# Conceal to Coordinate

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July 2018

**Abstract**

How much information can a leader convey to others if she also wants to convince them to follow her? We study a team's decision to take on a risky project, when members' actions exhibit strategic complementarities. We show that the leader must conceal information in any cheap talk equilibrium: when she chooses to adopt the new project, she can only reveal that she will do so, but no more. We explore whether the ability to commit to full disclosure is valuable. We find that welfare and informational efficiency may be higher with partially informative cheap talk than with full disclosure.
JEL: G34, G39, D23, D82

Keywords: Leadership, Cheap talk, Coordination, Disclosure

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Communication is key to effective leadership, especially in the absence of contracts and formal authority. As Hermalin (1998) emphasizes, "following a leader is a voluntary, rather than coerced, activity." An effective leader must both *inform* her team about the appropriate course of action, and *convince* them to follow her. We study how these two roles interact to jointly determine the nature of communication between a leader and her team. For instance, one might expect that when the leader's incentives are more closely aligned with those of her followers, such communication is more credible and informative. We show that the very opposite result holds — the leader's motive to coordinate the team's actions diminishes her credibility.

Consider the CEO of a firm that is deciding whether to initiate an internal reorganization of the firm, or to maintain the status quo. The CEO and her team of division managers are privately informed about the relative benefits of adopting the reorganization, but the information is "soft" (i.e., not verifiable). Each member of the team must decide whether or not to switch from the status quo, and the team has an incentive to coordinate: the payoff from adoption to each member depends, in part, on whether others also participate.[1] To focus on the impact of communication, we abstract from considerations of contracting and delegation by assuming that the participation decision is simultaneous and switching requires (unobservable) effort.

When the leader cannot commit to her communication strategy, we show that she *conceals* information. If she chooses to switch from the status quo, her message can only reveal that she will do so, but nothing more. This is because the leader's incentives are not aligned with those of her followers, conditional on her private information, even if they are perfectly aligned ex-ante. Specifically, when the leader is optimistic enough to switch, she has an incentive to mislead her teammates so they follow her, irrespective of her information. As such, her desire to convince others to follow her is too strong to credibly convey any additional information.

Given the leader's limited ability to communicate credibly via cheap talk, we then ask whether she would commit to full disclosure if she could. We find that both the leader and her followers may prefer partially-informative cheap talk to full disclosure.[2] Standard intuition suggests that the followers should prefer full disclosure, since they receive more

[1] In the analysis, we also allow for their coordination incentives to be misaligned by letting the leader's payoff differ from the other members' by a known bias when both adopt the project.

[2] This is in contrast to pure sender-receiver games. In standard cheap-talk settings, both the sender and the receiver prefer commitment to full disclosure (e.g., Crawford and Sobel (1982)). In standard models of Bayesian persuasion (e.g., Rayo and Segal (2010) and Kamenica and Gentzkow (2011)), the receiver prefers more informative messages even if the sender may prefer to commit to partially-informative communication.

information about fundamentals. However, unlike pure sender-receiver games, players in our setting face both fundamental uncertainty (is the reorganization beneficial?) and strategic uncertainty (will my teammates adopt it?). These two dimensions of uncertainty introduce a tradeoff. On the one hand, full disclosure leads to less fundamental uncertainty for the followers since they receive a more informative message about the reorganization. On the other hand, we show that the leader faces less strategic uncertainty with cheap talk, and as a result, all team members benefit from better coordination.[3] The overall impact of these offsetting effects depends on how biased in favor of switching the leader is relative to her followers. When the bias is large, the loss of fundamental information under cheap talk implies followers would prefer full disclosure. However, when the bias is small, the benefits of improved coordination outweigh the informational costs, and the followers prefer partially-informative cheap talk.

Finally, we consider how informational efficiency of the team's decision varies across these scenarios. Efficiency measures the extent to which the team's actions match fundamentals and, as such, may be easier to measure empirically than welfare. Inefficiency is driven by two sources: under-adoption when the new project is better than the status quo, and over-adoption when it is worse. Facilitating communication leads to more informed choices and better coordination. When the alternative is better than the status quo, these effects reinforce each other and improve efficiency. When the alternative is worse, these effects operate in opposite directions, and can decrease efficiency by inducing too much switching (over-adoption).

These effects interact with the endogenous nature of information revealed by strategic communication. When the manager is biased in favor of the status quo, the informational cost of the cheap-talk equilibrium is low, but improved coordination implies efficiency is higher with cheap talk. However, when the manager is very biased in favor of switching, overall efficiency is higher with full disclosure because the informational advantage outweighs the loss in coordination benefits.

Our analysis speaks to the literature that studies how CEO biases affect firm decisions (e.g., Malmendier and Tate (2005, 2008); Ben-David, Graham, and Harvey (2013); Graham, Harvey, and Puri (2013)). Our results imply that the impact of a CEO's biased beliefs on the efficiency of her firm's decisions is non-monotonic, and depends on the information environment within the organization. Consistent with the empirical evidence in the literature,

[3]Specifically, we show that at a conjectured threshold for adoption, followers are more optimistic about the reorganization under the cheap-talk equilibrium than under the full disclosure equilibrium. All else equal, this implies they are more likely to switch, which reduces the strategic uncertainty faced by the leader.

our model predicts that optimistic (positively biased) CEOs are more likely to abandon the status quo and over-invest in new, risky projects. Our model also predicts that the degree of over-investment is likely to be larger in firms with less internal transparency and worse internal governance, which make commitment to full disclosure less feasible. Finally, our model suggests that firms are likely to make more efficient decisions when led by "reluctant" CEOs, who are moderately biased in favor of the status quo, especially in settings where internal coordination has a large impact on performance.[4]

Our paper also contributes to the large literature of how disclosure requirements and greater transparency can distort managerial behavior and firm outcomes (see Hermalin and Weisbach (2012) for a general treatment). The earlier literature has focused on how managers attempt to manipulate their compensation by engaging in "signal-jamming" activities, such as investing in short-term projects (e.g., Stein (1989)), providing less precise information to the board (e.g., Song and Thakor (2006)), and misreporting performance (e.g., Goldman and Slezak (2006)). Our analysis highlights a complementary channel through which higher internal transparency (e.g., mandatory full disclosure) can have adverse effects, by limiting the manager's ability to coordinate her team's behavior. In particular, we show that forcing full disclosure can reduce welfare and efficiency when the manager is moderately biased, and these adverse effects are worse for larger teams.

Our results apply more generally to settings where players have incentives to coordinate, but cannot commit to share information or formally coordinate behavior. For instance, activist fund managers in a "wolf-pack" try to implicitly coordinate their acquisition of a target without formally filing as a group for regulatory purposes (e.g., see Briggs (2007), Brav, Dasgupta, and Mathews (2014), and Coffee and Palia (2016)). While the informal nature of their coordination allows them to delay legal disclosure requirements (e.g., filing a Schedule 13D with the SEC) and avoid defensive measures (e.g., poison pills), it may hinder their ability to communicate with each other. Similarly, firms that are deciding whether to adopt a new industry standard have incentives to coordinate, but may be unable to share their private information about the new technology due to legal restrictions (e.g., anti-trust concerns) or competitive pressures. Finally, in venture capital investment, where "hard" information about investment opportunities is limited, the lead investor must both convey information about potential projects and convince others to coinvest (see Hochberg, Ljungqvist, and Lu (2007) for evidence of the impact of such network effects on investment

[4] Intuitively, the negative bias dampens the leader's incentive to switch and so tilts the tradeoff in favor of greater informational efficiency. This result differs from the implications of standard cheap-talk models, where eliminating the sender's bias tends to increase the efficiency of outcomes.

performance). Our welfare and efficiency results suggest that, in such informal teams, the leader's inability to commit to full information sharing may not be restrictive, because all team members may prefer partially-informative communication.

The next section briefly discusses the related literature. Section 2 introduces the model, and discusses some of the assumptions. Section 3 describes the equilibria under the no-communication and the full-disclosure benchmarks. Section 4 characterizes the cheap-talk equilibria of our model, and discusses an extension to the case of spillovers. Section 5 studies welfare and informational efficiency in the three scenarios. Section 6 discusses some implications of our results and concludes. Proofs and additional results are in the Appendix.

# 1 Related literature

The paper contributes to the literature on leadership in economics and finance, which studies how leaders can influence the behavior of their followers (e.g., Hermalin (1998), Rotemberg and Saloner (2000), Gervais and Goldstein (2007), Goel and Thakor (2008), Bolton, Brunnermeier, and Veldkamp (2013), and Almazan, Chen, and Titman (2017)). Hermalin (1998) considers a setting in which the leader always wants to induce high effort from her followers, and so is unable to credibly communicate any information to them. Instead, she convinces others to follow her either by offering gifts ("leader sacrifice"), or by exerting costly effort herself ("lead by example") to credibly communicate with them, and welfare is higher in the latter case. In related settings, Almazan et al. (2017) show how privately informed executives can distort their investment choices to affect the information conveyed to their employees. Rotemberg and Saloner (2000) show that how "visionary" (i.e., biased) leader can improve incentives for employees. Gervais and Goldstein (2007) show how an employee who is over-confident about her abilities can improve welfare for all team-members, but only when the leader is unbiased. Goel and Thakor (2008) characterize conditions under which a CEO who underestimates project risk can increase the value of her firm.

While we consider a different setting (binary action, global game instead of Hermalin (1998)'s public goods game), our results complement this literature. Because our focus is on the role of communication in leadership, our analysis abstracts from the optimal design of contracts and the effect of formal authority in contrast to some of these papers. In our setting, the leader's preference over her followers' action is state-dependent, which allows her to partially communicate her information. However, analogous to leading by example, the most she can convey is that she has adopted the new project. Moreover, our analysis allows us to study how the interaction between types of communication (full disclosure vs. cheap talk) and the leader's bias affects welfare and efficiency.

Bolton et al. (2013) also consider a setting where the leader of an organization communicates with her followers to encourage coordination. They study how the leader trades off encouraging coordination with flexibility and show that resoluteness in communication can help overcome the dynamic consistency problem that the leader faces. A key assumption in their analysis is that the leader can commit to a communication strategy before observing information about the underlying state. The central focus of our analysis is to study choice of communication in the absence of commitment, and whether the ability to commit to a disclosure policy is valuable.[5]

Second, our paper is related to the large literature on cheap talk initiated by Crawford and Sobel (1982) (see Sobel (2013) for a recent survey), and more specifically, models which introduce a cheap talk stage before a game with strategic complementarities (e.g., Baliga and Morris (2002), Alonso, Dessein, and Matouschek (2008), Rantakari (2008), and Hagenbach and Koessler (2010)).[6] Baliga and Morris (2002) study how adding a cheap talk stage before play affects a two player, one-sided incomplete information game with strategic complementarities and positive spillovers. They characterize sufficient conditions for full communication and no communication. Our setting differs from theirs in that it features two-sided incomplete information about a common fundamental that affects both players' payoffs.[7] However, some of our results are closely related to theirs. For instance, fully-informative cheap talk is not an equilibrium because the game we consider is not self-signaling for the leader — conditional on being sufficiently optimistic, she prefers to misreport her signal to convince more followers (see Aumann (1990) and Baliga and Morris (2002) for more discussion of self-signaling games). Moreover, partially-informative cheap talk is possible in our setting because the leader's preferences over her follower's actions depend on her private information (i.e., she wants to induce followers to adopt when she is optimistic, but is indifferent when she is pessimistic).[8]

[5]Moreover, in their model, the mission statement communicated by the leader is directly about fundamentals, while communication by the leader in our model conveys information about both fundamentals and her action.

[6]Our paper is also related to the literature on single sender-multiple receiver cheap talk models (e.g., Farrell and Gibbons (1989), Newman and Sansing (1993) and Goltsman and Pavlov (2011)), although unlike these earlier papers, our focus is not on how differences across receivers' beliefs / payoffs affect communication. In contrast to this earlier literature, receivers in our model have symmetric payoffs but have private information about fundamentals, and the sender can take an action in addition to sending messages.

[7]Since ours is a model with two-sided incomplete information and correlated types, it combines the distinguishing features of Examples 2 and 3 in Baliga and Morris (2002).

[8]This violates the sufficient condition for no communication in Baliga and Morris (2002). The positive

Our welfare implications also distinguish us from standard cheap-talk models and the recent literature on Bayesian persuasion models. In cheap talk models, commitment to full disclosure Pareto-dominates partially-informative cheap-talk equilibria — the receiver is usually better off with more informative communication. Similarly, in standard models of Bayesian persuasion (e.g., Kamenica and Gentzkow (2011)), while the sender may prefer to commit to partially informative communication, the receiver usually prefers more informative signals. In contrast, we find that *both* the sender and the receiver may prefer the less informative cheap talk equilibrium to fully informative communication. The key distinction from standard sender-receiver games is that in our model, both the sender and the receiver take actions that are strategic complements. As a result, welfare depends not only on the informativeness of the sender's messages but also on her actions.

Finally, our paper is related to the literature on global games (e.g., Carlsson and Van Damme (1993) and Morris and Shin (2003)), and in particular, papers that study the effect of public information in the presence of strategic complementarities. To the extent that any information communicated in our two-player game is effectively public, our model identifies another source of endogenous public information. However, the nature of the public information in our setting is distinct. First, the earlier literature has focused on the choice of a policymaker (or social planner) who commits to a disclosure policy. For instance, Morris and Shin (2002) and Angeletos and Pavan (2007) consider public disclosure of a particular class of signals, while Goldstein and Huang (2016) study a more general information design (Bayesian persuasion) problem of a policymaker facing a regime change.[9] The central focus of our analysis is to study choice of communication in the absence of commitment, and whether the ability to commit to a full disclosure policy is valuable. Second, while much of the earlier literature focuses on public information that either is directly about fundamentals (e.g., Morris and Shin (2002), Angeletos and Pavan (2007), Angeletos and Werning (2006), and Ozdenoren and Yuan (2008)) or reflects the action of other players (e.g., Angeletos, Hellwig, and Pavan (2006), Corsetti, Dasgupta, Morris, and Shin (2004), and Angeletos and Pavan (2013)), messages in our communication equilibria convey information about both. As such, the Morris and Shin (2002) tradeoff between greater informational efficiency and better coordination can have different implications on welfare in our setting.

spillover case of Section 4.1 satisfies their sufficient condition, and consequently, no informative cheap-talk communication is possible.

[9] Banerjee and Liu (2014) characterize optimal precision of public information in the Morris and Shin (2002) setting when the policymaker cannot commit to a disclosure policy, but is restricted to linear strategies.

## 2 Model

A manager ($M$, "she") and her team of $N$ employees (indexed by $e \in E$, "he") are deciding whether to adopt a risky project, or continue with the status quo. The incremental payoff, relative to the status quo, from adoption depends on fundamentals $\theta \in \{\theta_H, \theta_L\}$, which are high with prior probability $p_0 \equiv \Pr(\theta = \theta_H)$. Each team member receives a private signal of the form $x_i = \theta + \varepsilon_i$ (for $i \in \{M, E\}$), where $\varepsilon_i$ are independent and normally distributed with mean-zero and variance $\sigma_i^2$ (i.e., $\varepsilon_i \sim N(0, \sigma_i^2)$), and where all employees are symmetrically informed, i.e., $\sigma_i = \sigma_e$ for all employees.[10] Each player must decide whether to switch to the new project ($a_i = 1$) or not ($a_i = 0$). The (incremental) payoff to employee $e \in E$ from switching (i.e., $a_e = 1$) is given by

$$\theta - 1 + a_M \tag{1}$$

and his payoff from the status quo (i.e., $a_e = 0$) is normalized to zero. The payoff to the manager from adoption (i.e., $a_M = 1$) is given by

$$\theta - 1 + \frac{1+b}{N} \sum_{e \in E} a_e, \tag{2}$$

and from the status quo (i.e., $a_M = 0$) is zero. Specifically, each player incurs a cost (normalized to $-1$) of switching to the new project, but receives a payoff that depends on both the fundamentals of the project (i.e., $\theta$) and the actions of other team members (i.e., $a_i$).

