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## Article

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Games

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Article

# Information Transmission and Countervailing Biases in Organizations

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**Abstract:** A decision maker (DM) must choose between two projects or decide on no project. The expected benefits of these projects are correlated. The DM seeks advice from an agent with private information about the projects' benefits. However, the agent's divergent preferences for projects and lack of consideration for the DM's implementation costs may introduce two types of biases: project bias, favoring the agent's project, or pandering bias, favoring the project preferred by the DM. Our findings reveal that project correlation leads to these biases countervailing each other, facilitating the transmission of information. The agent typically recommends a project based on private information to dissuade the DM from choosing no project, as this would be detrimental to the agent. Additionally, we explore optimal delegation within organizations. In contrast to the prevailing literature advocating for delegation to biased agents for enhanced information elicitation, our study suggests limited benefits in the context of project correlation.

**Keywords:** bias; cheap talk; correlation; outside options

**JEL Classification:** C72; D23; D83



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## 1. Introduction

A significant challenge in organizations and markets arises when the decision maker (DM) relies on advice from a more informed agent. An extensive literature, dating back to Crawford and Sobel (1982) [1], investigated the credibility of “cheap talk” in situations with conflicts of interest between the DM and the agent. Che, Dessein, and Kartik (2013) [2] contributed to understanding strategic communication by incorporating an outside option into a cheap talk model, examining the economics of pandering. This paper introduces a novel consideration: in strategic communication through cheap talk, how does the correlation between project benefits influence information transmission amidst multiple dimensions of conflicts of interest between players? Our key insight is that project correlation leads to project bias (favoring the agent's project) and pandering bias (favoring the DM's preferred project), offsetting each other and facilitating information transmission.

In organizational decision making, a crucial concern is eliciting information when interests among stakeholders, such as the firm's CEO and local managers, diverge. We explore whether conflicts of interest consistently hinder information transmission and identify scenarios where misalignment may be beneficial. Our model simplifies organizational dynamics into a principal–agent relationship, where a DM seeks advice from an agent who privately knows the benefits of two projects or the option of no project. Conflicting preferences and biases, like project bias or pandering bias, independently impede information transmission. However, the negative correlation of benefits between the two projects offsets these biases, collectively facilitating information transmission.

Real-world examples demonstrate the relevance of our study. Consider a conglomerate that decides to invest in one of two projects or to not invest in any project at all (the outside option). If the available option is between two projects related to the airline and oil

industries, respectively, we can expect negative correlation in payoffs to the two projects<sup>1</sup>. But, between two projects related to the airline and hotel industries, respectively, a positive correlation can be assumed because both industries complement each other. If the available option is between a wind power project and a solar power project, there is a positive correlation because government regulations are to boost/suppress the market as a whole<sup>2</sup>. If it is between an oil energy project and a renewable energy project, we may expect a negative correlation. If we compare projects related to Mac OS X and Macbook, respectively, there is a positive correlation between the payoffs from the two projects<sup>3</sup>, while between projects related to Mac OS X and Windows operation system, respectively, there may be a negative correlation. The assumption of the correlation in each example is reasonable based on inherent project relationships, contributing to the practical relevance of our study.

To capture these real-world settings, we allow the DM to choose between projects 1 and 2 or opt for no project, incurring the full implementation cost. The agent possesses perfect and private information on the state, determining the benefits (excluding costs) of each project. There are four states: state 1, where both projects yield large benefits, state 2, where project 1 yields large benefits and project 2 yields small benefits, state 3, where project 2 yields large benefits and project 1 yields small benefits, and state 4, where both projects yield small benefits. After observing the state, the agent sends a cheap talk message to the DM, who then makes a choice. Ex ante, players may have different project preferences (project bias). The DM's bias is toward project 1, expecting larger benefits based on the common prior. The agent's bias may align or differ from the DM. Due to the DM's bias, the outside option is less likely when project 1 is recommended. To avoid the outside option, the agent might recommend project 1, even if project 2 yields more benefits. This scenario is a form of pandering bias identified by CDK [2].

The main result from our analysis is that the correlation between the benefits of the two projects counteracts pandering bias, impacting information transmission and welfare. This counteracting effect is stronger with a more highly negative correlation between the projects' benefits. Let us explain the intuition behind this result. Consider a scenario where the state is almost certainly either state 2 or 3. If the DM and agent biases differ, the agent has a small incentive to hide information. For instance, in state 2, the agent may want project 2, but hides this to reduce the probability of the DM selecting the outside option. In state 3, revealing this information increases the outside option probability, but the agent prefers project 2. Hence, the agent is willing to reveal information in either state. Yet, if both players are biased toward project 1, both biases cause the agent to hide state 3 and always report state 2 to the DM. On the contrary, with a highly positive correlation, the DM chooses between project 1 and the outside option in either state. Consequently, the agent has no incentive to reveal state 4, leading the DM to choose the outside option, regardless of the project bias. The positive correlation weakens the project bias's ability to counteract the pandering bias.

Next, we explore an important extension for real-world applications before concluding in Section 5. One significant extension involves determining the optimal organizational structure in the resource allocation problem faced by a DM responsible for funding projects. As the principal, the DM controls the organization's resources and makes the final investment decisions on projects, aiming to effectively elicit the agent's information. We assess two mechanisms for optimizing organizational structure: non-delegation and veto-based delegation. While delegation implies a loss of control, an uninformed principal may lead to information loss. Our findings suggest that, in scenarios with a substantial project bias, veto-based delegation enhances information transmission in decision making, benefiting both parties. Our baseline model seamlessly accommodates these extensions, and our key insights on negative correlation offsetting project and pandering biases remain robust, ensuring effective information transmission.

The subsequent sections of the article are organized as follows: Section 2 reviews the related literature, Section 3 introduces a model with discrete projects and an outside option, emphasizing the impact of correlation in project payoffs on communications. Section 4

explores optimal delegation, and Section 5 provides concluding remarks. Proofs are available in Appendix A.

## 2. Related Literature

Our work is related to cheap talk models in CDK [2] and CS [1]. CDK focuses on the economics of pandering, where the agent may bias his recommendations towards the DM's conditionally better looking project. The agent has an incentive to distort information to dissuade the DM from choosing the outside option. The more valuable the option, the stronger this incentive becomes. In contrast to CDK, our model allows for correlation among projects, resulting in non-monotonic information transmission in project bias, while keeping pandering bias constant. CS only examined project bias, whereas our study delves into the interactions between pandering and project biases. CS revealed a monotonic relationship between project bias and information transmission, while our findings showcase a non-monotonic relationship.

Chiba and Leong (2013 [3] and 2015 [4]) studied cheap talk models with countervailing biases. In their 2013 study, an outside option was introduced to a uniform quadratic case in CS. Their 2015 study featured a model with two projects and an outside option, where the payoffs to the two projects were perfectly negatively correlated. Both studies unveiled a non-monotonic relationship between information transmission and project bias, but did not allow for an examination of the impact of correlation on information transmission. Moreover, these works do not provide an explanation for why project bias counteracts pandering bias. In our model, which involves discrete projects, we consider the full range of possible project payoff correlations. This enables us to discuss the effect of project correlation on the non-monotonic relationship between information transmission and project bias.

In contrast to our study, which explores the interaction between project and pandering biases, Chakraborty and Harbaugh (2007 [5] and 2010 [6]) examined other types of countervailing biases in cheap talk models. In their models, the decision maker (DM) determines the investment allocation for multiple projects, and the multi-dimensional state determines the optimal investment amount for each project. However, they did not study the impact of correlation among projects' benefits or the presence of an outside option. Their focus was on identifying conditions that mitigate the negative impact of project bias on information transmission. Chakraborty and Harbaugh (2007) showed that, if both players' payoff functions are supermodular, they can reach an agreement on the comparative ranking of projects, irrespective of the level of project bias. This leads to an equilibrium, where the agent conveys the comparative ranking of projects to the DM. In Chakraborty and Harbaugh (2010), the agent has state-independent linear preferences, seeking to induce the largest possible project in each dimension. They found that, if the DM's payoff function is quasi-convex, an informative equilibrium can be established. In this equilibrium, the agent partitions the multi-dimensional state space into multiple regions, causing the agent to be indifferent among the DM's responses in all regions of the partition.

Brandenburger and Polak (1996) [7], in addition to CDK, considered the logic of pandering, where an investment manager of a firm has incentives to skew investment decisions towards a project that the market believes is likely to succeed. However, they did not incorporate strategic communications into their model. Heidhues and Lagerlof (2003) [8] investigated similar pandering issues in electoral competition with multi-agent models.

Our work is connected to the literature exploring the impact of project bias on information transmission, as examined by Landier, Sraer, and Thesmar (2009) [9]. They investigated a costly signaling model featuring an informed manager and an uninformed worker. The manager deliberately chose the suboptimal project for the agent to encourage optimal effort from the agent during project implementation. Our model is similar to theirs in the context of a veto-based delegation model, especially when the correlation between projects is negative.

Our model is related to communication games, particularly those involving veto stages, where an outside option representing a veto of a proposal can be chosen. In Matthews (1989) [10] and Shimizu (2013 [11], 2017 [12]), the DM selects a proposal based on the agent's message, and the agent can either accept or veto it. Unlike our paper, they permitted the agent, rather than the DM, to choose an outside option. In legislative procedure models with a closed rule by Gilligan and Krehbiel (1987) [13] and Krishna and Morgan (2001) [14], the agent recommends a project, and the DM decides whether to authorize or veto it. Unlike our veto-based delegation game, their models do not consider countervailing biases or correlation between project payoffs. Chiba and Leong (2023) [15] studied the relationship between the benefits of delegation and the level of project bias, without considering how the interaction of project and pandering biases leads to this result. Blume and Board (2013) [16] also studied a cheap talk model with an outside option, but their main focus differs from ours. In their model, players are language-constrained at different levels, resulting in different language usage.

### 3. Model

Our model is closely related to cheap models with an outside option in CDK [2], as well as Chiba and Leong (2015) [4], using the same terminology from the two papers, unless otherwise specified.

#### 3.1. Setup

An organization identifies two potential projects—projects 1 and 2. The organization can either proceed with a project,  $P \in \{1, 2\}$ , or choose no project (the outside option),  $P = \emptyset$ .

The organization has two players: an uninformed decision maker (DM) and an informed agent (A). The agent possesses information: he/she observes a two-dimensional state of the world  $\theta = (\theta_1, \theta_2)$  defined as follows:

$$\theta = \begin{cases} (1, 1) & \text{w.p. } \frac{1+\rho}{4} \\ (1, l) & \text{w.p. } \frac{1-\rho}{4} \\ (l, 1) & \text{w.p. } \frac{1-\rho}{4} \\ (l, l) & \text{w.p. } \frac{1+\rho}{4} \end{cases} \quad (1)$$

where  $l \in (0, 1)$  and  $\rho \in (-1, 1)$ .

