# Information Acquisition, Decision Making, and Implementation in Organizations*

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We study a decision process of a two-agent organization that consists of a decision-maker who selects a project and an implementer who implements and executes the selected project. Each of the decision-maker and the implementer has intrinsic and possibly divergent preferences over projects. Key features of the model are that (i) there is the separation of decision and implementation, and the implementer may choose to execute no project if the cost of implementation is high; and (ii) the implementer engages in both acquiring additional information and implementing the project. We show that the implementer's incentives to gather information and to implement the selected project interact with each other in a non-trivial way. We in particular show how this interaction affects the optimality of diversity of preferences in organizations as well as the implementer's strategic communication.

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# 1 Introduction

It is now well known that at the time of making movie *The Godfather*, director Francis Ford Coppola and Paramount Pictures had a lot of disagreements, particularly about casting choices. Although Coppola thought Marlon Brando was the right actor for Don Vito Corleone,[1] Coppola was told by the Paramount president who had the decision right, "As long as I'm president of Paramount, Marlon Brando will not be in the picture." Despite this refusal, Coppola continued to persuade the president and the executives, and finally succeeded in turning around their opinions by performing screen test and listing reasons why Brando was necessary for *The Godfather*.

The executives of Paramount also disagreed with Coppola about the casting of Michael Corleone. While the studio wanted to cast a young blond star as Michael, Coppola wanted the image of an Italian-American found in then unknown Al Pacino.[2] Although Coppola tried to persuade the vice president in charge of the production of the movie, he did not accept Coppola's opinion. Furthermore, the producer of the movie got upset about Coppola's taking a lot of test films of Al Pacino. However, these test films helped the studio to alter the opinion.[3] While *The Godfather* without Marlon Brando and Al Pacino might have been a good film, we could not watch the classic film without Coppola's effort.

How did the initial divergence in preferences between Coppola and Paramount executives affect the outcome? Coppola probably worked hard to gather additional information about actors, exactly because of the disagreements, in order to convince the executives to follow his opinion. Paramount executives probably thought that it was Coppola who directed the film anyway,[4] and he probably knew more about what he was doing to make the film succeed, and hence they had probably stronger incentives to respond to his claim in order to motivate him to direct the film enthusiastically than when they had similar preferences.

More generally, two key features of this story apply naturally to decision processes in organizations, such as a new product development process. First, there is division of labor between decision and implementation: The studio made final decisions and Coppola implemented them as a director. As is summarized by Gibbons et al. (2012), a decision process of an organization is often described as moving from choice to execution (Mintzberg, 1979) or from ratification to implementation (Fama and Jensen, 1983). The development of a new car model is executed by a team of engineers often led by a product manager (Clark and Fujimoto, 1991), only after it is ratified by top management. A decision is rarely implemented by the same person, and the authority of the decision maker is often ineffective and the subordinate implementer has some freedom to choose whether or not to obey the decisions (Arrow, 1974; Barnard, 1938; Simon,

[1] According to Lebo (2005, p.48), Coppola said "I listed the reasons (...), one of them being that he had an aura about him when he was surrounded by other actors, similar to that of Don Corleone with the people."

[2] According to Lebo (2005, p.63), Coppola said "I always saw this face of Al Pacino in this Sicily section."

[3] Marlon Brando also saw the test films and recognized the ability of Al Pacino. The studio chief eventually allowed Al Pacino to be cast after talking to Brando (Lebo, 2005).

[4] It is said that he was almost replaced not once but several times. However, he was not fired, and we do not consider such a possibility in this paper.

1947). Takahashi (1997) argues, based on surveys of white-collar workers of Japanese firms, that they commonly avoid completing their tasks so long that they sometimes become unnecessary.

Second, the person who implements the decision is very often the one who is in a better position to access to information valuable for decision making by exerting effort. Coppola engaged in both gathering additional information related to the success of the film *and* expending effort to direct the film following the approval by the studio. This feature is also commonly found in organizations. As emphasized by Hayek (1945) and Jensen and Meckling (1992), information relevant to decision making is dispersed, and important part of information is specific to "the particular circumstances of time and place." Furthermore, as Arrow (1974) emphasizes, the acquisition of information is costly and there is "a complementarity between a productive activity and some kinds of information. (p.42)" In the example of a new product development in the automobile industry, the product manager who is typically an engineer exerts considerable efforts before the project is ratified, such as recruiting project members from functional departments, spending off-duty hours for acquiring new knowledge, developing the prototype products, and so on (Niihara, 2010).

To study a decision process with these two features, we consider a two-agent organization the owner of which hires a decision maker and an implementer.[5] The decision maker selects one of two relevant projects and the implementer decides whether or not to implement the selected project after observing the cost of implementation. A project succeeds if and only if it "fits" the true state of nature *and* the implementation effort is exerted. Furthermore, before project choice, the implementer chooses an information-gathering effort to obtain a signal about the state of nature. The probability that an informative signal is observed is increasing in his effort. The informative signal indicates which project is more likely to succeed.

We analyze two cases separately, the case of symmetric information in which the signal gathered by the implementer is observable to the decision maker as well, and the case of asymmetric information where the signal is the implementer's private and soft information and hence there is a strategic communication problem.[6]

We are in particular interested in diversity in values or preferences between the decision maker and the implementer. The Coppola-Paramount example suggests that their initial divergent preferences have incentive effects that eventually lead to good outcomes. It is frequently emphasized in business press and by business people that diversity in the workplace pays. For example, the Stanford GSB lecturer and chairman of JetBlue Airways Joel Peterson writes as follows.[7]

> More important, building a homogeneous organization is just bad business. You won't have the variety of perspectives, backgrounds, and skills that are invaluable

[5]Throughout the paper we assume the decision maker is female and the implementer is male, for the purpose of identification only.

[6]If the signal is the implementer's private and hard information, all the results under symmetric information continue to hold.

[7]`http://www.gsb.stanford.edu/insights/joel-peterson-what-are-most-common-hiring-mistakes`

> when you're up against big problems, or facing big opportunities. You want to work with a group of people who challenge each others' perspectives, and push each other beyond perceived limitations. The value of a great hire becomes clear when people on your team are forced out of their comfort zone by an infusion of new ideas. That's when the world begins to look a little different.

Research on diversity or heterogeneity in organizations has also been proliferating in management literature, although its effects on performance are mixed, partly due to the vague meaning of diversity (see, for example, Harrison and Klein, 2007, for a recent overview of the literature from the standpoint of defining diversity). There is also literature showing evidence of the bright side of intragroup conflict in organizations, in particular, task-related diversity such as dissimilarity in expertise, education, organizational tenure, and so on (see, for example, Horwitz and Horwitz, 2007, for a recent review of the literature).

To capture preference diversity between the decision maker and the implementer, we assume that each of them prefers one of two projects to be implemented than the other, *ceteris paribus*, and enjoys a higher private benefit from the success of the former, favorite project than that of the latter. We call the organization *homogeneous* if their favorite projects coincide, and call it *heterogeneous* if their favorite projects differ. The unbiased owner chooses either homogeneous or heterogeneous organization to maximize her expected profit.[8]

Under the assumption of symmetric information, we find three reasons why preference heterogeneity between the decision maker and the implementer becomes optimal for the owner. First, the decision maker is more likely to "react" to the signal and to select her unfavorite project when the signal indicates it is more likely to succeed (Paramount probably reacted to Coppola in order to motivate him to direct the film enthusiastically). The decision maker is more likely to react under the heterogeneous organization because her unfavorite project is the implementer's favorite one, and hence the implementer is more motivated to exert effort to implement the project.

Second, the implementer is more motivated to exert effort to gather additional information under the heterogeneous organization since "ignorance" is more costly (Coppola was probably more motivated to gather additional information in order to avoid status quo casting). Suppose that the signal is so informative that, whether preferences are homogeneous or heterogeneous, the decision maker reacts to the signal and implements the project with a higher probability of success. If no informative signal is observed, the decision maker simply chooses her favorite project, which is the unfavorite one for the implementer under the heterogeneous organization. The implementer with the conflicting preference thus has a stronger incentive to exert effort to avoid ending up with no additional information and implementing his unfavorite project. We call it the *ignorance-avoiding effect.*

[8] Our paper is thus similar in spirit to Prendergast (2008), who shows that "firms partially solve agency problems by hiring agents with particular preferences (p.201)" and the agents' biases rise as contracting distortions become larger, although we assume away contracting issues.

The third reason why the owner prefers diversity comes from interaction between the decision maker's reactivity and his incentive to gather additional information (Coppola was probably more motivated to gather additional information, in order to induce Paramount to react). Suppose that the informativeness of the signal is intermediate and the decision maker reacts to it only under the heterogeneous organization. Then the only case in which the implementer can implement his favorite project is that the signal favoring that project is observed under the heterogeneous organization. This incentive to implement the favorite project in turn reinforces his incentive to gather information if the signal is sufficiently important.

Of course, diversity of preferences has its own cost. The decision maker chooses her favorite project when the signal favors it or when no additional information is available. It is however the implementer's unfavorite project and hence his motivation to implement the project is lower under the heterogeneous organization. We in fact show that the owner *strictly* prefers the homogeneous organization if the signal is little informative, or if it is reasonably informative but the implementer's marginal cost of information-gathering effort is sufficiently high. However, we show that the heterogeneous organization is optimal for the owner if *both* the signal is sufficiently informative and the implementer's marginal cost is sufficiently low.

We then extend the analysis to the case in which the signal is the implementer's private and soft information and the implementer can send any "cheap talk" message to the decision maker. The implementer has no incentive to manipulate information under the homogeneous organization. Under the heterogeneous organization, however, the implementer has incentives to induce the decision maker to choose his favorite project by deviating from truth-telling, and in general there is no equilibrium in which the signal observed by the implementer is perfectly communicated to the decision maker.

This lack of information does not always reduce the performance of the heterogenous organization because the implementer's favorite project is more likely to be selected and thus his motivation to implement it increases. The owner of the heterogenous organization thus benefits from asymmetric information when the implementer's marginal cost of information acquisition is sufficiently high. Otherwise, however, the heterogeneous organization is less likely to be optimal for the owner, and in particular, the ignorance-avoiding effect, on which the second reason why the owner prefers diversity is based, no longer exists. We argue that the vulnerability of heterogenous organization to the manipulation of soft information points to a critical importance of information sharing among members when they have conflicting preferences.

The separation of decision and implementation has recently been formalized and analyzed by Blanes i Vidal and Möller (2007), Marino et al. (2010), Van den Steen (2010b), and Zábojník (2002). These papers study issues different from us, such as leadership, interpersonal authority, labor market conditions, and delegation of authority. Landier et al. (2009) is most closely related to ours. They show that preference heterogeneity between the decision maker and the implementer may be optimal for the owner. In their model, it is the decision maker who observes an informative signal. Furthermore, the decision maker always observes an informative signal without cost, and hence the incentive to acquire information is not an issue. Borrowing from their modeling approach, we study a complementary situation in which the implementer, exactly because he is the one who executes a project, can access to information valuable to decision making, only by exerting costly effort.[9]

Since the seminal work Dessein (2002), literature on strategic communication problems in organizations have been growing fast. We study how the implementer's incentive to acquire information is affected by differences of preferences, and in this respect, our paper is related to Che and Kartik (2009), Dur and Swank (2005), Gerardi and Yariv (2008), Hori (2008), Omiya et al. (2014), and Van den Steen (2010a). Che and Kartik (2009) and Van den Steen (2010a) show that an agent who has "opinion" different from the decision maker (modeled as different priors) has more incentive to acquire information to persuade the decision maker. Dur and Swank (2005), Gerardi and Yariv (2008), Hori (2008), and Omiya et al. (2014) point out that biased preferences can have positive effects on the agent's incentive to acquire information, which are similar to our ignorance-avoiding effect. In contrast to our model, however, the privately informed agent in these papers is an "adviser" who does not engage in implementation of a project.

The bottom line is that our paper is an attempt to study the benefits and costs of preference diversity in organizations by unifying two issues previously analyzed separately, that is, (a) the separation of choice and implementation and (b) information acquisition and strategic communication.

Our theoretical analysis offer some interesting implications for complementarities in organizations. Our results imply that organizational practices such as information technology usage, investment in human capital, and information sharing exhibit complementarities, that is consistent with much of the existing empirical evidence (Ennen and Richter, 2010; Brynjolfsson and Milgrom, 2012). However, we show that such complementarities exist *only in the heterogenous organization.* We are currently unaware of any empirical research studying complementarities among organizational elements including preference diversity.

The rest of the paper is structured as follows. In Section 2, we introduce the model, and in Section 3 we report the main results under the assumption of symmetric information. In Section 4 we analyze alternative settings such as the decision maker exerting effort to gather information, and discuss how our results change. In Section 5, we assume that additional signal is the implementer's private information and analyze strategic communication issues. In section 6, the concluding section, we discuss empirical implications.

[9] Chiba and Leong (2013) is also related though in their model the decision maker both chooses and implements a project. The other agent in their model is an advisor who observes a signal privately and communicates it to the decision maker.

## 2 The Model

An owner of a hierarchical organization hires two agents, decision maker (hereafter DM, female) and implementer (IM, male), to select and execute a project. The owner first chooses either a *homogeneous* or *heterogeneous* organization (whose meanings are to be explained below). DM then chooses a project. There are potentially many projects, of which only two, called projects 1 and 2, are relevant: there are two possible states of nature $\theta \in \{1, 2\}$, and project $d \in \{1, 2\}$ is efficient if and only if the true state is $\theta = d$. We assume $\mathbb{P}[\theta = 1] = \mathbb{P}[\theta = 2] = 1/2$.

IM then exerts effort $e \in \{0, 1\}$ to implement and execute the selected project. Effort $e = 1$ costs $\tilde{c}$ to IM, which is random and distributed according to a cumulative distribution function $F(\cdot)$ with $f(\cdot)$ as the corresponding density function. We assume $F(0) = 0$ and $F(\cdot)$ is strictly increasing. IM chooses effort after observing the realization of $\tilde{c}$.

Project efficiency and IM's effort are perfect complements: The implemented project $d$ succeeds if and only if it is efficient ($\theta = d$) *and* IM chooses $e = 1$. If the project succeeds, the owner obtains profit which we normalize to 1, and DM and IM enjoy private benefits $B > 0$ and $b > 0$, respectively. The payoffs to all three parties are zero, otherwise. We can interpret private benefits as intrinsic motivation, perks on the jobs, acquisition of human capital, benefits from other ongoing projects, the possibility of signaling abilities, and so on.

Furthermore, private benefits to DM and IM depend on whether or not their *favorite* projects are implemented. Without loss of generality, we assume DM prefers project 1, *ceteris paribus*, and obtains $B = B_H$ if project 1 is implemented and succeeds, while her private benefit is $B = B_L < B_H$ if project 2 is implemented and succeeds. Similarly, IM enjoys $b_H$ ($b_L$) if his favorite (respectively, unfavorite) project is implemented and succeeds, where $b_H > b_L$ holds.

When IM prefers project 1, DM and IM agree about the favorite project and we call such an organization *homogeneous*. The organization where IM prefers project 2 is called *heterogeneous*. We denote DM's *bias* toward her favorite project as $\Gamma \equiv B_H/B_L > 1$ and IM's bias as $\gamma \equiv b_H/b_L > 1$. The owner, in contrast, has no bias toward a particular project, and hence chooses an organization to maximize the probability of success.

In addition to implementation and execution of a project, IM can engage in information acquisition and generate signal $\sigma \in \{\phi, 1, 2\}$. Before DM chooses a project, IM chooses information-gathering effort $\pi \in [0, 1]$. The cost of information-gathering effort $\pi$ is denoted by $\eta(\pi; k)$, where $k \in (0, +\infty)$ is a parameter representing, for example, investment in information technology, the extent of IM's discretion over his time allocation between information acquisition and other tasks, the magnitude of organizational support for his activities, and so on, that reduces the marginal cost of effort. For simplicity, we assume it is quadratic in $\pi$, that is, $\eta(\pi; k) = \pi^2/(2k)$.