The parameter $b$ captures a potential conflict of interest between the manager and her employees. When $b > 0$ ($b < 0$), the manager is biased in favor of (against, respectively) coordinated actions relative to her employees.[11] While we will explore the effects of a positive or negative bias on outcomes in the later sections, our focus will be on the natural benchmark case of $b = 0$ in which the payoffs to the manager are unbiased relative to those of her employees. We maintain the following assumptions on the parameters:

(A1) $\theta_L < 0 < 1 < \theta_H$: This ensures that in the benchmark case of $b = 0$, it is efficient for each player to adopt the new project in the "good" state when fundamentals are high (i.e., $\theta = \theta_H$) and to continue with the status quo in the "bad" state when fundamentals are low (i.e., $\theta = \theta_L$).

[10] We sometimes use index $E$ to denote employees collectively, warranted by the symmetry of employees.

[11] As we discuss in Section 2.1, our results also apply when the manager $M$ is always biased in favor (against) of the new project (i.e., if the payoff to her is $\theta + b - 1 + \frac{1}{N}\sum_{e \in E} a_e$) under appropriate parameter restrictions on $b$.

(A2) $-\theta_L > b > -1$: This ensures that the manager's bias is not too large; despite her bias, all players coordinate on the new project when fundamentals are good (i.e., $\theta = \theta_H$), and on the status quo when fundamentals are bad (i.e., $\theta = \theta_L$).[12]

We allow the manager to send a message $\mu(x_M)$ about her signal to her employees before they decide whether or not to adopt the new project. Specifically, we assume that a messaging rule $\mu : \Re \to B$ is a function that takes a signal realization $x_M$ to an element (or *message*) $m = \mu(x_M) \in B$, where $B$ is the Borel algebra on the reals $\Re$. We consider three scenarios: (i) no communication ($NC$), (ii) full disclosure communication ($FC$), and (iii) strategic communication ($SC$). The no communication scenario serves as a benchmark when the players are not allowed to communicate (i.e., $\mu(x_M) = \Re$). The full disclosure communication scenario assumes that the manager commits to perfectly disclosing her signal before they decide on the project (i.e., $\mu(x_M) = x_M$). Finally, in the strategic communication scenario, the manager can send an arbitrary message $\mu(x_M)$ about her signal $x_M$ to her employees after they each observe their signals, but before they decide their course of action.

We restrict attention to a finite number of fundamental states due to tractability. In particular, updating beliefs conditional on private information and messages takes a log-linear form in our setting, as the next result highlights.[13]

**Lemma 1.** *Conditional on a signal $x_i = x$, and a message $m \in B$, posterior beliefs about $\theta$ are given by $p(x,m) \equiv \Pr(\theta = \theta_H | x_i = x, x_j \in m)$, where*

$$\log\left(\frac{p(x,m)}{1-p(x,m)}\right) = \log\left(\frac{p_0}{1-p_0}\right) + \frac{1}{\sigma_i^2}(\theta_H - \theta_L)\left(x - \frac{\theta_H+\theta_L}{2}\right) + \log\left(\frac{\Pr(x_j \in m|\theta_H)}{\Pr(x_j \in m|\theta_L)}\right). \tag{3}$$

*Also, note that* $\log\left(\frac{\Pr(x_j = x|\theta_H)}{\Pr(x_j = x|\theta_L)}\right) = \frac{1}{\sigma_j^2}(\theta_H - \theta_L)\left(x - \frac{\theta_H+\theta_L}{2}\right)$*, and*

$$\log\left(\frac{\Pr(c_1 < x_j \le c_2|\theta_H)}{\Pr(c_1 < x_j \le c_2|\theta_L)}\right) = \log\left(\frac{\Phi\left(\frac{c_2-\theta_H}{\sigma_j}\right) - \Phi\left(\frac{c_1-\theta_H}{\sigma_j}\right)}{\Phi\left(\frac{c_2-\theta_L}{\sigma_j}\right) - \Phi\left(\frac{c_1-\theta_L}{\sigma_j}\right)}\right).$$

As expected, the posterior belief $p(x,m)$ increases in the realization of the private signal $x$ for a fixed message $m$. Moreover, the above result characterizes the posterior for two types of messages. When the message itself is a point (i.e., $m = x_j$), then the log-likelihood ratio is

[12] When $b \le -1$, $M$ has a higher payoff from switching when $e$ does not switch, and the resulting game is one of strategic substitutability.

[13] With a continuum of states and standard distributional assumptions (e.g., normal or uniform priors), updating beliefs about fundamentals using both a private signal and general messages in equilibrium is less analytically tractable.

linear in the two signals (i.e., $x_i$ and $x_j$). When the message is an interval (i.e., $m = (c_1, c_2]$), then the log-likelihood ratio depends on the relative probability of $x_j$ being in the interval (i.e., $x_j \in (c_1, c_2]$) conditional on fundamentals being high vs. low.

Conditional on observing a signal $x$ and receiving a message $m$, an employee's expected payoff from the new project is given by

$$\pi_e (x, m) = \begin{array}{c} p (x, m) [\theta_H - 1 + \Pr (a_M = 1|\theta_H, m)] \\ + (1 - p (x, m)) [\theta_L - 1 + \Pr (a_M = 1|\theta_L, m)] \end{array} . \tag{4}$$

Since $\pi_e (x, m)$ is increasing in $x$ for a fixed $m$, each employee optimally chooses to follow a cutoff strategy: employee $e$ only abandons the status quo when his signal is greater than or equal to a cutoff $k_e (m)$ (i.e., when $x_e \geq k_e (m)$), but not otherwise. Given the symmetric cutoff strategies of her employees, the manager's expected payoff from the new project conditional on a signal $x$ is given by

$$\begin{aligned} \pi_M (x, m) &= \mathbb{E} \left[ \theta - 1 + \tfrac{1+b}{N} \sum_{e \in E} \Pr (a_e = 1|\theta, m) \,\middle|\, x_M = x \right] \\ &= \begin{array}{c} \Pr (\theta = \theta_H | x_M = x) [\theta_H - 1 + (1 + b) \Pr (x_e \geq k_e (m) |\theta_H)] \\ + \Pr (\theta = \theta_L | x_M = x) [\theta_L - 1 + (1 + b) \Pr (x_e \geq k_e (m) |\theta_L)] \end{array} \end{aligned} \tag{5}$$

As with the employees, since the payoff to switching is increasing in $x$ for a fixed $m$, the manager optimally chooses to follow a cutoff strategy: she will adopt the new project if and only if her signal is higher than a cutoff $k_M (m)$, i.e., $x_M \geq k_M (m)$. Finally note that since the payoff from the status quo is zero for the manager and her employees, the cutoff $k_i (m)$ for each player is characterized by the indifference condition:

$$\pi_i (k_i (m), m) = 0. \tag{6}$$

We focus on pure strategy, Perfect Bayesian equilibria.[14] In particular, an equilibrium of the game with $SC$ is characterized by a messaging rule $\mu : \Re \to B$ and cutoff strategies $\{k_M (m), k_e (m)\}$, such that: (i) the messaging rule $\mu$ is truthful (i.e., for all $x_M$, $x_M \in \mu (x_M)$), (ii) the messaging rule $\mu$ is optimal for player $M$, (iii) given a message $m$, it is optimal for player $i$ to only adopt the new project when $x_i \geq k_i (m)$ (i.e., expression (6) holds), and (iv) players' beliefs satisfy Bayes' rule wherever it is well-defined. In particular,

[14]Since the sender's type (her signal) is continuous and unbounded, restriction to pure strategies is without loss of generality.

the restriction to pure-strategy, truth-telling equilibria implies that given a messaging rule $\mu$, each possible signal realization $x_M$ maps into only one message $\mu(x_M)$. For the games with $NC$ and $FC$, an equilibrium is characterized by conditions (iii) and (iv) above, since the messaging rule is exogenously specified ($\mu(x_M) = \Re$ and $\mu(x_M) = x_M$, respectively).

## 2.1 Discussion of assumptions

The assumption that players can take one of a finite number of actions does not drive our results. For instance, suppose players are risk-neutral, but can choose an effort level $a_i \in [0,1]$, and the payoff to player $i$ from adopting the new project is given by $a_i(\theta - 1 + a_j)$. In this case, a player's optimal decision is characterized by the same cutoff strategy as in our benchmark specification, since each player chooses the maximum effort level ($a_i = 1$) if she chooses the risky project.[15]

We explore alternative payoff specifications in supplementary analysis. Specifically, for the proofs of our main results, we consider the case where both $M$ and $e \in E$ can have biased payoffs, i.e., if everyone switches, the payoffs are $(\theta + b_M, \theta + b_e)$. This does not qualitatively change the characterization of equilibria in the three scenarios. Similarly, as we show in Appendix B, the equilibria do not qualitatively change when the cost to switching alone for the manager can be different; if she switches but her employees do not, her payoffs are $(\theta - c, 0)$. Finally, Section 4.1 considers a specification with spillovers: the manager receives an incremental payoff $\frac{\nu}{N}$ when each of her employees adopts the new project, irrespective of whether she does.

The assumptions of (i) no payoff externalities within employees (i.e., an employee's payoff does not depend on the actions of other employees), and (ii) one-sided (manager to employee) communication are made for tractability. However, such restrictions can arise naturally in many settings. Leaders usually have more influence over performance evaluations and compensation of their followers, and so employees naturally have a strong incentive to "follow the leader." Moreover, large teams and firms are usually organized in hierarchical structures to facilitate top-down communication, while bottom-up percolation of information is more difficult to sustain. In our setting, one can show that fully-informative, two-sided (i.e., manager to employee, employee to manager), cheap-talk communication can be sustained

[15] We assume that if a player is indifferent, he or she chooses the new project i.e., $a_i = 1$. One could consider a more general setting in which the employee takes one of a finite number of actions (e.g., $a_e \in \{0, 1, 2, \ldots, k\}$) and the manager has state-dependent preferences over these. We conjecture that under reasonable assumptions of monotonicity (e.g., the lowest type of managers prefer $a_e = 0$, the next type prefers $a_e = 1$, and so on), more informative cheap talk may be possible.

when the manager's payoff is unbiased (i.e., when $b = 0$), and the equilibrium decision is analogous to the welfare-maximizing decision we describe in Proposition 8. Unfortunately, the analysis of two-sided cheap talk communication with conflicts of interest (i.e., $b \neq 0$) is not tractable in the current setting. Similarly, a complete analysis of a setting with inter-employee payoff externalities is beyond the scope of the current paper, and left for future work.

Since we assume that an employee's payoff does not depend on the actions of other employees, the assumption that employees do not communicate with each other does not qualitatively change the nature of the equilibrium. In particular, we can show that if employees are allowed to share their information with each other, there exist corresponding equilibria to those described in Sections 3 and 4 in which (i) each employee perfectly reveals her private signal to the other employees, (ii) each employee replaces her private signal $x_i$ with an aggregate signal $\bar{x}_e = \frac{1}{N}\sum_{i \in E} x_i$, and (iii) the equilibrium cutoffs are characterized by the same expressions as in Propositions 1, 2, 3, and 4, with the standard deviation $\sigma_e$ replaced by $\sigma_e/\sqrt{N}$. While the qualitative nature of the equilibria remains unchanged, allowing for communication among employees can impact some equilibrium outcomes. For instance, when the number of employees in the team becomes arbitrarily large, investment efficiency decreases to zero when employees cannot communicate with each other, but remains bounded away from zero when they can. We discuss this further in Section 5.3.

Finally, we abstract away from an optimal contracting or mechanism design approach because our primary focus is to understand how communication affects coordination in the absence of commitment. In a richer model, one can endogenously derive the payoffs we assume for the players as outcomes of optimal contracts; however, this would be at the cost of tractability and transparency of our main results. And while commitment to full disclosure is a natural and appealing benchmark, it would be interesting to explore the properties of other forms of communication with commitment (e.g., the leader's optimal disclosure policy, a la Kamenica and Gentzkow (2011)). Unfortunately, this analysis is not immediately tractable in our setting and so left for future work.

# 3 Benchmarks and the impact of communication

This section characterizes the equilibria under two benchmark scenarios: no communication and full communication. The analysis highlights how allowing for communication changes the nature of the coordination game. With no communication, employees face uncertainty about fundamentals (fundamental uncertainty) and about the behavior of the manager (strategic uncertainty). As a result, their best response functions to the manager's cutoff is upward sloping: a higher cutoff for the manager is bad news for the employees since it implies she will switch less often. As has been recognized in the global games literature, this can generate multiplicity of equilibria under certain parameter values.

In contrast, with full disclosure, the employees face no strategic uncertainty since they know whether or not the manager will switch to the new project. In this case, conditional on the manager switching, a higher manager's cutoff is good news for the employees since it implies a higher signal about fundamentals. As a result their best response function is downward sloping and, consequently, there always exists a unique equilibrium under full disclosure.

## 3.1 No communication

The no communication benchmark recovers a standard result from the global games literature.

**Proposition 1.** *Let the function $K(k; b, \sigma_i, \sigma_j)$ be defined as:*

$$K(k; b, \sigma_i, \sigma_j) \equiv \frac{\theta_H + \theta_L}{2} + \frac{\sigma_i^2}{\theta_H - \theta_L}\left\{\log\left(\frac{(1+b)\Phi\left(\frac{k-\theta_L}{\sigma_j}\right) - (\theta_L + b)}{(\theta_H + b) - (1+b)\Phi\left(\frac{k-\theta_H}{\sigma_j}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\}, \qquad (7)$$

*where $\Phi(\cdot)$ is the CDF of the standard normal distribution. Suppose the manager cannot communicate with her employees: for all $x_M$, we have $\mu(x_M) = \Re$. Then there exist equilibria characterized by cutoffs $k_{M,NC}$ and $k_{e,NC}$, which solve the system: $k_{M,NC} = K(k_{e,NC}; b, \sigma_M, \sigma_e)$ and $k_{e,NC} = K(k_{M,NC}; 0, \sigma_e, \sigma_M)$. For given $b$, $\theta_H$ and $\theta_L$, there exist cutoffs $\bar{a}(b, \theta_H, \theta_L)$ and $\underline{a}(b, \theta_H, \theta_L)$ so that if $\frac{\sigma_M^2}{\sigma_e} < \bar{a}$ and $\frac{\sigma_e^2}{\sigma_M} < \underline{a}$, the equilibrium is unique. When $\sigma_M = \sigma_e = \sigma$, there exists a cutoff $a(b, \theta_H, \theta_L)$ such that if $\sigma < a$, the equilibrium is unique.*

The best response function (7) is increasing in the other player's cutoff. This is intuitive — player $j$ is less likely to switch when her cutoff is higher, which leads player $i$ to respond by increasing her own cutoff. However, increasing best response functions imply that there may be multiple equilibria. As we discuss in the proof for Proposition 1, a sufficient condition for uniqueness is that the slope of the best response function (7) is less than one (i.e., $\frac{\partial K_i}{\partial k_j} < 1$). In the special case when the signals are symmetrically distributed (i.e., $\sigma = \sigma_e = \sigma_M$), the sufficient condition for uniqueness mirrors those in the earlier literature which require that private signals are sufficiently accurate (see Morris and Shin (2001), Frankel, Morris, and Pauzner (2003), and Morris and Shin (2003) for extensive discussions). In the general case, the sufficient conditions require not only that each player's private signal is sufficiently precise, but also that neither player's signal is too precise relative to the other's signal. If player $j$'s signal is too precise relative to player $i$'s, then player $i$'s best response changes very quickly when $k_j$ is close to either $\theta_H$ or $\theta_L$. This can lead to multiple solutions for the system of equations in Proposition 1, and consequently, multiple equilibria. In contrast, as we show in the next subsection, there always exists a unique equilibrium when the manager can commit to revealing her information perfectly.