Both players are risk-neutral and aim to maximize payoffs. If the DM selects a project, both players' payoffs depend on the state, the project, and the cost of implementation. On the contrary, if the DM chooses the outside option, each player's payoff (or expected payoff) is zero. The payoff of player  $j \in \{DM, A\}$  is denoted as  $U^j(a, \theta, c_j)$ :

$$U^j(P, \theta, c_j) = \begin{cases} \theta_1 - c_j & \text{if } P = 1 \\ b_j \theta_2 - c_j & \text{if } P = 2 \\ 0 & \text{if } P = \emptyset \end{cases} \quad (2)$$

where  $b_{DM} \in (l, 1)$ ,  $b_A \in (l, 1/l)$ , and  $c_A = 0$ . The parameter  $c_{DM}$  is drawn from a uniform distribution with support  $[0, 1]$ .

The project set, the distributions of  $\theta$  and  $c_{DM}$ , and the parameters  $(\rho, c_A, b_{DM}, b_A)$  are common knowledge. The parameter  $c_{DM}$  is publicly observed just before the DM's decision making. The state  $\theta$  is only observable to the agent. Before the DM chooses  $P$ , the agent sends a cheap talk message  $m \in M$  to the DM, where  $M$  is any large space (e.g.,  $M = \mathbb{R}_{++}^2$ ).

Timeline:

- Step 1. Nature selects the state  $\theta$ . This is privately and perfectly observed by the agent.
- Step 2. The agent sends a cheap talk message  $m$ . The DM observes this message without noise.

- Step 3. The DM’s project cost  $c_{DM}$  is determined and publicly observed.
- Step 4. The DM decides whether to implement a project  $P \in 1, 2$  or the outside option of no project  $P = \emptyset$ .
- Step 5. Both players’ payoffs are realized, and the game concludes.

This model incorporates two dimensions of biases—*project bias* and *pandering bias*—and a *correlation* between the benefits of the two projects.

The *project bias* pertains to the difference in preferences over projects, akin to the “preference similarity parameter” ( $b$ ) in CS [11]. We interpret  $|b_{DM} - b_S|$  as the level of project bias, assuming  $b_{DM} \in (l, 1)$  and  $b_A \in (l, 1/l)$  as mentioned above.

Assumption  $b_{DM} < 1$  implies that the DM is ex ante biased toward project 1, while  $l < b_{DM}$  implies that the DM does not always strictly prefer project 1 over project 2 under perfect information. The DM strictly prefers project 1 to project 2 given  $\theta \in \{(1, 1), (1, l), (l, l)\}$ , while the DM strictly prefers project 2 over project 1 given  $\theta = (l, 1)$ .

On the other hand, the agent can be ex ante biased toward either project: the agent is ex ante biased toward project 1 and project 2 if  $b_A < 1$  and  $b_A > 1$ , respectively. The agent is ex ante indifferent between the two projects if  $b_A = 1$ . Assumption  $b_A \in (l, 1/l)$  implies that the agent does not always strictly prefer one project over the other under perfect information<sup>4</sup>. The preference ranking of the agent under perfect information is dependent on the parameter. If  $b_A \in (l, 1)$ , the agent strictly prefers project 1 over project 2 given  $\theta \in \{(1, 1), (1, l), (l, l)\}$ , while the agent strictly prefers project 2 over project 1 given  $\theta = (l, 1)$ . If  $b_A \in (1, 1/l)$ , the agent strictly prefers project 1 over project 2 given  $\theta = (1, l)$ , while the agent strictly prefers project 2 over project 1 given  $\theta \in \{(1, 1), (l, 1), (l, l)\}$ .

The *pandering bias* is related to the preference for the outside option of no project, represented by  $c_j$ , the cost incurred by player  $j$  when a project is implemented. For simplicity,  $c_A = 0$ , and  $c_{DM}$  follows a uniform distribution with support  $[0, 1]$ . The agent never finds the outside option optimal, while the DM may prefer the outside option in certain states.

The parameter  $\rho$  is the *correlation* coefficient between  $\theta_1$  and  $\theta_2$ . Additionally, for both players,  $\rho$  is the correlation coefficient between the benefits of the two projects<sup>5</sup>.

While our setup is different in some aspects, it is essential to note that  $\rho = 0$  similar to CDK’s model with multiple projects and continuous states, and  $\rho = -1$  is similar to Chiba and Leong’s (2015) [4] model with two states and two projects (see Figure 1). The value of  $\rho$  depends on the pair of projects being compared in a uniform quadratic example of CS, where there are continuous projects and continuous states.

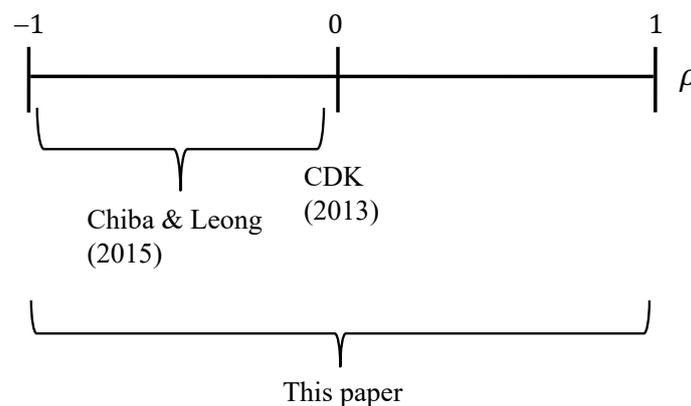


Figure 1. Correlations in models

We choose not to adopt a setup directly comparable to existing literature like CDK [2] and CS [1]. Here are the reasons for our departure:

First, we consider four states for two projects, deviating from CDK, CS, and Chiba and Leong (2015) [4], who assumed continuous states and either discrete or continuous projects. This choice helps explain the impact of the correlation between the benefits of the

two projects on information transmission. Additionally, our setup isolates the parameter  $\rho$ , influencing the correlation of the two projects' benefits for both players without affecting the mean or variance of a project for any player.

Next, in CDK's model of pandering, project costs are predetermined and publicly known<sup>6</sup>.

However, we introduce an analysis of the interaction between pandering bias and project bias. The assumption of continuous project costs is more general from a theoretical standpoint, although our main result remains unchanged even with the fixed cost assumption.

### 3.2. Results

The solution concept employed is Perfect Bayesian Equilibrium (PBE). The agent's strategy is represented by a function  $q(m | \theta)$ , linking each state  $\theta$  with a message distribution used by the agent in that state. The DM's strategy is denoted as  $P(m, c_{DM})$ , associating the agent's message  $m$  and the DM's cost  $c_{DM}$  with the DM's decision  $P$ . The DM's belief is captured by a function  $\mu(\theta|m)$ , where  $\mu(\theta | m) \geq 0$  and

$$\int_{\theta \in \{1,l\}^2} \mu(\theta | m) = 1,$$

reflecting the DM's posterior as a function of  $m$  by Bayes' rule.

The interaction between project and pandering biases can either reinforce or counteract each other, impacting information transmission and welfare. Crucially, we demonstrate that this counteracting effect hinges on the correlation in project benefits. As the correlation coefficient  $\rho$  approaches  $-1$ , the project bias exerts a stronger influence, opposing the direction of the pandering bias. Consequently, a larger project bias can enhance information transmission and improve welfare.

Our initial lemma, akin to CDK's Lemma 1 (CDK [2], p. 57), states that the agent consistently favors a project over the outside option. The agent tactically selects messages to maximize the probability of his/her preferred project being chosen, either by revealing his/her preference or withholding information entirely. Consequently, the agent needs at most two messages.

**Lemma 1.** *Every PBE is equivalent to one where the agent's strategy involves at most two messages.*

To streamline our analysis, we adopt a binary message set  $M = \{1, 2\}$ . Without loss of generality, we focus on equilibria where the agent's strategy complies with:

$$q(1|\theta = (1,l)) \geq q(1|\theta = (l,1)) \tag{3}$$

This implies that the agent more frequently recommends project 1 in scenarios where it is superior for both players than in the reverse situation.

The subsequent lemma adapts CDK's Lemma 2 from their discrete project and continuous state model (CDK [2], pp. 57–58) to our discrete state and discrete project framework.

**Lemma 2.** *For any PBE, the following statements hold:*

(1) *If  $q(1|\theta = (l,1)) > 0$  holds, then,*

$$q(1|\theta = (1,1)) = q(1|\theta = (1,l)) = q(1|\theta = (l,l)) = 1 \tag{4}$$

*holds.*

(2) *If  $q(1|\theta = (1,1)) \in (0,1)$  or  $q(1|\theta = (l,l)) \in (0,1)$  holds, then*

$$q(1|\theta = (1,l)) = 1 \quad \text{and} \quad q(1|\theta = (l,1)) = 0 \tag{5}$$

*hold.*

(3) If  $q(1|\theta = (1, l)) < 1$  holds, then

$$q(1|\theta = (1, 1)) = q(1|\theta = (l, 1)) = q(1|\theta = (l, l)) = 0 \tag{6}$$

holds.

Lemma 2 establishes that, if the agent sends  $m = 1$  with a positive probability given  $\theta = (l, 1)$ , then the agent sends  $m = 1$  for sure given any  $\theta \in \{(1, 1), (1, l), (l, l)\}$ . Similarly, if the agent sends  $m = 2$  with a positive probability given  $\theta = (1, l)$ , then the agent sends  $m = 2$  for sure given any  $\theta \in \{(1, 1), (l, 1), (l, l)\}$ . If the agent mixes between two messages given at least either of  $\theta = (1, 1)$  and  $\theta = (l, l)$ , then, he/she sends  $m = 1$  for sure given  $\theta = (1, 1)$  and  $m = 2$  for sure given  $\theta = (l, l)$ , respectively.

We will define the types of equilibria based on CDK's terminology:

- Definition 1.** (1) In a truthful equilibrium (T),  $q(1|\theta = \theta') = 1$  for any  $\theta' \in \{(1, l), (1, 1), (l, l)\}$  and  $q(1|\theta = (l, 1)) = 0$  and  $P(m, c_{DM}) \in \{m, \emptyset\}$  for any  $m$ .
- (2) In a pandering-toward-1 equilibrium (P1),  $q(1|\theta = \theta') = 1$  for any  $\theta' \in \{(1, l), (1, 1), (l, l)\}$  and  $q(1|\theta = (l, 1)) \in (0, 1)$  and  $P(m, c_{DM}) \in \{m, \emptyset\}$  for any  $m$ .
- (3) In a pandering-toward-2 equilibrium (P2),  $q(1|\theta = (1, l)) = 1$ ,  $q(1|\theta = \theta') \in (0, 1)$  for some  $\theta' \in \{(1, 1), (l, l)\}$  and  $q(1|\theta = (l, 1)) = 0$  and  $P(m, c_{DM}) \in \{m, \emptyset\}$  for any  $m$ .
- (4) In a pandering-toward-2 equilibrium' (P2'),  $q(1|\theta = (1, l)) = 1$  and  $q(1|\theta = \theta') = 0$  for any  $\theta' \in \{(1, 1), (l, l), (l, 1)\}$  and  $P(m, c_{DM}) \in \{m, \emptyset\}$  for any  $m$ .
- (5) In a zero equilibrium (Z),  $q(1|\theta = \theta') = 1$  for any  $\theta'$  and  $P(m, c_{DM}) \in \{1, \emptyset\}$  for any  $m$ .