When IM chooses $\pi \in [0, 1]$, each value of the signal realizes with the following probabilities:

For $d, d' \in \{1, 2\}$ and $d' \neq d$,

$$\mathbb{P}[\sigma = d \mid \theta = d] = \pi\alpha$$
$$\mathbb{P}[\sigma = d' \mid \theta = d] = \pi(1 - \alpha)$$
$$\mathbb{P}[\sigma = \phi \mid \theta = d] = 1 - \pi$$

where $\alpha \in (1/2, 1]$ is the informativeness of the signal: IM succeeds in gathering additional information $\sigma \in \{1, 2\}$ with probability $\pi$, while with probability $1-\pi$ no additional information is available ($\sigma = \phi$ realizes). The posterior probability is hence $\mathbb{P}[\theta = d \mid \sigma = d] = \alpha > 1/2$ and $\mathbb{P}[\theta = d \mid \sigma = d'] = 1 - \alpha < 1/2$. Parameter $\alpha$ can be interpreted, for example, as IM's knowledge about technological environments relevant to the projects, the importance of information acquisition for decision making, and so on. Given that information gathering is successful, the probability of observing $\sigma = 1$ and that of observing $\sigma = 2$ are equal to $1/2$.

The timing of decisions and information structure are summarized as follows.

1. The owner selects either a homogeneous or heterogeneous organization.[10] The owner chooses the homogenous organization if indifferent. Whether the organization is homogeneous or heterogeneous, as well as private benefits, are observable to DM and IM.

2. IM chooses information-gathering effort $\pi \in [0, 1]$ that is unobservable to DM.

3. Signal $\sigma \in \{\phi, 1, 2\}$ realizes. We assume $\sigma$ is observable to DM and IM before Section 5, where we alternatively assume $\sigma$ is IM's private information and IM sends a message to DM.

4. DM chooses a project $d \in \{1, 2\}$, which is observable to IM. DM chooses her favorite project 1 if indifferent.

5. The cost of implementation $\tilde{c}$ is realized and observed only by IM.

6. IM chooses the effort of implementation $e \in \{0, 1\}$.

7. The outcome of the project is realized.

# 3 Analysis

We solve the subgame perfect equilibrium of the model by moving backwards, analyzing in order (i) IM's implementation decision, (ii) DM's project choice, (iii) IM's information-gathering effort, and (iv) the owner's choice of an organization. The proofs not in the main text are found in Appendix.

[10] We assume that project choice, implementation decision, outcomes, additional signal, and payoffs to IM and DM are all unverifiable and hence the owner cannot design contingent payment schemes.

### 3.1 Project Implementation

IM's choice of implementation effort depends on which project DM has chosen as well as whether IM has additional information about the state of nature. Suppose throughout this subsection DM has chosen project $d \in \{1, 2\}$ with IM's private benefit $b \in \{b_L, b_H\}$. We denote the probability that the project is implemented given signal $\sigma$ by $q(b, d, \sigma) \equiv \mathbb{P}[e = 1 \mid b, d, \sigma]$.

First, suppose IM has no additional information, so that he only knows the project selected by DM succeeds with probability 1/2. IM then chooses $e = 1$ if and only if $(b/2) - \tilde{c} \geq 0$. DM then expects IM to exert implementation effort with $q(b, d, \phi) = F(b/2)$.

Next, suppose IM obtains additional information. If $\sigma = d \in \{1, 2\}$, IM provides implementation effort for project $d$ if and only if $\alpha b - \tilde{c} \geq 0$. If $\sigma \neq d$,[11] IM chooses $e = 1$ to implement project $d$ if and only if $(1 - \alpha)b - \tilde{c} \geq 0$. The probabilities that IM chooses $e = 1$ are thus given as $q(b, d, d) = F(\alpha b)$ and $q(b, d, d') = F((1 - \alpha)b)$, respectively. Note that these probabilities are strictly increasing in $b$: IM is more likely to implement a project if it is his favorite one. To guarantee that they are less than one for all $\alpha$, we assume $F(b_H) \leq 1$ throughout the paper.

### 3.2 Project Choice

Moving backwards, we next analyze DM's project choice. We denote the probability of the project being successful by $p(b, d, \sigma)$ given IM's private benefit $b$, project $d$, and signal $\sigma$. For each signal $\sigma$, DM chooses a project that maximizes her expected benefit, which we denote by $d^*_{\text{hom}}(\sigma)$ and $d^*_{\text{het}}(\sigma)$ under the homogeneous organization and the heterogeneous organization, respectively.

#### No Additional Information

First suppose $\sigma = \phi$. Then IM chooses $e = 1$ with probability $q(b, d, \phi)$, and then the project succeeds with probability 1/2. Hence

$$p(b, d, \phi) = \frac{1}{2} q(b, d, \phi) = \frac{1}{2} F\left(\frac{b}{2}\right).$$

DM's expected benefit given her private benefit $B$ is then

$$p(b, d, \phi)B = \frac{1}{2} F\left(\frac{b}{2}\right) B.$$

Under the homogeneous organization in which project 1 is the favorite project for both DM and IM, it is obvious that DM chooses project 1 because it's success probability as well as her private benefit is higher under $d = 1$ than $d = 2$: $p(b_H, 1, \phi)B_H > p(b_L, 2, \phi)B_L$.

Under the heterogeneous organization in which DM (IM) prefers project 1 (2, respectively), there is a tradeoff. If DM chooses her favorite project 1, her private benefit under success will

[11] By $\sigma \neq d$, we always mean $\sigma = d' \in \{1, 2\}$ and $d' \neq d$.

be higher while IM is less likely to implement the project. DM's expected benefits under $d = 1$ and $d = 2$ are, respectively, given as follows:

$$p(b_L, 1, \phi)B_H = \frac{1}{2}F\left(\frac{b_L}{2}\right)B_H$$
$$p(b_H, 2, \phi)B_L = \frac{1}{2}F\left(\frac{b_H}{2}\right)B_L$$

DM chooses her favorite project 1 if $p(b_L, 1, \phi)B_H \geq p(b_H, 2, \phi)B_L$, which is equivalent to

$$\Gamma = \frac{B_H}{B_L} \geq \frac{F(b_H/2)}{F(b_L/2)}. \tag{1}$$

In order to focus on a natural and interesting case where DM prefers her favorite project without further information, from now on we assume (1).

**Assumption 1.** $\Gamma \geq F(b_H/2)/F(b_L/2)$.

DM is more intrinsically biased than IM in the sense of Assumption 1. We think this represents a realistic situation in which an important decision is made at a higher hierarchical rank and those who make the decision are more experienced and confident than those who implement the decision at lower ranks.[12] Under Assumption 1, it is optimal for DM to choose her favorite project 1 without additional information, even when the organization is heterogeneous: $d^*_{\text{hom}}(\phi) = d^*_{\text{het}}(\phi) = 1$.

In addition, we sometimes make the following assumption that directly compares the bias of DM and that of IM.

**Assumption 2.** $\Gamma \geq \gamma$.

Assumptions 1 and 2 are equivalent if $\tilde{c}$ is uniformly distributed over $[0, 1]$. If $F(\cdot)$ is convex, Assumption 2 is implied by Assumption 1.

### Additional Information

Next suppose $\sigma \in \{1, 2\}$. The success probabilities are given as follows.

$$p(b, d, d) = \alpha q(b, d, d) = \alpha F(\alpha b)$$
$$p(b, d, d') = (1 - \alpha)q(b, d, d') = (1 - \alpha)F((1 - \alpha)b)$$

First, consider the homogeneous organization. If $\sigma = 1$, the optimal project for DM is again project 1 since (i) project 1 is more likely to succeed than project 2, (ii) IM is more likely

[12] The corresponding assumption is also made in Landier et al. (2009). If Assumption 1 does not hold, DM chooses her unfavorite project even though there is no additional information, in order to raise IM's implementation probability. In the discussion section (Section 4) we explain how the results change under this alternative assumption.

to implement project 1, and (iii) success yields higher private benefit $B_H$. We thus obtain $d^*_{\text{hom}}(1) = 1$.

On the other hand, if $\sigma = 2$, DM's expected benefit from her favorite project 1 is $p(b_H, 1, 2)B_H = (1-\alpha)F((1-\alpha)b_H)B_H$. DM's expected benefit from project 2 is $p(b_L, 2, 2)B_L = \alpha F(\alpha b_L)B_L$. Then $d^*_{\text{hom}}(2) = 2$ if and only if

$$\alpha F(\alpha b_L)B_L > (1-\alpha)F((1-\alpha)b_H)B_H$$

holds. Define $\alpha_{\text{hom}} \in (1/2, 1)$ as the solution to

$$\alpha F(\alpha b_L) = (1-\alpha)F((1-\alpha)b_H)\Gamma. \tag{2}$$

Then $d^*_{\text{hom}}(2) = 2$ if and only if $\alpha > \alpha_{\text{hom}}$.

We say DM is *reactive* to signal $\sigma$ if for each signal DM chooses a project with higher probability of success: $d^*_{\text{hom}}(\sigma) = \sigma$ for $\sigma \in \{1, 2\}$. Under the homogeneous organization, DM is reactive if $\alpha > \alpha_{\text{hom}}$. Otherwise, she always chooses her favorite project 1 irrespective of the informative signal, in which case DM is called *non-reactive*.

Next consider the heterogeneous organization. If $\sigma = 1$ is received, DM's expected benefit from her favorite project 1 is $p(b_L, 1, 1)B_H = \alpha F(\alpha b_L)B_H$. Similarly, her expected benefit from project 2 is given as $p(b_H, 2, 1)B_L = (1-\alpha)F((1-\alpha)b_H)B_L$. Using $\alpha > 1/2$ and Assumption 1 yield

$$\alpha F(\alpha b_L)B_H > \frac{1}{2}F\left(\frac{b_L}{2}\right)B_H \geq \frac{1}{2}F\left(\frac{b_H}{2}\right)B_L > (1-\alpha)F((1-\alpha)b_H)B_L,$$

and hence $d^*_{\text{het}}(1) = 1$: Under Assumption 1, there is no difference between homogeneous and heterogeneous organizations if the signal indicates that project 1 is more likely to succeed.

If $\sigma = 2$, on the other hand, DM's expected benefits from projects 1 and 2 are, respectively, given as $p(b_L, 1, 2)B_H = (1-\alpha)F((1-\alpha)b_L)B_H$ and $p(b_H, 2, 2)B_L = \alpha F(\alpha b_H)B_L$. DM is reactive if

$$\alpha F(\alpha b_H)B_L > (1-\alpha)F((1-\alpha)b_L)B_H.$$

Define $\alpha_{\text{het}} \in [1/2, 1)$ as the solution to

$$\alpha F(\alpha b_H) = (1-\alpha)F((1-\alpha)b_L)\Gamma. \tag{3}$$

Then $d^*_{\text{het}}(2) = 2$ if and only if $\alpha > \alpha_{\text{het}}$ holds.

From (2) and (3) one can easily show $1/2 \leq \alpha_{\text{het}} < \alpha_{\text{hom}} < 1$: *DM is more likely to be reactive under the heterogeneous organization than under the homogeneous organization.* We have solved for DM's optimal project choice as summarized in the following lemma.[13]

[13]If Assumption 1 holds with equality, (3) yields $\alpha_{\text{het}} = 1/2$ and hence Case 1 in the proposition does not arise. Similar remarks apply to other results as well.

**Lemma 1.** *Under Assumption 1, there exist thresholds $\alpha_{\text{hom}}$ and $\alpha_{\text{het}}$ satisfying $1/2 \leq \alpha_{\text{het}} < \alpha_{\text{hom}} < 1$, such that DM's optimal project choice is $d^*_{\text{hom}}(\phi) = d^*_{\text{het}}(\phi) = 1$ for all $\alpha \in (1/2, 1]$, and for informative signals, it is given as follows:*

**Case 1:** *If $\alpha \in (1/2, \alpha_{\text{het}}]$, then DM is non-reactive under both organizations: $d^*_{\text{hom}}(\sigma) = d^*_{\text{het}}(\sigma) = 1$ for $\sigma \in \{1, 2\}$;*

**Case 2:** *If $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$, then DM is non-reactive under the homogeneous organization but is reactive under the heterogeneous organization: $d^*_{\text{hom}}(\sigma) = 1$ and $d^*_{\text{het}}(\sigma) = \sigma$ hold for $\sigma \in \{1, 2\}$;*

**Case 3:** *If $\alpha \in (\alpha_{\text{hom}}, 1]$, DM is reactive under both organizations: $d^*_{\text{hom}}(\sigma) = d^*_{\text{het}}(\sigma) = \sigma$ for $\sigma \in \{1, 2\}$.*

As Lemma 1 and Table 1 given below make clear, there is no difference in project choice between homogeneous organization and heterogeneous organization if the signal is uninformative or a good news for DM's favorite project 1. DM possibly makes a different choice if the signal favors her unfavorite project 2. In either organization, DM is reactive if the signal is sufficiently informative. DM's incentive to be reactive is stronger under the heterogeneous organization because IM derives a higher private benefit from project 2 and is hence more likely to implement it.

Table 1: DM's optimal project choice

| | Homogeneous | | Heterogeneous | |
|---|---|---|---|---|
| | $\alpha \leq \alpha_{\text{hom}}$ | $\alpha > \alpha_{\text{hom}}$ | $\alpha \leq \alpha_{\text{het}}$ | $\alpha > \alpha_{\text{het}}$ |
| $\sigma = \phi$ | project 1 | | project 1 | |
| $\sigma = 1$ | project 1 | | project 1 | |
| $\sigma = 2$ | project 1 | project 2 | project 1 | project 2 |

## 3.3 IM's Incentive to Gather Additional Information

Moving backwards further, we now analyze IM's optimal information-gathering effort. Let $K(b, d, \sigma)$ be IM's expected net benefit given private benefit $b$, project $d$, and signal $\sigma$:

$$K(b, d, \sigma) = p(b, d, \sigma)b - \mathbb{E}[\tilde{c} \mid b, d, \sigma]$$

where IM's expected cost of implementation effort $\mathbb{E}[\tilde{c} \mid b, d, \sigma]$ is given by

$$\mathbb{E}[\tilde{c} \mid b, d, \sigma] = \int_0^{\mathbb{P}[\theta = d \mid \sigma] b} c f(c) dc.$$

Then for each signal $\sigma$, IM's expected net benefit is calculated as follows:

$$K(b,d,\phi) = \frac{1}{2}F\left(\frac{b}{2}\right)b - \int_0^{b/2} cf(c)dc = \int_0^{b/2} F(c)dc$$
$$K(b,d,d) = \alpha F(\alpha b)b - \int_0^{\alpha b} cf(c)dc = \int_0^{\alpha b} F(c)dc$$
$$K(b,d,d') = (1-\alpha)F((1-\alpha)b)b - \int_0^{(1-\alpha)b} cf(c)dc = \int_0^{(1-\alpha)b} F(c)dc$$

Hence we simply write these as $K(b/2)$, $K(\alpha b)$, and $K((1-\alpha)b)$, respectively. $K(x) = \int_0^x F(c)dc$ satisfies $\partial K(x)/\partial x > 0$ and $\partial^2 K(x)/\partial^2 x > 0$ for all $x > 0$.

**Homogeneous Organization**

Consider the homogeneous organization and suppose first $\alpha \leq \alpha_{\text{hom}}$ so that DM is non-reactive. IM's expected payoff is equal to the expected benefit minus the cost of information acquisition:

$$\frac{\pi}{2}\left[K(\alpha b_H) + K((1-\alpha)b_H)\right] + (1-\pi)K\left(\frac{b_H}{2}\right) - \eta(\pi;k).$$

The first-order condition with respect to $\pi$ yields the optimal effort as follows:

$$\pi_{\text{hom}}^{\text{N}}(\alpha,k) = \min\left\{k\left(\frac{1}{2}K(\alpha b_H) + \frac{1}{2}K((1-\alpha)b_H) - K\left(\frac{b_H}{2}\right)\right), 1\right\}.$$

Note that $\pi_{\text{hom}}^{\text{N}}(\alpha,k)$ is strictly increasing in $\alpha$ and $k$ if $\pi_{\text{hom}}^{\text{N}}(\alpha,k) < 1$. Furthermore, $\pi_{\text{hom}}^{\text{N}}(\alpha,k) > 0$ holds for all $\alpha \in (1/2, 1]$ and $k > 0$ by the strict convexity of $K(\cdot)$: *Although DM is non-reactive, IM still has an incentive to gather additional information.* This is because additional information enables him to decide whether or not to implement project 1 contingent on the informative signal. With additional information, IM chooses to implement project 1 if $c \leq \alpha b_H$ under signal $\sigma = 1$ and $c \leq (1-\alpha)b_H$ under signal $\sigma = 2$. With no additional information, his decision can depend only on whether $c \leq (1/2)b_H$ holds or not.