## 3.2 Commitment to full disclosure

Suppose the manager can commit to fully disclosing her private information, i.e., $\mu(x_M) = x_M$ for all $x_M$. Then, conditional on $x_M$ and his own signal $x_e$, an employee's posterior beliefs about $\theta = \theta_H$ are given by

$$\log\left(\frac{p}{1-p}\right) = \log\left(\frac{p_0}{1-p_0}\right) + \frac{1}{\sigma_M^2}(\theta_H - \theta_L)\left(x_M - \frac{\theta_H+\theta_L}{2}\right) + \frac{1}{\sigma_e^2}(\theta_H - \theta_L)\left(x_e - \frac{\theta_H+\theta_L}{2}\right). \quad (8)$$

Since the employee can perfectly observe the manager's signal, there is no uncertainty about whether she will switch. This implies that if $M$ reveals her signal $x_M$ and uses a cutoff $k_M$, the employee's best response is to switch only if $x_e \geq K_{FC}(x_M, k_M)$, where

$$K_{FC}(x,k) \equiv \begin{cases} \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - x\right) + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(-\frac{\theta_L}{\theta_H}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) & \text{if } x \geq k, \\ \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - x\right) + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(\frac{1-\theta_L}{\theta_H-1}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) & \text{if } x < k. \end{cases} \quad (9)$$

Intuitively, the employee's best response is decreasing in the manager's signal — a higher signal implies that the higher state ($\theta = \theta_H$) is more likely, and this leads $e$ to lower his cutoff. The next result characterizes the equilibrium in this scenario in terms of the above best response function.

**Proposition 2.** *Let $k_{M,FC}$ be the (unique) fixed point of $x = K(K_{FC}(x,x), b, \sigma_M, \sigma_e)$, where $K(\cdot)$ is defined by equation (7), and $K_{FC}(\cdot)$ is defined by (9). If the manager can commit to revealing her information perfectly (i.e., $\mu(x_M) = x_M$ for all $x_M$), then the unique equilibrium is characterized by the cutoff $k_{M,FC}$ for the manager and the cutoff (function) $K_{FC}(x_M, k_{M,FC})$ for player $e \in E$.*

The result highlights how the manager's ability to communicate changes the nature of the coordination game: unlike the $NC$ scenario, there always exists a unique equilibrium with full disclosure. The equilibrium is characterized by the manager's cutoff (i.e., $k_M$) given her employees' cutoff *conditional* on the information that her signal is equal to her cutoff (i.e., $x_M = k_M$). In contrast to the $NC$ scenario, each employee faces no uncertainty about whether the manager adopts the new project. This implies that conditional on the manager's signal being equal to her cutoff (i.e., $x_M = k_M$), a higher cutoff is good news about fundamentals and so the employees' best response decreases in $k_M$.[16] As we show in the proof, this ensures that there always exists a unique solution to the fixed point problem in Proposition 2 that characterizes the equilibrium.

# 4 Strategic communication

We now turn to the case where the manager can strategically choose to send an arbitrary message to her employees after observing her signal. As is common in cheap talk models, there exist multiple equilibria. However, as the following proposition describes, they are all characterized by a common feature: the manager conceals information about the realization of her signal when she adopts the new project.[17]

**Proposition 3.** *Let $k_{M,SC}$ be the fixed point of $x = K(K_e(x), b, \sigma_M, \sigma_e)$, where $K$ is defined by (7), and $K_e(x)$ is given by:*

$$K_e(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{-\theta_L}{\theta_H}\right) - \log\left(\frac{p_0}{1-p_0}\right) - \log\left(\frac{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)}\right)\right\}. \tag{10}$$

*In any sender-optimal strategic equilibrium, (i) the manager switches if and only if $x_M \geq k_{M,SC}$ and (ii) the messaging rule is equivalent to $\mu(\cdot)$, where for any signal $x_M \geq k_{M,SC}$, the optimal message is $\mu(x_M) = [k_{M,SC}, \infty)$.*

Instead of detailing the proof of the above result, we provide some intuition for this result. First, note that the manager's message affects her payoff only through the likelihood that her employees switch. For signal realizations where the manager chooses to switch to the new project, she always has an incentive to report that her signal is higher than it actually

[16] This is analogous to the effect of observing the action of an earlier player in a sequential move global game (e.g., Corsetti et al. (2004)).

[17] Note that the nature of cheap talk equilibrium is not an immediate consequence of the fact that employees have a binary action space. For instance, Chakraborty and Yılmaz (2017) consider a setting in which detailed cheap talk communication arises even though the receiver has a binary action.

is, since this increases the likelihood that her employees follow her, but does not affect her payoff otherwise. However, this implies that she cannot convey *any* additional information credibly when she chooses to switch.[18] The restriction to sender-optimal equilibria rules out equilibria in which the manager either babbles, or pools some low (status quo) signals with high (adopt) signals.[19]

Second, as we argue in the proof, it is natural that the messaging rule and the adoption decisions are determined by the same cutoff. Intuitively, the message $m$ equivalent to "$M$ will switch" should include all signal realizations such that $M$ chooses to switch having sent message $m$, but should exclude any signal realizations such that $M$ optimally chooses the status quo having sent that message. Also, note that if $M$ chooses to switch at a signal realization $x_M$, having sent message $m$, then she must necessarily choose to switch for all signal realizations $x > x_M$, conditional on sending message $m$. This, in turn, ensures that the adoption and messaging rule intervals are half-lines.

Finally, the unique cutoff $k_{M,SC}$ is the solution to a fixed point problem: the manager's cutoff (i.e., $k_M$) is her best response to the employees' cutoff *conditional* on the information that her signal is greater than or equal to her cutoff (i.e., $x_M \geq k_M$). As in the $FC$ scenario, the existence and uniqueness of this cutoff is guaranteed by the fact that the employees' best response (10) is decreasing in the manager's cutoff, conditional on her message. However, unlike the $FC$ scenario, uniqueness of the cutoff $k_{M,SC}$ does not imply uniqueness of equilibria. This is because, for signal realizations where the manager does not switch (i.e., $x_M < k_{M,SC}$), she is indifferent to various messaging rules. This naturally gives rise to two extreme equilibria, which can be characterized by how informative the manager's message is about her signal in this region. We describe these in the following result.

**Proposition 4.** *(i) The least informative strategic equilibrium is characterized by the messaging rule:*

$$\mu(x_M) = \begin{cases} (-\infty, k_{M,SC}) & \text{if } x_M < k_{M,SC} \\ [k_{M,SC}, \infty) & \text{if } x_M \geq k_{M,SC} \end{cases}, \tag{11}$$

*and the cutoff $k_{M,SC}$ for the manager and the cutoff function $K_{SC}(m)$ for employee $e \in E$,*

[18] As we discuss in the proof, there is some indeterminacy. We show that while $M$ can send other messages when $x_M \geq k_{M,SC}$, they must be equivalent to the message $x_M \in [k_{M,SC}, \infty)$ in terms of their impact on $e$'s posterior beliefs. As a result, for all economically relevant implications, the messaging rules are equivalent to the one stated in the Proposition when $x_M \geq k_{M,SC}$.

[19] In either case, a sender with a high signal realization should strictly prefer to separate herself from these status-quo, low types.

*where*

$$K_{SC}\left((-\infty,k_{M,SC})\right)=\frac{\theta_H+\theta_L}{2}+\frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{1-\theta_L}{\theta_H-1}\right)-\log\left(\frac{p_0}{1-p_0}\right)-\log\left(\frac{\Phi\left(\frac{k_{M,SC}-\theta_H}{\sigma_M}\right)}{\Phi\left(\frac{k_{M,SC}-\theta_L}{\sigma_M}\right)}\right)\right\}, \tag{12}$$

$$K_{SC}\left([k_{M,SC},\infty)\right)=K_e\left(k_{M,SC}\right). \tag{13}$$

*(ii) The most informative strategic equilibrium is characterized by the messaging rule:*

$$\mu\left(x_M\right)=\begin{cases}x_M & \text{if } x_M<k_{M,SC}\\ [k_{M,SC},\infty) & \text{if } x_M\geq k_{M,SC}\end{cases}, \tag{14}$$

*and the cutoff $k_{M,SC}$ for the manager and the cutoff function $K_{SC}(m)$ for employee $e\in E$, where*

$$K_{SC}\left(x_M\right)=\frac{\theta_H+\theta_L}{2}+\frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2}-x_M\right)+\frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(\frac{1-\theta_L}{\theta_H-1}\right)-\log\left(\frac{p_0}{1-p_0}\right)\right), \tag{15}$$

$$K_{SC}\left([k_{M,SC},\infty)\right)=K_e\left(k_{M,SC}\right). \tag{16}$$

In the least informative equilibrium, the manager sends one of two possible messages which correspond to whether or not she switches. In the most informative equilibrium, she reveals her signal perfectly when she chooses the status quo, but conceals the realization of her signal when she switches. The manager is indifferent between these equilibria because her payoff from the status quo is unaffected by the employees' action. As we discuss in the next subsection, this indifference plays a key role in ensuring one-sided cheap talk is partially informative in our setting.

It is worth emphasizing that perfectly informative cheap talk is not sustainable in our setting even when the manager's payoffs are unbiased ($b=0$), because the manager also takes an action and actions exhibit strategic complementarity. This is in sharp contrast to a standard, sender-receiver setting where the sender does not take an action and her payoff depends only on the receiver's action. In particular, suppose the manager can send a cheap talk message to her employees, and her payoff is given by $\frac{\theta+b}{N}\sum_{e\in E}a_e$. The payoff to each employee from switching to the new project is $\theta$ and from the status quo is zero. As the following result establishes, perfectly informative communication is sustainable in this case when payoffs are aligned.

**Proposition 5.** *Suppose the manager cannot take an action and her payoffs are unbiased* *(i.e., $b = 0$). Then, there exists a strategic communication equilibrium in which the manager perfectly reveals her signal to the receivers.*

## 4.1 Spillovers

The manager's preferences over her employees' actions are state-dependent in our model: she strictly prefers they switch when she switches, but is indifferent when she does not switch. In this section, we consider an alternative specification to highlight the role this state-dependence plays in sustaining partially-informative communication. In particular, we assume that the employees' decisions generate a spillover for the manager irrespective of whether she switches. The case of positive spillovers may also be a more natural assumption when modeling a manager who derives private benefits of control (e.g., an "empire builder" who gets utility when her team exerts effort, irrespective of the project fundamentals).

Suppose the payoffs to the employees are as before, but the manager's payoffs are given by

$$\theta - 1 + \frac{1+\nu}{N} \sum_{e \in E} a_e \tag{17}$$

when she switches and

$$\frac{\nu}{N} \sum_{e \in E} a_e \tag{18}$$

when she does not switch. In this case, the employees' decision to switch has a spillover on the manager's payoffs: irrespective of whether she switches, the manager receives an incremental payoff of $\frac{\nu}{N}$ when an employee switches. To ensure we are in the interesting region of the parameter range, the assumptions (A1)-(A2) generalize to the following: (i) $\theta_L < 0 < 1 < \theta_H$, (ii) $\nu > -1$ and $\nu < -\theta_L$. While an employee's incremental payoff from switching, $\pi_e$, remains the same as in the benchmark model, the manager's optimal decision is given by

$$\max_{a_M \in \{0,1\}} a_M \pi_M^1 (x, m) + (1 - a_M) \pi_M^0 (x, m), \tag{19}$$

where $\pi_M^a (x, m)$ is the payoff for action $a \in \{0, 1\}$:

$$\pi_M^1 (x, m) = \begin{array}{c} p(x) \left[\theta_H - 1 + (1+\nu) \Pr\left(x_e \geq k_e(m) | \theta_H\right)\right] \\ + (1 - p(x)) \left[\theta_L - 1 + (1+\nu) \Pr\left(x_e \geq k_e(m) | \theta_L\right)\right] \end{array}, \text{ and} \tag{20}$$

$$\pi_M^0 (x, m) = \nu \left\{ p(x) \Pr\left(x_e \geq k_e(m) | \theta_H\right) + (1 - p(x)) \Pr\left(x_e \geq k_e(m) | \theta_L\right) \right\}, \tag{21}$$

and $p(x) = \Pr(\theta = \theta_H | x_M = x)$. Her incremental payoff from switching is independent of $\nu$, since

$$\begin{aligned}\pi_M(x,m) &= \pi_M^1(x,m) - \pi^0(x_M,m) \\ &= p(x)\left[\theta_H - 1 + \Pr(x_e \geq k_e(m)\,|\theta_H)\right] + (1-p(x))\left[\theta_L - 1 + \Pr(x_e \geq k_e(m)\,|\theta_L)\right].\end{aligned}$$

As a result, the $NC$ and $FC$ equilibria with a spillover are identical to the corresponding equilibria in the benchmark model with $b = 0$. However, as the following result establishes, with cheap talk, even partially-informative communication is difficult to sustain.

**Proposition 6.** *If the employees' decision generates a positive spillover for the manager (i.e., $\nu > 0$), there can (effectively) be no communication in any strategic equilibrium. If the employees' decision generates a negative spillover for the manager (i.e., $\nu < 0$), any strategic equilibrium is equivalent to the least informative equilibrium described in Proposition 4 (with $b = 0$).*

The presence of spillovers limits the manager's ability to communicate effectively. In fact, if the spillover is positive, even if arbitrarily small, no information can be communicated in a one-sided cheap talk equilibrium. When the spillover is negative, only a partially informative cheap-talk equilibrium analogous to the least-informative $SC$ equilibrium above survives. This is because, even if the manager decides not to switch, she has an incentive to increase (decrease) the likelihood that her employees switch when the spillover $\nu$ is positive (negative, respectively). As a result, when the spillover is positive, the manager always has an incentive to distort her message upwards, and so cannot communicate any information via cheap talk. When the spillover is negative, she has an incentive to distort her message upwards (downwards) when she chooses to switch (not switch, respectively), and so cannot convey any additional information.

The above result is also related to Baliga and Morris (2002) who establish that, in special cases of their one-sided, incomplete information model, no informative communication is possible when there are positive spillovers. Morris and Shin (2003) informally discuss a two-player game (similar to ours) where both players impose spillovers. They suggest that an argument similar to Baliga and Morris (2002) implies that fully informative cheap talk is possible when spillovers are negative, but not when spillovers are positive. Our analysis suggests that the assumption of symmetric payoffs is important for these conclusions: with one-sided spillovers, we show one-sided cheap talk cannot be informative at all with positive spillovers and is, at best, partially informative when spillovers are negative.

# 5 Welfare and informational efficiency

We explore whether the ability to commit to full disclosure is valuable in our setting, using two measures: welfare and informational efficiency. Welfare measures the expected payoff to team members, including the benefits of coordination and incremental payoff externalities to the manager (i.e., the effect of $b$). Informational efficiency measures how well the team's decision matches the project fundamentals. One might expect that both welfare and efficiency are higher when the manager commits to full disclosure. However, we find that neither result need hold. We show that when the bias ($b$) in the manager's payoff is near zero, both she and her employees may prefer the partially informative, cheap-talk equilibrium to the full disclosure equilibrium.[20] Similarly, we find that efficiency can be higher under the cheap talk equilibrium, especially when the manager is biased against coordinated adoption (i.e., $b$ is negative).

## 5.1 Communication and strategic uncertainty

A key difference of our model relative to standard, sender-receiver games is that receivers (i.e., employees) face not only fundamental uncertainty, but also strategic uncertainty. Specifically, without communication, employees are uncertain about whether the manager will switch, and this discourages them from switching (due to complementarities in the adoption decision). In contrast, with communication, the employees can infer perfectly whether the manager switches, and this decrease in strategic uncertainty leads them to follow more often. Anticipating this response, the manager also switches more aggressively in the communication equilibria (i.e., her adoption threshold is higher under $NC$ than under $SC$).

Next, note that employees do not face strategic uncertainty in either the $SC$ or $FC$ scenarios, since they can perfectly infer whether the manager adopts the new project. However, in the $SC$ scenario, each employee conditions on the information that the manager's signal is higher than her cutoff, while in the $FC$ scenario, he conditions on the realization of the signal itself. For any cutoff $k$ chosen by the manager, the information that her signal is greater than or equal to her cutoff (i.e., $x_M \geq k$) makes the employee more optimistic about fundamentals than the information that her signal is equal to her cutoff (i.e., $x_M = k$) — this is because the distribution of the signal, parameterized by $\theta$, satisfies the monotone likelihood ratio property. As we show in the proof of the next result, this implies that, for any

[20]This is in contrast to standard cheap-talk models, where both parties usually prefer to commit to full disclosure, and to Bayesian persuasion models, where the receiver prefers full disclosure.

cutoff $k$ chosen by the manager, an employee's best response to $x_M = k$ in the $FC$ scenario is always higher than his response to $x_M \geq k$ in the $SC$ scenario. But this, in turn, implies that the manager faces less strategic uncertainty about the employees' decisions under the $SC$ scenario, which leads her to switch more often (i.e., $k_{M,FC} \geq k_{M,SC}$). These observations are summarized in the following result.