In a zero equilibrium (Z), the agent does not reveal any information. The remaining equilibria are partition equilibria, where the agent partitions the state space into two parts and discloses which partition the state  $\theta$  belongs to (see Figure 2).

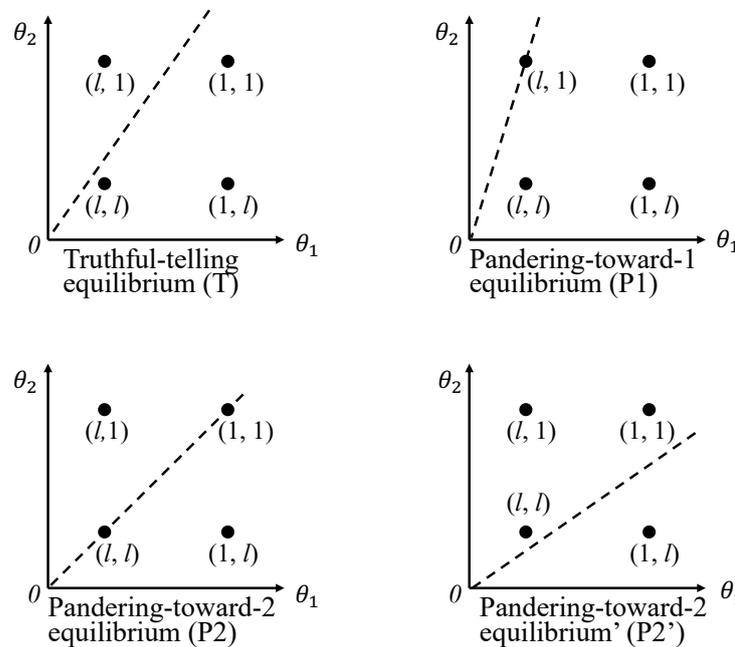


Figure 2. Information partitions in different types of equilibria

The first four equilibria, namely T, P1, P2, and P2', are referred to as informative equilibria. Equilibrium messages are interpreted in two ways: indicating a ranking between the two projects or recommending a specific project. In an informative equilibrium, the agent can induce either project by sending  $m = 1$  ( $m = 2$ ) with a positive probability. In a zero equilibrium, there is no information transmission, and the agent can only induce project 1 or the outside option, regardless of the message sent.

According to the first interpretation, in T, the agent consistently discloses the true ranking for the decision maker (DM). As explained in the previous section, under perfect information, the DM strictly prefers project 1 over project 2 given  $\theta \in \{(1, 1), (1, l), (l, l)\}$ , while the DM strictly prefers project 2 over project 1 given  $\theta = (l, 1)$ . Hence, in T, given any state, the agent truthfully recommends a project that the DM should prefer. Therefore, we call this a truthful equilibrium. This equilibrium is not a full revelation equilibrium. As we will show, a full revelation equilibrium does not exist in this model.

In P1, the agent recommends project 1, which is ex ante preferred by the DM, more often than in T. Hence, we call this a pandering-toward-1 equilibrium. In P2 and P2', the agent recommends project 2 more often than in T. Hence, we call the two equilibria a pandering-toward-2 equilibrium and a pandering-toward-2 equilibrium', respectively.

In the second interpretation, the agent uses her/his information on the state and recommends either project in an informative equilibrium, whereas the agent always recommends project 1 regardless of her/his information in a zero equilibrium.

Based on Blackwell's informativeness, the agent transmits more information to the DM in any of T, P1, P2, and P2' than in Z because the information transmitted in Z is constructed by garbling of the information transmitted in any of T, P1, P2, and P2'. However, we cannot compare the informativeness among T, P1, P2, and P2' in Blackwell's sense.

The subsequent lemma presents a characterization of all equilibria for fixed parameters and compares their welfare.

**Lemma 3.** *For any fixed parameters, the following statements hold:*

- (1) *There exist at most two types of equilibria, an informative equilibrium (T, P1, P2, or P2') and a zero equilibrium (Z). Moreover, Z always exists.*
- (2) *There is a unique informative equilibrium if T, P1, or P2' exists.*
- (3) *If an informative equilibrium exists, the informative equilibrium makes both players better off than Z.*

Lemma 3 shows that multiple types of informative equilibria do not exist together. Only possible multiplicity is one type of informative equilibrium (T, P1, P2, or P2') and a zero equilibrium (Z). When T, P1, or P2' exists, this is the unique informative equilibrium. However, when P2 exists, there can be multiple P2s. Moreover, the informative equilibrium is better than a zero equilibrium for both players.

Because of Lemma 3, if there is T, P1, or P2', we focus on the unique informative equilibrium. If there is P2, meaning that multiple P2s can exist, we will focus on the one that maximizes the DM's ex ante expected payoff. Otherwise, we consider Z. Accordingly, the following result provides comparative statics across parameters<sup>7</sup>.

**Proposition 1.** *Let*

$$B(\rho, l) := \frac{2 + (1 + \rho)l}{3 + \rho},$$

$$D(b_{DM}, \rho, l) := 1 + \frac{2(l + 1)(1 - b_{DM})^2}{\rho b_{DM}(b_{DM} + 1)(1 - l) + (3 + 5l - (5 + 3l)b_{DM})b_{DM}},$$

$$d(\rho, l) := 1 - \frac{(1 - \rho)(1 - l)}{l + l\rho + 2}.$$

*Then, for any fixed  $b_{DM}$ ,  $\rho$ , and  $l$ :*

- (1) *A truthful equilibrium (T) exists for  $b_A \in \left[\frac{B(\rho, l) \cdot l}{b_{DM}}, \frac{B(\rho, l)}{b_{DM}}\right]$ ;*
- (2) *A pandering-toward-1 equilibrium (P1) exists for  $b_A \in \left(\frac{l + l^2}{2b_{DM}}, \frac{B(\rho, l) \cdot l}{b_{DM}}\right)$ ;*

(3) A pandering-toward-2 equilibrium (P2) exists for

$$b_A \in \left( \frac{B(\rho,l)}{b_{DM}}, D(b_{DM}, \rho, l) \right) \quad \text{if } b_{DM} < d(\rho, l),$$

$$b_A \in \left( \frac{B(\rho,l)}{b_{DM}}, \frac{1}{b_{DM} \cdot B(\rho,l)} \right) \quad \text{if } b_{DM} \geq d(\rho, l);$$

(4) A pandering-toward-2 equilibrium' (P2') exists for  $b_A \in \left[ \frac{1}{b_{DM} \cdot B(\rho,l)}, \frac{1}{l} \right]$  if  $b_{DM} \geq d(\rho, l)$ ;

(5) The only equilibrium is a zero equilibrium (Z) otherwise.

Furthermore, the DM's ex ante expected payoff is not monotonic in  $|b_A - b_{DM}|$  if  $b_{DM} < \sqrt{B(\rho, l) \cdot l}$ .

Figure 3 illustrates the most informative type of equilibrium for various values of  $b_{DM}$  and  $b_A$ , given  $l = 0.5$  and  $\rho = -0.4$ . According to the definitions, the following holds:

$$D(b_{DM}, \rho, l) < \frac{1}{b_{DM} \cdot B(\rho, l)} \quad \text{iff } b_{DM} < d(\rho, l) \tag{7}$$

For  $b_{DM} < d(\rho, l)$ , line  $D(b_{DM}, \rho, l)$  distinguishes areas for P2 and Z, respectively. When  $b_{DM} \geq d(\rho, l)$ , line  $\frac{1}{b_{DM} \cdot B(\rho, l)}$  separates areas for P2 and P2'. Notably, for smaller  $b_{DM}$ , informative equilibria (T, P1, P2, or P2') exist in a narrower range of  $b_A$ . Furthermore, if  $b_{DM}$  is so small that  $b_{DM} < \sqrt{B(\rho, l) \cdot l}$ , the truthful equilibrium (T) exists only for  $b_A > b_{DM}$ .

Later, we will come back to Figure 3 and explain how we define lines separating the space of parameters  $(b_{DM}, b_A)$  into the parts where an informative equilibrium (T, P1, P2, or P2') exists and the part where only Z exists.

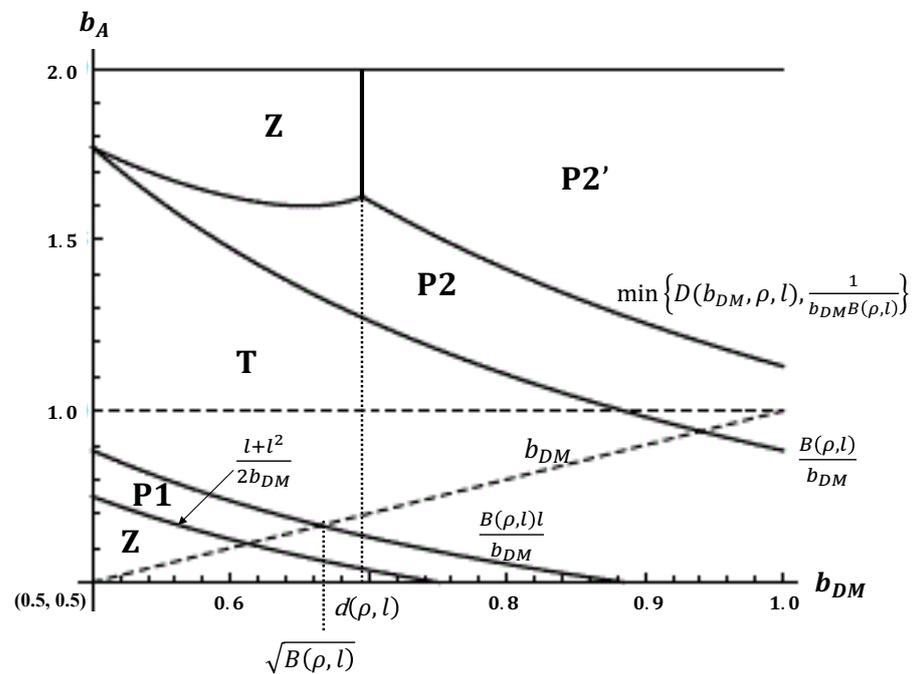
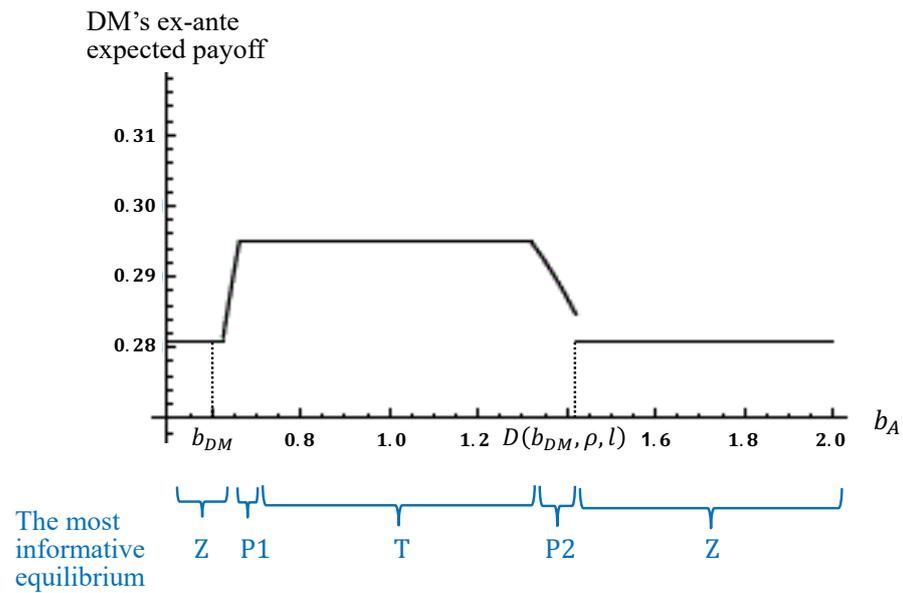
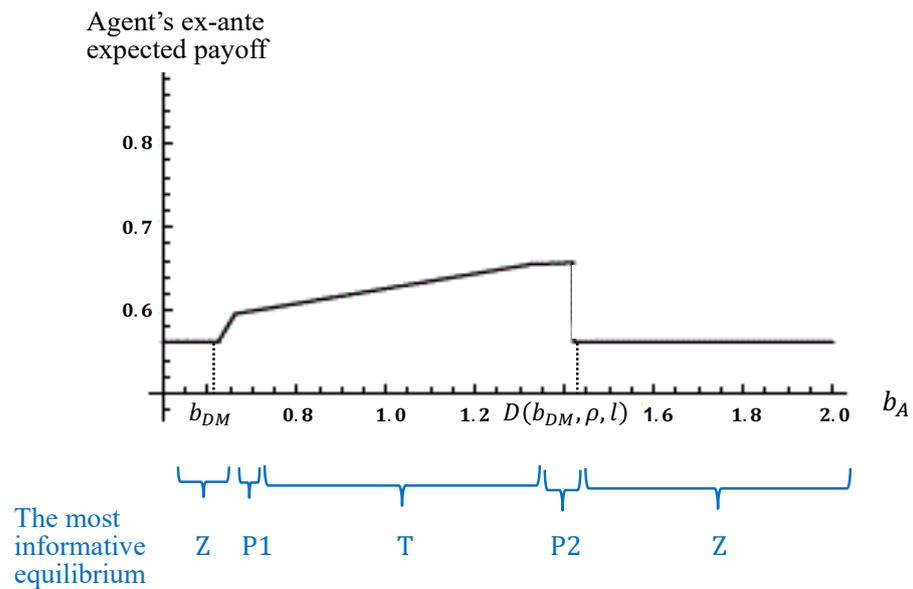