Suppose next $\alpha > \alpha_{\text{hom}}$ so that DM is reactive. IM's expected payoff is given by

$$\frac{\pi}{2}\left[K(\alpha b_H) + K(\alpha b_L)\right] + (1-\pi)K\left(\frac{b_H}{2}\right) - \eta(\pi;k).$$

By taking the first-order condition with respect to $\pi$, we obtain the optimal effort as follows:

$$\pi_{\text{hom}}^{\text{R}}(\alpha,k) = \min\left\{k\left(\frac{1}{2}K(\alpha b_H) + \frac{1}{2}K(\alpha b_L) - K\left(\frac{b_H}{2}\right)\right), 1\right\},$$

which is strictly increasing in $\alpha$ unless $\pi_{\text{hom}}^{\text{R}}(\alpha,k) = 1$. The following lemma proves that $\pi_{\text{hom}}^{\text{R}}(\alpha,k) > 0$ holds for all $\alpha \in (\alpha_{\text{hom}}, 1]$ and $k > 0$ under Assumptions 1 and 2. By this lemma, $\pi_{\text{hom}}^{\text{R}}(\alpha,k)$ is strictly increasing in $k$ if $\pi_{\text{hom}}^{\text{R}}(\alpha,k) < 1$.

**Lemma 2.** *Under Assumptions 1 and 2, $\pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha, k) > 0$ holds for all $\alpha \in (\alpha_{\mathrm{hom}}, 1]$ and $k > 0$.*

Denote the optimal level of the information-gathering effort under the homogeneous organization by $\pi_{\mathrm{hom}}(\alpha, k)$:

$$\pi_{\mathrm{hom}}(\alpha, k) = \begin{cases} \pi^{\mathrm{N}}_{\mathrm{hom}}(\alpha, k) & \text{if } \alpha \leq \alpha_{\mathrm{hom}} \\ \pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha, k) & \text{if } \alpha > \alpha_{\mathrm{hom}} \end{cases}$$

Suppose $\pi^{\mathrm{N}}_{\mathrm{hom}}(\alpha, k) < 1$. Then $\pi_{\mathrm{hom}}(\alpha, k)$ discontinuously jumps up at $\alpha = \alpha_{\mathrm{hom}}$ if and only if $\Gamma > \gamma$. To see this, first note $\pi^{\mathrm{N}}_{\mathrm{hom}}(\alpha, k) = \pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha, k)$ holds when $\alpha b_L = (1-\alpha) b_H$, or

$$\alpha = \alpha_\gamma \equiv \frac{\gamma}{1+\gamma}, \tag{4}$$

which satisfies $\alpha_\gamma \leq \alpha_{\mathrm{hom}}$ if and only if Assumption 2 holds, with strict inequality if $\Gamma > \gamma$. Then when $\alpha$ is in the interval $(\alpha_\gamma, \alpha_{\mathrm{hom}}]$, IM would have stronger incentives to gather additional information if DM were reactive. However, the precision of the signal is not high enough for DM to react to it. Hence IM's incentives rise discontinuously at $\alpha_{\mathrm{hom}}$ beyond which DM becomes reactive.[14] In Figure 1 given below, $\pi_{\mathrm{hom}}(\alpha, k)$ is depicted as the dashed curve under the assumption of uniform distribution.

Define also $\overline{k}_{\mathrm{hom}}(\alpha) > 0$ as the minimum $k$ satisfying $\pi_{\mathrm{hom}}(\alpha, k) = 1$: $\overline{k}_{\mathrm{hom}}(\alpha) = \overline{k}^{\mathrm{N}}_{\mathrm{hom}}(\alpha)$ for $\alpha \leq \alpha_{\mathrm{hom}}$; and $\overline{k}_{\mathrm{hom}}(\alpha) = \overline{k}^{\mathrm{R}}_{\mathrm{hom}}(\alpha)$ for $\alpha > \alpha_{\mathrm{hom}}$, where

$$\begin{aligned} \overline{k}^{\mathrm{N}}_{\mathrm{hom}}(\alpha) &= \left( \frac{1}{2} K(\alpha b_H) + \frac{1}{2} K((1-\alpha) b_H) - K\left(\frac{b_H}{2}\right) \right)^{-1} \\ \overline{k}^{\mathrm{R}}_{\mathrm{hom}}(\alpha) &= \left( \frac{1}{2} K(\alpha b_H) + \frac{1}{2} K(\alpha b_L) - K\left(\frac{b_H}{2}\right) \right)^{-1}. \end{aligned}$$

It is easy to see $\overline{k}_{\mathrm{hom}}(\alpha)$ is strictly decreasing in $\alpha$, and discontinuously drops at $\alpha = \alpha_{\mathrm{hom}}$ if $\Gamma > \gamma$.

### Heterogenous Organization

Consider next the heterogeneous organization. We can obtain IM's optimal information-gathering effort $\pi_{\mathrm{het}}(\alpha, k)$ in a way similar to $\pi_{\mathrm{hom}}(\alpha, k)$:

$$\pi_{\mathrm{het}}(\alpha, k) = \begin{cases} \pi^{\mathrm{N}}_{\mathrm{het}}(\alpha, k) & \text{if } \alpha \leq \alpha_{\mathrm{het}} \\ \pi^{\mathrm{R}}_{\mathrm{het}}(\alpha, k) & \text{if } \alpha > \alpha_{\mathrm{het}} \end{cases}$$

[14] If Assumption 2 is not satisfied and hence $\Gamma < \gamma$, then $\alpha_\gamma > \alpha_{\mathrm{hom}}$ holds and $\pi_{\mathrm{hom}}(\alpha, k)$ *drops* discontinuously at $\alpha = \alpha_{\mathrm{hom}}$, possibly to zero. However, most of our results are valid without Assumption 2.

where $\pi^{\mathrm{N}}_{\mathrm{het}}(\alpha, k)$ and $\pi^{\mathrm{R}}_{\mathrm{het}}(\alpha, k)$ are defined as follows.

$$\pi^{\mathrm{N}}_{\mathrm{het}}(\alpha, k) = \min\left\{k\left(\frac{1}{2}K(\alpha b_L) + \frac{1}{2}K((1-\alpha)b_L) - K\left(\frac{b_L}{2}\right)\right), 1\right\};$$
$$\pi^{\mathrm{R}}_{\mathrm{het}}(\alpha, k) = \min\left\{k\left(\frac{1}{2}K(\alpha b_L) + \frac{1}{2}K(\alpha b_H) - K\left(\frac{b_L}{2}\right)\right), 1\right\}$$

Both of them are strictly increasing in $\alpha$ and $k$ (unless they are equal to one) and positive for all $\alpha > 1/2$ and $k > 0$. It is easy to show that for all $\alpha \in (1/2, 1]$, $\pi^{\mathrm{R}}_{\mathrm{het}}(\alpha, k) \geq \pi^{\mathrm{N}}_{\mathrm{het}}(\alpha, k)$ holds with strict inequality if $\pi^{\mathrm{N}}_{\mathrm{het}}(\alpha, k) < 1$: IM would have more incentives to gather information if DM were reactive. In Figure 1, $\pi_{\mathrm{het}}(\alpha, k)$ is depicted as the solid curve.

We also define $\overline{k}_{\mathrm{het}}(\alpha)$ as the minimum $k$ satisfying $\pi_{\mathrm{het}}(\alpha, k) = 1$: $\overline{k}_{\mathrm{het}}(\alpha) = \overline{k}^{\mathrm{N}}_{\mathrm{het}}(\alpha)$ for $\alpha \leq \alpha_{\mathrm{het}}$ and $\overline{k}_{\mathrm{het}}(\alpha) = \overline{k}^{\mathrm{R}}_{\mathrm{het}}(\alpha)$ for $\alpha > \alpha_{\mathrm{het}}$ where

$$\overline{k}^{\mathrm{N}}_{\mathrm{het}}(\alpha) = \left(\frac{1}{2}K(\alpha b_L) + \frac{1}{2}K((1-\alpha)b_L) - K\left(\frac{b_L}{2}\right)\right)^{-1}$$
$$\overline{k}^{\mathrm{R}}_{\mathrm{het}}(\alpha) = \left(\frac{1}{2}K(\alpha b_L) + \frac{1}{2}K(\alpha b_H) - K\left(\frac{b_L}{2}\right)\right)^{-1}$$

$\overline{k}_{\mathrm{het}}(\alpha)$ is strictly decreasing in $\alpha$, and discontinuous at $\alpha = \alpha_{\mathrm{het}}$.

#### Comparison

We examine how IM's incentive to gather additional information differs between two organizations. We sometimes adopt the following assumption.

**Assumption 3.** *$xf(x)$ is (weakly) increasing in $x > 0$.*

This assumption means that $F(\cdot)$ is not "very concave." It is satisfied if $F(\cdot)$ is convex. In particular, it holds if $\tilde{c}$ is uniformly distributed.

The following proposition summarizes the result.

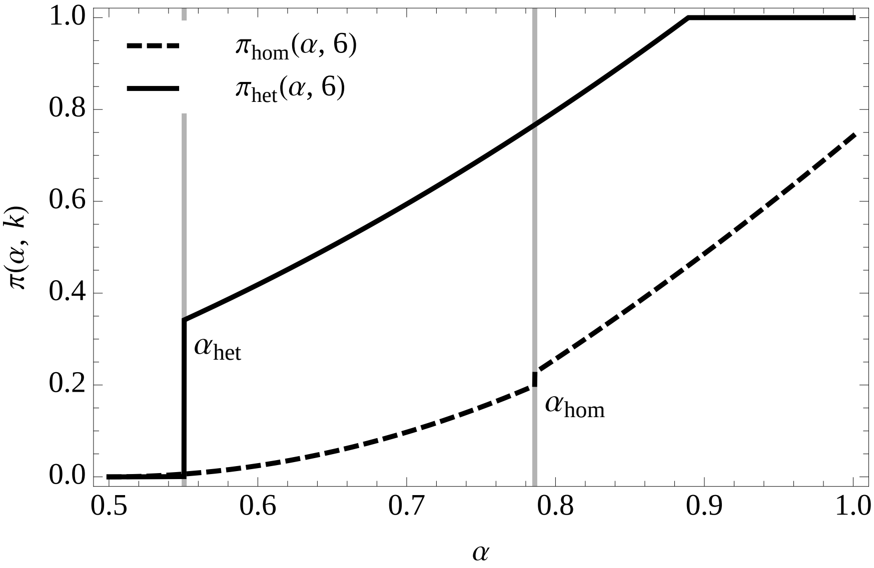
**Proposition 1.** *Under Assumptions 1 and 2, IM's incentive to gather additional information differs between homogeneous and heterogeneous organizations as follows.*

**Case 1:** *Suppose $\alpha \in (1/2, \alpha_{\mathrm{het}}]$. If Assumption 3 is also satisfied, $\pi_{\mathrm{hom}}(\alpha, k) \geq \pi_{\mathrm{het}}(\alpha, k)$ for all $k > 0$. The inequality is strict if $k < \overline{k}_{\mathrm{het}}(\alpha)$: IM is more likely to obtain information under the homogeneous organization than under the heterogeneous organization.*

**Case 2:** *Suppose $\alpha \in (\alpha_{\mathrm{het}}, 1]$. Then $\pi_{\mathrm{hom}}(\alpha, k) \leq \pi_{\mathrm{het}}(\alpha, k)$ holds for all $k > 0$. The inequality is strict if $k < \overline{k}_{\mathrm{hom}}(\alpha)$: IM is more likely to obtain information under the heterogeneous organization than under the homogeneous organization.*

Figure 1 illustrates Proposition 1 by depicting IM's optimal level of the information-gathering efforts. If the informativeness of the signal is so low that DM is non-reactive under either

Figure 1: Comparison of Incentives to Gather Information




In the figure, we assume $\tilde{c}$ is uniformly distributed over $[0, 1]$, $b_L = B_L = 0.3$, $b_H = 0.9$, and $B_H = 1.35$. Then $\alpha_{\text{het}} \approx 0.55$, $\alpha_{\text{hom}} \approx 0.78$, and $\alpha_\gamma = 0.75$. The cost parameter is set to $k = 6$.

organization (Case 1), IM is more likely to gather additional information when the project selected by DM is his favorite one. This is because additional information is more valuable to IM when he decides whether or not to implement his favorite project 1 than his unfavorite project 2. Assumption 3 is not necessary. The strict relationship $\pi_{\text{hom}}(\alpha, k) > \pi_{\text{het}}(\alpha, k)$ can hold if $F(\cdot)$ is not "very concave." The conclusion may not hold if $F(\cdot)$ is so concave that gathering information is "much more risky" under IM's favorite project than under his unfavorite one.

Next suppose the signal is sufficiently informative (Case 2). There are two sub-cases. If $\alpha > \alpha_{\text{hom}}$, then DM is reactive under either organization. The difference in IM's incentive to gather information is then solely due to the difference in his expected benefit under no additional information. Without additional information, DM chooses project 1, which is IM's favorite (unfavorite) project under the homogeneous (respectively, heterogeneous) organization. IM thus has a stronger incentive to acquire information under the latter organization, in order to avoid ending up with no additional information and implementing his unfavorite project. We call it the *ignorance-avoiding effect.*[15]

Finally, if $\alpha_{\text{het}} < \alpha \leq \alpha_{\text{hom}}$, DM is reactive only under the heterogeneous organization. The difference in the marginal benefit from acquiring information, which in turn determines the

[15] The ignorance-avoiding effect should be distinguished from the "persuasion effect" pointed out by Che and Kartik (2009) and Van den Steen (2010a), which arises from different priors. An effect similar to our ignorance-avoiding effect is pointed out by Dur and Swank (2005), Gerardi and Yariv (2008), Hori (2008), Omiya et al. (2014), as well as Che and Kartik (2009, Section VI).

difference in the optimal efforts, consists of the following three effects:

$$
\begin{aligned}
&\left[\frac{1}{2}K(\alpha b_L)+\frac{1}{2}K(\alpha b_H)-K\left(\frac{b_L}{2}\right)\right]-\left[\frac{1}{2}K(\alpha b_H)+\frac{1}{2}K((1-\alpha)b_H)-K\left(\frac{b_H}{2}\right)\right] \\
&\quad=\left[K\left(\frac{b_H}{2}\right)-K\left(\frac{b_L}{2}\right)\right]+\frac{1}{2}\left[K(\alpha b_H)-K((1-\alpha)b_H)\right]-\frac{1}{2}\left[K(\alpha b_H)-K(\alpha b_L)\right]
\end{aligned}
\tag{5}
$$

The difference in the first brackets represents the ignorance-avoiding effect, which is positive. The terms in the second and third brackets represent the effects from the difference in reactivity between two organizations. The difference in the second brackets is positive because DM chooses the more successful project 2 given signal $\sigma = 2$ only if IM succeeds in gathering additional information under the heterogenous organization. This effect of divergent preferences increases IM's motivation for implementation because he finds the project selected is more likely to succeed.

However, there is a cost of preference heterogeneity as represented by the difference in the last brackets. This cost is due to the fact that DM, when she observes $\sigma = 1$, chooses her favorite project 1, which IM does not like and is less likely to implement under the heterogenous organization.

While the ignorance-avoiding effect is positive, the other effects may hurt the incentive to gather information: the sum of the second and third effects is not necessarily positive for all $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$. It is positive if $\alpha > \alpha_\gamma$ but negative if $\alpha < \alpha_\gamma$. And which of $\alpha_{\text{het}}$ and $\alpha_\gamma$ is larger depends on the biases of DM and IM as follows:[16]

$$
\alpha_{\text{het}} \gtreqless \alpha_\gamma \quad \Leftrightarrow \quad \Gamma \gtreqless \Gamma_\gamma \equiv \frac{\alpha_\gamma F(\alpha_\gamma b_H)}{(1-\alpha_\gamma)F((1-\alpha_\gamma)b_L)}. \tag{6}
$$

If DM's bias is sufficiently high, $\alpha_{\text{het}}$ is so high that in the relevant range of $\alpha$, the positive second effect always more than offsets the negative third effect. If DM's bias is lower than $\Gamma_\gamma$, however, the sum of the second and third effects first reduces the advantage of heterogenous organization due to the ignorance-avoiding effect for $\alpha \in (\alpha_{\text{het}}, \alpha_\gamma)$, and then reinforces the ignorance-avoiding effect for $\alpha \in (\alpha_\gamma, \alpha_{\text{hom}}]$. Figure 1 corresponds to the latter case ($\alpha_{\text{het}} < \alpha_\gamma$). Despite this negative third effect, however, Proposition 1 (Case 2) states that the heterogenous organization is advantageous in terms of information acquisition for all $\alpha \in (\alpha_{\text{het}}, 1]$.

