Monitoring Team Members: Information Waste and the Transparency Trap*

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Abstract

We study contract design and endogenous monitoring within a model of moral hazard in teams where a firm can exploit individual and team performance measures to incentivize teamwork. Our analysis reveals that firms' concerns about low trust among teammates can justify three common but otherwise puzzling observations: information waste, targeted monitoring, and a transparency trap. First, we show that firms primarily use individual performance bonuses, ignoring relevant information about team output. Second, we demonstrate that firms monitor some workers more closely than others, even when workers are ex-ante homogeneous. Finally, we demonstrate that workers optimally engage in a self-defeating race toward higher effort transparency, eventually obtaining the same low expected payoffs as when the firm is not concerned about trust. The key novel trade-off driving our results is the one between the classical information rents of moral hazard problems and the strategic insurance rents that arise from trust concerns, both in teams with complementary and substitute workers. Perhaps surprisingly, the firm may be indifferent or even benefit from trust concerns.

Keywords: Teamwork, Robustness, Bonus design, Information waste, Endogenous monitoring, Self-Promotion, Transparency

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1 Introduction

At least since the mid-1980s, the classical top-down hierarchical model has been giving way to a new organizational system based on teams (Devine et al., 1999).[1] However, although teamwork may improve the efficiency of complex production processes, it also poses challenges in monitoring individual contributions. Indeed, while the team output (e.g., the overall project outcome) is relatively easy to measure, firms typically rely on imperfect individual performance measures (e.g., working hours, reports, etc.).

The literature on moral hazard in teams suggested that, in these contexts, firms should exploit all relevant information to incentivize teamwork. However, compensation practice reports point to a possible puzzle: firms appear overly cautious in using team-performance measures to incentivize their employees. For example, Payscale (2019) highlights how out of the more than 70% of American firms relying on variable wages, about 90% employ individual-performance bonuses, and only 28% employ team-performance bonuses.[2] Inspired by practitioners, management scholars, and experimental evidence, we show how low-trust teams and firms' trust concerns might help explain this mismatch between classical theory and corporate practices.[3]

In particular, our analysis shows how firms' concerns about low trust among team members can justify three otherwise puzzling practices: information waste, targeted monitoring, and transparency trap. Specifically, we show that: (1) Firms should mostly employ individual-performance bonuses, optimally ignoring statistically-relevant information about the team output. (2) Firms should monitor some workers more closely than others (even when ex-ante homogeneous). (3) Workers optimally engage in a self-defeating race toward higher effort transparency (*transparency trap*), eventually obtaining the same (low) expected payoffs as when the firm is not concerned about trust; A counterintuitive outcome of this dynamic is that the firm may be indifferent to, or even benefit from, trust concerns. The key novel trade-off in our analysis is the one between the classical *information rents* of moral hazard problems and the *strategic insurance rents* arising from trust concerns.

To shed light on the main forces at stake, we consider a stylized model where a firm incentivizes a team of risk-neutral workers to work on a joint project that can either

[1] Bersin (2016) reports that 76% of large firms (62% overall) are organized in teams.

[2] Other popular forms of variable pay are hiring and retention bonuses. Company-wide bonuses and stock options are also relevant but usually far removed from the performance of any single team.

[3] See, for example, Merriman (2008), Thompson (2016), and Kuhn and Yockey (2003).

succeed or fail. Each team member privately chooses between working and shirking. Working is costly but increases the team's probability of success at a rate that may vary with the colleagues' efforts. The firm aims to maximize the probability of team success at the lowest possible cost. The firm can compensate each worker based on the team's outcome and/or (noisy) signals about her individual performance.

To assess the impact of trust concerns, we first establish a benchmark where all workers *trust* each other, i.e., believe all their colleagues will exert effort whenever rationalizable. This aligns with the classical assumption that, given any compensation scheme, workers coordinate on the firm-preferred equilibrium. Consistent with Holmström (1979)'s classical *informativeness principle*, the firm in this benchmark optimally exploits all statistically-relevant information on workers' efforts to minimize information rents. Optimal contracts provide bonuses only if the team succeeds and the individual performance signal is positive, making workers indifferent between working and shirking when expecting full participation. However, these contracts are vulnerable: if any worker does not trust her colleagues, i.e., attaches positive probability to at least one of them shirking when rationalizable, all workers will shirk.

A firm concerned about trust aims to ensure teamwork regardless of the trust level among workers.[4] To reach this goal of *robustly implementing teamwork* (RITW), the firm could still reward workers based on both individual and team performance, providing extra rents (*strategic insurance rents*) to ensure teamwork even in low trust environments. However, our first main contribution is to show that the informativeness principle ceases to hold in the presence of trust concerns. The firm optimally rewards some workers solely with individual performance bonuses, even though the team output provides additional and statistically-relevant information about their efforts. Our model is thus broadly consistent with the empirical insight that firms mostly employ individual bonuses and that team bonuses typically cover only a small fraction of the employees (Ledford Jr, Lawler III and Mohrman, 1999; Payscale, 2019).

Our second contribution reveals that the firm optimally discriminates among team members in terms of both total rents and bonus types. First, we establish that the firm splits workers into two contractual categories: *insulated workers* (IW), rewarded if and only if their individual signal is positive, and *non-insulated workers* (NW),

[4] To better address trust concerns, we consider *robust implementation* of teamwork á la Bergemann and Morris (2009). However, with complementary efforts, RITW is equivalent to uniquely implementing teamwork (or implementing it in the firm's least-preferred equilibrium).

rewarded only if also the team performance is positive. Intuitively, assigning a worker to IW entails higher information rents, as it disregards relevant information about her effort. Yet, it also secures the worker's effort irrespective of her beliefs, thereby reducing the strategic insurance rents necessary to incentivize her NW colleagues. This trade-off between information and strategic insurance rents typically results in both IW and NW being non-empty.[5] Moreover, within NW, the firm adopts a multi-tier contract structure with higher tiers indicating higher strategic insurance rents. When efforts are complementary, this results in a complete ranking (one worker per tier) similar to Winter (2004). However, unlike Winter (2004), pay discrimination persists even when efforts are substitutes, with IW non-empty and NW organized into distinct contractual tiers (though not always a complete ranking).

Our third key contribution explores how trust concerns shape firms' and workers' incentives toward monitoring. To this end, we characterize how workers' heterogeneous signal precisions affect their contract allocation and the rents they receive. First, we prove that the firm optimally assigns the workers with the highest signal precisions to IW (despite them being cheaper both in IW and NW). Second, when effort complementarities are sufficiently strong, the firm grants higher ranks to workers with higher signal precision to limit strategic insurance rents at the top.

Building on this sharp characterization, we analyze how trust concerns affect workers' incentives to alter the transparency of their efforts. To this end, we assume that, before the firm sets the contracts, each worker can costly adjust the precision of her own performance signal (or, *monitorability*) away from a common baseline. In the high-trust benchmark, workers optimally reduce their monitorability to maximize their information rents, consequently reducing the effectiveness of individual bonuses. When the adjustment cost is low, this compels the firm to rely solely on team bonuses.

Conversely, when concerned about trust, the firm provides not only information but also strategic insurance rents. If workers opted for the same low signal precision as in the benchmark, they would benefit at the firm's expense. However, our fourth main contribution reveals that the competition for these extra rents triggers a *transparency trap*: workers select higher and higher monitorability, ultimately obtaining the same (low) payoffs as the high-trust benchmark. Intuitively, if all NW workers chose the same low monitorability as in the benchmark, they would be arbitrarily

[5] Note that discrimination in the bonus types and information waste persist even in settings à la Halac, Lipnowski and Rappoport (2021) where homogeneous workers obtain the same rent.

ranked. However, by infinitesimally increasing her monitorability, a worker can ensure a higher rank, giving up infinitesimal information rents but gaining significant strategic insurance rents. This shift benefits the firm and the worker at the expense of her colleagues, fuelling the race to higher monitorability. However, as this race progresses and monitorability levels rise, the sacrifice in terms of information rents grows and eventually exceeds the gain in strategic insurance rents. This ends the race. As a result of this race, workers obtain the same low equilibrium payoffs as in the high-trust benchmark. Instead, the impact of trust concerns on the firm's payoff depends is ambiguous. Perhaps surprisingly, we show that low trust can benefit the firm, particularly in teams where the workers can cheaply raise their monitorability or where the baseline monitoring is inherently high. Moreover, absent adjustment costs, both the firm and the workers obtain the same payoffs as in the high-trust benchmark. Yet, even in this case, trust concerns significantly impact the optimal contract structure, leading to higher monitorability and insulated workers (IW).

This result further justifies the prevalence of individual bonuses and offers a rationale for why workers often want to make their effort more transparent and engage in self-promotion.[6] Unlike in classical literature (focusing on high trust), transparency is not simply detrimental for a worker: it is also a strategic means to climb the ranks and secure higher strategic insurance rents at her colleagues' expense.

Finally, we examine the firm's incentive to invest in monitoring. In high-trust teams, the firm monitors workers homogeneously. Conversely, when monitoring investments are targetable, trust concerns prompt heterogeneous monitoring. Specifically, IW workers face closer monitoring and, within NW, higher ranks not only earn more but also face closer monitoring.