Figure 3. The most information equilibrium ( $l = 0.5$  and  $\rho = -0.4$ )

Figures 4 and 5 show the ex ante expected payoff of the DM and the agent, respectively, for different levels of  $b_A$ , given  $l = 0.5$ ,  $\rho = -0.4$ , and  $b_{DM} = 0.6$ , that is  $b_{DM} < \min \left\{ \sqrt{B(\rho, l) \cdot l}, d(\rho, l) \right\}$ . For both players' payoffs, there is a jump at  $b_A = D(b_{DM}, \rho, l)$ , below which a pandering-toward-2 equilibrium (P2) exists, and above which only a zero equilibrium (Z) exists.



**Figure 4.** DM’s ex-ante expected payoff in the most informative equilibrium ( $b_{DM} = 0.6, l = 0.5,$  and  $\rho = -0.4$ )



**Figure 5.** Agent’s ex-ante expected payoff in the most informative equilibrium ( $b_{DM} = 0.6, l = 0.5,$  and  $\rho = -0.4$ )

To explain the intuition behind this result, we outline the proof. Let  $E[\theta_i | m = j]$  represent the DM’s updated belief about  $\theta_i$  when the agent sends message  $m = j$ , where  $i, j$  are in the set  $\{1, 2\}$ . In an informative equilibrium, the DM should agree with the project ranking (or recommendation) proposed by the agent. The following two conditions must be satisfied.

$$E[\theta_1 | m = 1] \geq b_{DM} \cdot E[\theta_2 | m = 1] \tag{8}$$

and

$$b_{DM} \cdot E[\theta_2 | m = 2] \geq E[\theta_1 | m = 2] \tag{9}$$

Condition (8) implies that, when the agent sends  $m = 1$  (suggesting that project 1 is better than project 2), the DM also favors project 1 over project 2. Condition (9) means that, when the agent sends  $m = 2$ , the DM prefers project 2 over project 1. Due to the DM's inherent bias toward project 1, (8) holds in every type of equilibrium, while (9) may not. If both (8) and (9) hold, the DM implements a recommended project if the cost is below the expected benefit from the project. Specifically, the DM selects  $P = 1$  if  $m = 1$  and  $E[\theta_1 | m = 1] \geq c_{DM}$ ;  $P = 2$  if  $m = 2$  and  $b_{DM} \cdot E[\theta_2 | m = 2] \geq c_{DM}$ ; and  $P = \emptyset$  otherwise.

Conversely, in an informative equilibrium, the agent should also have the incentive to disclose information. Hence, for a truthful equilibrium (T) to exist, in addition to (8) and (9), the following two conditions should also hold:

$$\underbrace{\theta_1}_{\text{Agent's payoff from project 1}} \cdot \underbrace{E[\theta_1 | m = 1]}_{\text{Probability that project 1 is implemented}} \geq \underbrace{b_A \cdot \theta_2}_{\text{Agent's payoff from project 2}} \cdot \underbrace{b_{DM} \cdot E[\theta_2 | m = 2]}_{\text{Probability that project 2 is implemented}} \tag{10}$$

Agent's expected payoff from sending  $m=1$ . Agent's expected payoff from sending  $m=2$ .

Condition (10) holds given  $\theta \in \{(1, l), (1, 1), (l, l)\}$  in T. In addition:

$$\underbrace{b_A \cdot \theta_2}_{\text{Agent's payoff from project 2}} \cdot \underbrace{b_{DM} \cdot E[\theta_2 | m = 2]}_{\text{Probability that project 2 is implemented}} \geq \underbrace{\theta_1}_{\text{Agent's payoff from project 1}} \cdot \underbrace{E[\theta_1 | m = 1]}_{\text{Probability that project 1 is implemented}} \tag{11}$$

Agent's expected payoff from sending  $m=2$ . Agent's expected payoff from sending  $m=1$ .

Condition (11) holds given  $\theta = (l, 1)$  in T. Condition (10) indicates that the agent aims to induce project 1 (i.e., sends  $m = 1$ ). Condition (11) implies the agent's aims to induce project 2 (i.e., sends  $m = 2$ ). For example, in a truthful equilibrium (T), the DM's consistent beliefs are:

$$E[\theta_1 | m = 1] = \frac{2 + (1 + \rho)l}{3 + \rho} = B(\rho, l),$$

$$E[\theta_2 | m = 1] = \frac{2l + (1 + \rho)}{3 + \rho}.$$

To verify the existence of this equilibrium, we check whether conditions (8)–(11) hold based on these beliefs. Similar checks are performed for other types of equilibria, and it can be easily shown that multiple types of informative equilibrium do not exist.

According to conditions (8)–(11), a smaller  $b_{DM}$  (stronger DM bias toward project 1) results in a more pronounced pandering bias. The agent is more inclined to recommend project 1 as suggesting project 2 leads to a reduced probability of implementation. Moreover, for smaller  $b_{DM}$ , the DM finds a ranking where project 2 is superior to project 1 less agreeable.

Figure 3 can be explained as follows, associated with conditions (8)–(11). The space of parameters  $(b_{DM}, b_A)$  is separated into multiple parts with regard to which type of informative equilibrium exists. We call the part where T exists *the area for T*. The areas for P1, P2, and P2' are defined similarly. We call the part where only Z exists *the area for Z*.

Start with a point  $(b_{DM}, b_A)$  in the area for T, where  $b_{DM} < d(\rho, l)$  (the DM's ex ante bias toward project 1 is strong). Then, we increase  $b_A$  with  $b_{DM}$  held fixed. As  $b_A$  increases, the agent becomes more biased toward project 2, and hence, the agent is willing to recommend project 2 (i.e., condition (10) is violated) given  $\theta \in \{(1, 1), (l, l)\}$  in T. As a result, the informative equilibrium existing changes from T to P2. This transition defines the borderline between the areas for T and P2.

As  $b_A$  increases further, the agent is biased toward project 2 further. The agent recommends project 2 more frequently, which reduces the DM's belief on the benefit from project 2 and allows condition (10) to be satisfied given  $\theta \in \{(1, 1), (l, l)\}$  in P2. But, once the DM's belief about the benefit from project 2 goes under some cutoff level, the DM ignores the agent's recommendation of project 2 and chooses project 1. As a result, the informative equilibrium existing changes from P2 to none (i.e., only Z exists). This transition defines the borderline between the areas for P2 and Z.

Again, start with a point  $(b_{DM}, b_A)$  in the area for T where  $b_{DM} < d(\rho, l)$  (the DM's bias is strong). Now, we decrease  $b_A$  with  $b_{DM}$  held fixed. As  $b_A$  decreases, the agent becomes more biased toward project 1, and hence, the agent is willing to recommend project 1 (i.e., condition (11) is violated) given  $\theta = (l, 1)$  in T. As a result, the informative equilibrium existing changes from T to P1. This transition defines the borderline between the areas for T and P1.

As  $b_A$  decreases further, the agent is biased toward project 1 further. The agent recommends project 1 more frequently, which reduces the DM's belief about the benefit from project 1 and allows condition (11) to be satisfied with equality given  $\theta = (l, 1)$  in P1. But, eventually, the agent always recommends project 1 given any state, and condition (11) is violated given  $\theta = (l, 1)$  in P1. As a result, the informative equilibrium existing changes from P1 to none (i.e., only Z exists). This transition defines the borderline between the areas for P1 and Z<sup>8</sup>.

When the DM's ex ante bias is so weak that  $b_{DM} > d(\rho, l)$ , the area for P2' exists, while each borderline is defined similarly. Even if  $b_A$  continues to increase and the agent recommends project 2 more frequently in P2 than in T, the DM still obeys the agent's recommendation of project 2 (i.e., condition (9) is satisfied). As  $b_A$  increases further, the agent does not recommend project 1 at all (i.e., condition (10) is violated) given  $\theta \in \{(1, 1), (l, l)\}$  in P2. As a result, the informative equilibrium existing changes from P2 to P2'. This transition defines the borderline between the areas for P2 and P2'<sup>9</sup>.