[16] For example, if $\tilde{c}$ is uniformly distributed over $[0, 1]$, $\Gamma_\gamma = \gamma^3$.

### 3.4 Optimal Organization

We finally investigate the optimal organization for the owner. Let $V_{\text{hom}}(\alpha,k)$ and $V_{\text{het}}(\alpha,k)$ be the owner's expected profits:[17]

$$V_{\text{hom}}(\alpha,k) = \begin{cases} V^{\text{N}}_{\text{hom}}(\alpha,k) & \text{if } \alpha \leq \alpha_{\text{hom}} \\ V^{\text{R}}_{\text{hom}}(\alpha,k) & \text{if } \alpha > \alpha_{\text{hom}} \end{cases}$$

$$V_{\text{het}}(\alpha,k) = \begin{cases} V^{\text{N}}_{\text{het}}(\alpha,k) & \text{if } \alpha \leq \alpha_{\text{het}} \\ V^{\text{R}}_{\text{het}}(\alpha,k) & \text{if } \alpha > \alpha_{\text{het}} \end{cases}$$

Each of $V_{\text{hom}}(\alpha,k)$ and $V_{\text{het}}(\alpha,k)$ is equal to the success probability of the respective organization, and depends on whether DM is non-reactive (represented by superscript N) or reactive (superscript R).

We first present the main result formally in the following proposition, and then discuss intuition in detail. To this purpose, we define another important threshold for informativeness. Define $\hat{\alpha} \in (1/2, \alpha_\gamma)$ as the solution to

$$\alpha F(\alpha b_L) = (1-\alpha)F((1-\alpha)b_H). \tag{7}$$

While $\hat{\alpha}$ is smaller than $\alpha_{\text{hom}}$, which of $\alpha_{\text{het}}$ and $\hat{\alpha}$ is larger depends on the biases of DM and IM as follows:[18]

$$\alpha_{\text{het}} \gtreqless \hat{\alpha} \quad \Leftrightarrow \quad \Gamma \gtreqless \hat{\Gamma} \equiv \frac{\hat{\alpha}F(\hat{\alpha}b_H)}{(1-\hat{\alpha})F((1-\hat{\alpha})b_L)}. \tag{8}$$

We thus define $\hat{\alpha}_{\text{het}} \equiv \max\{\alpha_{\text{het}}, \hat{\alpha}\}$.

**Proposition 2.** *Under Assumptions 1–3, the optimal organization for the owner is given as follows.*

**Case 1:** *If $\alpha \in (1/2, \alpha_{\text{het}}]$, then $V_{\text{het}}(\alpha) < V_{\text{hom}}(\alpha)$ holds for all $k > 0$.*

**Case 2:** *If $\alpha \in (\hat{\alpha}_{\text{het}}, 1]$, there exists threshold $k(\alpha) \in \big(0, \overline{k}_{\text{het}}(\alpha)\big)$ such that $V_{\text{het}}(\alpha) < V_{\text{hom}}(\alpha)$ for all $k < k(\alpha)$ and $V_{\text{het}}(\alpha) \geq V_{\text{hom}}(\alpha)$ for all $k \geq k(\alpha)$, with strict inequality if $k \in (k(\alpha), \overline{k}_{\text{hom}}(\alpha))$*

In Appendix, we prove this proposition through three steps (lemmas). First, suppose $\alpha \in (1/2, \alpha_{\text{het}}]$. It is obvious from the definitions of the owner's expected profits that $V_{\text{hom}}(\alpha,k) > V_{\text{het}}(\alpha,k)$ holds for *all* $k > 0$. If the additional information is so uninformative that DM is non-reactive under either organization, the owner's optimal choice is the homogenous organization *irrespective of IM's incentive to gather information.* The owner prefers the homogenous organization for two reasons: (i) IM is more likely to implement the project; and (ii) he is more likely

[17] We relegate the exact formulas to Appendix A3.
[18] For example, if $\tilde{c}$ is uniformly distributed over $[0,1]$, $\hat{\Gamma} = \gamma^2$.

to obtain additional information. These advantages of the homogenous organization originate from DM's non-reactive decision to choose IM's favorite project.

Second, suppose the additional information obtained by IM is sufficiently informative: $\alpha \in (\alpha_{\text{hom}}, 1]$. DM then becomes reactive under both organizations. The difference in the owner's expected profit between heterogenous and homogeneous organizations is given by

$$\begin{aligned}\Delta_V^{\mathrm{R}}(\alpha,k) &\equiv V_{\text{het}}^{\mathrm{R}}(\alpha,k) - V_{\text{hom}}^{\mathrm{R}}(\alpha,k)\\ &= \frac{1}{2}\Delta_\pi^{\mathrm{R}}(\alpha,k)\left[\alpha F(\alpha b_H) + \alpha F(\alpha b_L) - F\left(\frac{b_H}{2}\right)\right]\\ &\quad - \frac{1}{2}(1-\pi_{\text{het}}^{\mathrm{R}}(\alpha,k))\left[F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right],\end{aligned} \tag{9}$$

where $\Delta_\pi^{\mathrm{R}}(\alpha,k) \equiv \pi_{\text{het}}^{\mathrm{R}}(\alpha,k) - \pi_{\text{hom}}^{\mathrm{R}}(\alpha,k)$. To understand the difference, first consider a hypothetical situation in which under either organization DM obtained additional information with the same, exogenously given probability $\pi$. Then the first term of $\Delta_V^{\mathrm{R}}(\alpha,k)$ would become zero and hence $\Delta_V^{\mathrm{R}}(\alpha,k) < 0$ unless $\pi = 1$: *the owner strictly prefers the homogeneous organization* because IM with no additional information is then more likely to implement the project selected by DM (project 1) than under the heterogenous organization.

A main feature of our model is that information acquisition is endogenously determined by IM's effort. Proposition 1 tells us that the ignorance-avoiding effect provides IM with a stronger incentive to gather information under the heterogenous organization than under the homogeneous organization. That is, $\Delta_\pi^{\mathrm{R}}(\alpha,k) \geq 0$ holds for all $\alpha \in (\alpha_{\text{hom}}, 1]$ and $k > 0$, and the inequality is strict for $(\alpha,k)$ satisfying $\pi_{\text{hom}}^{\mathrm{R}}(\alpha,k) < 1$ (or equivalently, $k < \overline{k}_{\text{hom}}(\alpha)$). Furthermore, both $\pi_{\text{het}}^{\mathrm{R}}(\alpha,k)$ and $\Delta_\pi^{\mathrm{R}}(\alpha,k)$ are increasing in $k$. Hence there exists a threshold of $k$ such that (a) if $k$ is smaller than the threshold, the stronger information-gathering incentive from heterogeneity does not overturn the implementation advantage of homogeneity; and (b) if $k$ is larger than the threshold, the stronger information-gathering incentive from heterogeneity benefits the owner so much that the heterogeneous organization is optimal.

The remaining case is $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$ in which while DM is reactive under heterogenous organization, she is non-reactive under homogeneous organization. The difference in the owner's expected profit is written as follows:

$$\begin{aligned}\Delta_V^{\mathrm{RN}}(\alpha,k) &\equiv V_{\text{het}}^{\mathrm{R}}(\alpha,k) - V_{\text{hom}}^{\mathrm{N}}(\alpha,k)\\ &= \frac{1}{2}\pi_{\text{het}}^{\mathrm{R}}(\alpha,k)\left[\alpha F(\alpha b_L) - (1-\alpha)F((1-\alpha)b_H) + F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right]\\ &\quad - \frac{1}{2}\left[F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right]\\ &\quad + \frac{1}{2}\left[\pi_{\text{het}}^{\mathrm{R}}(\alpha,k) - \pi_{\text{hom}}^{\mathrm{N}}(\alpha,k)\right]\left[\alpha F(\alpha b_H) + (1-\alpha)F((1-\alpha)b_H) - F\left(\frac{b_H}{2}\right)\right]\end{aligned} \tag{10}$$

Suppose first that the probability of obtaining additional information were exogenously given as $\pi$. If $\pi = 1$, then the last term is zero and hence which organization is optimal for the owner would be entirely determined by the sign of $\alpha F(\alpha b_L) - (1-\alpha)F((1-\alpha)b_H)$: the heterogenous organization has an advantage from DM's reactivity to signal $\sigma = 2$, while it has an disadvantage from IM's lower incentive to implement the unfavorite project under signal $\sigma = 1$. These effects cancel out at $\alpha = \hat{\alpha}$. Hence given $\pi = 1$, the owner would strictly prefer the heterogenous organization if $\alpha > \hat{\alpha}_{\text{het}} = \max\{\alpha_{\text{het}}, \hat{\alpha}\}$. If $\pi < 1$, however, the *homogeneous* organization is strictly preferred even at $\alpha = \hat{\alpha}_{\text{het}}$ because the reactivity advantage of the heterogenous organization is more than offset by the disadvantage due to its weaker implementation incentive under $\sigma = \phi$: the sum of the first two terms of (10) is negative.

Now return to our setting in which IM's information-gathering effort is endogenous and the heterogenous organization provides IM with stronger effort incentives. Then the fact that DM is non-reactive under the homogeneous organization for $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$ also affects IM's optimal information-gathering effort. This effect is captured in the first and third terms of (10), and they are strictly positive for $\alpha > \hat{\alpha}_{\text{het}}$. Since both $\pi^{\text{R}}_{\text{het}}(\alpha, k) - \pi^{\text{N}}_{\text{hom}}(\alpha, k)$ and $\pi^{\text{R}}_{\text{het}}(\alpha, k)$ are increasing in $k$, we can again show that there exists a threshold of $k$ such that the heterogeneous organization is optimal if and only if $k$ is equal to or above the threshold. This completes the intuitive explanation of Proposition 2.

Comparison with the related result of Landier et al. (2009) helps understand our result further. They show that the heterogeneous organization is strictly preferred by the owner to the homogenous organization if the informativeness of the signal satisfies $\alpha \in (\hat{\alpha}_{\text{het}}, \alpha_{\text{hom}})$, while the owner is indifferent between homogeneous and heterogenous organizations if the signal is sufficiently informative, that is, $\alpha \in [\alpha_{\text{hom}}, 1]$. In Landier et al. (2009), the additional information is always available ($\pi = 1$), and hence the advantage of the heterogenous organization is exclusively due to the fact that DM is more likely to react to additional information $\sigma = 2$ and select IM's favorite project 2.

Our result differs from theirs in two respects. First, in our model additional information is not always available ($\pi < 1$). As we have explained above, *this modification itself benefits the homogeneous organization* since IM without additional information is more motivated to implement his favorite project. As long as the probability of obtaining additional information is exogenously given, the homogenous organization is more likely to succeed than the heterogenous organization except for the extreme case of $\pi = 1$ where they are indifferent.

Our second, more fundamental extension is that IM engages in information-gathering activity and hence $\pi$ is determined endogenously. The heterogenous organization can then have an additional advantage from IM's stronger incentive to acquire information via the ignorance-avoiding effect when the additional signal is sufficiently informative, as shown in (9). Furthermore, the reactivity advantage of the heterogenous organization may also amplify IM's information-gathering incentive, as shown in (10).

Note, however, that IM's stronger information-gathering incentive does not always result in the optimality of heterogenous organization. Proposition 2 in fact shows that if $k$ is sufficiently small, the owner prefers the homogeneous organization *however informative the signal is.* And we show in Case 1 of Proposition 2 that if the informativeness of the signal is lower than $\alpha_{\text{het}}$, the homogeneous organization is optimal for *all* $k > 0$.

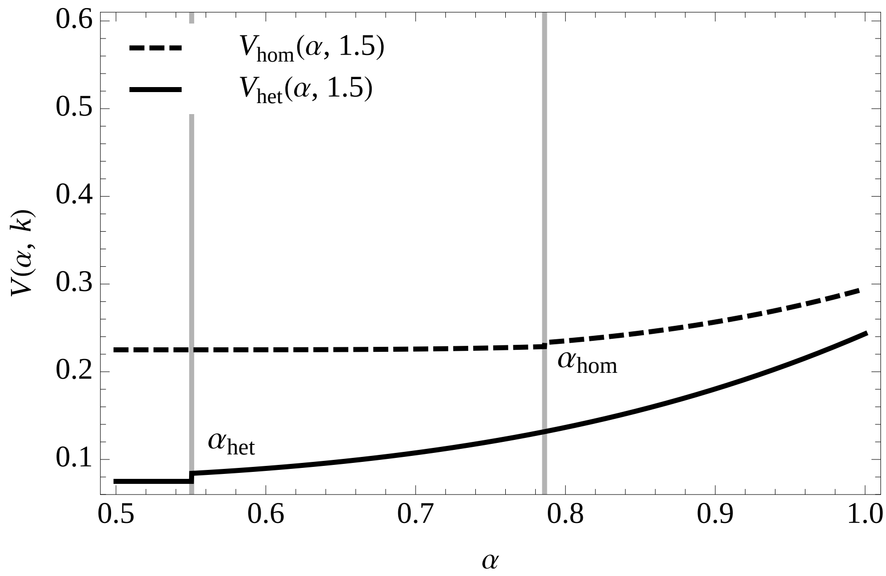
Based on Proposition 2, we can show that there exist two thresholds of $k$, *independent of* $\alpha$, such that if $k$ is below the smaller one of the thresholds, the homogeneous organization is optimal for *all* $\alpha \in (1/2, 1]$, while the heterogenous organization is optimal for *all* $\alpha \in (\hat{\alpha}_{\text{het}}, 1]$ if $k$ is above the larger one.

**Corollary 1.** *Under Assumptions 1–3, there exist thresholds* $\underline{k}$ *and* $\overline{k}$ *satisfying* $0 < \underline{k} < \overline{k} < \overline{k}_{\text{het}}(\hat{\alpha}_{\text{het}})$*, such that the optimal organization for the owner is given as follows.*

(a) *If* $k < \underline{k}$*, then* $V_{\text{het}}(\alpha, k) < V_{\text{hom}}(\alpha, k)$ *holds for all* $\alpha \in (1/2, 1)$*.*

(b) *If* $k > \overline{k}$*, then* $V_{\text{het}}(\alpha, k) \geq V_{\text{hom}}(\alpha, k)$ *holds for all* $\alpha \in (\hat{\alpha}_{\text{het}}, 1]$*. The inequality is strict if* $k \in (\overline{k}, \overline{k}_{\text{hom}}(\alpha))$*.*

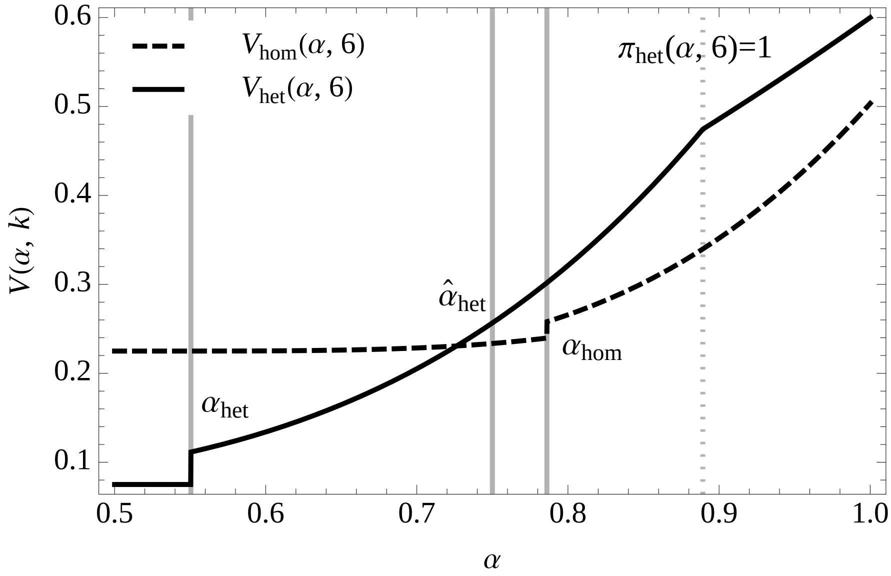
Figure 2: The Optimal Organization ($\Gamma < \hat{\Gamma}$, $k < \underline{k}$)




In the figure, we assume $\tilde{c}$ is uniformly distributed over $[0, 1]$, $b_L = B_L = 0.3$, $b_H = 0.9$, and $B_H = 1.35$. The cost parameter is set to $k = 1.5$.