**Proposition 7.** *The manager is more likely to switch to the new project under the strategic communication scenario than under the no-communication or forced communication scenarios:*

$$k_{M,NC} \geq k_{M,SC} \text{ and } k_{M,FC} \geq k_{M,SC}. \tag{22}$$

The comparison between the full disclosure ($FC$) and cheap-talk ($SC$) scenarios highlights a novel tradeoff between fundamental uncertainty and strategic uncertainty. On the one hand, because communication is more informative under full disclosure, fundamental uncertainty is lower in this case. On the other hand, because of the complementarity in decisions, strategic uncertainty (for the manager) is lower in the $SC$ scenario. The next two subsections characterize how this tradeoff affects welfare and efficiency in our model.

## 5.2 Welfare

In order to compute welfare, we define the expected utility for player $i \in \{M, E\}$, $U_i$, as the unconditional expected payoff over realizations of $x_i$:

$$U_i = \mathbb{E}\left[a_i\left(x_i\right)\left(a_j\left(\theta + b_i\right) + \left(1 - a_j\right)\left(\theta - 1\right)\right)\right], \tag{23}$$

where $b_e = 0$ and $b_M = b$. As a baseline, we first characterize the decision rule which maximizes welfare (i.e., the sum $U_M + \frac{1}{N}\sum_{e \in E} U_e$).

**Proposition 8.** *Conditional on signals $x_M$ and $x_e$, the decision rule that maximizes $U_M + \frac{1}{N}\sum_{e \in E} U_e$ is given by: all team members adopt the new project if and only if*

$$\sigma_e^2 x_M + \sigma_M^2 \sum_{e \in E} x_e \geq \left(N\sigma_M^2 + \sigma_e^2\right) \tfrac{\theta_H + \theta_L}{2} + \tfrac{\sigma_e^2 \sigma_M^2}{\theta_H - \theta_L}\left(\log\left(-\tfrac{b + 2\theta_L}{b + 2\theta_H}\right) - \log\left(\tfrac{p_0}{1 - p_0}\right)\right) \equiv K_M. \tag{24}$$

The above decision rule, which we refer to as the welfare-maximizing adoption strategy, represents the recommendation of a social planner who maximizes welfare conditional on all private signals. Relative to the $NC$, $FC$ and $SC$ scenarios, the decision rule is different for two reasons. First, it is informationally more efficient: team members' decisions are determined by the optimal use of all private signals.[21] Second, it accounts for the externality that each member's action has on the other members' payoffs. Since it provides an upper bound on the welfare that may be achieved in our setting, it serves as a natural benchmark for comparison.[22]

In general, the welfare outcomes in the $NC$, $FC$ and $SC$ scenarios are worse than under the above rule. However, as the manager's private signal becomes infinitely precise, welfare with communication (i.e., under $FC$ and $SC$) approaches this benchmark, while welfare under the no communication benchmark is strictly lower. This observation is summarized by the following result.

**Proposition 9.** *With full disclosure and strategic communication (i.e., in the $FC$ and $SC$ equilibria), welfare is maximized when the manager's private signal becomes infinitely precise (i.e., when $\sigma_M \to 0$) irrespective of the bias $b$. In the no communication equilibrium (i.e., the $NC$ equilibrium), welfare may not be maximized even when the manager's signal is infinitely precise.*

Moreover, when the manager's signal is noisy, welfare is still higher in the cheap-talk equilibrium than in the no communication equilibrium.

**Proposition 10.** *Expected utility for the manager and for the employees is higher under the least-informative strategic communication equilibrium than it is under no communication.*

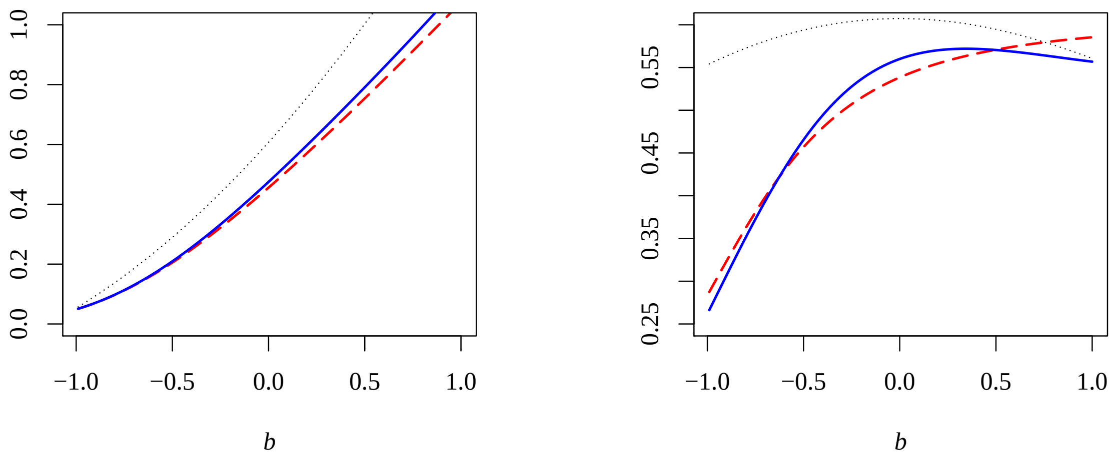
Since more information is communicated to employees under $SC$ than under $NC$, the intuition from standard strategic communication games suggests that the above result may be immediate. However, an important difference from pure sender-receiver games is that the sender's adoption strategy is also different across the two scenarios — specifically, as Proposition 7 suggests, the manager is more likely to switch under $SC$ than under $NC$. These effects reinforce each other when comparing the $NC$ and $SC$ equilibria, and as a result, expected utility is higher under $SC$ for the manager and her employees. However, the two effects offset each other when comparing the $FC$ and $SC$ scenarios: employees receive more information under $FC$, but the manager is more likely to switch under $SC$. This

[21] In contrast, even in the most informative of the other three scenarios, while employees condition on their signals and the manager's signals, the manager can only condition on her own signal.

[22] We do not claim this outcome is achievable using an optimally designed mechanism. Our analysis is concerned with situations in which players have no commitment power, and as such, cannot commit to using an optimal mechanism.

Figure 1: Expected utility as a function of $b$

The figure plots expected utility $U_M$ for the manager and expected utility $U_e$ for an employee $e \in E$ as a function of the bias parameter $b$ for the full disclosure communication equilibrium (dashed), the least informative strategic communication equilibrium (solid), and the welfare maximizing decision rule (dotted). The benchmark parameter levels are set to: $p_0 = 0.5$, $\theta_H = 2$, $\theta_L = -1$, $N = 1$ and $\sigma_M = \sigma_e = 4$.




(a) $U_M$ vs. $b$ (b) $U_e$ vs. $b$

implies that, in contrast to standard cheap-talk models, expected utility need not always be higher under commitment to full disclosure.

Unfortunately, analytically characterizing the players' expected utility under full disclosure is not tractable. Instead, we numerically compute the expected utility in the $FC$ and $SC$ equilibria for various ranges of parameter values. While we have explored the robustness of these results for other parameter values, we report the results based on a benchmark parametrization, where the values are set to the following unless otherwise specified: $p_0 = 0.5$, $\theta_H = 2$, $\theta_L = -1$, $\sigma_M = \sigma_e = 4$, $N = 1$. Figure 1 plots the expected utility for the manager ($U_M$) and an employee ($U_e$) as a function of $b$ for this parametrization.

The plots suggest that, interestingly enough, expected utility for both parties can be higher with strategic communication than with full disclosure. Specifically, for the parameter regions plotted, we find that this is always true for the manager, and true for the employee when the bias $b$ is close to zero. In other words, when the incentives to coordinate are better aligned ex-ante ($b$ is close to zero), neither the manager nor the employees prefer to commit to full disclosure by the manager. However, when incentives are not well aligned (i.e., $b$ is very positive or very negative), the expected utility for employees may be higher under full disclosure.

In interpreting these results, recall the two offsetting effects on an employee's expected utility: (i) fundamental uncertainty is lower under full disclosure but (ii) strategic uncertainty is lower with cheap talk since the manager is more likely to switch in this case. An employee's expected utility depends on the tradeoff between these effects. Conditional on knowing whether $M$ will switch, a message is more valuable to $e \in E$ when it is more informative about fundamentals around his cutoff (see Yang (2015) for a discussion of this in the context of flexible information acquisition). When the manager's bias is small, their cutoffs are close, and so the message with $SC$ is quite informative to an employee. In this case, even though the $FC$ equilibrium is more informative overall, the information advantage over $SC$ is not very large. As a result, the second effect dominates, and expected utility tends to be higher for $SC$.

However, if the bias is very positive, the manager's cutoff is much lower than the employee's, and so her message in $SC$ is not very valuable to him. In this case, the informational advantage of $FC$ dominates, and expected utility is higher for $FC$. Similarly, in the least-informative $SC$ equilibrium, signals below the cutoff are also concealed, and so expected utility can be lower than in the $FC$ (and the most-informative $SC$ equilibrium) when the bias is extremely negative (and consequently, the employee's cutoff is very high).

Comparing the $FC$ and $SC$ plots to the welfare-maximizing decision suggests that the largest loss in the employee's utility is when the manager is negatively biased relative to her followers (i.e., when $b$ is negative). Intuitively, by allowing the manager's decision to depend on $x_e$, the welfare-maximizing decision encourages switching by the manager when her bias is very negative, which improves welfare. This suggests that commitment to an optimal mechanism may be most valuable when the manager is biased against adoption.

### 5.3 Informational efficiency

Next, we turn to informational efficiency, which measures how well the team's decision matches the underlying fundamental. It provides an alternative external measure of the team's overall performance, and is arguably easier to measure empirically than welfare in certain settings. Specifically, measuring efficiency does not rely on knowledge of the payoff externalities of the team members' actions, but can be estimated by correlating the team members' actions to the project fundamentals.

The distribution of $\theta$ implies that switching is efficient when fundamentals are high (i.e., $\theta = \theta_H$), but inefficient when fundamentals are low (i.e., $\theta = \theta_L$). For any equilibrium, this allows us to characterize two sources of distinct measures of inefficiency:[23]

1. Under-adoption $UA$ in the good state, which we measure as:

$$UA = 1 - \Pr\left(a_M = 1, \{a_e = 1\}_{e \in E} \,|\theta_H\right). \tag{25}$$

2. Over-adoption $OA$ in the bad state, which we measure as:

$$OA = 1 - \Pr\left(a_M = 0, \{a_e = 0\}_{e \in E} \,|\theta_L\right). \tag{26}$$

Overall informational efficiency $IE$ can then be defined as a weighted average of the two:

$$IE = 1 - (p_0 UA + (1 - p_0) OA). \tag{27}$$

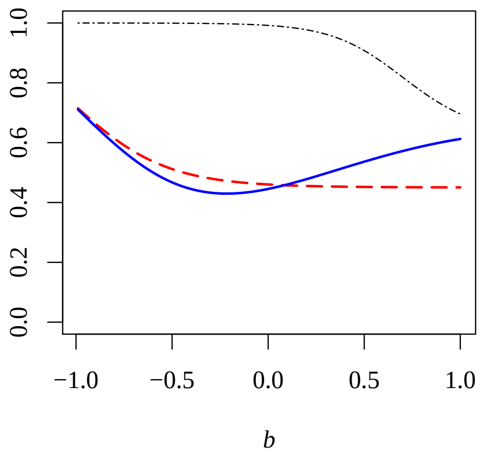
As with expected utility, comparing these efficiency measures across equilibria is not analytically tractable, and so we focus on numerical solutions across a wide range of parameter values. A common feature of the results below is the tradeoff that increased communication introduces in our setting. On the one hand, improving communication (e.g., going from the $NC$ equilibrium to the $FC$ or $SC$ equilibrium) increases informational efficiency since employees have access to more information — this increases efficiency since it allows them to form more precise beliefs about the fundamental state. On the other hand, improving communication increases the ability of the players to coordinate their actions. This improves efficiency by reducing under-adoption in the good state, but can decrease efficiency by increasing over-adoption in the bad state.

An important feature of the $SC$ equilibrium that distinguishes it from the $NC$ and $FC$ equilibria is that the amount of information communicated is endogenous. Since the manager does not fully disclose the realization of her signal in the region where she switches, $SC$ equilibria are less informative than the $FC$ equilibrium, but more informative than the $NC$ equilibrium. However, since the region over which information is concealed is endogenously determined, the efficiency ranking of $SC$ equilibria is not always between the $FC$ and $NC$ equilibria.

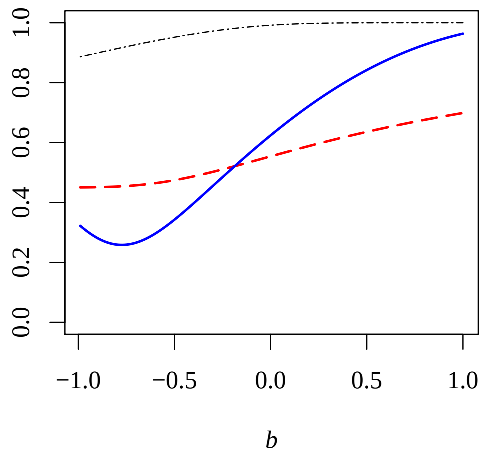
[23] These measures highlight that, in our setting, adoption is not always efficient. As a result, while measures of total adoption (e.g., $\Pr(a_M = 1) + \Pr(a_e = 1)$) may be interesting for other reasons, they do not capture a notion of efficiency.

Figure 2: Efficiency as a function of $b$

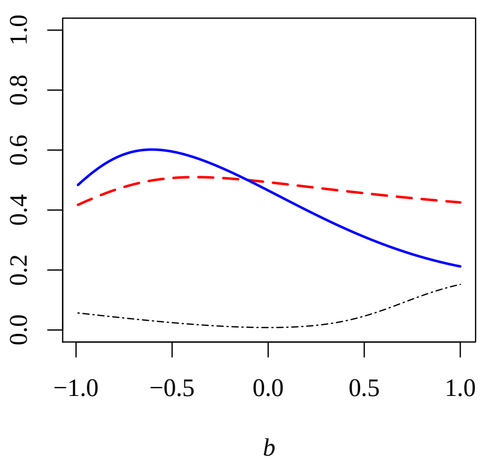
The figure plots (a) under-adoption ($UA$) in the good state, (b) over-adoption ($OA$) in the bad state, and (c) informational efficiency ($IE$) as a function of the bias parameter $b$ for the no communication equilibrium (dot-dashed), the full disclosure communication equilibrium (dashed), and the least informative strategic communication equilibrium (solid). The benchmark parameter levels are set to: $p_0 = 0.5$, $\theta_H = 2$, $\theta_L = -1$, $\sigma_M = \sigma_e = 4$.