Related literature. Since Alchian and Demsetz (1972), scholars have focused on how firms should exploit individual and team performance measures to incentivize teamwork. McAfee and McMillan (1991) argued that team bonuses suffice when workers are risk-neutral and have no limited liability. Holmström (1982) and Chaigneau, Edmans and Gottlieb (2014) proved that, violated such conditions, firms should exploit all statistically-relevant information to limit information rents (informativeness

[6] According to *Reward Gateway 2018 report* 43% of workers feel invisible or undervalued and look for a way to signal themselves to their manager. Many articles and books, e.g., *HBR Guide to Office Politics* indicate self-promotion as a way to "make sure people understand and see what you do," increasing chances of recognition and career advancements.

principle).[7] We contribute to this debate, showing how team bonuses may be not only insufficient but also detrimental when the firm is concerned about trust. Firms benefit from rewarding some workers based only on their individual performance.

Within the literature on contracting with externalities, pioneered by Segal (1999), a recent strand, started by Segal (2003) and Winter (2004), focuses on unique implementation, proving the optimality of ranking schemes that grant different rents to (possibly) homogeneous agents. Bernstein and Winter (2012) and Halac, Kremer and Winter (2020) characterize the mapping from agents' heterogeneity to ranking in different applications. Halac, Lipnowski and Rappoport (2021) shows how firms might benefit from keeping the workers uncertain about their ranks.

We contribute to this literature in five ways. First, we are the first to consider a signal structure rich enough to study the optimal balance between individual and team performance bonuses, establishing a clear link between robustness concerns and information waste.[8] Second, we are the first to study workers' incentives to adjust the transparency of their efforts, showing how competition for better visibility offsets the impact of robustness concerns on workers' rents. In so doing, we identify in the workers' monitoring choices a mechanism (complementary to Halac, Lipnowski and Rappoport (2021)) that eliminates the payoff discrimination typically associated with unique implementation models (e.g., Winter (2006)). Third, we are the first to show how firms may benefit from robustness concerns. Fourth, we endogenize the firm's monitoring choices, which relates our paper to two contemporary works. While they focus on designing *monitoring teams* within a firm where the mapping from the team efforts to the signal is either fixed (Halac, Kremer and Winter (2023)) or flexible (Cusumano, Gan and Pieroth (2023)), we address the complementary issue of how to monitor individual inputs *within* a given team.[9] Finally, in contrast to Winter (2004), we show that tiers and pay discrimination persist even when workers' efforts are substitutes. This finding highlights the potential impact of robustness concerns in the broad literature on free-riding in teams (e.g., Bonatti and Hörner (2011); Georgiadis (2015); Yildrim (2021); Ozerturk and Yildirim (2021)).

[7] See also Vander Veen (1995), and Bag and Wang (2019).

[8] This literature has established no such link and focused only on the two extreme cases where agents' individual choices are either (i) perfectly observable or (ii) non-contractible.

[9] In Halac, Kremer and Winter (2023), the firm allocates workers to teams and only observes the teams' outputs. Assigning a worker to smaller teams is thus seen as closer monitoring. In our setting, the firm obtains multiple signals about each team member (individual performance and team output) and selects the precisions of the individual signals.

Finally, our paper contributes to the literature on monitoring in teams, including Miller (1997), Strausz (1999), Winter (2010), Rahman (2012), Miller and Rozen (2014), and Gershkov and Winter (2015). While this literature focuses on partial implementation, we highlight the impact that trust concerns have on monitoring.

Structure. In Section 2, we set up and analyze the model for fixed signals' precisions. Section 3 endogenizes the monitoring structure, accounting for the firm's and workers' incentives to invest in monitorability. Then we study the workers' incentives to affect their colleagues' monitorability. Finally, we conclude and discuss extensions.

2 Model

Setting. A firm owns a project that, if successful, yields a fixed surplus. The project's success depends on the efforts of a team of n risk-neutral workers. Each worker $i \in N = \{1, ..., n\}$ privately chooses between working, $e_i = 1$, and shirking, $e_i = 0$. While shirking is free, the worker incurs a cost $c > 0$ if she chooses to work. For simplicity, we assume that each worker contributes equally to the success probability.[10] This allows us to represent the success probability as an increasing function of the total team effort, $F : \mathbb{N}_+ \to [0, 1]$, leveraging its convexity (concavity) to capture the complementarity (substitutability) of workers' efforts, i.e., how a worker's impact on team success is affected by her colleagues' efforts.

Whether the project succeeds or fails is publicly observable and provides valuable information about the aggregate effort exerted by the team, $\sum_{i=1}^{n} e_i$. Beyond observing the team performance (i.e., the project outcome), the firm obtains signals about the workers' individual contributions. In particular, we assume the principal observes n imperfect *individual-performance signals* about the workers' individual effort and a *team-performance signal* indicating whether the team succeeds or fails

$$S_i^{ind} = \begin{cases} e_i & \text{wp } p_i \\ 1 - e_i & \text{wp } 1 - p_i \end{cases} \qquad S^{team} = \begin{cases} 0 & \text{if team failure} \\ 1 & \text{if team success} \end{cases}$$

where $p_i \in \left[\frac{1}{2}, 1\right]$ is the precision of i's individual signal (hereafter *monitorability*).[11] Note that all signals are independent conditional on the effort profile $\mathbf{e} = (e_i)_{i \in N}$.

The firm incentivizes teamwork by publicly offering every worker i a wage that depends on the team performance and on the worker's individual-performance sig-

[10] The Appendix discusses cases where workers have heterogeneous impacts on the team output.
[11] In Section 3 we endogenize the monitoring structure $(p_i)_{i \in N}$.

nal, $W_i : \{0,1\}^2 \to \mathbb{R}$. Workers have limited liability, $W_i\left(S^{team}, S_i^{ind}\right) \geq 0$ for all S^{team}, S_i^{ind}. Thus, without loss, we can focus on bonus schemes. Moreover, since granting a positive bonus when both individual and team signals are negative can only decrease worker i's incentives to work, we can focus on contracts with $W_i\left(S^{team} = 0, S_i^{ind} = 0\right) = 0$. Hence, we can express the state-contingent wage as

$$W_i\left(S^{team}, S_i^{ind}\right) = b_i^{team} \cdot S^{team} + b_i^{ind} \cdot S_i^{ind} + b_i^{both} \cdot S_i^{ind} \cdot S^{team},$$

where $b_i^{team} \geq 0$ is the team-performance bonus, $b_i^{ind} \geq 0$ is the individual-performance bonus, and $b_i^{both} \geq -(b_i^{ind} + b_i^{team})$ is the bonus adjustment when both team and individual-performance signals are positive.

Timing. The order of moves is the following:

1. For every given distribution of signal precisions, $\mathbf{p} := (p_i)_{i \in N}$, the firm publicly offers each employee a contract $W_i\left(S^{team}, S_i^{ind}\right)$, i.e., it establishes the bonus plan $\boldsymbol{b} := (b_i)_{i \in N}$, where $\boldsymbol{b_i} := \left(b_i^{team}, b_i^{ind}, b_i^{both}\right)$.
2. Workers observe $\mathbf{b}$ and simultaneously choose whether or not to exert effort.
3. The project succeeds or fails, and the individual signals are generated.
4. The firm collects the possible project surplus and pays the employees according to the specified contracts.

In the second part of the paper, we will introduce two ex-ante steps where the firm can choose how much to invest in monitoring the individual contributions and the workers how much to facilitate or hinder such monitoring.[12]

The workers' problem. For every *monitoring structure* $\mathbf{p} := (p_i)_{i \in N}$ and bonus scheme $\boldsymbol{b}$, the workers choose whether to work or shirk. Formally, every $i \in N$ solves

$$\max_{e_i \in \{0,1\}} \sum_{n_{-i}=0}^{n-1} \mu_i(n_{-i}) \mathbb{E}\left[W_i | n_{-i}, e_i\right] - c e_i$$

where $\mu_i(n_{-i})$ is worker i's belief that exactly n_{-i} of her colleagues choose to work.[13] As a result, worker i works if and only if her participation constraint is satisfied, i.e.,

$$\sum_{n_{-i}=0}^{n-1} \mu_i(n_{-i}) \Big(\mathbb{E}\left[W_i | n_{-i}, e_i = 1\right] - \mathbb{E}\left[W_i | n_{-i}, e_i = 0\right] \Big) \geq c,$$

[12] We postpone to the dedicated sections the detailed description of those steps.

[13] With a slight abuse of notation we write W_i rather than $W_i\left(S^{team}, S_i^{ind}\right)$.

which can be rewritten as

$$\Delta_{p_i}^{ind} b_i^{ind} + \sum_{n_{-i}=0}^{n-1} \mu_i(n_{-i}) \left(\Delta_{n_{-i}}^{team} b_i^{team} + \Delta_{p_i,n_{-i}}^{both} b_i^{both} \right) \geq c, \qquad (IR_{i,\mu_i})$$

where $\Delta_{p_i}^{ind} := 2p_i - 1$, $\Delta_x^{team} := F(x+1) - F(x)$, and $\Delta_{p_i,x}^{both} := F(x+1)p_i - F(x)(1-p_i)$ denote the incremental impacts of i's work respectively on the probabilities that (i) the individual performance is positive $Pr(S_i^{ind} = 1)$, (ii) team performance is positive $Pr(S^{team} = 1)$, and (iii) both team and individual performance are positive $Pr\left(S_i^{ind} = 1, S^{team} = 1\right)$, given that exactly x of her colleagues also work.

Note that worker i's participation constraint IR_{i,μ_i} crucially hinges on her belief μ about her colleagues' efforts (*strategic uncertainty*). Depending on whether efforts are complements or substitutes, and the exact bonus $\mathbf{b_i}$ provided, worker i's incentive to work may increase or decrease when expecting fewer colleagues to work. Consequently, the bonus scheme $\mathbf{b}$ can lead to multiple equilibria, with workers coordinating on one equilibrium or the other depending on how much they *trust* each other.