Figure 2 depicts Corollary 1 (a), and Figures 3 and 4 depict Corollary 1 (b). The solid curve represents $V_{\text{het}}(\alpha, k)$ and the dashed curve $V_{\text{hom}}(\alpha, k)$. The parameter values are the same as those in Figure 1, except $k$ (Figure 2) and $B_H$ (Figure 4). In Figure 2, $k = 1.5 < \underline{k} \approx 2.2$, and thus the owner prefers the homogenous organization for all $\alpha \in (1/2, 1)$. In Figure 3, $k = 6 > \overline{k} \approx 5.2$ and $k = 6 < \overline{k}_{\text{hom}}(\alpha)$ for all $\alpha \in (\hat{\alpha}_{\text{het}}, 1]$. In Figure 4, $B_H$ is changed to $B_H = 6.6$ and hence $\Gamma = 22$. Then $\hat{\alpha}_{\text{het}} = \alpha_{\text{het}}$ holds. Since $k = 6 > \overline{k} \approx 5.85$, the heterogenous organization is *strictly* preferred to the homogeneous organization for all $\alpha \in (\alpha_{\text{het}}, 1]$.

Figure 3: The Optimal Organization ($\Gamma < \hat{\Gamma}$, $k > \overline{k}$)




In the figure, we assume $\tilde{c}$ is uniformly distributed over $[0, 1]$, $b_L = B_L = 0.3$, $b_H = 0.9$, and $B_H = 1.35$. The cost parameter is set to $k = 6$.

## 3.5 Complementarities

The analysis of the optimal organization in the previous subsection suggests that the heterogenous organization is more likely to be optimal as *both* $\alpha$ and $k$ are sufficiently high. In fact, we can show the following result.

**Proposition 3.** *Suppose Assumptions 1–3 are satisfied.*

(a) $V_{\text{hom}}(\alpha, k)$ *exhibits increasing differences in* $(\alpha, k)$ *if* $\alpha > \max\{\alpha_{\text{het}}, \alpha_\gamma\}$.

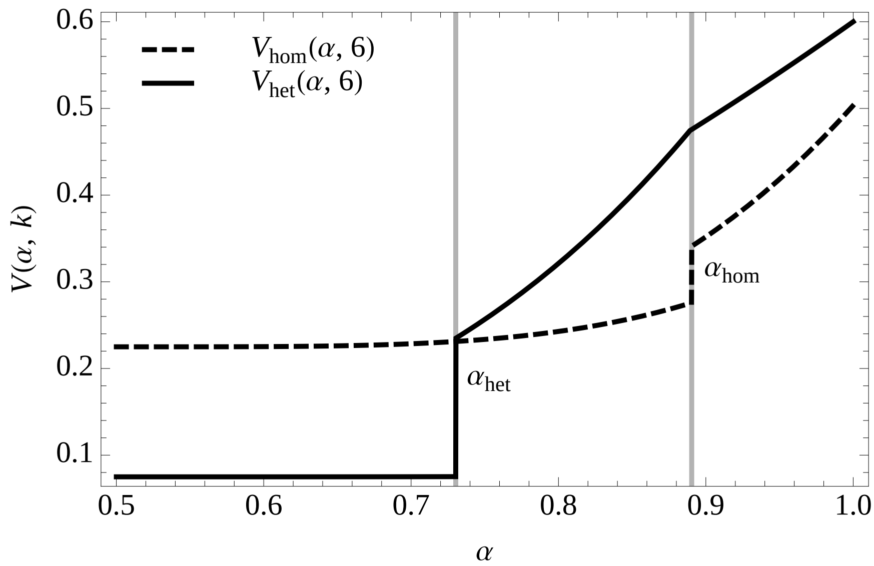
(b) $V_{\text{het}}(\alpha, k)$ *exhibits increasing differences in* $(\alpha, k)$.

(c) $V_{\text{het}}(\alpha, k) - V_{\text{hom}}(\alpha, k)$ *is increasing in* $(\alpha, k)$ *if* $\alpha > \alpha_{\text{het}}$ *and* $k < \overline{k}^{\text{R}}_{\text{het}}(\alpha)$.

Proposition 3 (a) and (b) imply that under either organization, decreasing IM's marginal cost of information acquisition (e.g., investing more in IT, granting IM more discretion over his time use, and so on) improves the performance of the organization more as additional signal is more informative (e.g., more training in human capital, higher knowledge in relevant technology and environments, and so on). These results are consistent with existing empirical evidence (Ennen and Richter, 2010; Brynjolfsson and Milgrom, 2012).

Furthermore, Proposition 3 (c) shows that, as we suggested in the previous subsection, the lower IM's marginal cost is or/and the more informative the signal is, the more performance improvement a change from homogeneous to heterogenous organization brings about. We are

Figure 4: The Optimal Organization ($\Gamma > \hat{\Gamma}$, $k > \overline{k}$)




In the figure, we assume $\tilde{c}$ is uniformly distributed over $[0, 1]$, $b_L = B_L = 0.3$, $b_H = 0.9$, and $B_H = 6.6$. The cost parameter is set to $k = 6$.

currently unaware of any empirical analysis studying the relationship between preference diversity in organizations and other organizational practices. Our analysis contributes to the empirical literature on complementarities by offering new testable predictions.

# 4 Discussions

In this section we discuss our results by modifying some of our settings and assumptions. The formal analysis is relegated to Online Appendix (in preparation). In Subsection 4.1 we argue that if Assumption 1 does not hold, the heterogenous organization no longer enjoys its main advantage that IM is more motivated to gather additional information. In particular, if Assumption 2 fails to hold as well (e.g., $\tilde{c}$ is uniformly distributed), IM's optimal effort under heterogenous organization is *never* higher than that under homogeneous organization.

In Subsection 4.2, we modify the decision process such that it is DM who exerts a information-gathering effort, before choosing a project. Then we argue that the relative advantage of the heterogenous organization over the homogeneous organization in terms of information acquisition is smaller than when DM engages in gathering additional information. In particular, if $\tilde{c}$ is uniformly distributed and DM's bias is sufficiently large, IM's optimal effort under homogeneous organization is higher than that under heterogeneous organization. This suggests that preference diversity is more likely to enjoy information acquisition and benefits the organization if the agent who implements the decision also engages in gathering information.

## 4.1 Less Biased Decision Maker

In the main analysis we makes Assumption 1 that implies DM's bias is sufficiently high and hence without additional information DM's optimal project choice is her favorite project 1 under heterogenous organization, as well as Assumption 2 that states directly that DM's bias is equal to or higher than IM's bias. In this subsection, we instead assume neither Assumption 1 nor Assumption 2 holds: $\Gamma < \min\{F(b_H/2)/F(b_L/2), \gamma\}$.[19] Under this alternative assumption, DM's optimal project choice and IM's optimal information-gathering effort under the homogeneous organization are the same as those in the previous section, and hence we focus on the heterogenous organization.

Since IM is relatively more biased, DM, observing $\sigma = \phi$, chooses IM's favorite project 2 in order to boost his implementation motivation. Furthermore, if the informativeness of the signal $\alpha$ is not sufficiently high, DM chooses project 2 even after observing $\sigma = 1$. We can show there exists $\breve{\alpha}_{\text{het}} \in (1/2, \alpha_{\text{hom}})$ such that DM's optimal choice after observing $\sigma = 1$ is project 2 if $\alpha < \breve{\alpha}_{\text{het}}$, and project 1 if $\alpha \geq \breve{\alpha}_{\text{het}}$. If $\sigma = 2$, DM always reacts and chooses project 2 since it is more likely to be implemented and succeed.

The optimal project choice is thus summarized as follows. If the informativeness of the additional signal is low ($\alpha < \breve{\alpha}_{\text{het}}$), DM is non-reactive under either organization and chooses project 1 under homogeneous organization and project 2 under heterogenous organization. If the informativeness is intermediate ($\breve{\alpha}_{\text{het}} \leq \alpha \leq \alpha_{\text{hom}}$), DM is again non-reactive under homogeneous organization. Under heterogenous organization, she is reactive. Finally, if the informativeness is sufficiently high ($\alpha > \alpha_{\text{hom}}$), DM is reactive under either organization. However, note that without additional information she chooses project 1 under homogeneous organization and project 2 under heterogenous organization.

Now consider IM's information-gathering effort under heterogenous organization. Since IM can implement his favorite project even without additional information, there is no longer the ignorance-avoiding effect and IM's incentive to acquire information is attenuated relative to that in the previous analysis. In fact, we can show that *IM's optimal effort under heterogenous organization is never higher than that under homogeneous organization.* Specifically, the optimal information-gathering effort is equal between two organizations when DM is either non-reactive under both organizations or reactive under both. And when DM is reactive only under heterogenous organization, IM's optimal effort is *lower* under heterogenous organization. Intuitively, while DM chooses a project less successful but favorite to IM under homogeneous organization and $\sigma = 2$, she chooses a project more successful but unfavorite to IM under heterogenous organization and $\sigma = 1$. Since IM's bias is high, the fact that his unfavorite project may be chosen works crucially against his incentive to gather additional information under heterogenous organization.

[19] In Online Appendix we also study the case in which Assumption 1 does not hold but Assumption 2 is satisfied.

### 4.2 Information Acquisition by the Decision Maker

Our results in the previous section show that the heterogenous organization benefits the owner mainly because additional information is more likely to acquired. We argue that an important reason for this benefit from preference diversity to realize is that it is IM who engages in gathering information. To this purpose, we instead assume DM chooses a costly effort to gather additional information before choosing a project. Note that IM's implementation decision and DM's project choice are not affected by this modification.

If $\tilde{c}$ is uniformly distributed and DM's bias is sufficiently large, IM's optimal effort under homogeneous organization is always higher than that under heterogeneous organization. The main reason DM's incentive for information acquisition is undermined under heterogenous organization is that the signal good for her favorite project ($\sigma = 1$) is bad for IM's implementation incentive (his unfavorite project will be implemented) and hence results in the probability of implementation lower than signal $\sigma = 2$. This misalignment does not arise under homogeneous organization where IM's favorite project will be implemented under signal $\sigma = 1$. And if it is IM who engages in information acquisition as in our previous analysis, this misalignment results not under heterogeneous organization but under homogeneous organization.

## 5 Information Manipulation

So far we have analyze the model by assuming that signal $\sigma$ is observable to both DM and IM. In this section, we assume that the signal is IM's private information and examine whether or not IM reports it truthfully. We denote IM's reported message by $\tilde{\sigma}$. We further assume that signal $\sigma$ is *soft information*, so that for each signal $\sigma \in \{\phi, 1, 2\}$, IM can report any element of $\{\phi, 1, 2\}$.[20]

Our main concern is whether or not there is an equilibrium in which IM reports the signal truthfully. We call such an equilibrium a *full communication equilibrium*: In a full communication equilibrium, IM reports $\tilde{\sigma} = \sigma$ for all $\sigma \in \{\phi, 1, 2\}$, and DM chooses an optimal project $d_h^*(\sigma)$ for $\sigma \in \{\phi, 1, 2\}$, where $h \in \{\text{hom}, \text{het}\}$. If a full communication equilibrium exists, our results under the assumption of symmetric information do not change.

Note that if DM is non-reactive, IM has obviously no incentive to manipulate information and hence a full communication equilibrium exists under either organization. Our analysis below thus focuses mostly on the case in which DM is reactive.

First, consider the homogeneous organization and suppose DM is reactive ($\alpha > \alpha_{\text{hom}}$). Since IM's favorite project is 1, he has no incentive to deviate from truthful revelation when $\sigma \in \{\phi, 1\}$. If $\sigma = 2$, IM can report $\tilde{\sigma} \in \{\phi, 1\}$ so as to induce DM to choose the favorite project 1. IM

[20] If signal $\sigma$ is *hard information*, that is, if IM can conceal the evidence of the signal but cannot make up false evidence ($\tilde{\sigma} \in \{\sigma, \phi\}$), it is easy to show that under either organization, truth-telling is a best response to DM's optimal project choice given DM's belief that IM reports the true signal. Hence our previous analysis applies.

reports truthfully ($\tilde{\sigma} = \sigma = 2$) if

$$\alpha F(\alpha b_L) b_L > (1-\alpha) F((1-\alpha) b_H) b_H \tag{11}$$

holds, which is equivalent to $\alpha > \alpha_\gamma$. This condition is satisfied under Assumption 2 since $\alpha_\gamma \leq \alpha_{\text{hom}}$ holds. Therefore, a full communication equilibrium exists for all $\alpha \in (1/2, 1)$ under the homogeneous organization.

Next, consider the heterogenous organization. We show that it is optimal for IM to report the signal truthfully only if either (i) DM is non-reactive or (ii) DM is reactive but the signal is so informative and the marginal cost of information acquisition is so low that $\pi^{\text{R}}_{\text{het}}(\alpha, k) = \pi^{\text{R}}_{\text{hom}}(\alpha, k) = 1$ holds. A full communication equilibrium fails to exist if DM is reactive ($\alpha > \alpha_{\text{het}}$) but the signal is not sufficiently informative ($\alpha \leq \alpha_\gamma$) or IM's optimal information-gathering effort is less than one.

Suppose that $\alpha > \alpha_{\text{het}}$, and DM expects IM to choose $\pi$ and report truthfully. Since IM's favorite project is 2, he chooses to report truthfully when $\sigma = 2$ is observed. If IM observes $\sigma = 1$, he does not deviate from reporting truthfully if $\alpha > \alpha_\gamma$ holds, for the same reason as IM, if he favored project 1 and observed $\sigma = 2$, would report truthfully.

When IM observes $\sigma = \phi$, reporting honestly leads DM to choose IM's unfavorite project 1. His expected benefit is $(1/2)F(b_L/2)b_L$. If he instead reports $\tilde{\sigma} = 2$, DM chooses his favorite project 2 and his expected benefit is $(1/2)F(b_H/2)b_H$. IM thus prefers to deviate from truthful revelation. Hence for a full communication equilibrium to exist, $\sigma = \phi$ cannot occur with a positive probability. In other words, IM's optimal effort choice must be $\pi = \pi^{\text{R}}_{\text{het}}(\alpha, k) = 1$. This is equivalent to $k \geq \overline{k}^{\text{R}}_{\text{het}}(\alpha)$.

Furthermore, $\pi^{\text{R}}_{\text{hom}}(\alpha, k) = 1$ must hold as well; otherwise, IM would prefer to deviate to some $\pi < 1$. To see this, suppose IM deviates from $\pi^{\text{R}}_{\text{het}}(\alpha, k) = 1$ to some $\pi < 1$. Then the best he can do, after obtaining $\sigma = \phi$, is to report $\tilde{\sigma} = 2$ to induce DM to choose his favorite project 2. He does not deviate to $\pi$ if

$$\frac{1}{2}\left[K(\alpha b_L) + K(\alpha b_H)\right] - \eta(1; k) \geq \frac{\pi}{2}\left[K(\alpha b_L) + K(\alpha b_H)\right] + (1-\pi) K\left(\frac{b_H}{2}\right) - \eta(\pi; k)$$

for all $\pi$. Since the right-hand side is maximized at $\pi = \pi^{\text{R}}_{\text{hom}}(\alpha, k)$, the existence of full communication equilibrium requires $\pi^{\text{R}}_{\text{hom}}(\alpha, k) = 1$. This is equivalent to $k \geq \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$.

Since $\overline{k}^{\text{R}}_{\text{hom}}(\alpha) > \overline{k}^{\text{R}}_{\text{het}}(\alpha)$ holds, the discussion given above concerning the existence of full communication equilibrium can be summarized as follows.

**Proposition 4.** *Suppose signal $\sigma$ is IM's private and soft information, and Assumptions 1–3 hold. Then* (a) *under the homogeneous organization, there exists a full communication equilibrium for all $\alpha \in (1/2, 1)$ and $k > 0$; and* (b) *under the heterogeneous organization, a full communication equilibrium exists if and only if either* (i) *DM is non-reactive ($\alpha \leq \alpha_{\text{het}}$), or* (ii) *$\alpha > \tilde{\alpha}_{\text{het}} \equiv \max\{\alpha_{\text{het}}, \alpha_\gamma\}$ and $k \geq \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$ hold.*

### Partial Communication Equilibrium

When no full communication equilibrium exists under the heterogenous organization with reactive DM, we consider the following *partial communication equilibrium*:

- IM reports $\tilde{\sigma} = 1$ when he observes $\sigma = 1$.
- IM reports $\tilde{\sigma} = 2$ when he observes $\sigma \in \{\phi, 2\}$.
- DM chooses $d^*_{\text{het}}(\tilde{\sigma}) = \tilde{\sigma}$ for $\tilde{\sigma} \in \{1, 2\}$.
- DM chooses $d^*_{\text{het}}(\phi) = 1$ with some consistent off-the-equilibrium beliefs.