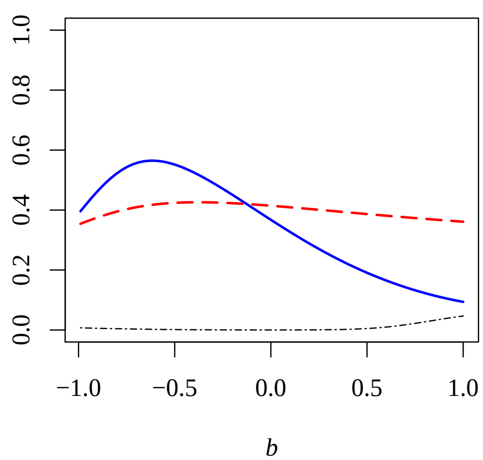

(a) Under-adoption ($N = 10$)




(b) Over-adoption ($N = 10$)




(c) Informational Efficiency ($N = 10$)




(f) Informational Efficiency ($N = 20$)

Figure 2 compares the various measures of efficiency across equilibria as the manager's bias changes. An increase in $b$ increases the manager's payoff from switching, and so lowers her cutoff $k_M$ across all equilibria, which increases the likelihood she switches for both realizations of fundamentals. When $b$ is close to $-1$, the under-adoption problem is very severe: there is very little to be gained from coordination, and the manager switches only if her posterior expectation of fundamentals is sufficiently close to 1 (in the limit as $b \downarrow -1$, she switches only if $\mathbb{E}[\theta|x_M] \geq 1$). In this region, the increase in efficiency due to lower $UA$ dominates the decrease in efficiency due to higher $OA$, and so efficiency for the communication equilibria ($FC$ and $SC$) initially increases in $b$. At the other extreme, when $b$ is close to $-\theta_L$, the over-adoption problem is very severe for both communication equilibria, because the manager is biased very strongly in favor of switching. In this region, the $OA$ effect dominates and so overall efficiency decreases in $b$.

Figure 2 also highlights that the ranking across equilibria can change with $b$. As expected, both the $UA$ and $OA$ problems are more severe in the no communication equilibrium than in either communication scenario across all $b$. However, the relative ranking of the cheap talk equilibrium and the full disclosure scenario depends on the level of $b$. Recall that the $SC$ equilibrium features higher fundamental uncertainty relative to full disclosure (since less information is conveyed to the employees), but offers lower strategic uncertainty (since the manager is more likely to switch). When the manager is negatively biased (i.e., $b$ is close to $-1$), both $OA$ and $UA$ are (weakly) lower with strategic communication. As we show in the proof of the following result, the manager's threshold is close to $\frac{\theta_H+\theta_L}{2}$ in this region, which makes the cheap-talk message in the strategic communication equilibrium very informative to the employees. However, as the bias towards adoption increases, the manager's threshold becomes lower and consequently, the cheap-talk message becomes less informative to the employees. As a result, the informational disadvantage of the $SC$ equilibrium outweighs the coordination benefit, and overall efficiency is lower than with full disclosure.

A normative implication of this effect is that aligning incentives ex-ante (i.e., setting the manager's bias $b = 0$) need not maximize efficiency even when coordination is valuable. For instance, the numerical analysis from Figure 2 suggests that for both communication equilibria, efficiency is maximized for a negative bias. The following result formalizes this observation more generally.

**Proposition 11.** *Suppose $p_0 = \frac{1}{2}$. Then efficiency in the least-informative, strategic communication equilibrium is maximized when the manager is biased against coordination. In addition, when $\theta_H + \theta_L = 1$, efficiency in the full disclosure communication equilibrium is also maximized when the manager is biased against coordination.*

Intuitively, the negative bias tilts the tradeoff from more communication in favor of greater informational efficiency by reducing the manager's incentive to coordinate on adoption. As such, in settings where the manager's payoff can be chosen exogenously (e.g., performance sensitive compensation contracts), it may be informationally efficient to bias her against coordination. This implication is in sharp contrast to the insights from standard cheap-talk models, where reducing the sender's bias tends to generate more informationally efficient outcomes.

### 5.3.1 Investment efficiency and team size

Panels (c) and (d) of Figure 2 illustrate the effect of increasing the number of employees (i.e., $N$) on investment efficiency. The plots suggest that an increase in $N$ leads to (weakly) lower efficiency in all three scenarios. This is intuitive — increasing the number of employees makes coordination on the appropriate action for each state more difficult. As an illustration, for the strategic communication scenario, note that we can express under-adoption and over-adoption as:

$$UA = 1 - \Phi\left(\frac{\theta_H - k_M}{\sigma_M}\right)\Phi\left(\frac{\theta_H - k_{e,1}}{\sigma_e}\right)^N \text{ and } OA = 1 - \Phi\left(\frac{k_M - \theta_L}{\sigma_M}\right)\Phi\left(\frac{k_{e,0} - \theta_L}{\sigma_e}\right)^N, \tag{28}$$

respectively. Since the cutoffs $k_M$ and $k_e$ do not depend on the number of employees, the above expressions imply that in the limit,

$$\lim_{N\to\infty} UA = \lim_{N\to\infty} OA = 1, \tag{29}$$

and consequently, informational efficiency is zero. Moreover, the difference in overall efficiency between the $SC$ and $FC$ scenarios increases with $N$. As such, our analysis suggests that changes in communication strategy (e.g., from cheap talk to full disclosure) have larger effects on efficiency for larger teams.

As we suggested in Section 2.1, when employees can communicate with each other, informational efficiency is bounded away from zero, even when the team size is arbitrarily large. Intuitively, this is because when employees communicate with each other, increasing the team size $N$ improves the information available to each employee (the variance of the aggregate signal $\bar{x}_e = \frac{1}{N}\sum_{i\in E} x_i$ is given by $\sigma_e/N$). As such, while coordination is more difficult due to an increase in the number of team members, it becomes easier because the information available to employees is better. For instance, one can show that in the strategic communication scenario, the cutoffs for the employees (i.e., $K_{SC}$) and the manager (i.e., $k_{M,SC}$) approach the following limits:

$$\lim_{N\to\infty} K_{SC}(N) = \frac{\theta_H + \theta_L}{2} \equiv \bar{k}_e, \text{ and} \tag{30}$$

$$\lim_{N\to\infty} k_{M,SC}(N) = \tfrac{\theta_H+\theta_L}{2} + \tfrac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\tfrac{1-\theta_L}{\theta_H+b}\right) - \log\left(\tfrac{p_0}{1-p_0}\right)\right\} \equiv \bar{k}_M, \tag{31}$$

respectively. As a result,

$$\lim_{N\to\infty} UA = \lim_{N\to\infty} 1 - \Phi\left(\frac{\theta_H - k_M}{\sigma_M}\right)\Phi\left(\frac{\theta_H - k_{e,1}}{\frac{\sigma_e}{\sqrt{N}}}\right)^N = 1 - \Phi\left(\frac{\theta_H - \bar{k}_M}{\sigma_M}\right), \text{ and} \tag{32}$$

$$\text{and } \lim_{N\to\infty} OA = \lim_{N\to\infty} 1 - \Phi\left(\frac{k_M - \theta_L}{\sigma_M}\right)\Phi\left(\frac{k_{e,0} - \theta_L}{\frac{\sigma_e}{\sqrt{N}}}\right)^N = 1 - \Phi\left(\frac{\bar{k}_M - \theta_L}{\sigma_M}\right), \tag{33}$$

which implies informational efficiency is bounded away from zero.

# 6 Implications and concluding remarks

The effectiveness of a leader is often driven by her ability to inform others and to induce them to act towards a common goal. We show that the very incentive to coordinate actions can limit a leader's ability to convey information to her followers. We study how a leader communicates with her followers when deciding whether to adopt a new project, where actions are strategic complements and all players are privately informed. We show that informative communication is difficult to sustain: in any cheap-talk equilibrium, the leader must conceal some information. For signal realizations where she chooses to switch, the leader can only reveal that she will switch. Moreover, in the presence of positive spillovers, no information can be conveyed via cheap talk.

We also find that the ability to commit to full disclosure may not be valuable, even though more information about fundamentals is communicated than in a cheap-talk equilibrium. When the leader is moderately biased in favor of (or against) the status quo, we find that every team member prefers a partially-informative cheap talk equilibrium to commitment to full disclosure. Moreover, when the leader is biased against coordination, informational efficiency can also be higher under strategic communication.

Our analysis lends itself naturally to experimental tests (see Crawford (1998) for an early survey of experiments on cheap-talk games). For example, our results are broadly consistent with the experimental evidence in Brandts, Cooper, and Fatas (2007), who suggest that simple, one-sided communication by a manager can be most effective at improving coordination across employees.[24] Our analysis also generates a number of implications for organizations and firms in real-world settings, although empirically identifying measures of communication and team performance is extremely challenging.

Arguably, the model's predictions are most readily testable in the context of the impact of CEO characteristics on firm performance. A stylized fact documented in the literature is that optimistic CEOs are likely to have higher investment (e.g., Ben-David et al. (2013)) and use more leverage (e.g., Graham et al. (2013)). This evidence of risk-taking is consistent with the model's prediction that a positive bias leads to over-adoption of the risky project. A novel prediction of our model is that such over-investment should be more severe in firms with weaker internal governance and transparency, because commitment to full disclosure is more difficult to implement in these cases. Over-investment should also be higher in firms where coordination within teams is more important and when employee decisions generate more positive spillovers for their managers.

Our analysis also has normative implications for how policy changes to the communication environment can affect the performance of a team. For instance, when the leader's bias towards coordination is sufficiently large or when the employees' actions generate positive spillovers for the leader, forcing greater disclosure by the leader improves both efficiency and welfare. This suggests that changes in the information environment, either due to external regulations or internal governance policies, that improve communication within a firm are most beneficial for firms with weak internal governance, and firms in which "empire building" is of greater concern (e.g., family firms, founder-run startups).

However, when the leader's incentives are more closely aligned with those of her followers, such changes to the information environment may not just be ineffective; they may actually be counter-productive. Furthermore, these adverse effects are likely to be more severe for larger teams and firms, especially when communication among team members is limited. Finally, contrary to standard intuition, aligning incentives need not improve informational efficiency. In fact, a "reluctant" leader, who is moderately biased in favor of the status quo, might improve efficiency of the firm's decisions: in both the full disclosure and strategic communication scenarios, efficiency can be higher when the leader is biased against coordination

[24] The setup they consider, though related, is distinct from ours. In their game, the manager is privately informed, but does not take an action herself. They find that simply emphasizing the benefits of coordination to employees is more effective at encouraging coordination than increasing incentives.

than if she is unbiased.

Although stylized, our analysis is based on a widely used model of coordination. Our results suggest that allowing for cheap-talk communication in such settings can lead to different conclusions than in a standard, sender-receiver setting (where only receivers take actions). Natural next steps would be to consider greater heterogeneity in receiver preferences, two-sided communication (follower to leader communication), and inter-receiver communication (communication among followers). We hope to explore this in future work.

# References

Almazan, A., Chen, Z., Titman, S., 2017. Firm investment and stakeholder choices: A top-down theory of capital budgeting. The Journal of Finance 72 (5).

Alonso, R., Dessein, W., Matouschek, N., 2008. When does coordination require centralization? The American Economic Review 98 (1), 145–179.

Angeletos, G.-M., Hellwig, C., Pavan, A., 2006. Signaling in a global game: Coordination and policy traps. Journal of Political Economy 114 (3), 452–484.

Angeletos, G.-M., Pavan, A., 2007. Efficient use of information and social value of information. Econometrica 75 (4), 1103–1142.

Angeletos, G.-M., Pavan, A., 2013. Selection-free predictions in global games with endogenous information and multiple equilibria. Theoretical Economics 8 (3), 883–938.

Angeletos, G.-M., Werning, I., 2006. Crises and prices: Information aggregation, multiplicity, and volatility. The American Economic Review 96 (5), 1720–1736.

Aumann, R., 1990. Nash equilibria are not self-enforcing. Economic Decision Making: Games, Econometrics and Optimisation, 201–206.

Baliga, S., Morris, S., 2002. Co-ordination, spillovers, and cheap talk. Journal of Economic Theory 105 (2), 450–468.

Banerjee, S., Liu, Q., 2014. Transparency versus tone: Public communication with limited commitment. Available at SSRN 2382667.

Ben-David, I., Graham, J. R., Harvey, C. R., 2013. Managerial miscalibration. The Quarterly Journal of Economics 128 (4), 1547–1584.

Bolton, P., Brunnermeier, M. K., Veldkamp, L., 2013. Leadership, coordination, and corporate culture. Review of Economic Studies 80 (2), 512–537.

Brandts, J., Cooper, D. J., Fatas, E., 2007. Leadership and overcoming coordination failure with asymmetric costs. Experimental Economics 10 (3), 269–284.

Brav, A., Dasgupta, A., Mathews, R. D., 2014. Wolf pack activism. Available at SSRN.

Briggs, T. W., 2007. Corporate governance and the new hedge fund activism: An empirical analysis. Journal of Corporation Law 32 (4).

Carlsson, H., Van Damme, E., 1993. Global games and equilibrium selection. Econometrica: Journal of the Econometric Society, 989–1018.

Chakraborty, A., Yılmaz, B., 2017. Authority, consensus, and governance. The Review of Financial Studies 30 (12), 4267–4316.

Coffee, John C, J. C., Palia, D., 2016. The wolf at the door: The impact of hedge fund activism on corporate governance. Annals of Corporate Governance 1 (1), 1–94.

Corsetti, G., Dasgupta, A., Morris, S., Shin, H. S., 2004. Does one soros make a difference? a theory of currency crises with large and small traders. Review of Economic Studies, 87–113.

Crawford, V., 1998. A survey of experiments on communication via cheap talk. Journal of Economic Theory 78 (2), 286–298.

Crawford, V. P., Sobel, J., 1982. Strategic information transmission. Econometrica: Journal of the Econometric Society, 1431–1451.

Farrell, J., Gibbons, R., 1989. Cheap talk with two audiences. The American Economic Review 79 (5), 1214–1223.

Frankel, D. M., Morris, S., Pauzner, A., 2003. Equilibrium selection in global games with strategic complementarities. Journal of Economic Theory 108 (1), 1–44.

Gervais, S., Goldstein, I., 2007. The positive effects of biased self-perceptions in firms. Review of Finance 11 (3), 453–496.

Goel, A. M., Thakor, A. V., 2008. Overconfidence, ceo selection, and corporate governance. The Journal of Finance 63 (6), 2737–2784.

Goldman, E., Slezak, S. L., 2006. An equilibrium model of incentive contracts in the presence of information manipulation. Journal of Financial Economics 80 (3), 603–626.

Goldstein, I., Huang, C., 2016. Bayesian persuasion in coordination games. American Economic Review 106 (5), 592–96.

Goltsman, M., Pavlov, G., 2011. How to talk to multiple audiences. Games and Economic Behavior 72 (1), 100–122.

Graham, J. R., Harvey, C. R., Puri, M., 2013. Managerial attitudes and corporate actions. Journal of Financial Economics 109 (1), 103–121.

Hagenbach, J., Koessler, F., 2010. Strategic communication networks. The Review of Economic Studies 77 (3), 1072–1099.

Hermalin, B. E., 1998. Toward an economic theory of leadership: Leading by example. American Economic Review, 1188–1206.

Hermalin, B. E., Weisbach, M. S., 2012. Information disclosure and corporate governance. The Journal of Finance 67 (1), 195–233.

Hochberg, Y. V., Ljungqvist, A., Lu, Y., 2007. Whom you know matters: Venture capital networks and investment performance. The Journal of Finance 62 (1), 251–301.

Kamenica, E., Gentzkow, M., 2011. Bayesian persuasion. American Economic Review 101 (6), 2590–2615.

Malmendier, U., Tate, G., 2005. Ceo overconfidence and corporate investment. The Journal of Finance 60 (6), 2661–2700.

Malmendier, U., Tate, G., 2008. Who makes acquisitions? ceo overconfidence and the market's reaction. Journal of Financial Economics 89 (1), 20–43.

Morris, S., Shin, H. S., 2001. Rethinking multiple equilibria in macroeconomic modeling. In: NBER Macroeconomics Annual 2000, Volume 15. MIT Press, pp. 139–182.

Morris, S., Shin, H. S., 2002. Social value of public information. The American Economic Review 92 (5), 1521–1534.

Morris, S., Shin, H. S., 2003. Global games: Theory and applications. In: Dewatripont, M., Hansen, L. P., Turnovsky, S. J. (Eds.), Advances in Economics and Econometrics. Cambridge University Press, pp. 56–114.

Newman, P., Sansing, R., 1993. Disclosure policies with multiple users. Journal of Accounting Research, 92–112.

Ozdenoren, E., Yuan, K., 2008. Feedback effects and asset prices. The Journal of Finance 63 (4), 1939–1975.

Rantakari, H., 2008. Governing adaptation. The Review of Economic Studies 75 (4), 1257–1285.

Rayo, L., Segal, I., 2010. Optimal information disclosure. Journal of Political Economy 118 (5), 949–987.