Trust. We say that a worker i *trusts* her colleagues if she believes (with probability one) that her colleagues work whenever rationalizable given the contracts in place. We call high-trust those environments where all team members trust each other and low-trust all the others, i.e., those where some team members believe that some of their colleagues might shirk when rationalizable.

The Firm's Problem. We consider a firm concerned about trust, i.e., willing to ensure teamwork not only in high-trust but also in low-trust environments. In particular, our firm's objective is to minimize the cost of robustly implementing teamwork (**RITW**), i.e., inducing all workers to work as the unique rationalizable outcome (see Bergemann and Morris (2009) for a general treatment of the concept of robust implementation).[14] For given signal precisions $p_1, ..., p_N$ the firm problem is thus

$$\min_{\boldsymbol{b}} \sum_{i \in N} \left(p_i b_i^{ind} + F(n) b_i^{team} + p_i F(n) b_i^{both} \right) \qquad \textit{subject to:}$$

$$\boldsymbol{b} = \left(b_i^{team}, b_i^{ind}, b_i^{both} \right)_{i \in N} \;\; \textbf{RITW},$$

i.e., IR_{i,μ_i} holding for all $i \in N$, μ_i consistent with rationalizability.

[14] To overcome the usual technical issue that the set of incentive schemes that robustly implement work is open, and thus a minimum does not exist, we assume that when indifferent between working and shirking, the workers choose to work.

2.1 Discussion of the Assumptions

Trust. A key assumption in our model is the potential lack of trust among teammates. Rooted in workers' beliefs, our definition of trust interlinks with equilibrium selection. When a bonus scheme generates multiple equilibria, only high-trust teams consistently coordinate on the one involving the most teammates working. Thus, by focusing on the *firm-preferred equilibrium*, the classical literature (following Holmström (1982)) implicitly confined the attention to high-trust teams. Trust, however, cannot be presumed, particularly in teams that are frequently multidisciplinary, short-tenured, and increasingly virtual (Thompson, 2016). Moreover, as emphasized in the management literature by Merriman (2008), Thompson (2016), and Kuhn and Yockey (2003), trust levels within a team critically influence the optimal compensation practices. To best capture this role, we consider a firm aiming to implement teamwork as the unique rationalizable outcome (à la Bergemann and Morris (2009)) rather than relying on workers trusting each other.

Contract space. We assume that a worker's contract cannot depend on the private signals that the firm receives from her colleagues. Although intriguing, this possibility would significantly complicate the analysis without changing the paper's main contribution (see Appendix 5.1.1). Moreover, as we show that the firm can benefit from these more flexible contracts only by providing workers with extra bonuses when their colleagues fail, this possibility would open a whole new set of criticisms.[15] Finally, in many applications of interest, workers cannot easily verify the private signals that the firm observes on their colleagues, undermining their actual contractability.

2.2 High-Trust Benchmark: the Firm-Preferred Equilibrium

To evaluate the impact of trust concerns on optimal compensation practices, we first analyze the classical benchmark where, absent trust concerns, the firm can coordinate the workers on its preferred equilibrium for any given contract scheme (partial implementation). In this case, the cheapest way to secure the workers' effort is to offer bonuses that make them indifferent between working and shirking when they expect all their colleagues to work. The firm's problem thus becomes

$$\min_{\boldsymbol{b}} \sum_{i \in N} \left(p_i b_i^{ind} + F(n) b_i^{team} + p_i F(n) b_i^{both} \right) \qquad \textit{subject to:}$$

[15] Contests easily backfire when cooperation is vital, causing sabotage and discouragement(cf. Dai and Toikka (2017), Chowdhury and Gürtler (2015), Sheremeta (2016), and Che and Yoo (2001).

$$b_i^{ind}\ \Delta_{p_i}^{ind} + b_i^{team}\ \Delta_{n-1}^{team} + b_i^{both}\ \Delta_{p_i,n-1}^{both} = c, \quad \forall i \in N$$

where we plugged $\mu_i(n-1)=1$ in each worker's participation constraint IR_{i,μ_i}.

Workers face no strategic uncertainty here: they are sure all their colleagues work. Thus the firm only needs to provide the usual *information rents* to limit the workers' moral hazard. Solving the firm's problem, we find that workers receive bonuses only if both their own individual performance and the team output are positive.

Proposition 1. *For every* $\left(p_i\right)_{i\in N}$*, in the firm-preferred equilibrium the incentive scheme* $\boldsymbol{b} = \left(b_i^{team}, b_i^{ind}, b_i^{both}\right)_{i\in N}$ *is such that for all* $i \in N$*,* $b_i^{team} = b_i^{ind} = 0$ *and*

$$b_i^{both} = \frac{c}{p_i F(n) - (1-p_i)F(n-1)} = \frac{c}{\Delta_{p_i,n-1}^{both}}.$$

Intuitively, in line with the informativeness principle (Holmström (1979); Chaigneau, Edmans and Gottlieb (2014)), since S_i^{ind} and S^{team} carry complementary information about i's effort, the firm optimally uses both to incentivize her. Moreover, given workers' risk neutrality, there is no benefit from distributing their payments across different states. Thus, the firm optimally rewards every worker $i \in N$ only conditional on the combination of signals' realizations that most strongly indicates that i worked rather than shirked, i.e., the one that maximizes the likelihood ratio: when both team and individual performance signals are positive.

Relation to high-trust environments. Note that $\mathbf{b} = \left(0, 0, c(\Delta_{p_i,n-1}^{both})^{-1}\right)_{i\in N}$ ensures teamwork in high-trust teams, where all workers anticipate their $n-1$ colleagues to work. However, it lacks robustness to low-trust environments, potentially leading to equilibria where workers shirk due to expectations of their colleagues' shirking.[16] As a result, focusing solely on the firm-preferred equilibrium effectively confines the classical analysis's applicability to high-trust environments.[17]

2.3 Analysis with Trust Concerns: Robust Incentive Scheme

This section returns to analyze the firm's problem of offering an incentive scheme that robustly implements effort at the lowest possible cost, given any fixed precision

[16] See also Winter (2004) for a similar argument.

[17] Note that no variation argument can justify the selection of the firm-preferred equilibrium in this context: starting from the firm-preferred equilibrium, no epsilon variation in the offered contracts would ensure the effort of all workers as the unique equilibrium outcome.

of the individual signals. The firm problem can be rewritten as

$$\min_{\boldsymbol{b}} \sum_{i \in N} \left(p_i b_i^{ind} + F(n) b_i^{team} + p_i F(n) b_i^{both} \right) \qquad \textit{subject to:} \tag{1}$$

$$\sum_{n_{-i}=0}^{n-1} \mu_i(n_{-i}) \left(\Delta_{n_{-i}}^{team}\, b_i^{team} + \Delta_{p_i, n_{-i}}^{both}\, b_i^{both} \right) + \Delta_{p_i}^{ind}\, b_i^{ind} \geq c, \quad \forall i \in N, \mu_i \in \Gamma_i(\boldsymbol{b}),$$

where $\Gamma_i(\boldsymbol{b})$ is the set of all beliefs of i that only assign positive probability to action profiles that are rationalizable given that the firm offers the bonus scheme $\boldsymbol{b}$.

Role of trust. Note that worker i's incentive to work depends on her beliefs about her colleagues' efforts (and thus on her trust) if and only if she receives team-related bonuses b_i^{both} or b_i^{team}. As we focus on the impact of trust concerns, it is thus useful to note that every incentive scheme $\boldsymbol{b} = \left(b_i^{team}, b_i^{ind}, b_i^{both}\right)_{i \in N}$ divides the workers into two mutually exclusive contractual categories:

- ***Insulated Workers*** **(IW)**, whose wages depend only on their individual-performance signals S_i^{ind}, fully insulated from their colleagues' effort choices:

$$IW_b = \left\{ i \in N : \left(b_i^{team}, b_i^{ind}, b_i^{both}\right) = \left(0, b_i^{ind}, 0\right) \right\}.$$

- ***Non-insulated Workers*** **(NW)**, whose wages depend also on the team performance S^{team}:[18] $NW_b := N \setminus IW_b$.

Trust has no impact for IW but is crucial for NW. Indeed, while workers in IW are insulated from strategic uncertainty and thus would work independently of their beliefs, those in NW workers face strategic uncertainty and thus would only work when they have high enough expectations about their colleagues' efforts.

2.3.1 Optimality of Tiers

First, we show that pay discrimination and ranking-like mechanisms, akin to those in Winter (2004), arise even when the firm can also use individual performance measures (beyond the team output) to incentivize workers. Additionally, we establish that the impact of robustness concerns is more extensive than previously suggested in the literature, affecting more than just teams with complementary workers.[19] In our model, trust concerns lead to ranking-like (*tiers*) mechanisms and pay discrimination

[18] Wages within NW can depend, to some extent, also on the workers' individual signals.

[19] In Winter (2004), robustness concerns have no effect when workers' efforts are substitutes; accordingly, subsequent papers mainly focused on complements.

regardless of whether workers' efforts are complements (F convex), substitutes (F concave), or neither (e.g., F initially convex and then concave).