We obtain conditions for each of IM and DM not to deviate from the specified strategies under the heterogeneous organization. The following proposition summarizes the conditions.[21]

**Proposition 5.** *Suppose signal $\sigma$ is IM's private and soft information, and Assumptions 1–3 hold. A partial communication equilibrium exists under the heterogenous organization if and only if either* (i) *DM is non-reactive ($\alpha \leq \alpha_{\text{het}}$) or* (ii) *$\alpha > \tilde{\alpha}_{\text{het}}$, $k < \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$, and $\Gamma < \tilde{\Gamma}(\alpha, k)$ hold, where $\tilde{\Gamma}(\alpha, k) > 1$ is an upper bound of DM's bias $\Gamma$ and is increasing in $\alpha$ and $k$.*

A partial communication equilibrium does not exist if DM's bias is so high that it is optimal for her to choose her favorite project 1 even after receiving IM's report $\tilde{\sigma} = 2$. This condition determines the upper bound $\tilde{\Gamma}(\alpha, k)$. It also fails to exist if $\alpha \in (\alpha_{\text{het}}, \alpha_\gamma]$, since the informativeness of additional information is so low that IM prefers to report $\tilde{\sigma} = 2$ when project 1 is more likely to succeed. Thus if $\alpha_\gamma$ is above $\alpha_{\text{het}}$ (and hence $\tilde{\alpha}_{\text{het}} = \alpha_\gamma$), there is a range of informativeness $(\alpha_{\text{het}}, \alpha_\gamma]$ in which neither full nor partial communication equilibrium exists under the heterogenous organization, despite its reactivity advantage.[22] Then only a "babbling equilibrium" exists in which IM sends a same report irrespective of the signal, and hence DM simply chooses her favorite project 1. DM is hence non-reactive for $\alpha \in (\alpha_{\text{het}}, \alpha_\gamma]$ under the heterogenous organization. Note, however, that as we have explained before, IM still has an incentive to choose a positive effort $\pi^{\text{N}}_{\text{het}}(\alpha, k) > 0$ in this region.

### Comparison

To compare between homogeneous and heterogenous organizations, we focus on most informative equilibrium, which is the full communication equilibrium for all $\alpha \in (1/2, 1)$ under homogenous organization. Under heterogenous organization, DM is non-reactive for $\alpha \leq \tilde{\alpha}_{\text{het}}$, and hence whether communication is full or partial or uninformative does not matter. For $\alpha > \tilde{\alpha}_{\text{het}}$, we assume $\Gamma < \tilde{\Gamma}(\alpha, k)$ and consider the partial communication equilibrium. Then

[21] Note that if $k \geq \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$, then IM never observes $\sigma = \phi$. The partial communication equilibrium specified above is then identical to the full communication equilibrium. In the proof, we show that if $k \geq \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$, the condition on $\Gamma$ is always satisfied for $\alpha > \tilde{\alpha}_{\text{het}}$

[22] By (6), $\alpha_\gamma > \alpha_{\text{het}}$ is equivalent to $\Gamma < \Gamma_\gamma$, and it is easy to show $\Gamma_\gamma > \tilde{\Gamma}(\alpha_\gamma, k)$. Hence $\alpha_\gamma > \alpha_{\text{het}}$ and $\Gamma < \tilde{\Gamma}(\alpha_\gamma, k)$ are compatible.

IM's optimal information-gathering effort under the heterogeneous organization becomes as follows.

$$\tilde{\pi}_{\text{het}}(\alpha,k)=\begin{cases}\pi^{\text{N}}_{\text{het}}(\alpha,k) & \text{if } \alpha\in(1/2,\tilde{\alpha}_{\text{het}}]\\ \pi^{\text{R}}_{\text{hom}}(\alpha,k) & \text{if } \alpha\in(\tilde{\alpha}_{\text{het}},1]\end{cases}$$

By comparing with the optimal effort under heterogenous organization with symmetric information reported in Proposition 1, we find IM's incentive to acquire information under heterogeneous organization is weaker under asymmetric information than under symmetric information for two reasons. First, since $\tilde{\alpha}_{\text{het}}\geq\alpha_{\text{het}}$, IM's incentive to implement his favorite project by misreporting $\sigma=1$ may enlarge the range of $\alpha$ in which DM acts non-reactively under heterogenous organization (Case 1). Second, the ignorance-avoiding effect no longer exists, and hence $\tilde{\pi}_{\text{het}}(\alpha,k)=\pi^{\text{R}}_{\text{hom}}(\alpha,k)<\pi^{\text{R}}_{\text{het}}(\alpha,k)$ for $\alpha>\tilde{\alpha}_{\text{het}}$.

The comparison of IM's incentive to acquire information under two organizations also changes for these two reasons, as reported in Proposition 6 below. We focus on the case in which $\tilde{\alpha}_{\text{het}}=\alpha_\gamma>\alpha_{\text{het}}$ (equivalently $\Gamma<\Gamma_\gamma$)[23] and thus assume $\Gamma\leq\tilde{\Gamma}(\alpha_\gamma,k)$.

**Proposition 6.** *Suppose signal $\sigma$ is IM's private and soft information, and $\Gamma\leq\tilde{\Gamma}(\alpha_\gamma,k)$ as well as Assumptions 1–3 holds. IM's optimal information-gathering effort differs as follows.*

**Case 1:** *If $\alpha\in(1/2,\alpha_\gamma]$, then $\pi_{\text{hom}}(\alpha,k)\geq\tilde{\pi}_{\text{het}}(\alpha,k)$ holds. The inequality is strict if $k<\overline{k}^{\text{N}}_{\text{het}}(\alpha)$: IM is more likely to obtain information under the homogeneous organization than under the heterogeneous organization.*

**Case 2:** *If $\alpha\in(\alpha_\gamma,\alpha_{\text{hom}}]$, then $\pi_{\text{hom}}(\alpha,k)\leq\tilde{\pi}_{\text{het}}(\alpha,k)$ holds. The inequality is strict if $k<\overline{k}^{\text{N}}_{\text{hom}}(\alpha)$: IM is more likely to obtain information under the heterogeneous organization than under the homogeneous organization.*

**Case 3:** *If $\alpha\in(\alpha_{\text{hom}},1]$, then $\pi_{\text{hom}}(\alpha,k)=\tilde{\pi}_{\text{het}}(\alpha,k)$ holds.*

The immediate consequence from the fact that the ignorance-avoiding effect no longer exists is that if the signal is sufficiently important (Case 3), there is no difference in IM's optimal effort between two organizations. The advantage of the heterogenous organization in terms of IM's effort incentive survives, however, when DM is not reactive under the homogeneous organization but reactive under the heterogenous organization (Case 2): This difference in reactivity in turn affects IM's optimal information-gathering effort. Remember that the difference in the marginal benefit from acquiring information consisted of three effects in (5). Although there is no ignorance-avoiding effect, the other two effects are still at work. And as we have explained, the sum of the latter two effects is positive for $\alpha>\alpha_\gamma$ as in Case 2.

We finally compare the owner's expected profit between homogeneous and heterogenous organizations. The expected profit to the owner under the heterogenous organization is equal

[23]If instead $\alpha_{\text{het}}>\alpha_\gamma$, then both $\Gamma>\Gamma_\gamma$ and $\Gamma<\tilde{\Gamma}(\alpha,k)$ must be satisfied. Such a $\Gamma$ does not always exist, however, for $\alpha>\alpha_{\text{het}}$ since $\tilde{\Gamma}(\alpha_{\text{het}},k)=F(b_H/2)/F(b_L/2)<\Gamma_\gamma$. In this case, we need an additional assumption on the region of $\alpha$ to guarantee that the two conditions are satisfied.

to

$$\tilde{V}_{\text{het}}(\alpha,k) = \begin{cases} V^{\text{N}}_{\text{het}}(\alpha,k) & \text{if } \alpha \in (1/2, \tilde{\alpha}_{\text{het}}] \\ V^{\text{R}}_{\text{hom}}(\alpha,k) & \text{if } \alpha \in (\tilde{\alpha}_{\text{het}}, 1]. \end{cases}$$

We then obtain the following result.

**Proposition 7.** *Suppose signal $\sigma$ is IM's private and soft information, and $\Gamma \leq \tilde{\Gamma}(\alpha_\gamma, k)$ as well as Assumptions 1–3 holds. Then the optimal organization for the owner is given as follows.*

*(a) If $\alpha \in (1/2, \alpha_\gamma]$, then $\tilde{V}_{\text{het}}(\alpha,k) < V_{\text{hom}}(\alpha,k)$ holds for all $k > 0$.*

*(b) If $\alpha \in (\alpha_\gamma, \alpha_{\text{hom}}]$, then $\tilde{V}_{\text{het}}(\alpha,k) > V_{\text{hom}}(\alpha,k)$ holds for all $k > 0$.*

*(c) If $\alpha \in (\alpha_{\text{hom}}, 1]$, then $\tilde{V}_{\text{het}}(\alpha,k) = V_{\text{hom}}(\alpha,k)$ holds for all $k > 0$.*

The possibility of IM's manipulation of his private information generally hurts the heterogeneous organization. First, DM becomes non-reactive for $\alpha \in (\alpha_{\text{het}}, \alpha_\gamma]$ where additional information were important enough to make her reactive in the case of symmetric information. Hence the homogenous organization is more likely to be optimal when the informativeness of the signal is low (Proposition 7 (a)). Second, IM's incentive to gather information is weaker, due to the lack of the ignorance-avoiding effect, and hence the owner never strictly prefers the heterogenous organization even though both $\alpha$ and $k$ are very high (Proposition 7 (c)).

However, the lack of the ignorance-avoiding effect can benefit the heterogenous organization *when $k$ is small*. IM can induce DM to choose his favorite project 2 under no additional information, and hence he is more likely to implement the project than when information is symmetric and DM chooses project 1 under no additional information. This new positive effect eliminates the advantage of homogeneous organization under $k < k(\alpha)$, and hence the heterogenous organization is strictly preferred to the homogeneous organization for *all* $k > 0$ when the informativeness of the signal is intermediate, as in Case (b). Note that this result favoring heterogenous organization under information manipulation is in part due to an artifact of our assumption that the owner is indifferent between two projects under no additional information.

The vulnerability of heterogenous organization to the manipulation of soft information is in contrast to the result of Landier et al. (2009). In their model, it is DM who always observes an informative signal privately without any cost. DM's project choice thus serves as a costly signaling device and the heterogeneous organization makes the project choice more informative about the true state. Hence private information benefits heterogenous organization. In our model, it is IM who chooses costly information-acquisition effort and is privately known about the signal. Then heterogenous organization is less beneficial to the owner under private information than under symmetric information because the possibility of information manipulation by IM attenuates his effort incentive to gather additional information.

## 6 Concluding Remarks

We have analyzed a decision process of two-member organization with two main features that are studied separately in existing literature: (a) separation of project choice by a decision maker and costly implementation by an implementer; and (b) costly information acquisition by the implementer. We have shown that when additional information is symmetrically observed, preference diversity between the decision maker and the implementer can be optimal because (i) the decision maker is more likely to react to additional information (ii) the implementer is also more motivated to acquire information to avoid being uninformative of the true state, and (iii) the reactivity advantage may reinforce the implementer's incentive to gather information. If additional information is the implementer's private and soft information, the second advantage due to the "ignorance-avoiding" effect no longer exists, and hence preference diversity is in general less likely to be optimal than under the symmetrically informed case.

A testable hypothesis obtained from our analysis is that choice of organization with preference diversity tends to be observed together with training in human capital, use of information technology, and information sharing or "transparency" of organizations, in particular, when information acquisition by lower-tier members is crucially important for decision making. Whether or not there is diversity in preferences among members, organizational investments in information acquisition such as information technology and human knowledge are obviously important. However, our analysis reveals that such investments are more important for organizations with preference diversity. Furthermore, only the performance of the heterogenous organization improves by making additional soft information symmetrically observed rather than privately known by implementers.

Our results in fact imply that these organizational practices exhibit complementarities. While there is ample evidence of complementarities (Ennen and Richter, 2010; Brynjolfsson and Milgrom, 2012), in particular, between information technology usage and human skills (see Bresnahan et al., 2002, among others), and between skills training and information sharing (see Ichniowski et al., 1997, among others), we are unaware of any empirical research studying complementarities among organizational elements including preference diversity, partly because of various difficulties defining and measuring diversity (Harrison and Klein, 2007). We hope our theoretical results will contribute to our further understandings of organizational complementarity by stimulating future empirical research.

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# Appendix

## A1 Proof of Lemma 2

We first show $\alpha_{\text{hom}} \geq \alpha_\gamma \equiv \gamma/(1+\gamma)$, where $\alpha_\gamma \in (1/2, 1)$ is the solution to $\alpha b_L = (1-\alpha)b_H$. By the definition of $\alpha_{\text{hom}}$, the claim is true if

$$\alpha_\gamma \leq (1-\alpha_\gamma)\Gamma,$$

which is equivalent to $\Gamma \geq \gamma$, that is, Assumption 2.

Now for all $\alpha > \alpha_{\text{hom}} \geq \alpha_\gamma$,

$$\frac{1}{2}K(\alpha b_H) + \frac{1}{2}K(\alpha b_L) - K\left(\frac{b_H}{2}\right) > \frac{1}{2}K(\alpha b_H) + \frac{1}{2}K((1-\alpha)b_H) - K\left(\frac{b_H}{2}\right) > 0,$$

by the convexity of $K(\cdot)$, which completes the proof.

## A2 Proof of Proposition 1

First suppose $\alpha \leq \alpha_{\text{het}}$ so that DM is non-reactive under either organization. In this case, the only difference between $\pi^{\text{N}}_{\text{hom}}(\alpha, k)$ and $\pi^{\text{N}}_{\text{het}}(\alpha, k)$ is in IM's private benefit $b$. For $b \in \{b_L, b_H\}$,

$$\begin{aligned}
&\frac{\partial}{\partial b}\left(\frac{1}{2}K(\alpha b) + \frac{1}{2}K((1-\alpha)b) - K\left(\frac{b}{2}\right)\right) \\
&= \frac{1}{2}\left[\alpha F(\alpha b) + (1-\alpha)F((1-\alpha)b) - F\left(\frac{b}{2}\right)\right] \\
&> 0
\end{aligned}$$

holds for $\alpha > 1/2$ because $\alpha F(\alpha b) + (1-\alpha)F((1-\alpha)b) - F(b/2)$ is strictly increasing in $\alpha$ by Assumption 3. Hence $\pi^{\text{N}}_{\text{hom}}(\alpha, k) \geq \pi^{\text{N}}_{\text{het}}(\alpha, k)$ holds, with strict inequality if $\pi^{\text{N}}_{\text{het}}(\alpha, k) < 1$, which is equivalent to $k < \overline{k}^{\text{N}}_{\text{het}}(\alpha)$.

Second suppose $\alpha > \alpha_{\text{hom}}$. From the definitions, it is easy to see $\pi^{\text{R}}_{\text{het}}(\alpha, k) \geq \pi^{\text{R}}_{\text{hom}}(\alpha, k)$ holds, with strict inequality if $\pi^{\text{R}}_{\text{hom}}(\alpha, k) < 1$, which is equivalent to $k < \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$.

Finally, suppose $\alpha_{\text{het}} < \alpha \leq \alpha_{\text{hom}}$. The relevant comparison is then between $\pi^{\text{N}}_{\text{hom}}(\alpha, k)$ and $\pi^{\text{R}}_{\text{het}}(\alpha, k)$. Suppose $\pi^{\text{R}}_{\text{het}}(\alpha, k) < 1$ and $\pi^{\text{N}}_{\text{hom}}(\alpha, k) < 1$. Then the sign of $\pi^{\text{R}}_{\text{het}}(\alpha, k) - \pi^{\text{N}}_{\text{hom}}(\alpha, k)$ is equal to that of

$$
\begin{aligned}
&\left[\frac{1}{2}K(\alpha b_L) - K\left(\frac{b_L}{2}\right)\right] - \left[\frac{1}{2}K((1-\alpha)b_H) - K\left(\frac{b_H}{2}\right)\right] \\
&\quad > \frac{1}{2}K\left(\frac{b_L}{2}\right) - \frac{1}{2}K\left(\frac{b_H}{2}\right) + K\left(\frac{b_H}{2}\right) - K\left(\frac{b_L}{2}\right) = \frac{1}{2}\left[K\left(\frac{b_H}{2}\right) - K\left(\frac{b_L}{2}\right)\right] > 0,
\end{aligned}
$$

and hence $\pi^{\text{R}}_{\text{het}}(\alpha, k) \geq \pi^{\text{N}}_{\text{hom}}(\alpha, k)$ holds, with strict inequality if $k < \overline{k}^{\text{N}}_{\text{hom}}(\alpha)$. This completes the proof.