Next, we discuss the welfare implications. Let  $V^{DM,T}(\rho, b_A, b_{DM}, l)$  represent the DM's ex ante expected payoffs in a truthful equilibrium (T). Similar notations are used for the ex ante expected payoff in other equilibrium types, denoted as  $V^{DM,P1}(\rho, b_A, b_{DM}, l)$  and  $V^{DM,P2}(\rho, b_A, b_{DM}, l)$ . The specific expressions are found in Appendix A. For any type of equilibrium X in {T, P1, P2, P2', Z}, the DM's ex ante expected payoff is given by:

$$\begin{aligned} &V^{DM,X}(\rho, b_A, b_{DM}, l) \\ &= Pr(m = 1) \int_0^{E[\theta_1|m=1]} (E[\theta_1|m = 1] - c) \cdot dc \\ &\quad + Pr(m = 2) \int_0^{b_{DM}E[\theta_2|m=2]} (b_{DM}E[\theta_2|m = 2] - c) \cdot dc \\ &= Pr(m = 1) \frac{E[\theta_1|m = 1]^2}{2} + Pr(m = 2) \frac{b_{DM}^2 E[\theta_2|m = 2]^2}{2} \end{aligned} \tag{12}$$

For any fixed parameters, the DM fares better in the informative equilibrium compared to the zero equilibrium.

To compare payoffs across parameters, the following observations are important.

Fix  $\rho$  and  $l$ , then:

- (1) T, P1, P2, and Z exist for small  $b_{DM}$ , while only T, P2, and P2' exist (i.e., P1 does not exist) for large  $b_{DM}$ .

(2) For any  $b_{DM}$ ,

$$V^{DM,T}(\rho, b_A, b_{DM}, l) > V^{DM,Z}(\rho, b_A, b_{DM}, l)$$

regardless of  $b_A$ .

(3)  $V^{DM,T}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l)$  strictly increases with  $b_{DM}$ .

(4) But, as  $b_{DM} \nearrow 1$ , then

$$V^{DM,T}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l) \searrow \frac{(1-\rho)(1-l)^2}{8(3+\rho)}.$$

(5) For any  $b_{DM}$ ,

$$V^{DM,T}(\rho, b_A, b_{DM}, l) > V^{DM,P2'}(\rho, b_A, b_{DM}, l)$$

regardless of  $b_A$ .

(6)  $V^{DM,T}(\rho, b_A, b_{DM}, l) - V^{DM,P2'}(\rho, b_A, b_{DM}, l)$  strictly decreases with  $b_{DM}$ .

(7) As  $b_{DM} \nearrow 1$ ,

$$V^{DM,T}(\rho, b_A, b_{DM}, l) - V^{DM,P2'}(\rho, b_A, b_{DM}, l) \searrow 0.$$

These observations lead to the conclusion that, for  $b_{DM} < \sqrt{B(\rho, l) \cdot l}$ , the truthful equilibrium (T) exists only when  $b_A > b_{DM}$ . Consequently, the DM's ex ante expected payoff is not monotonic in  $|b_A - b_{DM}|$ . Additionally, given  $\rho$  and  $l$ , varying levels of  $b_A$  significantly impact the DM's payoff for small  $b_{DM}$ , while the effect diminishes for large  $b_{DM}$ . Therefore, it is reasonable to focus on the non-monotonicity given  $b_A < \sqrt{B(\rho, l) \cdot l}$ .

A similar argument extends to the agent's ex ante expected payoff.

**Corollary 1.** For any fixed  $b_A, \rho$ , and  $l$ , the agent's ex ante expected payoff is not monotonic in  $|b_A - b_{DM}|$  if  $b_A < \sqrt{B(\rho, l) \cdot l}$ .

Let  $V^{A,X}(\rho, b_A, b_{DM}, l)$  denote the agent's ex ante expected payoffs in a type X equilibrium for  $X \in \{T, P1, P2, P2', Z\}$ . Since the agent does not bear the cost of implementing a project, his/her expected payoff is given by:

$$\begin{aligned} &V^{A,X}(\rho, b_A, b_{DM}, l) \\ &= Pr(m = 1) \int_0^{E[\theta_1|m=1]} E[\theta_1|m = 1]dc \\ &\quad + Pr(m = 2) \int_0^{b_{DM}E[\theta_2|m=2]} b_A E[\theta_2|m = 2]dc \\ &= Pr(m = 1)E[\theta_1|m = 1]^2 + Pr(m = 2)b_{DM}b_A E[\theta_2|m = 2]^2 \end{aligned} \tag{13}$$

We omit remaining details for the agent's ex ante expected payoffs. Finally, we present our main claim that the non-monotonicity between information transmission and the project bias is significant when the correlation is closer to  $-1$ .

**Proposition 2.** Fix  $l$ . Then,  $\sqrt{B(\rho, l) \cdot l}$  strictly decreases with  $\rho$ . Furthermore, fix  $l$  and  $b_{DM}$ . Then:

- (1)  $V^{DM,T}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l)$  strictly decreases with  $\rho$ .
- (2)  $V^{DM,T}(\rho, b_A, b_{DM}, l) > V^{DM,Z}(\rho, b_A, b_{DM}, l)$  for any  $\rho$ .
- (3)  $V^{DM,P2'}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l)$  strictly decreases with  $\rho$ .
- (4)  $V^{DM,P2'}(\rho, b_A, b_{DM}, l) > V^{DM,Z}(\rho, b_A, b_{DM}, l)$  only for small  $\rho$ .

Proposition 2 directly follows from expressions (12) and (13), as well as the DM's inferences in each type of equilibrium. As mentioned earlier, when  $b_{DM} < \sqrt{B(\rho, l) \cdot l}$ ,

information transmission does not exhibit monotonicity in  $|b_A - b_{DM}|$ . The first part of Proposition 2 indicates that the non-monotonicity becomes more prevalent with a highly negative correlation. Figure 6 compares the most informative equilibrium and the cutoff  $\sqrt{B(\rho, l)} \cdot l$  for  $l = 0.5$  and various  $\rho$ .

The second part of Proposition 2 suggests that the non-monotonicity in information transmission has a more pronounced impact, at least on the DM's ex ante expected payoff. Figures 7 and 8 compare the ex ante expected payoffs of the DM and the agent, respectively, for  $l = 0.5$  and various  $\rho$ .

We finish this section by discussing the applicability of our results to the model with continuous states. Lemmas 1–3 and Proposition 2 hold in a similar manner in such models. That is, if there is an informative equilibrium, the agent divides the entire state space (a subspace of the two-dimensional euclidean space) by the straight line going through the origin and, then, reveals which part the true state belongs to (i.e., the agent recommends one project over the other). Given fixed  $b_{DM}$ , the dividing line rotates clockwise around the origin (i.e., the agent recommends project 2 more frequently) as  $b_A$  increases (i.e., the agent becomes more biased toward project 2). However, we do not know how to define correlations among continuous states and compare the outcome across different levels of correlations. Hence, this paper focuses on the simple state space (with four points), which results in partition equilibria (as shown in CDK [2]) and allows the examination of different levels of correlations (which is not performed in CDK).

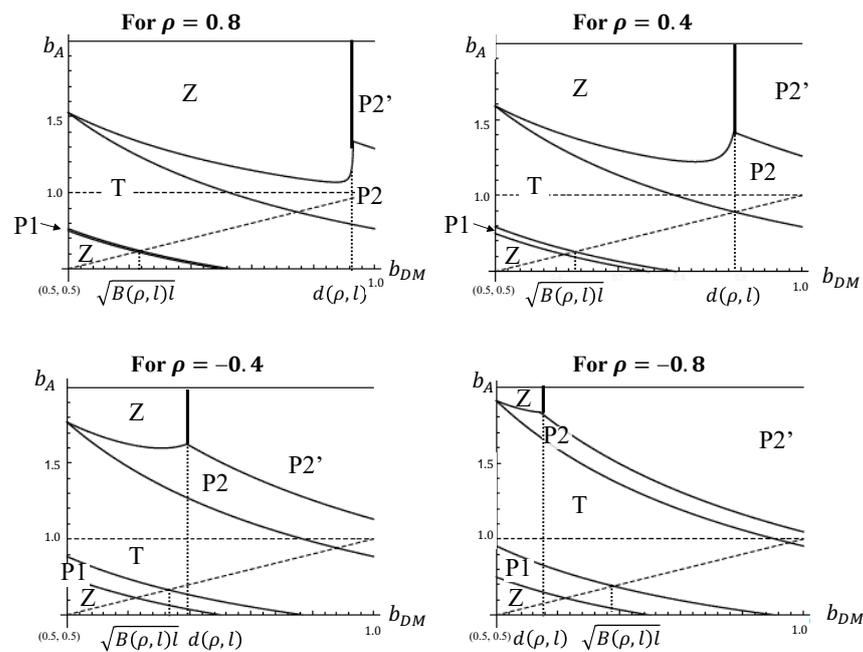
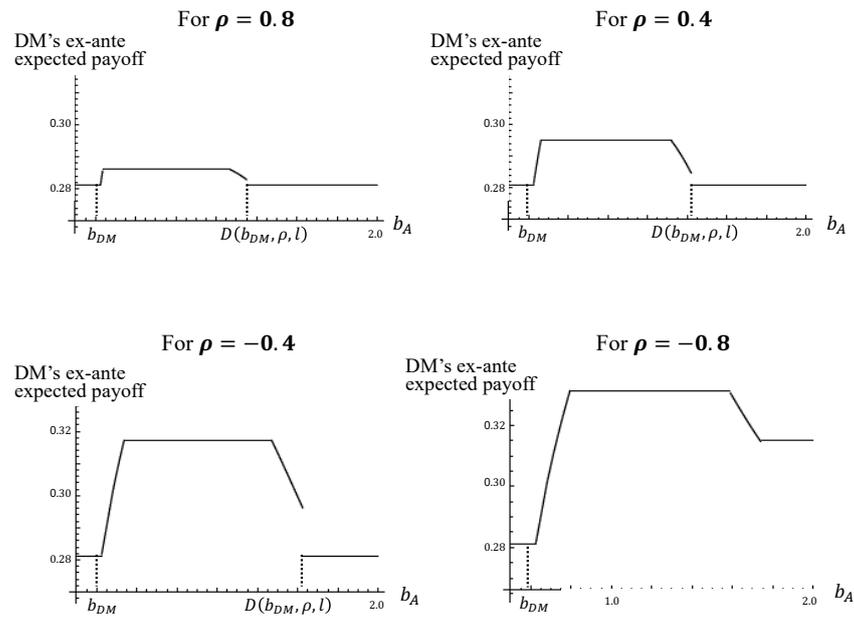
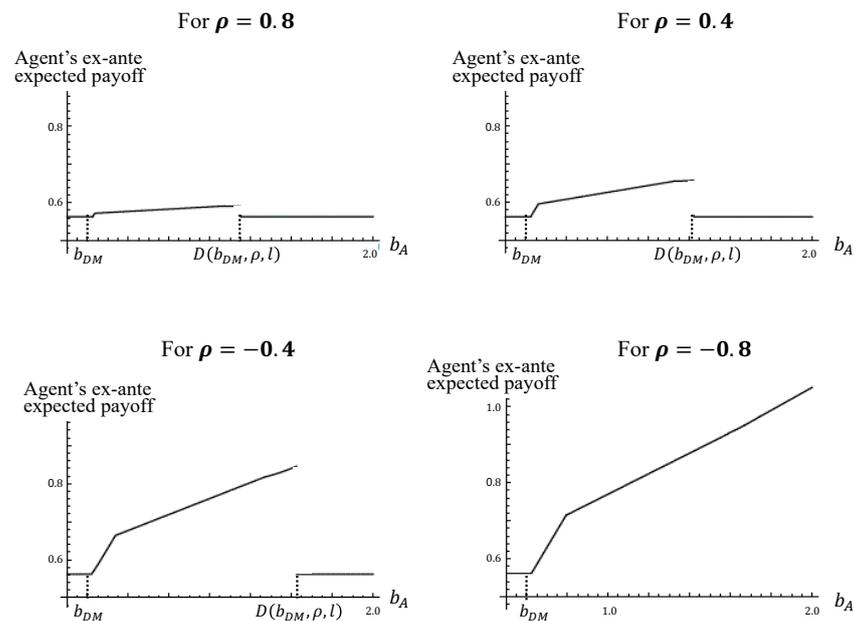


Figure 6. The most informative equilibrium ( $l = 0.5$  and various  $\rho$ ).