Definition 1. *A bonus scheme* $\boldsymbol{b} = \left(b_i^{team}, b_i^{ind}, b_i^{both}\right)_{i\in N}$ *creates* $T \leq |A|$ *tiers in* $A \subset N$ *if there exist a surjective function* $\mathcal{T} : A \to \{r \in \mathbb{N}_+ : r \leq T\}$ *such that:*

- *For every* $i \in A$,
$$\min_{x\in\mathbb{N}_+:|\mathcal{D}_{\mathcal{T}}(i)|\leq x\leq n-1} \Delta_x^{team}\ b_i^{team} + \Delta_{p_i,x}^{both}\ b_i^{both} + \Delta_{p_i}^{ind}\ b_i^{ind} = c,$$
where $\mathcal{D}_{\mathcal{T}}(i) := N \setminus \{j \in A : \mathcal{T}(j) \geq \mathcal{T}(i)\}$ *is the set of* i*'s dependable colleagues.*

- *If* $p_i = p_j$, *then* $\mathcal{T}(i) < \mathcal{T}(j)$ *if and only if* $\left(b_i^{team}, b_i^{ind}, b_i^{both}\right) > \left(b_j^{team}, b_j^{ind}, b_j^{both}\right)$.[20]

Moreover, we call the tier structure $\mathcal{T}$ *a complete ranking if* $\mathcal{T}$ *is bijective.*

In words, $\boldsymbol{b}$ creates a tier structure in A if there exists $\mathcal{T}$, assigning every $i \in A$ to a tier $\mathcal{T}(i) = t$, such that $\boldsymbol{b}$ renders every tier-t workers indifferent between working and shirking when at least her *dependable colleagues* $\mathcal{D}_{\mathcal{T}}(i)$ (i.e., those in $N \setminus A$ and those in higher tiers, $\mathcal{T}(j) < t$) work. Moreover, in this structure, higher tiers (indicated by lower $\mathcal{T}(i)$) correspond to greater expected pay for the same level of signal precision.

Theorem 1. *For every* $(p_i)_{i\in N}$ *and* NW, *if* $\boldsymbol{b}$ *is the optimal incentive scheme that RITW, then* $\boldsymbol{b}$ *creates* $T \in \mathbb{N}_+$ *tiers within* NW. *Additionally,*

- *If efforts are complements (F convex),* $\boldsymbol{b}$ *creates a complete ranking,* $T = |NW|$.

- *If efforts are substitutes (F concave) or non-complement (F non-convex), then* $T \in \{1, ..., |NW|\}$. *Moreover, in this case, if* $p_i = p$ *for all* $i \in NW$, *then* $T > 1$ *if and only if* $\exists x \in \{|IW|, ..., n-1\}$ *such that* $p \geq \frac{F(n-1)-F(x)}{(F(n)-F(x+1))+(F(n-1)-F(x))}$.

To gain intuition, consider n homogeneous teammates and a bonus scheme $\mathbf{b}$ assigning them to IW and NW. For $\mathbf{b}$ to be optimal, it must offer sufficient b_i^{ind} to IW to ensure their efforts. Moreover, to prevent shirking in low-trust settings, $\mathbf{b}$ must also ensure that working is iteratively dominant in NW. In principle, the firm could RITW by ensuring that working is dominant for all NW workers, but this is generally sub-optimal. The firm can save by creating tiers within NW and ensuring every tier t works when she expects at least her IW colleagues and those in higher tiers ($t' < t$) to work. For example, by ensuring the effort of tier 1 workers, the firm can reduce the strategic uncertainty for the other NW workers, thereby lowering the

[20] Imposing this condition when p_i and p_j are sufficiently close would deliver the same conclusions.

expected wage needed to incentivize them. As a result, pay discrimination arises even among homogeneous NW workers, with higher tiers (lower t) receiving higher pay.

The optimal tier structure depends on signal precisions and production technology. Similar to Winter (2004), when efforts are complements (F convex), the firm forms a complete ranking within NW, granting higher pay to higher-ranked workers. However, unlike Winter (2004), non-trivial tier structures ($T > 1$) and, thus, pay discrimination arise even when efforts are substitutes (F concave).

This discrepancy arises from our richer contract space. When efforts are substitutes, workers' impact on team success and, thus, on b^{team} diminishes as more colleagues work. Due to this free-riding force, when team bonuses are the firm's only option, no ranking structure or pay discrimination emerges (Winter, 2004). However, by allowing individual performance bonuses, our model decouples strategic and effort complementarities, introducing an additional force. For example, regardless of effort complementarity/substitutability, a positive individual signal has a higher impact on obtaining b_i^{both} when the team success probability is higher, i.e., when more colleagues work. With sufficiently high signal precisions p, this second force ensures workers' incentives are highest when all colleagues work, leading to non-trivial ranking structures where (even) homogeneous workers obtain different tiers and wages. However, due to the opposing free-riding force, workers' incentives are generally non-monotonic in their colleagues' efforts, and discrimination does not take the form of a complete ranking à la Winter (2004), but rather a multi-tier structure with multiple workers in the same tier. Ultimately, robustness concerns are relevant even when efforts are substitutes, leading to a distinctive type of rankings and pay discrimination.

2.3.2 Optimal Bonuses

As a second step, we characterize the workers' bonuses in IW and NW. First, note that in light of Theorem 1, we can rewrite the firm's problem in (1) as

$$\min_{NW,\mathcal{T},\boldsymbol{b}} \quad \sum_{i\in N} \left(b_i^{team}F(n) + b_i^{ind}p_i + p_iF(n)b_i^{both}\right) \qquad \textit{subject to:}$$

$$\Delta_{p_i}^{ind}\, b_i^{ind} = c, \qquad \forall i \in IW$$

$$\Delta_{x_{\mathcal{T},i}}^{team} b_i^{team} + \Delta_{p_i,x_{\mathcal{T},i}}^{both} b_i^{both} + \Delta_{p_i}^{ind} b_i^{ind} = c \qquad \forall i \in NW$$

where $x_{\mathcal{T},i} \in \underset{x\in\mathbb{N}_+:|\mathcal{D}_{\mathcal{T}}(i)|\le x\le n-1}{\arg\min} \Delta_x^{team}\, b_i^{team} + \Delta_{p_i,x}^{both}\, b_i^{both} + \Delta_{p_i}^{ind}\, b_i^{ind}$.

This suggests the firm can adopt a three-steps procedure: given precisions $\left(p_i\right)_{i\in N}$

1. Choose how to optimally partition workers into IW and NW.[21]

2. Given IW, choose the optimal tier structure $\mathcal{T}$ within NW.

3. Given NW and $\mathcal{T}$, assign each worker a bonus that minimizes her (equilibrium) expected wage while keeping her indifferent between working and shirking when exactly $x_{i,\mathcal{T}} \geq |\mathcal{D}_{\mathcal{T}}(i)|$ colleagues work.

Starting from the last step of this procedure, we establish the following Corollary.

Corollary 1. *For every given* $\mathbf{p}$, $NW \subseteq N$, *and tier structure* $\mathcal{T} : NW \to \{1, ..., T\}$, *the optimal incentive mechanism* $\boldsymbol{b} = \left(b_i^{team}, b_i^{ind}, b_i^{both}\right)_{i \in N}$ *is such that*

- *if* $i \in IW$, *then* $b_i^{team} = b_i^{both} = 0$ *and* $b_i^{ind} = \dfrac{c}{2p_i - 1} = \dfrac{c}{\Delta_{p_i}^{ind}}$

- *if* $i \in NW$, *then* $b_i^{team} = b_i^{ind} = 0$, $b_i^{both} = \frac{c}{p_i F\left(x_{\mathcal{T},i}+1\right) - (1-p_i) F\left(x_{\mathcal{T},i}\right)} = \frac{c}{\Delta_{p_i, x_{\mathcal{T},i}}^{both}}$, *and if* $\mathcal{T}(i) = T$, *then* $\Delta_{p_i, x_{\mathcal{T},i}}^{both} = \Delta_{p_i, n-1}^{both}$

While IW workers receive b_i^{ind} only (by definition), the corollary establishes that the optimal bonus type to incentivize a (risk-neutral) worker when $x_{i,\mathcal{T}} \geq |\mathcal{D}_{\mathcal{T}}(i)|$ colleagues work is still b_i^{both}, as in the high trust benchmark. Indeed, b_i^{both} most strongly indicates that i worked (maximizes the likelihood ratio) even when $x_{\mathcal{T},i} < n-1$. Moreover, each lowest-tier worker has $x_{\mathcal{T},i} = n-1$ (as in high-trust teams); otherwise, the firm would optimally assign her to an extra tier $T+1$, with $|\mathcal{D}_{\mathcal{T}}(i)| = n-1$.

Complements v.s. Substitutes. With complementary efforts, $\Delta_{p_i,x}^{both}$ increases in x. Thus, $x_{\mathcal{T},i} = |\mathcal{D}_{\mathcal{T}}(i)|$ and, since $\mathcal{T}$ is a complete NW ranking, $x_{\mathcal{T},i} = |IW| + \mathcal{T}(i) - 1$. If efforts are substitutes, this relation no longer holds, and $x_{\mathcal{T},i} > |\mathcal{D}_{\mathcal{T}}(i)|$ may occur.

2.3.2.1 Rent decomposition.

In the presence of trust concerns, the firm offers two conceptually distinct rent types:

- **Information rent** $\mathcal{I}_{b^s}$: the classical rent needed to motivate a worker with bonus type b^s when strategic uncertainty is not a concern (as in high-trust benchmark).

- **Strategic insurance rent** $\mathcal{R}_{b^s}$: the additional rent needed to motivate a worker with bonus type b^s because of trust concerns.