## A3 Proof of Proposition 2

The exact formulas of $V_{\text{hom}}(\alpha, k)$ and $V_{\text{het}}(\alpha, k)$, the success probability of homogeneous organization and heterogenous organization, respectively, are given as follows:

$$
\begin{aligned}
&V_{\text{hom}}(\alpha, k) \\
&\quad = \begin{cases} V^{\text{N}}_{\text{hom}}(\alpha, k) & \text{if } \alpha \leq \alpha_{\text{hom}} \\ V^{\text{R}}_{\text{hom}}(\alpha, k) & \text{if } \alpha > \alpha_{\text{hom}} \end{cases} \\
&\quad = \begin{cases} \pi^{\text{N}}_{\text{hom}}(\alpha, k)\frac{1}{2}\left[p(b_H, 1, \sigma = 1) + p(b_H, 1, \sigma = 2)\right] + (1 - \pi^{\text{N}}_{\text{hom}}(\alpha, k))p(b_H, 1, \sigma = \phi) & \text{if } \alpha \leq \alpha_{\text{hom}} \\ \pi^{\text{R}}_{\text{hom}}(\alpha, k)\frac{1}{2}\left[p(b_H, 1, \sigma = 1) + p(b_L, 2, \sigma = 2)\right] + (1 - \pi^{\text{R}}_{\text{hom}}(\alpha, k))p(b_H, 1, \sigma = \phi) & \text{if } \alpha > \alpha_{\text{hom}} \end{cases} \\
&\quad = \begin{cases} \frac{1}{2}\left(F\left(\frac{b_H}{2}\right) + \pi^{\text{N}}_{\text{hom}}(\alpha, k)\left[\alpha F(\alpha b_H) + (1-\alpha)F((1-\alpha)b_H) - F\left(\frac{b_H}{2}\right)\right]\right) & \text{if } \alpha \leq \alpha_{\text{hom}} \\ \frac{1}{2}\left(F\left(\frac{b_H}{2}\right) + \pi^{\text{R}}_{\text{hom}}(\alpha, k)\left[\alpha F(\alpha b_H) + \alpha F(\alpha b_L) - F\left(\frac{b_H}{2}\right)\right]\right) & \text{if } \alpha > \alpha_{\text{hom}} \end{cases}
\end{aligned}
$$

$$
\begin{aligned}
&V_{\text{het}}(\alpha, k) \\
&\quad = \begin{cases} V^{\text{N}}_{\text{het}}(\alpha, k) & \text{if } \alpha \leq \alpha_{\text{het}} \\ V^{\text{R}}_{\text{het}}(\alpha, k) & \text{if } \alpha > \alpha_{\text{het}} \end{cases} \\
&\quad = \begin{cases} \pi^{\text{N}}_{\text{het}}(\alpha, k)\frac{1}{2}\left[p(b_L, 1, \sigma = 1) + p(b_L, 1, \sigma = 2)\right] + (1 - \pi^{\text{N}}_{\text{het}}(\alpha, k))p(b_L, 1, \sigma = \phi) & \text{if } \alpha \leq \alpha_{\text{het}} \\ \pi^{\text{R}}_{\text{het}}(\alpha, k)\frac{1}{2}\left[p(b_L, 1, \sigma = 1) + p(b_H, 2, \sigma = 2)\right] + (1 - \pi^{\text{R}}_{\text{het}}(\alpha, k))p(b_L, 1, \sigma = \phi) & \text{if } \alpha > \alpha_{\text{het}} \end{cases} \\
&\quad = \begin{cases} \frac{1}{2}\left(F\left(\frac{b_L}{2}\right) + \pi^{\text{N}}_{\text{het}}(\alpha, k)\left[\alpha F(\alpha b_L) + (1-\alpha)F((1-\alpha)b_L) - F\left(\frac{b_L}{2}\right)\right]\right) & \text{if } \alpha \leq \alpha_{\text{het}} \\ \frac{1}{2}\left(F\left(\frac{b_L}{2}\right) + \pi^{\text{R}}_{\text{het}}(\alpha, k)\left[\alpha F(\alpha b_L) + \alpha F(\alpha b_H) - F\left(\frac{b_L}{2}\right)\right]\right) & \text{if } \alpha > \alpha_{\text{het}} \end{cases}
\end{aligned}
$$

The proof consists of three lemmas.

**Lemma A1.** *Under Assumptions 1–3,* $V_{\text{het}}(\alpha, k) < V_{\text{hom}}(\alpha, k)$ *for all* $\alpha \in (1/2, \alpha_{\text{het}}]$ *and* $k > 0$

*Proof.* Obvious from the definitions of the owner's expected profits. This proves Case 1 of Proposition 2. $\square$

**Lemma A2.** *Suppose Assumptions 1–3 and $\alpha \in (\alpha_{\text{hom}}, 1]$. There exists $k(\alpha) \in (0, \overline{k}^{\text{R}}_{\text{het}}(\alpha))$ such that $V_{\text{het}}(\alpha) < V_{\text{hom}}(\alpha)$ for all $k < k(\alpha)$, and $V_{\text{het}}(\alpha) \geq V_{\text{hom}}(\alpha)$ for all $k \geq k(\alpha)$, with strict inequality if $k \in (k(\alpha), \overline{k}^{\text{R}}_{\text{hom}}(\alpha))$.*

*Proof.* Since DM is reactive under either organization for $\alpha \in (\alpha_{\text{hom}}, 1]$, the relevant comparison is between $V^{\text{R}}_{\text{hom}}(\alpha, k)$ and $V^{\text{R}}_{\text{het}}(\alpha, k)$. Define $\Delta^{\text{R}}_V(\alpha, k)$ by

$$\begin{aligned}
\Delta^{\text{R}}_V(\alpha, k) &= V^{\text{R}}_{\text{het}}(\alpha, k) - V^{\text{R}}_{\text{hom}}(\alpha, k) \\
&= \frac{1}{2}\Bigg(\Delta^{\text{R}}_\pi(\alpha, k)\left[\alpha F(\alpha b_H) + \alpha F(\alpha b_L) - F\left(\frac{b_H}{2}\right)\right] \\
&\qquad - (1 - \pi^{\text{R}}_{\text{het}}(\alpha, k))\left[F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right]\Bigg),
\end{aligned} \tag{A1}$$

where $\Delta^{\text{R}}_\pi(\alpha, k) \equiv \pi^{\text{R}}_{\text{het}}(\alpha, k) - \pi^{\text{R}}_{\text{hom}}(\alpha, k)$, which, by definition, does not depend on $\alpha$ if $k < \overline{k}^{\text{R}}_{\text{het}}(\alpha)$. The expression in the first square bracket is positive since $\alpha F(\alpha b_L) > (1-\alpha)F((1-\alpha)b_H)$ at $\alpha = \alpha_{\text{hom}}$ and by Assumption 3. The expression in the second bracket is obviously positive.

Fix $\alpha \in (\alpha_{\text{hom}}, 1]$. $\Delta^{\text{R}}_V(\alpha, k)$ is negative as $k \downarrow 0$ (and hence $\pi^{\text{R}}_h(\alpha, k) \downarrow 0$, $h = \text{hom}, \text{het}$), increasing in $k$ since both $\pi^{\text{R}}_{\text{het}}(\alpha, k)$ and $\Delta^{\text{R}}_\pi(\alpha, k)$ are increasing in $k$, and positive at $k = \overline{k}^{\text{R}}_{\text{het}}(\alpha)$. Hence there exists $k(\alpha)$ satisfying $0 < k(\alpha) < \overline{k}^{\text{R}}_{\text{het}}(\alpha)$ such that $\Delta^{\text{R}}_V(\alpha, k(\alpha)) = 0$. The conclusion then follows. $\square$

**Lemma A3.** *Suppose Assumptions 1–3 and $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$. There exists $k(\alpha) \in (0, \overline{k}^{\text{R}}_{\text{het}}(\alpha))$ such that $V_{\text{het}}(\alpha) < V_{\text{hom}}(\alpha)$ for all $k < k(\alpha)$, and $V_{\text{het}}(\alpha) \geq V_{\text{hom}}(\alpha)$ for all $k \geq k(\alpha)$, with strict inequality if $k \in (k(\alpha), \overline{k}^{\text{N}}_{\text{hom}}(\alpha))$.*

*Proof.* DM is non-reactive (reactive) under the homogeneous (respectively, heterogenous) organization for $\alpha \in (\hat{\alpha}_{\text{het}}, \alpha_{\text{hom}}]$. The relevant comparison is hence between $V^{\text{R}}_{\text{het}}(\alpha, k)$ and $V^{\text{N}}_{\text{hom}}(\alpha, k)$. Define $\Delta^{\text{RN}}_V(\alpha, k)$ by

$$\begin{aligned}
\Delta^{\text{RN}}_V(\alpha, k) &= V^{\text{R}}_{\text{het}}(\alpha, k) - V^{\text{N}}_{\text{hom}}(\alpha, k) \\
&= \frac{1}{2}\Bigg(\pi^{\text{R}}_{\text{het}}(\alpha, k)\left[\alpha F(\alpha b_L) - (1-\alpha)F((1-\alpha)b_H) + F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right] \\
&\qquad - \left[F\left(\frac{b_H}{2}\right) - F\left(\frac{b_L}{2}\right)\right] \\
&\qquad + \Delta^{\text{RN}}_\pi(\alpha, k)\left[\alpha F(\alpha b_H) + (1-\alpha)F((1-\alpha)b_H) - F\left(\frac{b_H}{2}\right)\right]\Bigg),
\end{aligned} \tag{A2}$$

where $\Delta^{\text{RN}}_\pi \equiv \pi^{\text{R}}_{\text{het}}(\alpha, k) - \pi^{\text{N}}_{\text{hom}}(\alpha, k)$. The expressions in three square brackets are all positive: the expression in the first square bracket following $\pi^{\text{R}}_{\text{het}}(\alpha, k)$ is positive because it is increasing in $\alpha$ and is positive at $\alpha = 1/2$, and the expression in the third square bracket is positive by Assumption 3.

Fix $\alpha \in (\hat{\alpha}_{\text{het}}, \alpha_{\text{hom}}]$. $\Delta_V^{\text{RN}}(\alpha, k)$ is negative as $k \downarrow 0$, increasing in $k$ since both $\pi_{\text{het}}^{\text{R}}(\alpha, k)$ and $\Delta_\pi^{\text{RN}}(\alpha, k)$ are increasing in $k$. And $\Delta_V^{\text{RN}}(\alpha, k)$ is positive at $k = \overline{k}_{\text{het}}^{\text{R}}(\alpha)$. Hence there exists $k(\alpha) \in (0, \overline{k}_{\text{het}}^{\text{R}}(\alpha))$ such that $\Delta_V^{\text{RN}}(\alpha, k(\alpha)) = 0$. The conclusion then follows. □

## A4 Proof of Corollary 1

Define $\underline{k}_1, \overline{k}_1$ by $\underline{k}_1 = k(\alpha_{\text{hom}})$ and $\overline{k}_1 = k(\alpha_{\text{het}})$, respectively. Then $\underline{k}_1 < \overline{k}_1 < \overline{k}_{\text{het}}(\alpha_{\text{het}})$, and $\underline{k}_1 < k(\alpha)$ and $k(\alpha) < \overline{k}_1$ hold for all $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}})$. Hence if $k < \underline{k}_1$, $V_{\text{het}}(\alpha, k) < V_{\text{hom}}(\alpha, k)$ for all $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$; and if $k > \overline{k}_1$, $V_{\text{het}}(\alpha, k) \geq V_{\text{hom}}(\alpha, k)$ for all $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$, with strict inequality if $k \in (\overline{k}_1, \overline{k}_{\text{hom}}(\alpha))$.

Next, define $\overline{k}_2, \overline{k}_2$ by $\underline{k}_2 = k(1)$ and $\overline{k}_2 = k(\alpha_{\text{hom}})$, respectively. Then $\underline{k}_2 < \overline{k}_2 < \overline{k}_{\text{het}}(\alpha_{\text{hom}}) < \overline{k}_{\text{het}}(\hat{\alpha}_{\text{het}})$, and $\underline{k}_2 < k(\alpha)$ and $k(\alpha) < \overline{k}_2$ hold for all $\alpha \in (\alpha_{\text{hom}}, 1)$. Hence if $k < \underline{k}_2$, $V_{\text{het}}(\alpha, k) < V_{\text{hom}}(\alpha, k)$ for all $\alpha \in (\alpha_{\text{hom}}, 1]$; and if $k > \overline{k}_2$, $V_{\text{het}}(\alpha, k) \geq V_{\text{hom}}(\alpha, k)$ for all $\alpha \in (\alpha_{\text{hom}}, 1]$, with strict inequality if $k \in (\overline{k}_2, \overline{k}_{\text{hom}}(\alpha))$.

The conclusion then follows from $\underline{k} \equiv \min\{\underline{k}_1, \underline{k}_2\}$ and $\overline{k} \equiv \max\{\overline{k}_1, \overline{k}_2\}$.

## A5 Proof of Proposition 3

### Proof of (a)

First suppose $\alpha \leq \alpha_{\text{hom}}$ and hence $V_{\text{hom}}(\alpha, k) = V_{\text{hom}}^{\text{N}}(\alpha, k)$. The proof is obvious if $k \geq \overline{k}_{\text{hom}}^{\text{N}}(\alpha)$, and thus assume $k < \overline{k}_{\text{hom}}^{\text{N}}(\alpha)$. It is easy to show $\partial \pi_{\text{hom}}^{\text{N}}(\alpha, k)/\partial k > 0$ and $\partial^2 \pi_{\text{hom}}^{\text{N}}(\alpha, k)/\partial k \partial \alpha > 0$. Then

$$\begin{aligned}
\frac{\partial^2 V_{\text{hom}}^{\text{N}}}{\partial k \partial \alpha}(\alpha, k) &= \frac{1}{2} \frac{\partial^2 \pi_{\text{hom}}^{\text{N}}}{\partial k \partial \alpha}(\alpha, k) \left[ \alpha F(\alpha b_H) + (1-\alpha) F((1-\alpha) b_H) - F\left(\frac{b_H}{2}\right) \right] \\
&\quad + \frac{1}{2} \frac{\partial \pi_{\text{hom}}^{\text{N}}}{\partial k}(\alpha, k) \left[ F(\alpha b_H) - F((1-\alpha) b_H) + \alpha b_H f(\alpha b_H) - (1-\alpha) b_H f((1-\alpha) b_H) \right] \\
&> 0.
\end{aligned}$$

Suppose next $\alpha > \alpha_{\text{hom}}$ and hence $V_{\text{hom}}(\alpha, k) = V_{\text{hom}}^{\text{R}}(\alpha, k)$. The proof is obvious if $k \geq \overline{k}_{\text{hom}}^{\text{R}}(\alpha)$, and thus assume $k < \overline{k}_{\text{hom}}^{\text{R}}(\alpha)$. It is easy to show $\partial \pi_{\text{hom}}^{\text{R}}(\alpha, k)/\partial k > 0$ and $\partial^2 \pi_{\text{hom}}^{\text{R}}(\alpha, k)/\partial k \partial \alpha > 0$. Then

$$\begin{aligned}
\frac{\partial^2 V_{\text{hom}}^{\text{R}}}{\partial k \partial \alpha}(\alpha, k) &= \frac{1}{2} \frac{\partial^2 \pi_{\text{hom}}^{\text{R}}}{\partial k \partial \alpha}(\alpha, k) \left[ \alpha F(\alpha b_H) + \alpha F(\alpha b_L) - F\left(\frac{b_H}{2}\right) \right] \\
&\quad + \frac{1}{2} \frac{\partial \pi_{\text{hom}}^{\text{R}}}{\partial k}(\alpha, k) \left[ F(\alpha b_H) + F(\alpha b_L) + \alpha b_H f(\alpha b_H) + \alpha b_L f(\alpha b_L) \right] \\
&> 0.
\end{aligned}$$

Finally suppose $\alpha > \alpha_{\text{hom}} > \alpha' > \max\{\alpha_{\text{het}}, \alpha_\gamma\}$ and $k < \overline{k}^{\text{R}}_{\text{hom}}(\alpha)$. Then

$$\begin{aligned}
&\frac{\partial V^{\text{R}}_{\text{hom}}}{\partial k}(\alpha, k) - \frac{\partial V^{\text{N}}_{\text{hom}}}{\partial k}(\alpha', k) \\
&= \frac{1}{2}\frac{\partial \pi^{\text{R}}_{\text{hom}}}{\partial k}(\alpha, k)\left[\alpha F(\alpha b_H) + \alpha F(\alpha b_L) - F\left(\frac{b_H}{2}\right)\right] \\
&\quad - \frac{1}{2}\frac{\partial \pi^{\text{N}}_{\text{hom}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_H) + (1-\alpha')F((1-\alpha')b_H) - F\left(\frac{b_H}{2}\right)\right] \\
&\geq \frac{1}{2}\frac{\partial \pi^{\text{R}}_{\text{hom}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_H) + \alpha' F(\alpha' b_L) - F\left(\frac{b_H}{2}\right)\right] \\
&\quad - \frac{1}{2}\frac{\partial \pi^{\text{N}}_{\text{hom}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_H) + (1-\alpha')F((1-\alpha')b_H) - F\left(\frac{b_H}{2}\right)\right] \\
&> 0,
\end{aligned}$$

where the first inequality is due to $\alpha > \alpha'$ and the second inequality follows from $\alpha' > \alpha_\gamma$. This completes the proof of (a).

