, the optimal contract specifies the same effort levels in all states. This result is in sharp contrast with the standard concave-utility case where the principal specifies state-specific effort levels as long as the productivities of the agents are different.[2]

[1] This chapter is joint work with Kohei Daido, Kimiyuki Morita, and Takeshi Murooka, and published in *Economics Letters* 121.1 (2013): 35-38. (DOI link: http://dx.doi.org/10.1016/j.econlet.2013.06.040)

[2] As related literature, Heidhues and Kőszegi (2005, 2008) and Herweg and Mierendorff (2013) analyze the opti-

The rest of the paper is organized as follows. Section 2 sets up the model. Section 3 analyzes the model. Section 4 concludes.

# 2 The Model

## 2.1 Setup

Suppose one risk- and loss-neutral principal assigns a task to one of two agents. All of them are uncertain about the future state at the contracting stage. There are two states, $s = 1, 2$, and one of the states is realized after contracting. State 1 (resp. state 2) is realized with probability $q \in (0, 1)$ (resp. $1 - q$). The value of the task depends on the state, and the principal can write a contract *contingent on the state*. Agent $i = A, B$ works on the task if and only if the principal assigns the task to him, and only one agent can work on the task in each state. The agent in charge of the task exerts effort $e \in \mathbb{R}_+$ with effort cost $c(e) = e^2/2$. If agent $A$ (resp. agent $B$) is assigned to the task in state $s \in \{1, 2\}$ and exerts effort $e_s^A$ (resp. $e_s^B$), the principal earns $\alpha_s e_s^A$ (resp. $\beta_s e_s^B$) from the task. Assume that $\alpha_1 > \beta_1$, and $\alpha_2 < \beta_2$: the productivity of agent $A$ is higher (resp. lower) than that of agent $B$ in state 1 (resp. state 2). For brevity, we further assume that $\beta_1 = \beta_2 = 1$ and $q\alpha_1 + (1 - q)\alpha_2 > 1$: agent $B$'s productivity is constant across states and the average productivity of agent $A$ is higher than that of agent $B$.[3]

Since our focus is not on moral hazard issues, we consider a case in which *the effort level is contractible in each state*.[4] The principal offers a contract that specifies a wage scheme to each agent depending on the state $w = (w_1^A, w_2^A, w_1^B, w_2^B)$, the effort level in each state $e = (e_1, e_2)$, and which agent works on the task contingent on the state.[5] The states in which agent $A$ works on the task are denoted by $D \in \mathbb{D} \equiv \{\varnothing, \{1\}, \{2\}, \{1, 2\}\}$. For example, $D = \{1\}$ means agent $A$ works in state 1 but agent $B$ works in state 2. The contract is denoted by $C(w, e; D) \in \mathbb{R}^4 \times \mathbb{R}_+^2 \times \mathbb{D}$. Each agent accepts the contract if his expected utility is larger than or equal to his reservation utility, which is assumed to be zero. We call a task assignment is *state-independent* if the principal assigns the task to a single agent in both states; otherwise it is *state-dependent*. The timing is as follows:

1. The principal offers a contract to agents.

mality of state-independent pricing under consumer loss aversion.

[3] Our main results hold without imposing these specifications. See Daido et al. (2013) for general analysis.

[4] See, for example, Gill and Stone (2010) and Herweg et al. (2010) for analysis on moral-hazard problems under agent loss aversion.

[5] Note that in each state an agent who is not in charge of the task exerts zero effort.

2. Each agent chooses whether to accept the contract.
3. The state is realized.
4. The task assignment, the effort provision, and the payment are carried out according to the contract.