In IW, workers are insulated from strategic uncertainty and receive only information rents $\mathcal{I}_{b^{ind}}$. Yet, these rents exceed those in the high-trust benchmark, as the firm relies solely on b_i^{ind}, ignoring the team output. In line with the informativeness principle

[21] If indifferent, we assume the firm assigns the worker to NW, but any different tie-breaking rule delivers the same results.

$$\mathcal{I}_{b^{ind}} = \left(\frac{p_i c}{\Delta^{ind}_{p_i}} \right) - c > \frac{p_i F(n) c}{\Delta^{both}_{p_i, n-1}} - c = \mathcal{I}_{b^{both}}.$$

In contrast, for NW workers, the firm uses all available information. Consequently, the information rents are as low as in the high-trust case, $\mathcal{I}_{b^{both}}$. However, every worker $i \in NW$, with $\mathcal{D}_{\mathcal{T}}(i)$ dependable colleagues, also receives a strategic insurance rent

$$\mathcal{R}_{b^{both}}(x_{\mathcal{T},i}) = p_i F(n) \left(\frac{c}{\Delta^{both}_{p_i, x_{\mathcal{T},i}}} - \frac{c}{\Delta^{both}_{p_i, n-1}} \right) \geq 0,$$

compensating for her strategic uncertainty, ensuring her effort even in low-trust environments. Indeed, b_i^{both} makes worker i indifferent to working or shirking when only $x_{\mathcal{T},i} \leq n-1$ colleagues work; not all $n-1$ as in the high-trust benchmark. Only workers in the lowest tier ($\mathcal{T}(i) = T$) always have $x_{\mathcal{T},i} = n-1$ and obtain $\mathcal{R}_{b^{both}}(n-1) = 0$. Finally, note strategic insurance rents discretely increase as we move to higher tiers.

2.3.3 Information Waste

Our first main contribution is to show that trust concerns seriously undermine the informativeness principle: the firm optimally employs contracts that purposely ignore statistically-relevant information on workers' efforts. Specifically, we show that some workers receive only individual-performance bonuses ($IW \neq \emptyset$), even though the team performance carries additional information about their efforts. To better illustrate the rationale behind assigning workers to IW over NW, sacrificing relevant information, we focus on homogeneous teams ($p_i = p_j = p$ for all $i, j \in N$). However, all findings extend to the heterogeneous agent case, fully characterized in the next section.

As evident from our rent decomposition, the crucial trade-off between IW and NW is the one between information and strategic insurance rents. Intuitively, the firm has several options to deal with trust concerns. One possibility is to provide the same type of contracts as in the high-trust benchmark, assigning all workers to NW where they obtain b_i^{both} only (Figure 1 (iii)). This approach exploits all the information about the worker's effort, allowing the firm to keep information rents as low as in the high-trust benchmark (in green), but it creates the need for strategic insurance rents (in blue). Conversely, assigning all workers to IW (Figure 1 (ii)) allows the firm to avoid strategic insurance rents but requires extra information rents (in red) to offset the information waste. Neither of these extreme options is optimal.

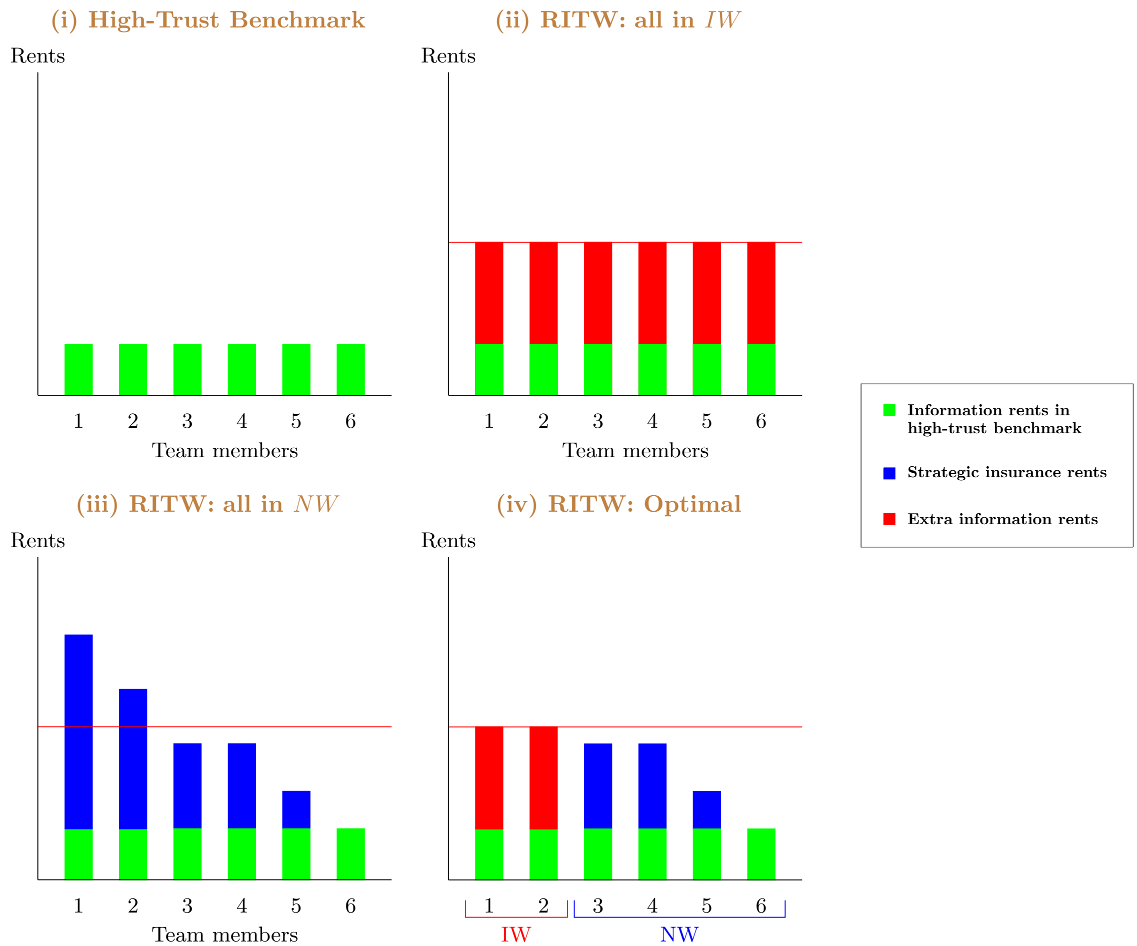

Figure 1: Example of expected rents of a team of six homogeneous workers in (i) the high-trust benchmark, and with trust concerns when the firm (ii) assigns all workers to IW (providing b_i^{ind} only), (ii) assigns all workers to NW (providing b_i^{both} only), (iv) splits optimally workers between IW and NW.

The firm typically opts to secure the efforts of some workers solely through individual bonuses, then leverages this dependable group of workers (IW) to reduce the strategic insurance rents needed to incentivize the others in NW (Figure 1 (iv)).

Proposition 2 (Information Waste)**.** *For all $p \in (0.5, 1)$, the optimal incentive scheme that RITW is such that $NW \neq \emptyset$. Moreover, $|IW| \neq \emptyset$, with*

$$|IW| = \max\left\{ s \in \{1, ..., n\} : \frac{2p-1}{p} > \frac{F(s) - F(s-1)}{F(n) - F(s-1)} \right\},$$

if and only if $\exists s \in \{1, ..., n\}$ such that $\frac{2p-1}{p} > \frac{F(s)-F(s-1)}{F(n)-F(s-1)}$.

The non-emptiness of NW is straightforward: workers in the last tier of NW require the lowest possible information rents and no strategic insurance rents. Conversely, understanding why IW may be non-empty is more complex. Despite all workers working in equilibrium, the firm must provide those in NW with substantial strategic insurance rents to ensure their efforts even when they anticipate their lower-tiered colleagues might shirk. The firm can reduce these rents only by limiting the strategic uncertainty that generates them. Intuitively, individual bonuses serve precisely this purpose, insulating workers from their colleagues' choices. Moreover, assigning i to IW makes her a dependable reference for her NW colleagues (i enters $\mathcal{D}(j)$ for all $j \in NW$), thereby reducing their strategic uncertainty. In contrast, tying a worker's wage to team success increases both her strategic uncertainty and that of her higher-tiered colleagues. Thus, every bonus based on team success imposes an additional strategic insurance cost on the firm, and this cost rises as NW grows. This dynamic eventually leads the firm to disregard the team signal for some workers, placing them in IW, thus sacrificing relevant information.

To gain intuition on the cardinality of IW, consider tier 1 workers in NW. Whether they are kept in NW or switched to IW would not affect the incentives of their colleagues: all their NW colleagues (lower tiers) would still consider them dependable, and their IW colleagues would remain unaffected.[22] Thus, the firm benefits from switching tier 1 workers to IW if and only if their expected gain in NW exceeds what they would receive in IW, i.e., if and only if[23]

$$\frac{pF(n)}{\min_{x\in\{|IW|,\ldots,n-1\}}\left(pF\left(x+1\right)-\left(1-p\right)F\left(x\right)\right)} > \frac{p}{2p-1},$$

i.e., if $\exists s \in \{|IW|, ..., n-1\}$ such that $\frac{2p-1}{p} > \frac{F(s)-F(s-1)}{F(n)-F(s-1)}$.

Finally, to better understand the determinants of $|IW|$, note that $\frac{2p-1}{p}$ increases in p and $\frac{F(s)-F(s-1)}{F(n)-F(s-1)} < 1$ for all $s < n$. Thus, as the monitoring precision increases, the number of team members in IW increases, eventually converging to $n-1$. Moreover, $\frac{F(s)-F(s-1)}{F(n)-F(s-1)}$ decreases in n, thus for any fixed $p \in (0.5, 1)$, $|IW|$ increases with the team size n.[24] Intuitively, strategic insurance rents become increasingly problematic in larger teams and firms react by placing more workers in IW.

[22]Given workers' homogeneity, switching any worker has the same effect.

[23]Note also that the expected payment of tier 1 workers decreases with $|NW|$.