## Proof of (b)

First suppose $\alpha \leq \alpha_{\text{het}}$ and hence $V_{\text{het}}(\alpha, k) = V^{\text{N}}_{\text{het}}(\alpha, k)$. The proof is obvious if $k \geq \overline{k}^{\text{N}}_{\text{het}}(\alpha)$, and thus assume $k < \overline{k}^{\text{N}}_{\text{het}}(\alpha)$. It is easy to show $\partial \pi^{\text{N}}_{\text{het}}(\alpha, k)/\partial k > 0$ and $\partial^2 \pi^{\text{N}}_{\text{het}}(\alpha, k)/\partial k \partial \alpha > 0$. Then

$$\begin{aligned}
\frac{\partial^2 V^{\text{N}}_{\text{het}}}{\partial k \partial \alpha}(\alpha, k) &= \frac{1}{2}\frac{\partial^2 \pi^{\text{N}}_{\text{het}}}{\partial k \partial \alpha}(\alpha, k)\left[\alpha F(\alpha b_L) + (1-\alpha)F((1-\alpha)b_L) - F\left(\frac{b_L}{2}\right)\right] \\
&\quad + \frac{1}{2}\frac{\partial \pi^{\text{N}}_{\text{het}}}{\partial k}(\alpha, k)\left[F(\alpha b_L) - F((1-\alpha)b_L) + \alpha b_L f(\alpha b_L) - (1-\alpha)b_L f((1-\alpha)b_L)\right] \\
&> 0.
\end{aligned}$$

Suppose next $\alpha > \alpha_{\text{het}}$ and hence $V_{\text{het}}(\alpha, k) = V^{\text{R}}_{\text{het}}(\alpha, k)$. The proof is obvious if $k \geq \overline{k}^{\text{R}}_{\text{het}}(\alpha)$, and thus assume $k < \overline{k}^{\text{R}}_{\text{het}}(\alpha)$. It is easy to show $\partial \pi^{\text{R}}_{\text{het}}(\alpha, k)/\partial k > 0$ and $\partial^2 \pi^{\text{R}}_{\text{het}}(\alpha, k)/\partial k \partial \alpha > 0$. Then

$$\begin{aligned}
\frac{\partial^2 V^{\text{R}}_{\text{het}}}{\partial k \partial \alpha}(\alpha, k) &= \frac{1}{2}\frac{\partial^2 \pi^{\text{R}}_{\text{het}}}{\partial k \partial \alpha}(\alpha, k)\left[\alpha F(\alpha b_L) + \alpha F(\alpha b_H) - F\left(\frac{b_L}{2}\right)\right] \\
&\quad + \frac{1}{2}\frac{\partial \pi^{\text{R}}_{\text{het}}}{\partial k}(\alpha, k)\left[F(\alpha b_L) + F(\alpha b_H) + \alpha b_L f(\alpha b_L) + \alpha b_H f(\alpha b_H)\right] \\
&> 0.
\end{aligned}$$

Finally suppose $\alpha > \alpha_{\text{het}} > \alpha'$ and $k < \overline{k}^{\text{R}}_{\text{het}}(\alpha)$. Then

$$
\begin{aligned}
&\frac{\partial V^{\text{R}}_{\text{het}}}{\partial k}(\alpha, k) - \frac{\partial V^{\text{N}}_{\text{het}}}{\partial k}(\alpha', k) \\
&= \frac{1}{2}\frac{\partial \pi^{\text{R}}_{\text{het}}}{\partial k}(\alpha, k)\left[\alpha F(\alpha b_L) + \alpha F(\alpha b_H) - F\left(\frac{b_L}{2}\right)\right] \\
&\quad - \frac{1}{2}\frac{\partial \pi^{\text{N}}_{\text{het}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_L) + (1-\alpha')F((1-\alpha')b_L) - F\left(\frac{b_L}{2}\right)\right] \\
&\geq \frac{1}{2}\frac{\partial \pi^{\text{R}}_{\text{het}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_L) + \alpha' F(\alpha' b_H) - F\left(\frac{b_L}{2}\right)\right] \\
&\quad - \frac{1}{2}\frac{\partial \pi^{\text{N}}_{\text{het}}}{\partial k}(\alpha', k)\left[\alpha' F(\alpha' b_L) + (1-\alpha')F((1-\alpha')b_L) - F\left(\frac{b_L}{2}\right)\right] \\
&> 0.
\end{aligned}
$$

This completes the proof of (b).

### Proof of (c)

First suppose $\alpha > \alpha_{\text{hom}}$ and hence $V_{\text{het}}(\alpha, k) - V_{\text{het}}(\alpha, k) = \Delta^{\text{R}}_V(\alpha, k)$. It is easy to show $\Delta^{\text{R}}_V(\alpha, k)$ is increasing in $(\alpha, k)$. Next suppose $\alpha \in (\alpha_{\text{het}}, \alpha_{\text{hom}}]$ and hence $V_{\text{het}}(\alpha, k) - V_{\text{het}}(\alpha, k) = \Delta^{\text{RN}}_V(\alpha, k)$. It is again easy to show $\Delta^{\text{RN}}_V(\alpha, k)$ is increasing in $(\alpha, k)$.

Finally suppose $\alpha > \alpha_{\text{hom}} > \alpha' > \alpha_{\text{het}}$. Then

$$
\Delta^{\text{R}}_V(\alpha, k) - \Delta^{\text{RN}}_V(\alpha', k) > \Delta^{\text{R}}_V(\alpha', k) - \Delta^{\text{RN}}_V(\alpha', k) > 0.
$$

This completes the proof of (c).

## A6 Proof of Proposition 5

Suppose $\alpha > \alpha_{\text{het}}$ and consider IM's reporting strategy first, given DM's strategy $d^*_{\text{het}}(\sigma) = \sigma$ for $\sigma \in \{1, 2\}$ and $d^*_{\text{het}}(\phi) = 1$. IM, observing $\sigma = 1$, chooses to report $\tilde{\sigma} = 1$ if and only if $\alpha > \alpha_\gamma$ holds as shown in the discussion preceding Proposition 4. Second, it is obvious to show that IM's optimal reporting choice is $\tilde{\sigma} = 2$ when he observes $\sigma \in \{\phi, 2\}$.

Next, consider DM's project choice given IM's reporting strategy and optimal information-gathering effort. $d^*_{\text{het}}(1) = 1$ is obviously optimal, and hence suppose DM receives $\tilde{\sigma} = 2$. Her posterior beliefs are $\mathbb{P}[\sigma = 2 \mid \tilde{\sigma} = 2] = \tilde{\pi}/(2 - \tilde{\pi})$ and $\mathbb{P}[\sigma = \phi \mid \tilde{\sigma} = 2] = 2(1 - \tilde{\pi})/(2 - \tilde{\pi})$ where $\tilde{\pi} \in (0, 1)$ is DM's belief of IM's information-gathering effort. In an equilibrium, $\tilde{\pi}$ must be equal to IM's optimal level of information-gathering effort. If DM chooses project 1, her expected benefit is

$$\mathbb{P}[\sigma = 2 \mid \tilde{\sigma} = 2](1-\alpha)F((1-\alpha)b_L)B_H + \mathbb{P}[\sigma = \phi \mid \tilde{\sigma} = 2]\frac{1}{2}F\left(\frac{b_L}{2}\right)B_H$$
$$= \frac{B_H}{2-\tilde{\pi}}\left[\tilde{\pi}(1-\alpha)F((1-\alpha)b_L) + (1-\tilde{\pi})F\left(\frac{b_L}{2}\right)\right].$$

If DM chooses project 2, her expected benefit is

$$\mathbb{P}[\sigma = 2 \mid \tilde{\sigma} = 2]\alpha F(\alpha b_H)B_L + \mathbb{P}[\sigma = \phi \mid \tilde{\sigma} = 2]\frac{1}{2}F\left(\frac{b_H}{2}\right)B_L$$
$$= \frac{B_L}{2-\tilde{\pi}}\left[\tilde{\pi}\alpha F(\alpha b_H) + (1-\tilde{\pi})F\left(\frac{b_H}{2}\right)\right].$$

Then DM does not deviate from $d^*_{\text{het}}(2) = 2$ if and only if the following condition is satisfied:

$$\alpha F(\alpha b_H) - (1-\alpha)F((1-\alpha)b_L)\Gamma > \frac{1-\tilde{\pi}}{\tilde{\pi}}F\left(\frac{b_L}{2}\right)\left(\Gamma - \frac{F(b_H/2)}{F(b_L/2)}\right). \tag{A3}$$

The left-hand side of (A3) is strictly decreasing in $\Gamma$ and strictly increasing in $\alpha$, and is equal to zero at $\alpha = \alpha_{\text{het}}$. The right-hand side is strictly increasing in $\Gamma$ and is zero if Assumption 1 holds with equality. Hence for each $\alpha > \alpha_{\text{het}}$, there exists an upper bound on $\Gamma$, denoted by $\tilde{\Gamma}(\tilde{\pi}, \alpha) > 1$, such that (A3) holds if and only if $\Gamma < \tilde{\Gamma}(\tilde{\pi}, \alpha)$: $\tilde{\Gamma}(\tilde{\pi}, \alpha)$ is DM's bias that satisfies (A3) with equality, and is strictly increasing in $\tilde{\pi}$ and $\alpha$, with $\tilde{\Gamma}(\tilde{\pi}, \alpha) \downarrow F(b_H/2)/F(b_L/2) > 1$ as $\alpha \downarrow \alpha_{\text{het}}$.

Finally, consider IM's optimal information-gathering effort. Suppose $\alpha > \tilde{\alpha}_{\text{het}} = \max\{\alpha_{\text{het}}, \alpha_\gamma\}$ (as defined in Proposition 4). Since DM is reactive, IM's expected payoff from information acquisition under the heterogeneous organization is written as

$$\frac{\pi}{2}\left[K(\alpha b_L) + K(\alpha b_H)\right] + (1-\pi)K\left(\frac{b_H}{2}\right) - \eta(\pi; k).$$

Then IM's optimal level of information-gathering effort, denoted by $\tilde{\pi}^{\text{R}}_{\text{het}}(\alpha, k)$, is obtained as follows:

$$\tilde{\pi}^{\text{R}}_{\text{het}}(\alpha, k) = \min\left\{k\left(\frac{1}{2}K(\alpha b_L) + \frac{1}{2}K(\alpha b_H) - K\left(\frac{b_H}{2}\right)\right), 1\right\} = \pi^{\text{R}}_{\text{hom}}(\alpha, k).$$

Note that $\tilde{\pi}^{\text{R}}_{\text{het}}(\alpha) > 0$ is satisfied for all $\alpha > \tilde{\alpha}_{\text{het}}$ since $\tilde{\alpha}_{\text{het}} \geq \alpha_\gamma$. IM prefers to report $\tilde{\sigma} = 2$ following uninformative signal $\sigma = \phi$ because by reporting $\tilde{\sigma} = 2$, he can induce his favorite project to be selected. In other words, the informational advantage of the heterogeneous organization due to the ignorance-avoiding effect identified by Proposition 1 no longer exists, and hence IM's incentive to avoid no additional information becomes weaker and his optimal effort decreases from $\pi^{\text{R}}_{\text{het}}(\alpha, k)$ to $\tilde{\pi}^{\text{R}}_{\text{het}}(\alpha, k)$.

Since $\tilde{\pi} = \tilde{\pi}^{\text{R}}_{\text{het}}(\alpha, k)$ must hold in equilibrium, we rewrite $\tilde{\Gamma}(\tilde{\pi}^{\text{R}}_{\text{het}}(\alpha, k), \alpha)$ as $\tilde{\Gamma}(\alpha, k)$, which is increasing in $\alpha$ and $k$. Condition $\tilde{\pi}^{\mathrm{R}}_{\mathrm{het}}(\alpha,k) = \pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha,k) < 1$ yields $k < \overline{k}^{\mathrm{R}}_{\mathrm{hom}}(\alpha)$. This completes the proof.

Note that if $k \geq \overline{k}^{\mathrm{R}}_{\mathrm{hom}}(\alpha)$, the condition on $\Gamma$ would become $\alpha F(\alpha b_H) > (1-\alpha)F((1-\alpha)b_L)\Gamma$, which is always satisfied for $\alpha > \alpha_{\mathrm{het}}$ by the definition of $\alpha_{\mathrm{het}}$. In this case, the partial communication equilibrium is in fact identical to the full communication equilibrium.

## A7 Proof of Proposition 6

Both Cases 1 and 3 are obvious, and hence suppose $\alpha \in (\alpha_\gamma, \alpha_{\mathrm{hom}}]$. All we need to show is $\pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha,k) \geq \pi^{\mathrm{N}}_{\mathrm{hom}}(\alpha,k)$, which is satisfied since the inequality holds for $\alpha \geq \alpha_\gamma > \alpha_{\mathrm{het}}$ (see the discussion following Lemma 2).

## A8 Proof of Proposition 7

Cases (a) and (c) are obvious from the definition of $\tilde{V}_{\mathrm{het}}(\alpha,k)$. In Case (b) where $\alpha \in (\alpha_\gamma, \alpha_{\mathrm{hom}}]$, the relevant comparison is between $\tilde{V}_{\mathrm{het}}(\alpha,k) = V^{\mathrm{R}}_{\mathrm{hom}}(\alpha,k)$ and $V^{\mathrm{N}}_{\mathrm{hom}}(\alpha,k)$:

$$\begin{aligned}\tilde{\Delta}^{\mathrm{RN}}_V(\alpha,k) &\equiv V^{\mathrm{R}}_{\mathrm{hom}}(\alpha,k) - V^{\mathrm{N}}_{\mathrm{hom}}(\alpha,k)\\ &= \frac{1}{2}\Bigg(\tilde{\Delta}^{\mathrm{RN}}_\pi(\alpha,k)\left[\alpha F(\alpha b_H) + (1-\alpha)F((1-\alpha)b_H) - F\left(\frac{b_H}{2}\right)\right]\\ &\quad + \tilde{\pi}^{\mathrm{R}}_{\mathrm{het}}(\alpha,k)(\alpha F(\alpha b_L) - (1-\alpha)F((1-\alpha)b_H))\Bigg) > 0,\end{aligned} \tag{A4}$$

where $\tilde{\Delta}^{\mathrm{RN}}_\pi(\alpha,k) \equiv \pi^{\mathrm{R}}_{\mathrm{hom}}(\alpha,k) - \pi^{\mathrm{N}}_{\mathrm{hom}}(\alpha,k)$. The expression in the square bracket is positive for all $\alpha > 1/2$ (see the proof of Proposition 1), and $\alpha F(\alpha b_L) - (1-\alpha)F((1-\alpha)b_H) > 0$ as well as $\tilde{\Delta}^{\mathrm{RN}}_\pi(\alpha,k) > 0$ holds by $\alpha > \alpha_\gamma > \hat{\alpha}$. Hence $\tilde{\Delta}^{\mathrm{RN}}_V(\alpha,k) > 0$ for all $\alpha \in (\alpha_\gamma, \alpha_{\mathrm{hom}}]$ and $k > 0$, which completes the proof.