## 2.2 Reference-Dependent Preferences

A key assumption of our model is that each agent's overall utility comprises intrinsic consumption payoffs and psychological gain-loss payoffs. We assume that each agent has expectation-based reference-dependent preferences à la Kőszegi and Rabin (2006, 2007). In our model, the agents have two consumption dimensions: wage and effort. For each consumption dimension, they feel a psychological gain or loss by comparing a realized outcome with a reference outcome. For deterministic reference points, we denote each agent's reference point for his wage and effort cost by $\hat{w}$ and $\hat{e}$, respectively. If his actual wage and effort are $w$ and $e$, then his overall utility is given by:

$$w - c(e) + \mu(w - \hat{w}) + \mu(-c(e) + c(\hat{e})),$$

where $\mu(\cdot)$ is a gain-loss function that corresponds to Kahneman and Tversky's (1979) value function. We assume that $\mu(\cdot)$ is piecewise linear to focus on the effect of loss aversion. Then, we can simply define the gain-loss function when consumption is $x$ and the reference point is $r$ as

$$\mu(x-r) = \begin{cases} x - r & \text{if } x - r \geq 0, \\ \lambda(x-r) & \text{if } x - r < 0. \end{cases}$$

where $\lambda \geq 1$ represents the degree of loss aversion.[6] The agent is loss-neutral when $\lambda = 1$.

Following Kőszegi and Rabin (2006, 2007), we assume that the reference point is determined by rational beliefs on outcomes and that the reference point itself is stochastic if the outcome is stochastic. Each agent feels a gain-loss by comparing every possible outcome with every reference point. For example, suppose that the principal assigns the task to agent $i$ in $s = 1$ but not in $s = 2$ with paying a constant wage $w^i$. Then, agent $i$ expects to incur effort cost $c(e_1)$ with probability $q$ and not to incur it with probability $1 - q$. If $s = 1$ is realized, then agent $i$ incurs $c(e_1)$ and hence he feels no gain-loss with probability $q$ and feels a loss by $c(e_1)$ with probability $1 - q$. If $s = 2$ is realized, then agent $i$ does not incur the effort cost and hence he feels a gain by $c(e_1)$ with

[6] We set the weight of the gain-loss payoffs in Kőszegi and Rabin (2006, 2007), $\eta$, is equal to one. Under the solution concept of this paper, $\eta$ can be normalized to one without loss of generality.

probability $q$ and feels no gain-loss with probability $1 - q$. Ex-ante the agent correctly anticipates all the above cases, and his expected gain-loss utility in the effort dimension is $-q(1-q)(\lambda-1)c(e_1)$. The expected gain-loss utility in the wage dimension is zero because the agent anticipates $w^i$ and actually receives it.

We derive the optimal contract based on the *choice-acclimating personal equilibrium* (CPE) defined by Kőszegi and Rabin (2007). Intuitively, each agent knows that his beliefs will be adapted to his accepted contract before he actually chooses his action, and hence he takes this change into account when accepting a contract. Formally, given $C(w, e; D)$ let $\mathbf{1}^i_s$ be the indicator function that takes a value of one if agent $i$ incurs an effort cost in state $s$ and takes zero otherwise. Because agent $i$'s accepted contract itself determines his reference points, the condition for accepting a contract $C(w, e; D)$ under CPE is represented by $U^i(w, e; D|w, e; D) \geq 0$, or equivalently,

$$\underbrace{qw^i_1 + (1-q)w^i_2 - \mathbf{1}^i_1 qc(e_1) - \mathbf{1}^i_2(1-q)c(e_2)}_{\text{intrinsic utility}} - \underbrace{q(1-q)(\lambda-1)\left(|w^i_1 - w^i_2| + |\mathbf{1}^i_1 c(e_1) - \mathbf{1}^i_2 c(e_2)|\right)}_{\text{gain-loss utility}} \geq 0. \tag{CPE-IR}$$

Condition (CPE-IR) means that the agent's utility when he expected to accept the contract and actually does so is no less than when he expected to decline the contract and actually does so.