[24]If efforts are complements, then $\frac{F(s)-F(s-1)}{F(n)-F(s)} < \frac{s}{n}$, and even a very low signal precision of 0.56 would be more than enough for $|IW| \geq 1$ in a team of five workers for any convex F.

Empirically, the comparison with the high-trust benchmark highlights how trust concerns might account for the failure of the classical informativeness principle in the data. In particular, trust concerns may explain why (i) firms are three times more likely to use individual bonuses than team bonuses and (ii) even where employed, team bonuses typically cover only a small fraction of the employees (Ledford Jr, Lawler III and Mohrman (1999), Payscale (2019))).[25]

2.3.4 Heterogeneous Monitorability

This section examines how workers' heterogeneous monitorabilities influence the optimal compensation scheme. Specifically, it analyzes how the firm sorts heterogeneous workers into IW and NW and, subsequently, how it ranks them within NW.

Split between IW and NW.

First, we establish that the firm optimally assigns the most monitorable workers to IW. This result is less obvious than it might initially appear. For instance, in comparing two workers, the firm may prefer to assign the least monitorable one to IW and the most monitorable one to NW rather than the opposite.[26] The complexity stems from the fact that assigning a worker to IW or NW affects the strategic insurance rents required to incentivize her colleagues, and this effect depends on the worker's monitorability.[27] Despite these intricacies, we establish the following.

Lemma 1. *Given any monitorability levels $(p)_{i \in n}$, if worker j is optimally assigned to IW and $p_i > p_j$, then also i is assigned to IW.*

The key rationale for this result is that the firm benefits more from limiting the information rents of less monitorable workers. For instance, an IW worker with low monitorability (p_i close to $\frac{1}{2}$) requires a very high information rent ($\frac{p_i c}{2-p_i} - c$). Since the firm can greatly reduce this information rent by exploiting also the team output, assigning poorly monitorable workers to NW becomes particularly appealing. Conversely, when an IW worker has high monitorability (p_i close to 1), her information rent is low, and moving her to NW would result in only a minimal rent reduction. Moreover, regardless of her monitorability, switching a worker to NW raises strategic

[25] This significant difference between individual and team bonuses cannot be attributed to the rarity of teamwork, as most firms employ teamwork (Bersin, 2016; Bikfalvi, Jäger and Lay, 2014).

[26] However, we prove this can only occur when the firm finds it optimal to assign both to IW.

[27] Indeed this decision can have a different impact on the optimal size and tier structure within NW depending on the worker's monitorability.

uncertainty for both the worker and her higher-tiered colleagues. As a result, it is more advantageous for the firm to place only those workers with lower monitorability in NW. This simple intuition highlights why, in equilibrium, only workers with signal precisions above a certain threshold are assigned to IW.

Optimal ranking within NW.

This section addresses how the firm optimally organizes NW into tiers. A preliminary examination reveals that, without further assumptions, there is no clear-cut relation between monitorability and rank: it can be positive, negative, or even non-monotonic. Indeed, while higher monitorability unambiguously reduces incentive costs, these savings may be higher either at top or bottom tiers. Nevertheless, we find that when effort complementarities are sufficiently strong, this relation becomes monotonic, with the firm optimally assigning more monitorable workers to higher tiers.

C1. *Sufficiently strong effort complementarities:* $\frac{(F(x+1)-F(x))^2}{F(x)}$ *is increasing in* $x \in \mathbb{N}$.

Note that, with complementary efforts, a worker's marginal impact $F(x+1)-F(x)$ increases with her colleagues' efforts x. Thus, C1 simply requires the relative increase of such impact $\frac{F(x+1)-F(x)}{F(x)}$ to be increasing (or not too decreasing) in x.

Proposition 3. *If C1 holds, for all* $(p_i)_{i\in N}$ *the optimal incentive scheme is such that:*

1. *Within* NW*, more monitorable workers are ranked higher, i.e.,*

$$\text{if } i, j \in NW \text{ and } p_i > p_j \text{ then } \mathcal{T}(i) < \mathcal{T}(j).$$

2. $NW \neq \emptyset$ *and* $IW = \left\{ i \in N : \frac{2p_i - 1}{p_i} > \frac{F(z(i)) - F(z(i)-1)}{F(n) - F(z(i)-1)} \right\}$*, where* $z : N \leftrightarrow \{1, .., n\}$ *such that* $z(i) < z(j)$ *if* $p_i < p_j$.

Conversely, if for all $(p_i)_{i\in N}$ *the optimal incentive scheme ranks more monitorable workers higher, then C1 must hold.*

Intuitively, with strong effort complementarities C1, strategic insurance rents grow steeply with the ranking and are supermodular in $p_i, z(i)$. This prompts the firm to assign more monitorable workers to higher ranks in order to better mitigate these rents. Moreover, we prove that condition C1 is sharp: if efforts are substitutes or not complementary enough, less monitorable workers may be assigned to higher tiers. Finally, the intuition for IW mirrors the one for homogeneous workers. However, with workers' heterogeneity, the impact of moving a worker from IW to NW (or vice versa) hinges on the tier she would occupy in NW, based on her monitorability (p_i). Nevertheless, since IW workers are more monitorable than those in NW (see Lemma 1) and higher monitorability also implies higher NW tiers, we can still fully characterize IW. As in the homogeneous case, IW grows when workers' monitorability increases, team size expands, or workers become more complementary.

2.4 A Useful Restriction: Separable Bonuses

So far, we have focused on scenarios where the firm can design contracts rather flexibly, exploiting individual and team performances. However, in some situations, firms might find themselves limited to, or see advantages in, simpler/clearer contracts. This section explores cases where the firm can only provide additively separable contracts:

$$W_i\left(S^{team}, S_i^{ind}\right) = b_i^{team} \cdot S^{team} + b_i^{ind} \cdot S_i^{ind}.$$

Under this contractual constraint, the firm still sorts workers into IW and NW, assigning the most monitorable to IW. In this case, however, NW workers' bonuses are based solely on team performance b_i^{team}. Thus, while a complete NW ranking persists with complementary efforts, similar to Winter (2004), this ranking vanishes when efforts are substitutes (NW workers are grouped in a single tier).

Proposition 4. *For every $(p_i)_{i\in I}$, the optimal additively separable incentive scheme $\mathbf{b}=\left(b_i^{team}, b_i^{ind}\right)_{i\in N}$ splits workers into IW and $NW = N \setminus IW$ such that:*

- *If $i \in IW$, then $b_i^{team} = 0$ and $b_i^{ind} = \frac{c}{2p_i-1}$.*
- *If $i \in NW$, then $b_i^{ind} = 0$ and $b_i^{team} = \frac{c}{F(\mathcal{D}_\mathcal{T}(i)+1)-F(\mathcal{D}_\mathcal{T}(i))}$, where $\mathcal{D}_\mathcal{T}(i) := |IW| + O(i)-1$ for an arbitrary NW ranking, $O : NW \leftrightarrow \{1,..,|NW|\}$, if efforts are complements, and $\mathcal{D}_\mathcal{T}(i) := n-1$ if efforts are substitutes.*
- *$IW = \left\{ i \in N : \frac{2p_i-1}{p_i} > \frac{F(z(i))-F(z(i)-1)}{F(n)-F(z(i)-1)} \right\}$, where $z : N \leftrightarrow \{1,..,n\}$ such that $z(i) < z(j)$ if $p_i < p_j$.*

The intuition is similar to the flexible case. However, the restriction to additively separable contracts introduces an even sharper contrast between IW and NW. While bonuses only depend on p_i in IW, they are independent of $\mathbf{p}$ in NW: NW workers only obtain b_i^{team} and, since all ranking permutations thus yield the same firm's expected payoff, the optimal ranking is arbitrary. This sharp contrast will be helpful to clarify the intuition underlying the next section's main result: the transparency trap.

3 Endogenous Monitoring

In earlier sections, we explored the impact of firms' trust concerns on team incentive mechanisms given fixed workers' monitorabilities $\mathbf{p}$. However, monitorability is often endogenous. Workers can increase the transparency of their contributions by seeking face time with management and engaging in self-promotion,[28] or they can diminish it by resisting surveillance, circumventing restrictions, and manipulating reports' accuracy through omissions or distortions. Similarly, the firm may also play a crucial role, e.g., by deciding how much to invest in monitoring its employees. Accordingly, this section focuses on firm's and workers' monitoring incentives. First, we demonstrate how workers' pursuit of strategic insurance rents results in a transparency trap, a crucial contribution of this paper. Second, we analyze the impact of trust concerns on the firm's monitoring investments.

3.1 Workers' Monitoring Choices

In this section, we examine the impact of trust concerns on workers' incentives to influence their own monitorability. To this end, we assume that, before contracts are set, workers can take costly actions to increase or decrease their monitorability p_i away from a given baseline level $\bar{p} \in [0, 1]$.[29] The timing is:

1. Workers simultaneously adjust their own monitorability from the common baseline $\bar{p}$ to a new level $p_i \in \left[\frac{1}{2}, 1\right]$, at a cost $g(p_i) \geq 0$, with $g : [\frac{1}{2}, 1] \to \mathbb{R}_+$ continuous, convex, and such that $g(\bar{p}) = 0$.[30]

2. The firm publicly sets up an optimal incentive scheme and then workers simultaneously choose whether to work or shirk (i.e., the previous analysis).

We characterize the subgame perfect equilibria of this game, focusing on how trust concerns affect workers' monitorability choices through their continuation payoffs. We denote by $\pi_i \in \Delta\left[\frac{1}{2}, 1\right]$ worker i's mixed strategy, and, with the usual abuse of notation, we denote by p_i the mixed strategy for which $\pi_i(p_i) = 1$.