**Figure 7.** DM's ex-ante expected payoff in the most informative equilibrium ( $b_{DM} = 0.6, l = 0.5$ , and various  $\rho$ ).



**Figure 8.** Agent's ex-ante expected payoff in the most informative equilibrium ( $b_{DM} = 0.6, l = 0.5$ , and various  $\rho$ ).

#### 4. The Effects of Correlations on Veto-Based Delegation

This section explores the possibility for decision makers (DM) to delegate choices to agents, aiming to alleviate the negative impact of two-dimensional bias. Our delegation model, akin to existing literature on delegation, can be linked to the framework of incomplete contracts (Grossman and Hart, 1996 [17]; Hart and Moore, 1990 [18]). Our model delves into optimal delegation in the context of two-dimensional bias, explaining how the interaction of the project and pandering biases influences the benefits of delegation for the DM.

The DM, acting as the principal, controls the organization's resources and makes decisions. The principal's interest lies in eliciting the agent's information for decision making. To explore the optimal organizational structure, we consider two mechanisms: non-delegation (communication) (Nd) and veto-based delegation (Vd). Full delegation is excluded from our discussion because, in our model, setting the DM bears the entire project implementation cost<sup>10</sup>. Like CDK [2], this paper focuses on the situations under which pandering incentives are strong (because only the DM incurs the project implementation costs) and examines how the level of correlation affects the DM's benefit of delegating the selection of the project in the presence of two-dimensional biases (the pandering and project biases).

Delegating decision-making implies a loss of control, but an uninformed principal (DM) holding decision-making authority inevitably results in a loss of information. Milgrom and Roberts's "delegation principle" suggests that decision-making power should be with an informed agent, like divisional managers in our case study (Milgrom and Roberts, 1992 [19]). The question is, under what circumstances does delegation benefit the DM?

In the case of non-delegation (Nd), players engage in the game described in Section 3. The timeline is as follows:

- Step 1. Nature selects the state  $\theta$ , privately and perfectly observed by the agent.
- Step 2. The agent sends a cheap talk message,  $m$ , which the DM observes without any noise.
- Step 3. The DM's project cost,  $c_{DM}$ , is determined and publicly observed.
- Step 4. The DM decides whether to implement project  $P$  from the set  $\{1, 2\}$  or choose the outside option of no project ( $P = \emptyset$ ).
- Step 5. Both players' payoffs are realized.

In Vd, the agent is authorized to choose between projects, but the principal can veto the agent's choice in favor of the outside option. This adjustment changes Step 4 under non-delegation (Nd) into Step 4':

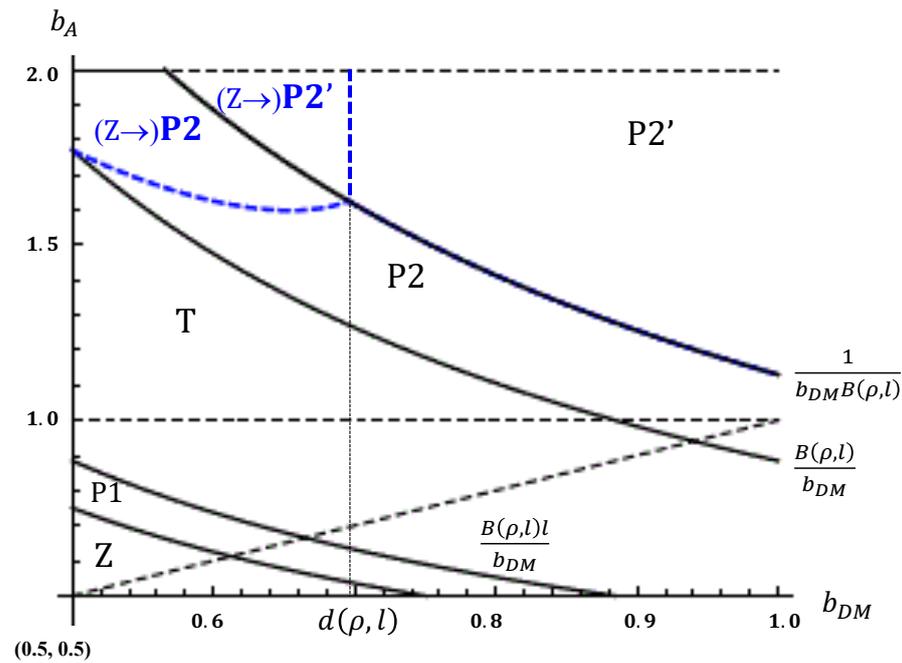
- Step 4'. The principal chooses  $P$  from the set  $\{m, \emptyset\}$ .

Similar to Section 3, we consider a binary message set,  $M = \{1, 2\}$ . The agent's message is denoted as  $m^d$ . The expression  $q^d(\theta)$  represents the probability that the agent sends  $m^d \in \{1, 2\}$  for each state  $\theta$ . The expression  $P^d(c, m^d)$  is the principal's strategy, and  $\mu^d(m^d)$  is the principal's posterior belief. Our focus is on equilibria where the agent's strategy satisfies condition (3) in Section 3.

Previously, we defined various types of equilibria, and they remain applicable for both delegation mechanisms. These include a truthful equilibrium (T), a pandering-toward-1 equilibrium (P1), a pandering-toward-2 equilibrium (P2), a pandering-toward-2 equilibrium' (P2'), and a zero equilibrium (Z). Section 3 discusses the results under Nd. Under Vd, conditions (8) and (9) are no longer necessary. In Vd, the agent is no longer required to persuade the principal (DM) to agree to the agent's project ranking.

With fixed values for  $\rho$ ,  $b_{DM}$ , and  $l$ , veto-based delegation (Vd) enhances information transmission compared to non-delegation (Nd) when there is a significant project bias, denoted as  $|b_A - b_{DM}|$ .

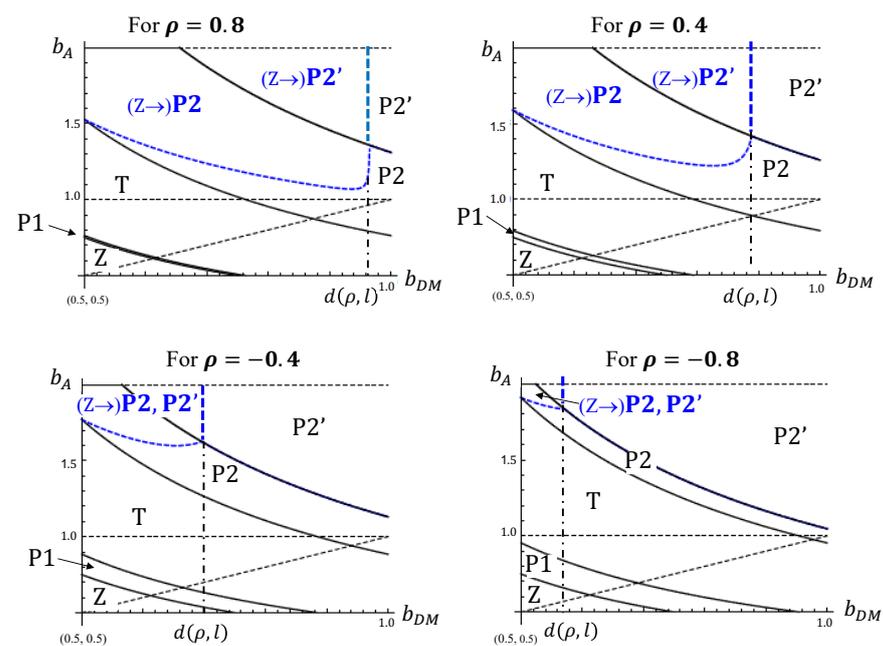
Figure 9 illustrates the existence of each equilibrium type for  $l = 0.5$  and  $\rho = -0.4$  under Vd. Assuming  $b_{DM}$  is small enough that  $b_{DM} < d(\rho, l)$ , for  $b_A > D(b_{DM}, \rho, l)$ , information aggregation occurs under Vd, whereas no informative equilibrium is present under Nd. The improvement is depicted by  $(Z \rightarrow)P2$  and  $(Z \rightarrow)P2'$  in Figure 9.



**Figure 9.** The most informative equilibrium under veto-based delegation (Vd) ( $l = 0.5$  and  $\rho = -0.4$ ) (The improvement on the most informative equilibrium under no-delegation (Nd) is described by  $(Z \rightarrow)P2$  and  $(Z \rightarrow)P2'$ ).

Next, set  $l$  to a fixed value. Then,  $d(\rho, l)$  strictly increases with  $\rho$ . Consequently, veto-based delegation (Vd) enhances the expected payoffs for both players compared to non-delegation (Nd) across a broader range of  $b_{DM}$  as  $\rho$  increases.

The first part of this observation is evident from the functional form of  $d(\rho, l)$ . Therefore, veto-based delegation (Vd) enhances information transmission over non-delegation (Nd) for a more extensive set of parameters. Figure 10 illustrates equilibria types under veto-based delegation (Vd) and demonstrates improved information transmission across various  $\rho$  values, with  $l$  fixed at 0.5.



**Figure 10.** The most informative equilibrium under Vd ( $l = 0.5$  and various  $\rho$ ).

Skipping the details due to their obvious nature, increased information transmission resulting from delegation consistently benefits the agent. However, this is not always the case for the DM. Yet, we observe that, particularly for  $b_A$  near and above  $D(b_{DM}, \rho, l)$ , enhanced information transmission due to delegation also benefits the DM.

Recall that, under Nd, for any fixed  $b_{DM} < d(\rho, l)$ , there is discontinuity at  $b_A = D(b_{DM}, \rho, l)$  in the level of information transmission. This discontinuity leads to a sudden drop in the DM's ex ante expected payoffs.

First, we establish:

$$V^{DM,P2}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l) > 0$$

at  $b_A = D(b_{DM}, \rho, l)$ .

Furthermore, concerning  $b_A$ ,  $V^{DM,Z}(\rho, b_A, b_{DM}, l)$  remains constant, whereas  $V^{DM,P2}(\rho, b_A, b_{DM}, l)$  is continuous. Hence, there exists  $\epsilon > 0$  such that:

$$V^{DM,P2}(\rho, b_A, b_{DM}, l) - V^{DM,Z}(\rho, b_A, b_{DM}, l) > 0$$

for  $b_A \in (D(b_{DM}, \rho, l), D(b_{DM}, \rho, l) + \epsilon)$ .