# 3 Analysis

## 3.1 The Optimal Contract under Concave Utility

First, as a benchmark we study a case in which agents have concave utility and are not loss averse. Suppose the agents have concave utility for wages which is separable from the effort cost, $u(w)-c(e)$. Let $u(\cdot)$ be strictly increasing, concave, and $u(0) = 0$. Note that in the optimal contract Condition (CPE-IR) holds with equality. The principal offers a constant wage to each agent due to the concavity of $u(\cdot)$. Because the principal's maximization problem is state-separable, she assigns the task to the agent with the highest productivity in each state. These considerations lead to the following result:

**Result 1.** *Suppose agents have concave utility and are loss-neutral. Then, the state-dependent contract* $C(\bar{w}, \bar{e}; \{1\})$ *where* $\bar{w}^A_1 = \bar{w}^A_2 = u^{-1}(qc(\bar{e}_1))$, $\bar{w}^B_1 = \bar{w}^B_2 = u^{-1}((1-q)c(\bar{e}_2))$, $\bar{e}_1 = \operatorname{argmax}_{e_1} q\alpha_1 e_1 - u^{-1}(qc(e_1))$, *and* $\bar{e}_2 = \operatorname{argmax}_{e_2}(1-q)e_2 - u^{-1}((1-q)c(e_2))$ *is optimal.*

Because an agent who works on the task is determined to maximize the social surplus in each state, state-independent contracts are never optimal when agents are not loss averse.[7] Further, the effort levels specified in the optimal contract vary across states because the agents' productivity levels depend on the state; even if agent $A$ were to work on the task in both states, the principal would still specify state-specific effort levels.

### 3.2 The Optimal Contract under Loss Aversion

Next, we examine the case where agents are loss averse. Since the agents are loss averse to wage uncertainty, we can show that each agent obtains a constant wage across states in the optimal contract. We denote the constant wage by $w_s^i = w^i$. In addition, given our setting it is straightforward to show that contracts with $D = \{\varnothing\}$ and $D = \{2\}$ are strictly dominated under any parameters. Hence, we restrict the attention to contracts with $D = \{1\}$ and $D = \{1, 2\}$.[8]

Given a task-assignment scheme $D$, the expected utility of agent $A$ if he accepts contract $C(w, e; D)$ becomes

$$U^A(w, e; \{1\}|w, e; \{1\}) = w^A - q\frac{e_1^2}{2} - q(1-q)(\lambda - 1)\frac{e_1^2}{2},$$

$$U^A(w, e; \{1, 2\}|w, e; \{1, 2\}) = w^A - q\frac{e_1^2}{2} - (1-q)\frac{e_2^2}{2} - q(1-q)(\lambda - 1)\frac{|e_1^2 - e_2^2|}{2}.$$

The expected utility of agent $B$ can be described in the same manner. Note that Condition (CPE-IR) holds with equality in the optimal contract. We denote the optimal wage by $w^*(D)$ with abbreviating the notations to $w^*(\{1\}) = w_1^*$ and $w^*(\{1, 2\}) = w_{12}^*$. By substituting each optimal wage, the principal's payoff function in each task-assignment scheme is represented by

$$\pi(w_1^*, e; \{1\}) = q\alpha_1 e_1 + (1-q)e_2 - q\frac{e_1^2}{2} - (1-q)\frac{e_2^2}{2} - q(1-q)(\lambda - 1)\frac{e_1^2}{2} - q(1-q)(\lambda - 1)\frac{e_2^2}{2},$$

$$\pi(w_{12}^*, e; \{1, 2\}) = q\alpha_1 e_1 + (1-q)\alpha_2 e_2 - q\frac{e_1^2}{2} - (1-q)\frac{e_2^2}{2} - q(1-q)(\lambda - 1)\frac{|e_1^2 - e_2^2|}{2}.$$

By solving the principal's problem in each case, we derive the optimal effort levels:

**Lemma 1.** *Suppose agents are loss averse. Let* $\bar{\lambda} = \frac{\alpha_1 + q(\alpha_1 - \alpha_2)}{\alpha_2 + q(\alpha_1 - \alpha_2)}$.