[28] The lack of communication from a self-promoting employee can easily be interpreted as a negative signal about her effort.

[29] This common baseline may be influenced by the job type, prior investments by the firm, etc.

[30] Note that g admits left and right derivatives and, if g is also differentiable, then $g'(\bar{p}) = 0$.

3.1.1 High-Trust Benchmark

As a first step, consider the high-trust benchmark, where workers trust their colleagues to work whenever rationalizable, and the firm takes advantage of this high trust (Section 2.2). In this case, workers only receive information rents, which are decreasing in their own monitorability. Thus, every worker optimally reduces her p_i to maximize her rent. Specifically, each worker solves $\max_{p_i \in \left[\frac{1}{2},1\right]} \frac{p_i F(n) c}{p_i F(x+1) - F(x)(1-p_i)} - g(p_i)$.

Corollary 2. *In the high-trust benchmark case, workers reduce their equilibrium monitorability below the baseline $\bar{p}$. Formally, every $i \in N$ selects $p_i = p^{HT} \leq \bar{p}$, where $p^{HT} = \bar{p}$ if only if either $\bar{p} = \frac{1}{2}$ or g's left derivative is $g'_-(\bar{p}) \leq -\frac{F(n-1)F(n)c}{(F(n)-F(n-1))^2 \bar{p}^2}$. Moreover, if $g'_+\left(\frac{1}{2}\right) \geq -\frac{4F(n-1)F(n)c}{(F(n)-F(n-1))^2}$, then $p^{HT} = \frac{1}{2}$.*

Intuitively, workers have no incentive to increase their visibility. Instead, if the marginal cost is not too high, $g'_-(\bar{p}) \leq -\frac{F(n-1)F(n)c}{(F(n)-F(n-1))^2 \bar{p}^2}$, workers optimally reduce their monitorability, hindering the effectiveness of individual bonuses. Furthermore, if doing so is cheap (or free), $g'_+\left(\frac{1}{2}\right) \geq -\frac{4F(n-1)F(n)c}{(F(n)-F(n-1))^2}$, all workers select $p^{HT} = \frac{1}{2}$. In this case, individual signals become uninformative, compelling the firm to rely exclusively on team bonuses.

3.1.2 Trust Concerns: Robust Incentive Scheme

To evaluate the impact of trust concerns, we assume that workers anticipate the firm will robustly implement teamwork in the subsequent stage when adjusting their p_i. Akin to the high-trust benchmark, monitorability reduces workers' information rents at any given contract type and rank. However, under trust concerns, greater monitorability may also lead to a more favorable contract assignment and higher strategic insurance rents, introducing a novel tradeoff. This leads to this section's main result: competition for higher individual (strategic insurance) rents drives workers into a self-defeating race toward higher effort transparency that only benefits the firm.

We denote by $\pi_i^{LT} \in \Delta\left[\frac{1}{2}, 1\right]$, worker i's equilibrium (stochastic) strategy.

Theorem 2 (Transparency Trap)**.** *If the firm aims to RITW and C1 holds, then every worker optimally selects $\pi_i^{LT} \in \Delta\left[\frac{1}{2}, 1\right]$ such that $\{p^{HT}\} \subsetneq Supp\left(\pi_i^{LT}\right) \subseteq \left[p^{HT}, 1\right]$ unless $p^{HT} = 1$, in which case $\pi_i^{LT}(1) = 1$. Moreover, every worker obtains the same (low) expected equilibrium payoff as in the high-trust benchmark.*

To gain intuition, suppose all workers adjust their monitorability to $p_i = p^{HT}$, as in the high-trust benchmark, and are optimally assigned to NW. By doing so, workers would maximize their information rents while also obtaining additional (strategic insurance) rents. However, by infinitesimally increasing her monitorability above her colleagues', a worker could secure the highest rank in NW,[31] sacrificing infinitesimal information rents for a significant gain in strategic insurance rents.[32] This deviation benefits both the individual worker and the firm but at the expense of her colleagues, who are then motivated to engage in similar behavior, fueling a race towards higher monitorability levels. As this race proceeds and monitorability increases, the total rents available to workers diminish (workers receive no rent at $p_i = 1$). However, each worker can attain the same expected wage as in the high-trust benchmark by selecting $p_i = p^{HT}$ and thus receiving the lowest rank in NW. As we show, this potential deviation is the one that halts the race, leading to workers ultimately receiving the same low equilibrium payoffs as in the high-trust benchmark.

Since workers work and obtain the same equilibrium payoffs in both high and low trust environments (Theorem 2), trust concerns negatively impact the firm's payoffs only if they induce workers to invest more in adjusting their monitorability. Contrary to what might be expected, the firm may be indifferent to, or even benefit from, trust concerns. In particular, the firm's expected equilibrium payoff in the RITW case (i.e., with trust concerns) exceeds that in the high-trust benchmark if and only if $g(p^{HT}) \geq \frac{1}{N}\sum_{i\in N}\mathbb{E}_{\pi_i^{LT}}\left[(g(p_i^{LT})\right]$; strictly so if the inequality is strict. In conjunction with Theorem 2, Corollary 2, and the fact that g is convex (with minimum at $\bar{p}$), this finding leads to the following comparison.

Corollary 3. *Under C1, the firm*

- *Benefits from trust concerns if either $g(p_i) = 0$ for all $p_i > \bar{p}$ or $p^{LT}_{max} \leq \bar{p}$; strictly so if $g(p^{HT}) > 0$ also holds.*
- *Loses from trust concerns if either $g(p_i) = 0$ for all $p_i < \bar{p}$ or $p^{HT} = \bar{p}$; strictly so if $g(p^{LT}_{max}) > 0$ also holds.*
- *Is indifferent if either $p^{HT} = 1$ or $g(p_i) = 0$ for all $p_i \in \left[\frac{1}{2}, 1\right]$.*

Intuitively, trust concerns have a dual impact on the firm. On the one hand, they introduce strategic insurance rents. On the other hand, they trigger a race toward

[31] Recall that, with sufficiently strong complementarities ($C1$), the firm optimally forms a complete ranking and ranks more monitorable workers higher.

[32] This logic also applies if some workers are placed to IW when they all select p^{HT}. Yet, in this case, by infinitesimally increasing her p_i, the lowest-ranked worker in NW, who receives no strategic insurance rent, can obtain to be placed in IW where she receives extra information rent.

higher monitorability, thereby reducing information rents. Whether the firm benefits or loses from trust concerns depends on the baseline $\bar{p}$ and the cost g. If the baseline monitoring is high (e.g., $\bar{p}=1$, so that $p^{LT}_{max} \leq \bar{p}$), or if workers can cheaply enhance their visibility (e.g., $g(p_i)=0$ for all $p_i \geq \bar{p}$), the second effect prevails, and the firm obtains a higher payoff when workers do not trust each other. Additionally, the firm strictly benefits from trust concerns when we also have $g(p^{HT}) > 0$, which is always the case, e.g., when $\bar{p} > \frac{1}{2}$, g is differentiable and strictly convex in $\left[\frac{1}{2}, \bar{p}\right]$. Conversely, the firm benefits from high trust when the baseline monitoring is low (e.g., $\bar{p}=\frac{1}{2}$), when workers can cheaply reduce their monitorability (e.g., $g(p_i)=0$ for all $p_i \geq p$), or when the costs to reduce monitorability are so high that they discourage such choice (e.g., $g'_-(\bar{p}) \leq -\frac{F(n-1)F(n)c}{(F(n)-F(n-1))^2\bar{p}^2}$, so that $p^{HT}=\bar{p}$).

Notably, when workers can adjust their monitorability without any costs in either direction, both they and the firm attain the same expected payoffs as in the high-trust benchmark. However, identical payoffs do not imply an identical contract structure. Typically, with trust concerns, monitorability is significantly higher and not all workers' bonuses are contingent on team performance, i.e., $NW \neq N$.

This discrepancy with the high-trust benchmark is even more apparent when we focus on additively separable contracts. In this case, the firm finds it optimal to reward all workers with individual performance bonuses only.[33]

Proposition 5. *Suppose $C1$ holds, $g(p_i)=0$ for all $p_i \in [\frac{1}{2}, 1]$, and the firm can only employ additively separable bonuses and aims to RITW. Then, in every pure strategy equilibrium, all $i \in N$ select $p_i = p^*$ such that*

- *Firms and workers obtain the same expected payoff as in the high-trust benchmark,* $\mathbb{E}(W_i|e_i=1) = \frac{p^*c}{2p^*-1} = \frac{F(n)c}{F(n)-F(n-1)}$.[34]
- *The firm finds it optimal to offer b_i^{ind} only, $IW = N$.*

With additively separable contracts (and $g(\cdot)=0$), we can fully characterize the equilibrium in pure strategies.[35] In particular, all workers opt for $p_i = p^*$ so high

[33]Technically, there are two equilibria: one where all workers are in IW and one where only one worker is in NW. These equilibria are payoff equivalent and involve the same monitorability.

[34]Perhaps surprisingly, the restriction to additively separable contracts does not impact the firm's and workers' payoffs when workers can freely adjust their monitorability. Thus, these simple contracts may be quite prevalent in practical settings where contract complexity entails a cost.

[35]In this case, the cost of incentivizing NW workers depends on $\mathbf{p}$ solely through $|NW|$.

that in IW, they receive the same low payoff as in NW's lowest rank, and the firm is indifferent between placing them all in IW or keeping just one last worker in NW.