Veto-based delegation (Vd) enhances the DM's ex ante expected payoff compared to no-delegation (Nd), particularly for  $b_A$  within the range  $(D(b_{DM}, \rho, l), D(b_{DM}, \rho, l) + \epsilon)$ . This confirms the second part of our observation.

Greater potential for improvement exists when the correlation is closer to 1. In simpler terms, non-delegation can be effective when project payoffs exhibit negative correlation. This aligns with our observation in Section 3 that negative correlation offsets the project and pandering biases.

This finding deviates from existing literature. Dessein (2002) [20] examined a model with continuous projects and states, demonstrating that veto-based delegation strictly dominates non-delegation if and only if the project bias is small. Mylovantov (2008) [21] suggested that, with the optimal choice of the default project, Vd can replicate any optimal outcome under Nd for large bias. Contrary to CDK [2], which compared delegation regimes based on comparative statics with respect to the principal's payoff for the outside option, our model suggests that, even when communication is not influential, delegation can be strictly preferred over communication by the DM.

## 5. Conclusions

The inclusion of the outside option introduces two different dimensions of biases between the players, involving project and pandering biases. A strong negative correlation between project payoffs amplifies the countervailing impact of the project bias on pandering bias. Consequently, the project bias exhibits a non-monotonic relationship with information transmission and the decision maker's (DM) ex ante expected payoffs.

When looking at delegation in the presence of these biases, our findings differ from what is in the existing literature. Veto-based delegation improves information gathering in decision making, especially when the project bias is significant. Also, an increase in correlation between project payoffs expands the range where this improvement is seen.

Future research should explore the best delegation method when countervailing biases are present. We need to check if the conclusions made by Gilligan and Krehbiel (1987) [13], Krishna and Morgan (2001) [14], and Martin (1997) [22] about closed-rule dominance over open-rule still apply when there are countervailing biases among multiple agents and the principal. Future studies should also try to endogenize the pandering bias (cf. Rantakari (2012) [23]).

Lastly, we are interested in adding an agent to the current model. Battaglini (2002) [24], Levy and Razin (2007) [25], and Ambrus and Takahashi (2008) [26] investigated cheap talk models with two agents and a two-dimensional state space. In their models, the state, the DM's choice, the agents' optimal choices, and the biases of the agents are all defined on two-dimensional euclidean space, and each player is better off as the DM's choice is closer

to her/his optimal choice. They showed that full revelation is possible in a large state space and when biases are not largely different given small state spaces. On the contrary, our choice set and our two-dimensional biases are not defined in their ways. It is not trivial that their conclusions hold in our model.

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## Appendix A

### Appendix A.1. Proof of Lemma 1

Given  $\theta = (\theta_1, \theta_2)$ , the agent’s expected payoff by sending arbitrary message  $m'$  is:

$$\begin{aligned} & \theta_1 \cdot Pr(\text{DM implements project 1 given } m = m') \\ & + b_A \cdot \theta_2 \cdot Pr(\text{DM implements project 2 given } m = m'). \end{aligned}$$

If the agent wants to induce project 1 given some  $\theta$ , the agent prefers a message that induces the DM to select project 1 with the highest probability. Multiple messages that induce project 1 survive only if these messages induce project 1 with the same probability. The argument is similar for the case when the agent wants to induce project 2. Hence, every equilibrium outcome is replicated by an equilibrium in which the agent uses the same number of messages as the number of projects implemented on the equilibrium path. That is, we need to use at most two messages to construct an equilibrium in this model.

### Appendix A.2. Proof of Lemma 2

Suppose that the DM implements the project recommended by the agent. Then, if the agent sends  $m = 1$ , the probability of DM implementing project 1 is given by:

$$E[\theta_1 | m = 1].$$

If the agent sends  $m = 2$ , the probability of the DM implementing project 2 is given by:

$$b_{DM} \cdot E[\theta_2 | m = 2].$$

In the following proofs, we use these results:

- (1) Suppose that  $q(1|\theta = (l, 1)) > 0$  holds. That is, given  $\theta = (l, 1)$ :

$$\underbrace{\theta_1 \cdot E[\theta_1 | m = 1]}_{\text{The agent's expected payoff if he/she sends } m=1} \geq \underbrace{(b_A \cdot \theta_2) \cdot (b_{DM} \cdot E[\theta_2 | m = 2])}_{\text{The agent's expected payoff if he/she sends } m=2}.$$

Then, strict inequality should hold given any  $\theta \in \{(1, 1), (1, l), (l, l)\}$ . That means:

$$q(1|\theta = (1, 1)) = q(1|\theta = (1, l)) = q(1|\theta = (l, l)) = 1$$

- (2) Suppose that  $q(1|\theta = (1,1)) \in (0,1)$  or  $q(1|\theta = (l,l)) \in (0,1)$  holds. That is, given any  $\theta \in \{(1,1), (l,l)\}$ :

$$\theta_1 \cdot E[\theta_1|m = 1] = b_A \cdot \theta_2 \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

Then, the strict inequality:

$$\theta_1 \cdot E[\theta_1|m = 1] > b_A \cdot \theta_2 \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

should hold given  $\theta = (1,l)$ . That means  $q(1|\theta = (1,l)) = 1$ . In addition, the strict inequality:

$$\theta_1 \cdot E[\theta_1|m = 1] < b_A \cdot \theta_2 \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

should also hold given  $\theta = (l,1)$ . That means  $q(1|\theta = (l,1)) = 0$ .

- (3) Suppose that  $q(1|\theta = (1,l)) < 1$  holds. That is, given  $\theta = (1,l)$ :

$$\theta_1 \cdot E[\theta_1|m = 1] \leq b_A \cdot \theta_2 \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

Then, strict inequality should hold given any  $\theta \in \{(1,1), (l,1), (l,l)\}$ . That means:

$$q(1|\theta = (1,1)) = q(1|\theta = (l,1)) = q(1|\theta = (l,l)) = 0$$

### Appendix A.3. Proof of Lemma 3

- (1) From Lemma 2, T, P1, P2, and P2' are the only types of equilibria that can exist. We can also show that the DM's belief  $E[\theta_1|m = 1]$  is larger in P2' than in P2, in P2 than in T, and in T than in P1, respectively. Correspondingly, the DM's belief  $E[\theta_2|m = 2]$  is larger in P1 than in T, in T than in P2, and in P2 than in P2', respectively. Consider the set of parameters  $b_{DM}$  and  $b_A$  given which T exists. In T, the agent strictly prefers sending  $m = 1$  to  $m = 2$  given  $\theta = (1,l)$ , that is:

$$1 \cdot E[\theta_1|m = 1] > l \cdot b_A \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

We cannot construct P2 or P2', which requires

$$1 \cdot E[\theta_1|m = 1] \leq l \cdot b_A \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

with larger  $E[\theta_1|m = 1]$  and smaller  $E[\theta_2|m = 2]$ . Similarly, in T, the agent prefers sending  $m = 2$  to  $m = 1$  given  $\theta = (l,1)$ , that is:

$$l \cdot E[\theta_1|m = 1] \leq 1 \cdot b_A \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

We cannot construct P1, which requires

$$1 \cdot E[\theta_1|m = 1] = l \cdot b_A \cdot b_{DM} \cdot E[\theta_2|m = 2].$$

with smaller  $E[\theta_1|m = 1]$  and larger  $E[\theta_2|m = 2]$ .

Similarly, we can show that P1, P2, and P2' do not exist together.

The second sentence follows from the property of cheap talk models: there always exists an equilibrium where no information is revealed (a babbling equilibrium). In this model, without information, the DM never implements project 2. Thus, a zero equilibrium always exists.

- (2) From the definition, if T, P1, or P2' exists, the agent does not mix between the messages given any state, and hence, this is the only informative equilibrium. On the other hand, if P2 exists, there can be multiple P2s. P2 requires

$$E[\theta_1|m = 1] = b_A \cdot b_{DM} \cdot E[\theta_2|m = 2]$$

with larger  $E[\theta_1|m = 1]$  and smaller  $E[\theta_2|m = 2]$  than T. But, P2 allows the agent to mix between the two messages given  $\theta \in \{(1, 1), (l, l)\}$ , and the agent can mix differently given the two states.

- (3) The welfare comparison is trivial. If there is an informative equilibrium, both players prefer project 2 over project 1 given at least one state. However, in a zero equilibrium, only project 1 is implemented. Both players should be better off in an informative equilibrium than in a zero equilibrium.

*Appendix A.4. Proof of Proposition 1*

To find the existence conditions for each informative equilibrium, we compute the DM’s beliefs consistent with the agent’s message strategies. Then, we find parametric assumptions satisfying conditions (8) and (9) (the DM obeys the agent’s recommendation) and conditions (10) and (11) (the message strategy is incentive-compatible for the agent) in Section 3.

In a truthful equilibrium (T), the agent’s message strategy is:

$$\begin{aligned} m = 1 & \text{ w.p. } 1 \text{ if } \theta \in \{(1, l), (1, 1), (l, l)\} \\ m = 2 & \text{ w.p. } 1 \text{ if } \theta = (l, 1) \end{aligned}$$

The DM’s consistent beliefs are:

$$\begin{aligned} E[\theta_1|m = 1] &= \frac{2 + (1 + \rho)l}{3 + \rho}, \\ E[\theta_2|m = 1] &= \frac{2l + (1 + \rho)}{3 + \rho}, \\ E[\theta_1|m = 2] &= l, \\ E[\theta_2|m = 2] &= 1. \end{aligned}$$

These beliefs satisfy conditions (8) and (9).

Next, condition (10) binds given  $\theta = (1, 1)$ :

$$\begin{aligned} 1 \cdot \frac{2 + (1 + \rho)l}{3 + \rho} &\geq (1 \cdot b_A) \cdot (1 \cdot b_{DM}) \\ \Leftrightarrow b_A b_{DM} &\leq \frac{2 + (1 + \rho)l}{3 + \rho} = B(\rho, l). \end{aligned}$$

Condition (11) binds given  $\theta = (l, 1)$ :

$$\begin{aligned} (1 \cdot b_A) \cdot (1 \cdot b_{DM}) &\geq l \cdot \frac{2 + (1 + \rho)l}{3 + \rho} \\ \Leftrightarrow b_A b_{DM} &\geq l \cdot \frac{2 + (1 + \rho)l}{3 + \rho} = l \cdot B(\rho, l). \end{aligned}$$

Therefore, Proposition 1 (1) holds.