Rotemberg, J. J., Saloner, G., 2000. Visionaries, managers, and strategic direction. RAND Journal of Economics, 693–716.

Sobel, J., 2013. Giving and receiving advice. In: Acemoglu, D., Arellano, M., Dekel, E. (Eds.), Advances in Economics and Econometrics: TenthWorld Congress. Vol. 1. Cambridge University Press, pp. 305–341.

Song, F., Thakor, A. V., 2006. Information control, career concerns, and corporate governance. The Journal of Finance 61 (4), 1845–1896.

Stein, J. C., 1989. Efficient capital markets, inefficient firms: A model of myopic corporate behavior. The Quarterly Journal of Economics 104 (4), 655–669.

Yang, M., 2015. Coordination with flexible information acquisition. Journal of Economic Theory 158, 721–738.

# Appendix

## A Proofs of main results

**Proof of Proposition 1.** Since there is no communication, we have for $i \in \{M, E\}$,

$$\log\left(\tfrac{p_i}{1-p_i}\right) = \log\left(\tfrac{p_0}{1-p_0}\right) + \tfrac{1}{\sigma_i^2}\left(\theta_H - \theta_L\right)\left(x_i - \tfrac{\theta_H+\theta_L}{2}\right), \tag{34}$$

which implies that player $i$'s best response is to switch only when $x_i \geq K\left(k_j; b_i, \sigma_i, \sigma_j\right)$. Note that

$$\lim_{k_j \to -\infty} K\left(k_j\right) = \tfrac{\theta_H+\theta_L}{2} + \tfrac{\sigma_i^2}{\theta_H-\theta_L}\left\{\log\left(\tfrac{-(\theta_L+b_i)}{(\theta_H+b_i)}\right) - \log\left(\tfrac{p_0}{1-p_0}\right)\right\} \equiv \underline{k}, \tag{35}$$

$$\lim_{k_j \to \infty} K\left(k_j\right) = \tfrac{\theta_H+\theta_L}{2} + \tfrac{\sigma_i^2}{\theta_H-\theta_L}\left\{\log\left(\tfrac{1-\theta_L}{\theta_H-1}\right) - \log\left(\tfrac{p_0}{1-p_0}\right)\right\} \equiv \bar{k}, \tag{36}$$

and for $b_i > -1$, we have $\frac{\partial}{\partial k}K > 0$. Since $-\theta_H < -1 < b_i < -\theta_L$, $\underline{k}$ and $\bar{k}$ are well defined and finite. The equilibrium is characterized by the fixed point of $x = H\left(x\right)$, where

$$H\left(x\right) \equiv K\left(K\left(x; b_e, \sigma_e, \sigma_M\right); b_M, \sigma_M, \sigma_e\right). \tag{37}$$

Since $K$ is (strictly) increasing, so is $H$. Also, $H\left(-\infty\right) > -\infty$ and $H\left(\infty\right) < \infty$, which implies a fixed point exists. To ensure uniqueness, we require $H$ is a contraction, or equivalently,

$$\tfrac{\partial}{\partial x}H\left(x\right) < 1. \tag{38}$$

A sufficient condition for this to be true is that the best response function for each player has a slope less than one, i.e., $\frac{\partial}{\partial k}K < 1$. Note that

$$\tfrac{\partial}{\partial k}K = \tfrac{\sigma_i^2}{\theta_H-\theta_L}\left\{\frac{(1+b)\phi\left(\frac{k-\theta_H}{\sigma_j}\right)}{\sigma_j\left((\theta_H+b)-(1+b)\Phi\left(\frac{k-\theta_H}{\sigma_j}\right)\right)} - \frac{(1+b)\phi\left(\frac{k-\theta_L}{\sigma_j}\right)}{\sigma_j\left((\theta_L+b)-(1+b)\Phi\left(\frac{k-\theta_L}{\sigma_j}\right)\right)}\right\} \tag{39}$$

We need to bound the above. Let

$$g\left(x, \theta, b\right) = \tfrac{(1+b)\phi(x)}{\sigma_j((\theta+b)-(1+b)\Phi(x))} \tag{40}$$

$$\Rightarrow g_x = \tfrac{(1+b)\phi'(x)((\theta+b)-(1+b)\Phi(x))+(1+b)^2(\phi(x))^2}{\sigma_j((\theta+b)-(1+b)\Phi(x))^2} \tag{41}$$

$$= \tfrac{(1+b)\phi(x)[-x((\theta+b)-(1+b)\Phi(x))+(1+b)\phi(x)]}{\sigma_j((\theta+b)-(1+b)\Phi(x))^2} \tag{42}$$

A necessary condition for the extremum of $g\left(x, \theta, b\right)$ is that $g_x = 0$, or equivalently,

$$\tfrac{\theta+b}{1+b} = \left[\tfrac{\phi(x)}{x} + \Phi\left(x\right)\right]. \tag{43}$$

Recall that $b > -1$, $\theta_L + b < 0$ and $\theta_H > 1$. This implies $g(x, \theta_H, b) > 0$ and $g(x, \theta_L, b) < 0$. Moreover, this implies there is a solution $x_L^*(b, \theta_L) < 0$ for $\theta = \theta_L$ and a solution $x_H^*(b, \theta_H) > 0$ for $\theta = \theta_H$. Finally, the first order condition also implies that

$$g(x^*, \theta, b) = \frac{(1+b)\phi(x)}{\sigma_j((\theta+b)-(1+b)\Phi(x))} = \frac{x^*}{\sigma_j}, \tag{44}$$

that is, $g(x, \theta_H, b)$ is maximized at $\frac{x_H^*(b,\theta_H)}{\sigma_j}$ and $g(x, \theta_L, b)$ is minimized at $\frac{x_L^*(b,\theta_L)}{\sigma_j}$. But this implies that

$$\frac{\partial}{\partial k}K = \frac{\sigma_i^2}{\theta_H-\theta_L}\left\{g\left(\frac{k-\theta_H}{\sigma_j}, \theta_H, b\right) - g\left(\frac{k-\theta_L}{\sigma_j}, \theta_L, b\right)\right\} \leq \frac{\sigma_i^2}{\theta_H-\theta_L}\left\{\frac{x_H^*(b,\theta_H)-x_L^*(b,\theta_L)}{\sigma_j}\right\} \tag{45}$$

Given $b$, $\theta_H$ and $\theta_L$ and $\sigma_j$, one can always pick $\sigma_i^2$ small enough so that $\frac{\partial}{\partial k}K_i < 1$. In particular,

$$\frac{\sigma_M^2}{\sigma_e} < \frac{\theta_H-\theta_L}{x_H^*(b_M,\theta_H)-x_L^*(b_M,\theta_L)} \equiv \bar{a}, \quad \frac{\sigma_e^2}{\sigma_M} < \frac{\theta_H-\theta_L}{x_H^*(b_e,\theta_H)-x_L^*(b_e,\theta_L)} \equiv \underline{a} \tag{46}$$

ensures that there is a unique equilibrium. □

**Proof of Proposition 2.** Given the belief updating in equation (8), player $e$'s best response cutoff is given by

$$K_{FC}(x,k) = \frac{1}{2}(\theta_H+\theta_L) + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(\frac{(1+b_e)1_{\{x\leq k\}}-(\theta_L+b_e)}{(\theta_H+b_e)-(1+b_e)1_{\{x\leq k\}}}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - x\right). \tag{47}$$

If the signal $x$ coincides with the cutoff $k$, the above best response simplifies to

$$K_{FC}(k,k) = \frac{1}{2}(\theta_H+\theta_L) + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(\frac{-(\theta_L+b_e)}{(\theta_H+b_e)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - k\right) \equiv g(k), \tag{48}$$

and note that $g(k)$ is decreasing in $k$. Moreover, note that $M$ should only switch when $x_M \geq k_M$, where

$$k_M = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(1+b_M)\Phi\left(\frac{g(k_M)-\theta_L}{\sigma_e}\right)-(\theta_L+b_M)}{(\theta_H+b_M)-(1+b_M)\Phi\left(\frac{g(k_M)-\theta_H}{\sigma_e}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} \equiv H(k_M) \tag{49}$$

The equilibrium cutoff $k_M$ is given by the solution to the fixed point $x = H(x)$. Since

$$\lim_{x\to-\infty} H(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{1-\theta_L}{\theta_H-1}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} > -\infty, \tag{50}$$

$$\lim_{x\to\infty} H(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(-\frac{\theta_L+b_M}{\theta_H+b_M}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} < \infty, \tag{51}$$

and $H_x < 0$, we have that a fixed point exists and is unique. □

**Proof of Proposition 3.** Since we focus on pure strategy messaging rules with truth telling, and consider sender optimal equilibria, the image $\mathcal{M}(\mu) = \{\mu(x_M) : x_M \in \Re\}$ for messaging rule $\mu$ is a partition or $\Re$.[25] Given a message $m \in \mathcal{M}(\mu)$ and cutoff $k$, player $R$'s best response is a cutoff $K_{e,SC}(m,k)$ given by

$$K_{e,SC}(m,k) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{\Pr(x_M<k|x_M\in m,\theta_L)(1+b_e)-(\theta_L+b_e)}{\theta_H+b_e-\Pr(x_M<k|x_M\in m,\theta_H)(1+b_e)}\right) - \log\left(\frac{p_0}{1-p_0}\right) - \log\left(\frac{\Pr(x_M\in m|\theta_H)}{\Pr(x_M\in m|\theta_L)}\right)\right\}. \tag{52}$$

Given this best response, each message $m$ corresponds to a cutoff $k(m)$ for player $M$, given by:

$$k(m) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(1+b)\Phi\left(\frac{K_{e,SC}(m,k(m))-\theta_L}{\sigma_e}\right)-(\theta_L+b)}{(\theta_H+b)-(1+b)\Phi\left(\frac{K_{e,SC}(m,k(m))-\theta_H}{\sigma_e}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\}. \tag{53}$$

First we show that for any message $m$ in equilibrium, we must have $k(m) \notin \text{int}(m)$, where $\text{int}(m)$ denotes the interior of $m$. Suppose otherwise, and let $m_1 = m \cap \{x < k(m)\}$and $m_2 = m \setminus m_1$. Then, it must be that $m_1$ is to the left of $m_2$, i.e., $\limsup m_1 < \liminf m_2$ — denote this as $m_1 \prec m_2$. This implies that $K_{e,SC}(m_1, k(m)) > K_{e,SC}(m, k(m)) > K_{e,SC}(m_2, k(m))$, which in turn implies $k(m_2) < k(m) < k(m_1)$, which implies $M$ does not switch for $x_M \in m_1$ and always switches for $x_M \in m_2$, and is strictly (weakly) better off for $x_M \in m_2$ ($x_M \in m_1$, respectively) using messages $\{m_1, m_2\}$ instead of $m$.

This implies that for any candidate equilibrium messaging rule $\mu$, the corresponding messages must be such that $k(m) \notin \text{int}(m)$. This implies that we can partition the image of $\mu$, $\mathcal{M}(\mu)$, into two subsets $\bar{F}(\mu) = \{m \in \mathcal{M}(\mu) : k(m) \leq \liminf(m)\}$ and $\underline{F}(\mu) = \mathcal{M}(\mu) \setminus \bar{F}(\mu)$. Note that $\bar{F}(\mu)$ is the set of all messages $m \in \mathcal{M}(\mu)$ where $M$ switches. If we define $c_1(\mu) \equiv \sup\{x : \bar{F}(\mu) \geq x\}$ and $c_2(\mu) \equiv \inf\{x : \underline{F}(\mu) \leq x\}$. It is immediate to see $c_1(\mu) \leq c_2(\mu)$; otherwise, the interval $(c_2(\mu), c_1(\mu))$ does not exist in $\mathcal{M}(\mu)$. Suppose $c_1(\mu) < c_2(\mu)$. Then, in $(c_1(\mu), c_2(\mu))$, there exists a real number $y$ such that a left neighborhood of $y$ belongs to $\bar{F}(\mu)$ and a right neighborhood of $y$ belongs to $\underline{F}(\mu)$. It implies that $\lim_{z\uparrow y} U_M(z, m(z)) \geq 0$ and $\lim_{z\downarrow y} U_M(z, m(z)) \leq 0$, and one of the inequalities is strict. As a result, the indifference requirement at $y$ is violated. Hence, we have $c_1(\mu) = c_2(\mu) \equiv c(\mu)$, and $\limsup \underline{F}(\mu) \leq c(\mu)$ and $\liminf \bar{F}(\mu) \geq c(\mu)$.

Unless $\bar{F}(\mu)$ consists of a single interval, for any $m \in \bar{F}(\mu)$, there exists a $\tilde{m} \in \bar{F}(\mu)$, such that $cl(m) \cap cl(\tilde{m}) \neq \varnothing$, where $cl(m)$ denotes the closure of $m$. The optimality of $\mu$ requires that for any $x_M \in cl(m) \cap cl(\tilde{m})$, $M$ is indifferent between sending the message $m$ and $\tilde{m}$, but this implies $K_{e,SC}(m, k(m)) = K_{e,SC}(\tilde{m}, k(\tilde{m}))$. Since $m, \tilde{m} \in \bar{F}(\mu)$ (i.e., for any signals $x_M$, $M$ switches given message $m$, $\tilde{m}$ and so $\Pr(x_M < k(m) | x_M \in m, \theta) = \Pr(x_M < k(\tilde{m}) | x_M \in \tilde{m}, \theta) = 0$) this in turn must imply

$$\frac{\Pr(x_M \in m|\theta_H)}{\Pr(x_M \in m|\theta_L)} = \frac{\Pr(x_M \in \tilde{m}|\theta_H)}{\Pr(x_M \in \tilde{m}|\theta_L)}. \tag{54}$$

But $\bar{F}(\mu)$ is a partition of the half-line $[c(\mu), \infty)$, and so for all $m \in \bar{F}(\mu)$, $\frac{\Pr(x_M\in m|\theta_H)}{\Pr(x_M\in m|\theta_L)} = t$

[25] Specifically, sender optimality rules out some sender types sending a message $m = \Re$, since it is not optimal for senders with high signals to be pooled with senders with low signals.

for some constant. This implies that

$$t = \frac{\sum_{m\in\bar{F}} \Pr\left(x_M \in m|\theta_H\right)}{\sum_{m\in\bar{F}} \Pr\left(x_M \in m|\theta_L\right)} = \frac{\Pr\left(x_M \in \cup_{m\in\bar{F}} m|\theta_H\right)}{\Pr\left(x_M \in \cup_{m\in\bar{F}} m|\theta_L\right)} = \frac{\Pr\left(x_M \in \bar{F}|\theta_H\right)}{\Pr\left(x_M \in \bar{F}|\theta_L\right)}. \tag{55}$$

This implies any candidate messaging rule $\mu$ is equivalent to a messaging rule $\tilde{\mu}$, where

$$\tilde{\mu}(x) = \begin{cases} \mu(x) & \text{if } x < k(\mu) \\ [k(\mu), \infty) & \text{if } x \geq k(\mu) \end{cases} \tag{56}$$

and $M$ switches if and only if $x_M \geq k(\mu)$. An optimal messaging rule must satisfy player $M$'s indifference condition:

$$\pi_M\left(k, [k, \infty)\right) = 0, \tag{57}$$

This is characterized by the solution $k_{SC}$ to the fixed point problem $k = K\left(K_e(k), b_M, \sigma_M, \sigma_e\right) \equiv H(k)$, where

$$K_e(k) \equiv K_{e,SC}\left(k, [k, \infty)\right) \tag{58}$$

$$= \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{-(\theta_L+b_e)}{\theta_H+b_e}\right) - \log\left(\frac{p_0}{1-p_0}\right) - \log\left(\frac{1-\Phi\left(\frac{k-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{k-\theta_L}{\sigma_M}\right)}\right)\right\} \tag{59}$$

since for $x \in [k, \infty]$, $e$ knows that $M$ switches (i.e., $\Pr\left(a_M = 0|x \in [k, \infty], \theta\right) = 0$). Note that $\lim_{x\to\infty} K_e(x) = -\infty$ and $\lim_{x\to-\infty} K_e(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{-(\theta_L+b_e)}{\theta_H+b_e}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} \equiv \underline{k} < \infty$, and $K_e$ is decreasing in $x$. But this implies

$$\lim_{x\to\infty} H(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(-\frac{\theta_L+b_M}{\theta_H+b_M}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} \leq \infty \tag{60}$$

$$\lim_{x\to-\infty} H(x) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(1+b_M)\Phi\left(\frac{\underline{k}-\theta_L}{\sigma_e}\right)-(\theta_L+b_M)}{(\theta_H+b_M)-(1+b_M)\Phi\left(\frac{\underline{k}-\theta_H}{\sigma_e}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} \geq -\infty \tag{61}$$

and $H$ is decreasing in $x$, a fixed point exists. Note that for $x_M \leq k_{SC}$, $M$ does not switch and so is indifferent between different messaging rules $\mu$ that differ in this region. □