*(i) Given* $D = \{1, 2\}$, *if* $\lambda < \bar{\lambda}$ *the optimal effort levels are* $\alpha_2 < e_2^*(w_{12}^*) < e_1^*(w_{12}^*) < \alpha_1$ *where* $e_1^*(w_{12}^*) = \frac{\alpha_1}{1 + (1-q)(\lambda - 1)}$ *and* $e_2^*(w_{12}^*) = \frac{\alpha_2}{1 - q(\lambda - 1)}$*; if* $\lambda \geq \bar{\lambda}$ *the optimal effort levels are* $e_1^*(w_{12}^*) = e_2^*(w_{12}^*) = q\alpha_1 + (1-q)\alpha_2$.

[7] Note that a state-dependent task assignment, $D = \{1\}$, is optimal even when agents have concave consumption utility with a unitary consumption dimension, $u(w - c(e))$. In this case, however, the optimal wages are not constant across states; each agent obtains a positive wage if and only if he actually works on the task.

[8] See Daido et al. (2013) for a detailed derivation.

*(ii) Given $D = \{1\}$, the optimal effort levels are $e_1^*(w_1^*) = \frac{\alpha_1}{1+(1-q)(\lambda-1)} < \alpha_1$ and $e_2^*(w_1^*) = \frac{1}{1+q(\lambda-1)} < 1$.*

*Proof.* (i) It is straightforward to show that $e_1(w_{12}^*) < e_2(w_{12}^*)$ is never optimal. Suppose $e_1(w_{12}^*) \geq e_2(w_{12}^*)$. If $\lambda \geq 1 + \frac{1}{q}$, then the principal's payoff is increasing in $e_2$; hence $e_1^*(w_{12}^*) = e_2^*(w_{12}^*) = q\alpha_1 + (1-q)\alpha_2$. If $\lambda < 1 + \frac{1}{q}$, the first-order condition yields $e_1(w_{12}^*) = \frac{\alpha_1}{1+(1-q)(\lambda-1)}$ and $e_2(w_{12}^*) = \frac{\alpha_2}{1-q(\lambda-1)}$. Note that $\frac{\alpha_1}{1+(1-q)(\lambda-1)} > \frac{\alpha_2}{1-q(\lambda-1)}$ if and only if $\lambda < \bar{\lambda}$. Because $1 + \frac{1}{q} - \bar{\lambda} > 0$, the principal specifies the same effort levels if and only if $\lambda \geq \bar{\lambda}$. (ii) The optimal effort levels are derived from the first-order conditions of the principal's payoff. $\square$

Lemma 1 (i) shows that if the principal assigns the task to agent $A$ in both states, then the difference between state-specific effort levels reduces as the degree of loss aversion increases. Note that optimal effort levels are given by $e_1 = \alpha_1$ and $e_1 = \alpha_2$ if agents are loss neutral; $e_1^*(w_{12}^*)$ moves downward from $\alpha_1$ and $e_2^*(w_{12}^*)$ moves upward from $\alpha_2$ as $\lambda$ increases. Further, if $\lambda$ is larger than or equal to $\bar{\lambda}$, then $e_1^*(w_{12}^*)$ coincides with $e_2^*(w_{12}^*)$ at $q\alpha_1 + (1-q)\alpha_2$ and hence the agent does not incur any effort-cost uncertainty. Intuitively, because each agent dislikes the effort-cost uncertainty at the first order due to loss aversion, the principal needs to compensate for the expected losses to make the agent accept the contract. This never happens in the concave-utility case where the principal specifies different effort levels whenever productivity levels are different. If $\lambda$ is large, the benefit of alleviating expected losses by specifying the same effort levels exceeds that of improving productivity by specifying different effort levels. Lemma 1 (ii) states that if the principal chooses a state-dependent task-assignment scheme, then the effort levels are lower than those in the loss-neutral case. In this scheme, each agent works in one state but not in the other state. This uncertainty of the task assignment generates expected losses in the effort-cost dimension for which the principal must compensate. Therefore, the principal has an incentive to reduce the amount of effort in state 1 in order to decrease expected losses.