In P1, the agent’s message strategy is:

$$\begin{aligned} m = 1 & \text{ w.p. } 1 \text{ if } \theta \in \{(1, l), (1, 1), (l, l)\}, \\ m = 1 & \text{ w.p. } q \text{ and } m = 2 \text{ w.p. } 1 - q \text{ if } \theta = (l, 1) \end{aligned}$$

for some  $q \in (0, 1)$ . The DM’s consistent beliefs are:

$$\begin{aligned} E[\theta_1|m = 1] &= \frac{2 + (1 + \rho + q(1 - \rho))l}{3 + \rho + q(1 - \rho)}, \\ E[\theta_2|m = 1] &= \frac{2l + (1 + \rho + q(1 - \rho))}{3 + \rho + q(1 - \rho)}, \\ E[\theta_1|m = 2] &= l, \\ E[\theta_2|m = 2] &= 1. \end{aligned}$$

Condition (11) should hold with equality given  $\theta = (l, 1)$ :

$$(1 \cdot b_A) \cdot (1 \cdot b_{DM}) = l \cdot \frac{2 + (1 + \rho + q(1 - \rho))l}{3 + \rho + q(1 - \rho)}$$

$$\Leftrightarrow q^{P1} := \frac{(2 + (1 + \rho)l)l - b_{DM}b_A(3 + \rho)}{(1 - \rho)(b_{DM}b_A - l^2)}$$

We can show  $q^{P1} \in (0, 1)$  for

$$\frac{l + l^2}{2b_{DM}} < b_A < \frac{B(\rho, l)l}{b_{DM}}$$

Conditions (8)–(10) do not bind. Proposition 1(2) holds.

From Lemma 3, P2 requires

$$E[\theta_1 | m = 1] = b_A \cdot b_{DM} \cdot E[\theta_2 | m = 2].$$

As expression (12) shows, the DM’s beliefs determine the DM’s ex ante expected payoff, independent of how the agent mixes the two messages given each of  $\theta \in \{(1, 1), (l, l)\}$ . Hence, we compute the simple P2, where the agent’s message strategy is

$$m = 1 \text{ w.p. } 1 \text{ if } \theta = (1, l),$$

$$m = 1 \text{ w.p. } q \text{ and } m = 2 \text{ w.p. } 1 - q \text{ if } \theta \in \{(1, 1), (l, l)\},$$

$$m = 2 \text{ w.p. } 1 \text{ if } \theta = (l, 1)$$

for some  $q \in (0, 1)$ . The DM’s consistent beliefs are:

$$E[\theta_1 | m = 1] = \frac{1 - \rho + q(1 + \rho)(1 + l)}{1 - \rho + 2q(1 + \rho)},$$

$$E[\theta_2 | m = 1] = \frac{(1 - \rho)l + q(1 + \rho)(1 + l)}{1 - \rho + 2q(1 + \rho)},$$

$$E[\theta_1 | m = 2] = \frac{(1 - \rho)l + (1 - q)(1 + \rho)(1 + l)}{1 - \rho + 2(1 - q)(1 + \rho)},$$

$$E[\theta_2 | m = 2] = \frac{1 - \rho + (1 - q)(1 + \rho)(1 + l)}{1 - \rho + 2(1 - q)(1 + \rho)}.$$

Condition (10) should hold with equality given  $\theta = (1, 1)$ :

$$E[\theta_1 | m = 1] = b_A b_{DM} E[\theta_2 | m = 2]$$

$$\Leftrightarrow \frac{1 - \rho + q(1 + \rho)(1 + l)}{1 - \rho + 2q(1 + \rho)} = b_A b_{DM} \frac{1 - \rho + (1 - q)(1 + \rho)(1 + l)}{1 - \rho + 2(1 - q)(1 + \rho)}.$$

The parameter  $q$  satisfying the last equality is uniquely determined. Let  $q^{P2}$  denote such a unique  $q$ . We can show that

$$q^{P2} \in (0, 1) \text{ for } b_A \in \left( \frac{B(\rho, l)}{b_{DM}}, \frac{1}{b_{DM}B(\rho, l)} \right).$$

But, condition (9) additionally requires:

$$b_{DM} \cdot E[\theta_2 | m = 2] \geq E[\theta_1 | m = 2]$$

$$\Leftrightarrow q \geq 1 - \frac{(b_{DM} - l) \cdot (1 - \rho)}{(1 - b_{DM})(1 + \rho)(1 + l)} =: \underline{q}.$$

Hence,  $q^{P2} \geq \underline{q}$  is the necessary condition for the existence of P2, which holds if and only if

$$b_A \leq D(b_{DM}, \rho, l),$$

where we find  $D(\rho, l, b_{DM})$  by plugging  $q = \bar{q}(b_{DM}, l, \rho)$  into

$$\frac{1 - \rho + q(1 + \rho)(1 + l)}{1 - \rho + 2q(1 + \rho)} = b_{DM}b_A \frac{1 - \rho + (1 - q)(1 + \rho)(1 + l)}{1 - \rho + 2(1 - q)(1 + \rho)}.$$

In summary, P2 exists for

$$q^{P2} \in (0, 1) \text{ for } b_A \in \left( \frac{B(\rho, l)}{b_{DM}}, \min \left\{ \frac{1}{b_{DM}B(\rho, l)}, D(b_{DM}, \rho, l) \right\} \right).$$

We can also show that (9) binds and

$$D(b_{DM}, \rho, l) < \frac{1}{b_{DM}B(\rho, l)}$$

iff  $b_{DM} < d(\rho, l)$ . Proposition 1(3) holds.

In P2', the agent's message strategy is

$$\begin{aligned} m = 1 \text{ w.p. } 1 & \text{ if } \theta = (1, l) \\ m = 2 \text{ w.p. } 1 & \text{ if } \theta \in \{(1, 1), (l, l), (l, 1)\}. \end{aligned}$$

The DM's consistent beliefs are:

$$\begin{aligned} E[\theta_1 | m = 1] &= 1, \\ E[\theta_2 | m = 1] &= l, \\ E[\theta_1 | m = 2] &= \frac{1 + \rho + 2l}{3 + \rho}, \\ E[\theta_2 | m = 2] &= \frac{2 + (1 + \rho)l}{3 + \rho} = B(\rho, l). \end{aligned}$$

These beliefs satisfy conditions (8) and (9) only if  $b_{DM} \geq d(\rho, l)$ . Condition (11) binds given  $\theta = (1, 1)$ :

$$b_A b_{DM} B(\rho, l) \geq 1 \Leftrightarrow b_A \geq \frac{1}{b_{DM}B(\rho, l)}.$$

For  $b_A < 1/l$ , (10) holds given  $\theta = (1, l)$ . Proposition 1(4) holds.

For  $b_{DM} < d(\rho, l)$ , (9) is violated even if we can construct an incentive-compatible message strategy for the agent. There is discontinuity in the sense that, as we increase  $b_{DM}$ , the informative equilibrium shifts from P2 to Z, skipping P2' because the DM's bias is too strong to obey.

The non-monotonicity of the DM's ex ante expected payoff directly follows from claims (1)–(5) in Proposition 1 and expression (12) in Section 3. We can compute the ex ante expected payoff of the DM using the above-mentioned results.

For example,

$$\begin{aligned} V^{DM,T}(\rho, b_A, b_{DM}, l) &= \frac{(2 + (1 + \rho)l)^2}{8(3 + \rho)} + \frac{(1 - \rho)b_{DM}^2}{8}, \\ V^{DM,P2'}(\rho, b_A, b_{DM}, l) &= \frac{1 - \rho}{8 + \frac{(2 + (1 + \rho)l)^2 b_{DM}^2}{8(3 + \rho)}}, \\ V^{DM,Z}(\rho, b_A, b_{DM}, l) &= \frac{(1 + l)^2}{8}. \end{aligned}$$

#### Appendix A.5. Proof of Corollary 1

This result follows from Proposition 1 and expression (13) in Section 3. We can compute the ex ante expected payoff of the DM using the above-mentioned results.

For example,

$$V^{A,T}(\rho, b_A, b_{DM}, l) = \frac{(2 + (1 + \rho)l)^2}{4(3 + \rho)} + \frac{(1 - \rho)b_{DM}b_A}{4},$$

$$V^{A,P2'}(\rho, b_A, b_{DM}, l) = \frac{1 - \rho}{4} + \frac{(2 + (1 + \rho)l)^2 b_{DM} b_A}{4(3 + \rho)},$$

$$V^{A,Z}(\rho, b_A, b_{DM}, l) = \frac{(1 + l)^2}{4}.$$

#### Appendix A.6. Proof for Section 4

Under Vd, conditions (8) and (9) in Section 3 do not need to hold any more. Hence, from Proposition 1, the equilibrium outcome is different only for  $b_{DM} < d(\rho, l)$  and  $b_A \geq D(b_{DM}, \rho, l)$ .

For  $b_{DM} < d(\rho, l)$ , there is no discontinuity in the sense that P2 exists for

$$b_A \in \left( \frac{B(\rho, l)}{b_{DM}}, \frac{1}{b_{DM}B(\rho, l)} \right)$$

and P2' exists for

$$b_A \in \left( \frac{1}{b_{DM}B(\rho, l)}, \frac{1}{l} \right).$$

## Notes

- 1 “Over the past 50 trading sessions, there has been a strong inverse correlation between the airline index and oil prices.” See <https://www.reuters.com/article/us-usa-airlines-stocks/rising-oilprices-help-ground-u-s-airline-stocks-could-make-them-cheap-idUSKCN1IM24C> (accessed on 30 November 2023).
- 2 There has been a positive correlation between wind and solar power since 2009. See <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7110436> (accessed on 30 November 2023). From 2002 to 2012, the average annual growth rates for wind and solar power were 26.1% and 50.1%, respectively. See <http://www.energies-renouvelables.org/observer/html/inventaire/pdf/15e-inventaire-Chap01-Eng.pdf> (accessed on 30 November 2023).
- 3 Apple receives a 30% commission on software bought through the Mac App Store. See <https://discussions.apple.com/thread/7032123> (accessed on 30 November 2023).
- 4 For example, if  $b_A \leq l$ , the agent prefers project 1 given any state. If  $b_A \geq 1/l$ , the agent prefers project 2 given any state. We eliminate these situations from our analysis.
- 5 For each player  $j \in \{DM, A\}$ , a correlation coefficient of the two projects' benefits  $\text{corr}(\theta_1, b_j\theta_2)$  is  $\rho$ . But, regardless of  $\rho$ , the unconditional means of project 1 and project 2 are  $E[\theta_1] = \frac{1+l}{2}$  and  $E[b_j\theta_2] = \frac{b_j(1+l)}{2}$ , and their unconditional variances are  $\text{Var}[\theta_1] = \frac{(1-l)^2}{2}$  and  $\text{Var}[b_j\theta_2] = \frac{b_j^2(1-l)^2}{2}$ .
- 6 CDK [2] did not consider the project cost; instead, they examined different payoffs resulting from selecting the outside option for different players: a positive payoff for the principal and a zero payoff for the agent.
- 7 Lemma 3 and Proposition 1 are closely related to Chiba and Leong (2015) [4].
- 8 For very large  $b_{DM}$ , there is no area for Z below the area P1 since we assume  $b_A > l$ . If we relax this assumption, the area Z appears below the area P1 for any level of  $b_{DM} < 1$ .
- 9 Since we assume  $b_A < 1/l$ , there is no area for Z above P2' for  $b_{DM} > d(\rho, l)$ . If we relax our assumption and consider  $b_A \geq 1/l$ , then the informative equilibrium existing eventually changes from P2' to none (i.e., only Z exists).
- 10 We can also show that full delegation always makes the DM worse off than veto-based delegation given our model setting.

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