**Proof of Proposition 5.** It is sufficient to show

$$x_M = \arg\max_{m_M} \mathbb{E}\left[1_{\{x_e > k_e(m_M)\}}\theta|x_M\right], \tag{62}$$

where $\mathbb{E}\left[\theta|m_M, k_e(m_M)\right] = 0$. Note that

$$k_e(m_M) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - m_M\right) + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(-\frac{\theta_L}{\theta_H}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right)$$

The objective function is

$$\mathbb{E}\left[1_{\{x_e > k_e(m_M)\}}\theta|x_M\right] = \theta_H p(x_M)\left[1-\Phi\left(\frac{k_e(m_M)-\theta_H}{\sigma_e}\right)\right] + \theta_L\left(1-p(x_M)\right)\left[1-\Phi\left(\frac{k_e(m_M)-\theta_L}{\sigma_e}\right)\right] \tag{63}$$

where

$$\log\left(\frac{p(x_M)}{1-p(x_M)}\right)=\log\left(\frac{p_0}{1-p_0}\right)+\frac{\theta_H-\theta_L}{\sigma_M^2}\left(x_M-\frac{\theta_H+\theta_L}{2}\right).$$

The first-order condition is

$$0=\theta_H p(x_M)\,\phi\left(\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\right)+\theta_L\left(1-p(x_M)\right)\phi\left(\tfrac{k_e(m_M)-\theta_L}{\sigma_e}\right). \tag{64}$$

Equivalently,

$$\begin{aligned}
0&=\log\left(\tfrac{p_0}{1-p_0}\right)-\log\left(-\tfrac{\theta_L}{\theta_H}\right)+\tfrac{\theta_H-\theta_L}{\sigma_M^2}\left(x_M-\tfrac{\theta_H+\theta_L}{2}\right)+\log\frac{\phi\left(\frac{k_e(m_M)-\theta_H}{\sigma_e}\right)}{\phi\left(\frac{k_e(m_M)-\theta_L}{\sigma_e}\right)} &(65)\\
&=\log\left(\tfrac{p_0}{1-p_0}\right)-\log\left(-\tfrac{\theta_L}{\theta_H}\right)+\tfrac{\theta_H-\theta_L}{\sigma_M^2}\left(x_M-\tfrac{\theta_H+\theta_L}{2}\right)+\tfrac{\theta_H-\theta_L}{\sigma_e^2}\left(k_e(m_M)-\tfrac{\theta_H+\theta_L}{2}\right) &(66)\\
&=\begin{array}{c}\log\left(\tfrac{p_0}{1-p_0}\right)-\log\left(-\tfrac{\theta_L}{\theta_H}\right)+\tfrac{\theta_H-\theta_L}{\sigma_M^2}\left(x_M-\tfrac{\theta_H+\theta_L}{2}\right)\\ +\tfrac{\theta_H-\theta_L}{\sigma_e^2}\left[\tfrac{\sigma_e^2}{\sigma_M^2}\left(\tfrac{\theta_H+\theta_L}{2}-m_M\right)+\tfrac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(-\tfrac{\theta_L}{\theta_H}\right)-\log\left(\tfrac{p_0}{1-p_0}\right)\right)\right]\end{array} &(67)\\
&=\tfrac{\theta_H-\theta_L}{\sigma_M^2}\left(x_M-m_M\right) &(68)
\end{aligned}$$

The second-order condition is given by, noting $\phi'(x)=-x\phi(x)$,

$$\begin{aligned}
&\theta_H p(x_M)\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\phi\left(\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\right)+\theta_L\left(1-p(x_M)\right)\tfrac{k_e(m_M)-\theta_L}{\sigma_e}\phi\left(\tfrac{k_e(m_M)-\theta_L}{\sigma_e}\right) &(69)\\
=&\theta_H p(x_M)\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\phi\left(\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\right)-\theta_H p(x_M)\tfrac{k_e(m_M)-\theta_L}{\sigma_e}\phi\left(\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\right) &(70)\\
=&-\theta_H p(x_M)\,\phi\left(\tfrac{k_e(m_M)-\theta_H}{\sigma_e}\right)\tfrac{\theta_H-\theta_L}{\sigma_e} &(71)\\
<&0, &(72)
\end{aligned}$$

where the first equality comes from the first-order condition. Therefore, the objective function is maximized at

$$m_M=x_M, \tag{73}$$

implying that truth-telling is optimal. □

**Proof of Proposition 6.** First consider the positive spillover case, i.e., $\nu>0$. Suppose there is an equilibrium in which $M$ can communicate some information about $x_M$ to $R$. Then there are messages $m$ and $\tilde{m}$ such that (i) $cl(m)\cap cl(\tilde{m})\neq\varnothing$, (ii) fixing the cutoff strategy $k_M$ for $M$, $\Pr(a_e=0|\theta,m)\neq\Pr(a_e=0|\theta,\tilde{m})$, and (iii) for $x_M\in cl(m)\cap cl(\tilde{m})$, $\Pi_M(x_M,m)=\Pi_M(x_M,\tilde{m})$. Without loss of generality, suppose $\Pr(a_e=0|\theta,m)>\Pr(a_e=0|\theta,\tilde{m})$. This implies that given a signal $x_M$, one of the following cases must arise:

(i) $M$ switches for $m$ and $\tilde{m}$: But in this case,

$$\Pi_M(x_M,\tilde{m})-\Pi_M(x_M,m)=\pi_M^1(x_M,\tilde{m})-\pi_M^1(x_M,m) \tag{74}$$

$$= -(1+\nu)\left(\Pr\left(a_e = 0|\tilde{m}\right) - \Pr\left(a_e = 0|m\right)\right) \neq 0 \tag{75}$$

and so we have a contradiction.

(ii) $M$ does not switch for $m$ and $\tilde{m}$:

$$\Pi_M\left(x_M, \tilde{m}\right) - \Pi_M\left(x_M, m\right) = \pi_M^0\left(x_M, \tilde{m}\right) - \pi_M^0\left(x_M, m\right) \tag{76}$$

$$= -\nu\left(\Pr\left(a_e = 0|\tilde{m}\right) - \Pr\left(a_e = 0|m\right)\right) \neq 0 \tag{77}$$

and so we have a contradiction.

(iii) $M$ switches for $m$ but not for $\tilde{m}$: Since $\Pr\left(a_e = 0|\theta, m\right) > \Pr\left(a_e = 0|\theta, \tilde{m}\right)$, we have $\pi_M^1\left(x, \tilde{m}\right) > \pi_M^1\left(x, m\right)$. But since $M$ is indifferent at $x_M$, we have $\pi_M^0\left(x_M, \tilde{m}\right) = \pi_M^1\left(x_M, m\right)$, which implies $\pi_M^1\left(x_M, \tilde{m}\right) > \pi_M^0\left(x_M, \tilde{m}\right)$, i.e., it cannot be optimal to not switch at $x_M$ with message $\tilde{m}$, and so we have a contradiction.

(iv) $M$ switches for $\tilde{m}$ but not for $m$: Since $\Pr\left(a_e = 0|\theta, m\right) > \Pr\left(a_e = 0|\theta, \tilde{m}\right)$, we have $\pi_M^0\left(x, \tilde{m}\right) > \pi_M^0\left(x, m\right)$. But since $M$ is indifferent at $x_M$, we have $\pi_M^1\left(x_M, \tilde{m}\right) = \pi_M^0\left(x_M, m\right)$. But this implies $\pi_M^0\left(x_M, \tilde{m}\right) > \pi_M^1\left(x_M, \tilde{m}\right)$, i.e., it cannot be optimal to switch at $x_M$ with message $\tilde{m}$, and so we have a contradiction.

This implies that in any strategic equilibrium, $M$ effectively cannot communicate any information to $R$.

When the spillover is negative (i.e., $\nu < 0$), analogous arguments establish for $\Pr\left(a_e = 0|\theta, m\right) > \Pr\left(a_e = 0|\theta, \tilde{m}\right)$ and $x_M \in cl\left(m\right) \cap cl\left(\tilde{m}\right)$, we can only have case (iv), i.e., $M$ switches for $\tilde{m}$ but does not switch for $m$. Moreover, since cases (i) and (ii) are not possible, the message $m$ must be equivalent to $m = \{a_M = 0\}$ and the message $\tilde{m}$ must be equivalent to $\tilde{m} = \{a_M = 1\}$. Since the incremental payoff to switching $\pi_M\left(x_M, m\right)$ is independent of $\nu$, the equilibrium in this case is equivalent to the least informative equilibrium in our main model, when $b = 0$. □

**Proof of Proposition 7.** Denote the (equilibrium) best response functions for the receiver $R$ in each of the three scenarios as:

$$k_{e,NC}\left(x\right) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(1+b_e)\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)-(\theta_L+b_e)}{(\theta_H+b_e)-(1+b)\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\} \tag{78}$$

$$k_{e,FC}\left(x\right) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(-\frac{\theta_L+b_e}{\theta_H+b_e}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) + \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2} - x\right) \tag{79}$$

$$k_{e,SC}\left(x\right) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_e^2}{\theta_H-\theta_L}\left\{\log\left(-\frac{\theta_L+b_e}{\theta_H+b_e}\right) - \log\left(\frac{p_0}{1-p_0}\right) - \log\left(\frac{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)}\right)\right\} \tag{80}$$

$$k_M\left(x\right) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(1+b_M)\Phi\left(\frac{x-\theta_L}{\sigma_e}\right)-(\theta_L+b_M)}{(\theta_H+b_M)-(1+b_M)\Phi\left(\frac{x-\theta_H}{\sigma_e}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\}, \tag{81}$$

Note that

$$k_{e,NC}\left(x\right) - k_{e,SC}\left(x\right)$$

$$= \frac{\sigma_e^2}{\theta_H - \theta_L} \left\{ \underbrace{\log\left( \frac{(1+b_e)\Phi\left(\frac{x-\theta_L}{\sigma_M}\right) - (\theta_L + b_e)}{(\theta_H + b_e) - (1+b)\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)} \right) - \log\left( -\frac{\theta_L + b_e}{\theta_H + b_e} \right)}_{\geq 0} + \underbrace{\log\left( \frac{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)} \right)}_{\geq 0} \right\} \geq 0 \quad (82)$$

and

$$k_{e,FC}(x) - k_{e,SC}(x) = \frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H + \theta_L}{2} - x\right) + \frac{\sigma_e^2}{\theta_H - \theta_L} \log\left( \frac{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)} \right) \quad (83)$$

$$= \frac{\sigma_e^2}{\sigma_M^2} \frac{\sigma_M^2}{\theta_H - \theta_L} \log\left[ e^{\frac{\theta_H - \theta_L}{\sigma_M^2}\left(\frac{\theta_H + \theta_L}{2} - x\right)} \left( \frac{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)} \right) \right] \quad (84)$$

$$= \frac{\sigma_e^2}{\theta_H - \theta_L} \left\{ \log\left( \frac{\phi\left(\frac{x-\theta_L}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_L}{\sigma_M}\right)} \right) - \log\left( \frac{\phi\left(\frac{x-\theta_H}{\sigma_M}\right)}{1-\Phi\left(\frac{x-\theta_H}{\sigma_M}\right)} \right) \right\} \geq 0 \quad (85)$$

Since $k_{M,NC} = k_M(k_{e,NC}(k_{M,NC}))$, $k_{M,FC} = k_M(k_{e,FC}(k_{M,FC}))$, and $k_{M,SC} = k_M(k_{e,SC}(k_{M,SC}))$, we must have $k_{M,NC} \geq k_{M,SC}$ and $k_{M,FC} \geq k_{M,SC}$. □

**Proof of Proposition 8.** First, note that it is never optimal to have only some of the players switch. If this was the preferred outcome, the total payoff must be higher than if both players switch and if both players do not switch. Let $U = U_M + \frac{1}{N}\sum_{e\in E} U_e$.

- If all players switch, $U = 2\theta + b$. If no player switches, then $U = 0$. As such, if all players switch / do not switch together, $U^* = \max\{0, 2\theta + b\}$.

- If the manager does not switch, but all employees do, then $U = \theta - 1$. To have $U > U^*$, we need either (i) $\theta > 1$, which implies $\theta - 1 < 2\theta + b$ (since $b > -1$), or (ii) $-\theta - 1 > b$, which contradicts $b > -1$. This implies $U \leq U^*$.

- If the manager and $n < N$ of the employees switch, then $U = \left(1 + \frac{n}{N}\right)\theta + \frac{n}{N}(1+b) - 1$. To have $U > U^*$, we need either (i) $\left(1 + \frac{n}{N}\right)\theta + \frac{n}{N}(1+b) - 1 > 0$, but this contradicts $U > 2\theta + b$, or we need (ii) $\left(1 + \frac{n}{N}\right)\theta + \frac{n}{N}(1+b) - 1 > 2\theta + b$, which implies $\theta < 0$, but this contradicts $\left(1 + \frac{n}{N}\right)\theta + \frac{n}{N}(1+b) - 1 > 0$.

This implies that $M$ recommends switching, conditional on observing $x_M$ and $\{x_e\}_{e\in E}$, when

$$\log\left(\frac{p_0}{1-p_0}\right) + \frac{1}{\sigma_M^2}(\theta_H - \theta_L)\left(x_M - \frac{\theta_H + \theta_L}{2}\right) + \frac{1}{\sigma_e^2}(\theta_H - \theta_L)\sum_{e\in E}\left(x_e - \frac{\theta_H + \theta_L}{2}\right) \geq \log\left(-\frac{b + 2\theta_L}{b + 2\theta_H}\right), \quad (86)$$

or equivalently,

$$\sigma_e^2 x_M + \sigma_M^2 \sum_{e\in E} x_e \geq \left(N\sigma_M^2 + \sigma_e^2\right)\frac{\theta_H + \theta_L}{2} + \frac{\sigma_e^2 \sigma_M^2}{\theta_H - \theta_L}\left(\log\left(-\frac{b + 2\theta_L}{b + 2\theta_H}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right) \equiv K_M \quad (87)$$

which gives us the result. □

**Proof of Proposition 9.** Given the expressions in equations (7), (9), (10), Proposition 4, and equation (24) we can show the following:

(i) For the $NC$, $FC$ and $SC$ equilibria, the sender's cutoff in the limit is given by

$$\lim_{\sigma_M \to 0} k_M = \tfrac{\theta_H + \theta_L}{2} \equiv k_M^0. \tag{88}$$

(ii) In the $NC$ equilibrium,

$$\lim_{\sigma_M \to 0} k_{e,NC} = \lim_{\sigma_M \to 0} \tfrac{\theta_H+\theta_L}{2} + \tfrac{\sigma_e^2}{\theta_H - \theta_L} \left\{ \log \left( \tfrac{(1+b_e)\Phi\left(\frac{k_M - \theta_L}{\sigma_M}\right) - (\theta_L + b_e)}{(\theta_H + b_e) - (1+b_e)\Phi\left(\frac{k_M - \theta_H}{\sigma_M}\right)} \right) - \log \left( \tfrac{p_0}{1-p_0} \right) \right\} \tag{89}$$

$$= \tfrac{\theta_H+\theta_L}{2} + \tfrac{\sigma_e^2}{\theta_H - \theta_L} \left\{ \log \left( \tfrac{1-\theta_L}{\theta_H + b_e} \right) - \log \left( \tfrac{p_0}{1-p_0} \right) \right\} \equiv k_{e,NC}^0. \tag{90}$$

(iii) In the $FC$ equilibrium,

$$k_{e,FC}^0 (x_M) \equiv \lim_{\sigma_M \to 0} K_{FC} (x_M, k_M) = \begin{cases} +\infty & \text{if } x_M < \frac{\theta_H+\theta_L}{2} \\ 0 & \text{if } x_M = \frac{\theta_H+\theta_L}{2} \\ -\infty & \text{if } x_M > \frac{\theta_H+\theta_L}{2} \end{cases}. \tag{91}$$

(iv) In the least informative $SC$ equilibrium,

$$k_{e,SC}^0 (m_M) \equiv \lim_{\sigma_M \to 0} K_{SC} (m_M) = \begin{cases} -\infty & \text{if } m_M = [k_{M,SC}, \infty), \\ +\infty & \text{if } m_M = (-\infty, k_{M,SC}) \end{cases} \tag{92}$$

and in the most informative $SC$ equilibrium,

$$k_{e,SC}^0 (m_M) \equiv \lim_{\sigma_M \to 0} K_{SC} (m_M) = \begin{cases} -\infty & \text{if } m_M = [k_{M,SC}, \infty), \\ +\infty & \text{if } m_M < k_{M,SC}, \text{ and } m_M = x_M < \frac{\theta_H+\theta_L}{2} \\ 0 & \text{if } m_M < k_{M,SC}, \text{ and } m_M = x_M = \frac{\theta_H+\theta_L}{2} \\ -\infty & \text{if } m_M < k_{M,SC}, \text{ and } m_M = x_M > \frac{\theta_H+\theta_L}{2} \end{cases}. \tag{93}$$

(v) For the welfare maximizing decision, both $M$ and $R$ switch if and only if

$$\lim_{\sigma_M \to 0} \sigma_e^2 x_M + \sigma_M^2 \sum_{e \in E} x_e \geq \lim_{\sigma_M \to 0} K_M, \tag{94}$$

or equivalently, $x_M \geq \frac{\theta_H+\theta_L}{2}$.