We next analyze the optimal contract for loss-averse agents. By substituting the optimal effort levels into the principal's profit function, we have

$$\pi(w_{12}^*, e^*; \{1,2\}) = \begin{cases} q\frac{\alpha_1^2}{2[1+(1-q)(\lambda-1)]} + (1-q)\frac{\alpha_2^2}{2[1-q(\lambda-1)]} & \text{if } \lambda < \bar{\lambda}, \\ \frac{[q\alpha_1+(1-q)\alpha_2]^2}{2} & \text{if } \lambda \geq \bar{\lambda}, \end{cases}$$

$$\pi(w_1^*, e^*; \{1\}) = q\frac{\alpha_1^2}{2[1+(1-q)(\lambda-1)]} + (1-q)\frac{1}{2[1+q(\lambda-1)]}.$$

Comparing these profits, we obtain our main proposition:

**Proposition 1.** *Suppose agents are loss averse.*

*(i) If $\lambda < \bar{\lambda}$, then the contract with the state-independent task assignment $C(w_{12}^*, e^*; \{1, 2\})$ is optimal if and only if $\frac{\alpha_2^2}{1-q(\lambda-1)} \geq \frac{1}{1+q(\lambda-1)}$. Otherwise, the state-dependent contract $C(w_1^*, e^*; \{1\})$ is optimal.*

*(ii) If $\lambda \geq \bar{\lambda}$, then the state-independent contract $C(w_{12}^*, e^*; \{1, 2\})$ is optimal if and only if $[q\alpha_1 + (1 - q)\alpha_2]^2 \geq q\frac{\alpha_1^2}{1+(1-q)(\lambda-1)} + (1 - q)\frac{1}{1+q(\lambda-1)}$. Otherwise, the state-dependent contract $C(w_1^*, e^*; \{1\})$ is optimal.*

In contrast to Result 1, a state-independent task assignment can be optimal: the principal may assign the task to a single agent in all states. Intuitively, under agent loss aversion the trade-off between improving productivity and alleviating expected losses arises, and therefore the state-independent assignment is optimal if the latter effect outweighs the former. In addition, as described in Lemma 1, when the degree of loss aversion is large, the optimal contract becomes state-independent in the sense that it specifies the same effort levels across states.[9] As a comparative statics result, the state-independent contract is more likely to be adopted as $\lambda$ increases because such a contract alleviates the agents' expected losses.

Note that the result of state-independent task assignments (i.e., always employing the same agent) is derived from two assumptions: that each agent has expectation-based loss aversion and that each agent's effort cost is strictly increasing in each state. On the other hand, the result of state-independent contracts (i.e., specifying the same effort level across states) relies on these two assumptions and an additional assumption that each agent's effort-cost function is state-independent. The principal may not specify the same effort level across states if the effort cost depends on the state. Even in this case, however, the principal would assign the task to a single agent in both states.

# 4 Concluding Remarks

We investigate a task-assignment problem under agent loss aversion and uncertain future states. We show that state-independent task assignments become optimal when the positive effect of alleviating expected losses outweighs the negative effect of reducing productivity. We also find that

[9]Note that our result is qualitatively different from that led by cost complementarity for assignments. Although cost complementarity could explain why the principal assigns a task to a single agent across states, we predict that the principal specifies the same effort levels across states when a single agent works on the task but not when different agents do.

the optimal state-independent contract specifies the same effort levels across states when the degree of loss aversion is large and the agents' effort-cost function is state-independent. This may help explain, for example, why fixed working-hour contracts are so popular even when employers can adjust the working hours of their employees contingent on situations. Our results could be also applicable to relevant issues on labor contracts, such as task specialization versus multitasking, uneven workload, work sharing, and over-time premium.

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