This implies that, as the precision of the sender's signal becomes infinite, the states in which there is adoption in the $SC$ and $FC$ equilibria coincide with those in which there is adoption under the welfare maximizing decision. However, for the $NC$ equilibrium, this is not the case and consequently, welfare is lower. $\square$

**Proof of Proposition 10.** First consider player $M$'s utility under $SC$ vs. $NC$. The equilibrium expected utility is given by

$$U_M(k_e) = \max_k \mathbb{E}^\theta \left[(\theta - 1)\Pr(x_M \geq k) + (b_M + 1)\Pr(x_M \geq k)\Pr(x_e \geq k_e)\right]. \tag{95}$$

By the envelope theorem,

$$\frac{\partial}{\partial k_e} U_M = \mathbb{E}^\theta \left[-\frac{1}{\sigma_e}(b_A + 1)\Pr(x_M \geq k)\,\phi\left(\frac{k_e - \theta}{\sigma_e}\right)\right] \leq 0, \tag{96}$$

which implies $U_{M,SC} = U_M(k_{e,SC}) \geq U_M(k_{e,NC}) = U_{M,NC}$. Next consider player $R$'s utility under $SC$ vs. $NC$. Let

$$V(k_M) = \max_k \mathbb{E}\left[(\theta - 1)\Pr(x_e \geq k, x_M < k_M) + (\theta + b_e)\Pr(x_M \geq k_M, x_e \geq k)\right] \tag{97}$$

and note that $U_{e,NC} = V(k_{M,NC})$. Moreover, since $k_{M,NC} > k_{M,SC}$, the envelope theorem implies $V(k_{M,NC}) < V(k_{M,SC})$. Finally, note that

$$U_{e,SC} = \max_{k_0,k_1} \mathbb{E}\left[(\theta - 1)\Pr(x_e \geq k_0, x_M < k_{M,SC}) + (\theta + b_e)\Pr(x_M \geq k_{M,SC}, x_e \geq k_1)\right] \tag{98}$$

$$\geq \max_k \mathbb{E}\left[(\theta - 1)\Pr(x_e \geq k, x_M < k_{M,SC}) + (\theta + b_e)\Pr(x_M \geq k_{M,SC}, x_e \geq k)\right] \tag{99}$$

$$= V(k_{M,SC}) > U_{e,NC}. \tag{100}$$

Hence, both $R$ and $M$ prefer the $SC$ equilibrium to the $NC$ equilibrium. $\square$

**Proof of Proposition 11.** Since $p_0 = \frac{1}{2}$, we have $IE(b) = 1 - \frac{1}{2}(UI(b) + OI(b))$. Let $k_{e,1} \equiv K_{SC}([k_{M,SC}, \infty))$, $k_{e,0} \equiv K_{SC}((-\infty, k_{M,SC}))$ and $k_M \equiv k_{M,SC}$, and we treat them as univariate functions of $b$. Given the expressions for $k_{e,1}$ and $k_{e,0}$, we have

$$k'_{e,1}(b) = \frac{\sigma_e^2}{\sigma_M(\theta_H - \theta_L)}\left[\frac{\phi\left(\frac{\theta_H - k_M}{\sigma_M}\right)}{\Phi\left(\frac{\theta_H - k_M}{\sigma_M}\right)} - \frac{\phi\left(\frac{\theta_L - k_M}{\sigma_M}\right)}{\Phi\left(\frac{\theta_L - k_M}{\sigma_M}\right)}\right] k'_M(b), \text{ and} \tag{101}$$

$$k'_{e,0}(b) = -\frac{\sigma_e^2}{\sigma_M(\theta_H - \theta_L)}\left[\frac{\phi\left(\frac{k_M - \theta_H}{\sigma_M}\right)}{\Phi\left(\frac{k_M - \theta_H}{\sigma_M}\right)} - \frac{\phi\left(\frac{k_M - \theta_L}{\sigma_M}\right)}{\Phi\left(\frac{k_M - \theta_L}{\sigma_M}\right)}\right] k'_M(b) \tag{102}$$

which implies that

$$\frac{\partial IE\left(b\right)}{\partial b} = \begin{array}{c} -\frac{1}{2\sigma_M}\phi\left(\frac{\theta_H-k_M}{\sigma_M}\right)\left[\Phi\left(\frac{\theta_H-k_{e,1}}{\sigma_e}\right)\right]^N k_M' \\ -\frac{N\sigma_e}{2\sigma_M(\theta_H-\theta_L)}\phi\left(\frac{\theta_H-k_{e,1}}{\sigma_e}\right)\left[\Phi\left(\frac{\theta_H-k_{e,1}}{\sigma_e}\right)\right]^{N-1}\Phi\left(\frac{\theta_H-k_M}{\sigma_M}\right)\left[\frac{\phi\left(\frac{\theta_H-k_M}{\sigma_M}\right)}{\Phi\left(\frac{\theta_H-k_M}{\sigma_M}\right)}-\frac{\phi\left(\frac{\theta_L-k_M}{\sigma_M}\right)}{\Phi\left(\frac{\theta_L-k_M}{\sigma_M}\right)}\right]k_M' \\ +\frac{1}{2\sigma_M}\phi\left(\frac{k_M-\theta_L}{\sigma_M}\right)\left[\Phi\left(\frac{k_{e,0}-\theta_L}{\sigma_e}\right)\right]^N k_M' \\ -\frac{N\sigma_e}{2\sigma_M(\theta_H-\theta_L)}\phi\left(\frac{k_{e,0}-\theta_L}{\sigma_e}\right)\left[\Phi\left(\frac{k_{e,0}-\theta_L}{\sigma_e}\right)\right]^{N-1}\Phi\left(\frac{k_M-\theta_L}{\sigma_M}\right)\left[\frac{\phi\left(\frac{k_M-\theta_H}{\sigma_M}\right)}{\Phi\left(\frac{k_M-\theta_H}{\sigma_M}\right)}-\frac{\phi\left(\frac{k_M-\theta_L}{\sigma_M}\right)}{\Phi\left(\frac{k_M-\theta_L}{\sigma_M}\right)}\right]k_M' \end{array} \tag{103}$$

Consider $b$ such that $k\left(b\right) = \frac{\theta_H+\theta_L}{2}$. In this case, we have

$$\frac{\theta_H-k}{\sigma_i} = \frac{k-\theta_L}{\sigma_i}, \tag{104}$$

implying that

$$\Phi\left(\frac{\theta_H-k}{\sigma_M}\right) = \Phi\left(\frac{k-\theta_L}{\sigma_M}\right), \tag{105}$$

$$\phi\left(\frac{\theta_H-k}{\sigma_i}\right) = \phi\left(\frac{k-\theta_L}{\sigma_i}\right) = \phi\left(\frac{k-\theta_H}{\sigma_i}\right) = \phi\left(\frac{\theta_L-k}{\sigma_i}\right). \tag{106}$$

Moreover, with the same value of $b$,

$$\begin{aligned} k_{e,1}\left(k\right)+k_{e,0}\left(k\right) &= \theta_H+\theta_L+\frac{\sigma_e}{\theta_H-\theta_L}\left\{\log\left(-\frac{\theta_L}{\theta_H}\right)+\log\left(\frac{1-\theta_L}{\theta_H-1}\right)-\log\left(\frac{\Phi\left(\frac{\theta_H-k}{\sigma_M}\right)}{\Phi\left(\frac{\theta_L-k}{\sigma_M}\right)}\right)-\log\left(\frac{\Phi\left(\frac{k-\theta_H}{\sigma_M}\right)}{\Phi\left(\frac{k-\theta_L}{\sigma_M}\right)}\right)\right\} \\ &= \theta_H+\theta_L, \end{aligned} \tag{107}$$

which implies that

$$\Phi\left(\frac{\theta_H-k_{e,1}(k)}{\sigma_e}\right) = \Phi\left(\frac{k_{e,0}(k)-\theta_L}{\sigma_e}\right) \text{ and } \phi\left(\frac{\theta_H-k_{e,1}(k)}{\sigma_e}\right) = \phi\left(\frac{k_{e,0}(k)-\theta_L}{\sigma_e}\right). \tag{108}$$

Combining the observations above, we conclude that when $k_M\left(b\right) = \frac{\theta_H+\theta_L}{2}$, we have $\frac{\partial IE(b)}{\partial b} = 0$. Now, when $p_0 = \frac{1}{2}$ and $b = 0$, we know $k_{M,NC} = \frac{\theta_H+\theta_L}{2}$, and by Proposition 7, we have that $k_{M,SC} < \frac{\theta_H+\theta_L}{2}$. Since $k_{M,SC}\left(b\right)$ is decreasing in $b$, it must be that $k_{M,SC}\left(b\right) = \frac{\theta_H+\theta_L}{2}$, and consequently, $\frac{\partial IE(b)}{\partial b} = 0$, for some $b < 0$.

Turning to $FC$, let

$$K_{FC,1}\left(x\right) = \frac{\theta_H+\theta_L}{2}+\frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2}-x\right)+\frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(-\frac{\theta_L}{\theta_H}\right)-\log\left(\frac{p_0}{1-p_0}\right)\right) \tag{109}$$

$$K_{FC,0}\left(x\right) = \frac{\theta_H+\theta_L}{2}+\frac{\sigma_e^2}{\sigma_M^2}\left(\frac{\theta_H+\theta_L}{2}-x\right)+\frac{\sigma_e^2}{\theta_H-\theta_L}\left(\log\left(\frac{1-\theta_L}{\theta_H-1}\right)-\log\left(\frac{p_0}{1-p_0}\right)\right). \tag{110}$$

$K_{FC,1}$ is the best response of employees when the manager switches, while $K_{FC,0}$ is when the manager does not. Since efficiency is[26]

$$1-\frac{1}{2}\left[1-\int_{k_{M,FC}}^{\infty}\Phi\left(\frac{\theta_H-K_{FC,1}(x)}{\sigma_e}\right)^N\frac{1}{\sigma_M}\phi\left(\frac{x-\theta_H}{\sigma_M}\right)dx\right]-\frac{1}{2}\left[1-\int_{-\infty}^{k_{M,FC}}\Phi\left(\frac{K_{FC,0}(x)-\theta_L}{\sigma_e}\right)^N\frac{1}{\sigma_M}\phi\left(\frac{x-\theta_L}{\sigma_M}\right)dx\right],$$

its derivative with respect to $b$ is

$$\begin{aligned}\frac{\partial IE(b)}{\partial b} &= -\frac{1}{2}\Phi\left(\frac{\theta_H-K_{FC,1}\left(k_{M,FC}\right)}{\sigma_e}\right)^N\frac{1}{\sigma_M}\phi\left(\frac{k_{M,FC}-\theta_H}{\sigma_M}\right)k'_{M,FC}(b)\\ &+\frac{1}{2}\Phi\left(\frac{K_{FC,0}\left(k_{M,FC}\right)-\theta_L}{\sigma_e}\right)^N\frac{1}{\sigma_M}\phi\left(\frac{k_{M,FC}-\theta_L}{\sigma_M}\right)k'_{M,FC}(b)\end{aligned}$$

If $\theta_H+\theta_L=1$,[27] we have

$$K_{FC,1}\left(\frac{\theta_H+\theta_L}{2}\right)+K_{FC,0}\left(\frac{\theta_H+\theta_L}{2}\right)=\theta_H+\theta_L,$$

similar to $k_{e,1}(k)+k_{e,0}(k)=\theta_H+\theta_L$ for $SC$. For $b$ that satisfies $k_{M,FC}(b)=\frac{\theta_H+\theta_L}{2}$, therefore, we again have

$$\frac{\partial IE(b)}{\partial b}=0.$$

By the same logic as in the $SC$ case, we conclude that the efficiency is maximized at $b<0$ due to the fact that $k'_{M,FC}(b)<0$. □

# B Misaligned cost of adoption

In this section, we consider an alternative specification which introduces an asymmetric cost of failing to coordinate. Suppose the payoffs are given by the following table:

| $M \setminus e$ | Switch ($a_e=1$) | Not switch ($a_e=0$) |
|---|---|---|
| Switch ($a_M=1$) | $\theta+b$, $\theta$ | $\theta-c$, 0 |
| Not switch ($a_M=0$) | 0, $\theta-1$ | 0, 0 |

As before, when both players switch, $M$ receives $\theta+b$ while $e$ receives $\theta$. Moreover, in this case, when $M$ switches but $e$ does not, $M$ receives $\theta-c$. Assumptions (A1)-(A2) generalize to the following: (i) $\theta_L<0<c<\theta_H$, (ii) $b>-c$, and (iii) $b<-\theta_L$. While $e$'s incremental payoff from switching $\pi_e$ is still given by (4), the incremental payoff to $M$ from switching is now given by

$$\pi_M(x_M,m)=\begin{array}{c}p(x_M,\Re)\left[(\theta_H+b)-(b+c)\Pr(a_e=0|\theta_H,m)\right]\\+(1-p(x_M,\Re))\left[(\theta_L+b)-(b+c)\Pr(a_e=0|\theta_L,m)\right]\end{array}. \quad (111)$$

[26] Still we assume $p_0=\frac{1}{2}$.
[27] This is the benchmark for our numerical examples.

The above payoffs imply that player $M$'s best response function is given by

$$K_M(k) = \frac{\theta_H+\theta_L}{2} + \frac{\sigma_M^2}{\theta_H-\theta_L}\left\{\log\left(\frac{(b+c)\Phi\left(\frac{k-\theta_L}{\sigma_e}\right)-(\theta_L+b)}{(\theta_H+b)-(b+c)\Phi\left(\frac{k-\theta_H}{\sigma_e}\right)}\right) - \log\left(\frac{p_0}{1-p_0}\right)\right\}. \tag{112}$$

The parameter restrictions imply that $\lim_{k\to\infty} K_M(k) < \infty$ and $\lim_{k\to-\infty} K_M(k) > -\infty$ and $\frac{\partial}{\partial k}K_M > 0$. This ensures that the proofs of Propositions 1, 2, and 3 apply immediately to this case, since the fixed point conditions (i.e., $x = H(x)$) that characterize the equilibria inherit analogous existence and uniqueness properties.