In summary, our analysis reveals that workers' ability to adjust their effort transparency eradicates wage discrimination among homogeneous workers, irrespective of trust concerns. However, trust concerns continue to significantly impact the type of bonuses offered and workers' monitoring choices when efforts are complements.[36]

Relative to the classical high-trust benchmark, our model with trust concerns reconciles several empirical regularities. For instance, contrary to the classical model's prediction that workers should try to conceal their efforts, many complain about feeling unseen (more than 40% according to the *Reward Gateway 2018 report*). Moreover, sources like the 'HBR Guide to Office Politics,' recommend self-promotion as a way to "make sure people understand and see what you do," increasing chances of recognition and career advancements. Such recommendations resonate with our model's predictions. In terms of bonuses, while the classical model predicts that team bonuses should be predominant (potentially the only bonus type) when workers can adjust their monitorability, best practice reports document that individual bonuses are by far the most prevalent. This observation aligns with our model's prediction that individual bonuses should be more common than team bonuses, possibly even more so when workers can adjust their monitorability.

		Predictions	
	Evidence	**High-Trust**	**Trust Concerns**
Workers' signals:	Self-promotion and seek face time with boss.	Uninformative	Informative
Bonus Type	Team bonuses largely neglected	Team only	Mostly individual

3.2 Firm's Monitoring Choices

In the previous section, we studied the workers' incentives to impact monitoring starting from an exogenous given level. However, in many settings, firms can also affect monitoring by choosing how and how much to invest in it. To focus on the

[36]In Appendix 5.1.4, we explore cases where efforts are substitutes, showing that trust concerns might not impact the equilibrium outcome in such scenarios: the equilibrium of the high-trust benchmark is also an equilibrium outcome of the RITW case.

firm's monitoring incentives, in this section, we abstract away from the possibility that workers may, ex-post, adjust their monitorability. The timing is

1. The firm publicly chooses $\mathbf{p} = (p_i)_{i \in N}$ at a cost $h(\mathbf{p})$.
2. The firm publicly sets up an optimal incentive scheme and then workers simultaneously choose whether to work or shirk (i.e., previous analysis).

In principle, the firm's monitoring investments may be scalable or non-targetable. In this case, the investment required to increase a worker's monitoring to $p_i > 0$ allows the firm to set $p_j = p_i$ for all colleagues (e.g., installing cameras, implementing a time clock system, or purchasing surveillance software to monitor browsing activities).[37] In this scenario, we could easily show that the firm would homogeneously monitor workers and respond to trust concerns with higher monitoring investments.

However, in the following, we focus on the more interesting case where the firm's monitoring investments are *worker-specific* and targetable (e.g., hiring a supervisor to monitor (some of) the team members, asking for one-to-one meetings, etc.). Accordingly, we assume $h(\mathbf{p}) = \sum_{i \in N} k(p_i)$, with k increasing and convex in $p_i \in [\frac{1}{2}, 1]$, $k'_+\left(\frac{1}{2}\right) = 0$, and $k'_-(1) = 0$.

3.2.1 High-Trust Benchmark: the Firm-Preferred Equilibrium

In the high-trust benchmark, the firm optimally selects the same monitoring level for all workers. Indeed, since workers' expected bonuses are optimally independent of their colleagues' monitorability (see Proposition 1), the firm's problem of selecting $\mathbf{p}$ simplifies into n identical problems, each of the form $\min\limits_{p_i} \frac{p_i F(n)}{p_i F(n) - (1-p_i) F(n-1)} + k(p_i)$. Exploiting this reformulation, we prove the optimality of homogeneous monitoring.

Corollary 4. *In the high-trust benchmark, the firm monitors workers homogeneously. $\forall i \in N$, $p_i = p$ is the unique solution of $\frac{F(n-1)F(n)}{(pF(n) - F(n-1)(1-p))^2} = k'(p)$.*

3.2.2 Analysis with Trust Concerns: Robust Incentive Scheme

In contrast, under trust concerns, we show that the firm adopts targeted monitoring even in an ex-ante homogeneous team. Specifically, it monitors the workers intended for IW (strictly) more closely than the rest and, at least when effort complementarities are strong enough, it monitors higher tiers more closely than lower ones.[38]

[37] Formally, we consider $h(\mathbf{p}) = \max\limits_{i \in N} k(p_i)$, with k increasing and convex in $p_i \in [\frac{1}{2}, 1]$.

[38] We assume homogeneous monitoring costs across workers. If costs were heterogeneous, our results would extend, with the firm monitoring cheaper workers more closely.

Proposition 6 (Targeted Monitoring)**.** *Suppose the firm aims to RITW. In equilibrium, $NW \neq \emptyset$ and, if monitoring is sufficiently cheap, $IW \neq \emptyset$. Moreover, the firm monitors homogeneous worker heterogeneously:*

- *If $i \in IW$ and $j \in NW$, then $p_i > p_j$.*
- *For all $i, j \in IW$, $p_i = p_j = p$ and p uniquely solves $\frac{1}{(2p-1)^2} = k'(p)$.*
- *If $i \in NW$, p_i uniquely solves $\frac{F(x_{\mathcal{T},i})F(n)c}{\left(p_i F(x_{\mathcal{T},i}+1) - F(x_{\mathcal{T},i})(1-p_i)\right)^2} = k'(p_i)$.*
  Moreover, if C1 holds, higher tiers are monitored more and paid more: $p_i > p_j \iff \mathcal{T}(i) < \mathcal{T}(j) \iff \mathbb{E}(W_i|\mathbf{e}=\mathbf{1}) > \mathbb{E}(W_i|\mathbf{e}=\mathbf{1})$.

Intuitively, regardless of effort complementarity, monitoring is more valuable in IW, where the firm relies solely on individual signals, compared to NW, where the firm also exploits the team output to curb their rents. So, IW workers undergo closer monitoring. Moreover, monitoring is heterogeneous across workers even within NW (it depends on $x_{\mathcal{T},i}$), as monitoring may be more effective in reducing strategic insurance rents at top or bottom tiers. When effort complementarities are sufficiently strong, strategic insurance rents are supermodular in $p_i, x_{\mathcal{T},i}$, prompting the firm to monitor higher tiers more closely. Despite the extra monitoring, higher-tier workers still obtain higher expected pay. In line with the previous section, this result suggests that, even with targetable (rather than non-targetable) monitoring, workers may individually benefit from increasing their visibility, facilitating the firm's monitoring.[39]

Finally, note that lower monitoring costs (i.e., a flatter k) imply closer monitoring and, by Proposition 3, a larger $|IW| > 0$. Thus, contractual heterogeneity (IW and NW) remains optimal even when the firm optimally selects monitoring.

3.3 Team-Manager and the Limits of Delegating Monitoring

We introduce the role of a team manager m, whose input is crucial for the team's success but scarcely monitorable. Formally, we assume that the only signal about the team manager's effort comes from the team output, i.e., $p_m = \frac{1}{2}$, and that

$$F(\boldsymbol{e}) = \begin{cases} 0 & \text{if } e_m = 0; \\ F\left(\sum_{i \neq m} e_i\right) & \text{if } e_m = 1. \end{cases}$$

[39] Depending on parameters, IW workers may be paid more or less than their NW colleagues.

Our analysis extends to this setting: workers still get split into IW and NW, assigned a rank in NW, and granted bonuses according to our previous characterization. The only difference is that, given the team-manager's crucial role in production and her scarce monitorability, her contract is unambiguously pinned down.

Proposition 7. *The team manager obtains the highest rank within NW and the highest wage with respect to the entire team.*

Intuitively, if m is not dependable for worker $i \in NW$, i.e., if $m \notin \mathcal{D}_{\mathcal{T}}(i)$, then worker i must be incentivized to work even when m shirks. However, the team cannot succeed if m shirks; thus, worker i would assign no value to any incentives linked to team success. To avoid this, the firm should make m dependable from the perspective of all NW workers. Moreover, since the manager's individual signal precision is extremely low, it would be too expensive to reward her with individual bonuses only. Thus the firm optimally grants m the highest rank in NW.

With this in mind, let us consider the idea that the firm delegate the task of monitoring the team members' efforts to the team manager. Although the team manager might be, in principle, in a better position to monitor the workers, our paper provides a troubling perspective on her monitoring incentives.

Corollary 5. *The team manager benefits from limiting her colleagues' monitorability.*

To understand this result, note that, as the highest rank in NW, the team manager obtains higher strategic insurance rents when more workers are in NW. Since higher monitorability leads to more workers being assigned to IW (by Proposition 3), the team manager would discourage any attempt to increase the subordinates' monitorability if given the opportunity. In this sense, the rhetoric about teamwork and lack of attributability may be more indicative of the team manager's incentive to protect her rent against the firm than to motivate team members. Thus, it should not be surprising if we observe team managers obstructing any form of direct monitoring of their subordinates, for example avoiding detailed reports and retaliating against subordinates who report directly to upper management or the property.

Delegating monitoring to other team members may appear a more viable solution, but it raises similar concerns. Workers have incentives to limit their colleagues' monitorability to obtain higher ranks and enjoy higher strategic insurance rents.

Proposition 8. *Workers benefit from limiting the monitorability of their colleagues.*

Taken all together, since no worker benefits from limiting her colleagues' monitorability in the high-trust benchmark, this section's analysis allows us to conclude that trust concerns present an obstacle to delegating monitoring.

4 Conclusions

This paper studies the impact of trust concerns on monitoring incentives and the optimal balance between individual and team-performance bonuses in teams, providing three main contributions. First, we show that the firm optimally incentivizes some team members with individual-performance bonuses only, sacrificing relevant information to reduce the strategic insurance rents. In line with corporate best practices, our model predicts that most bonuses should be tied to workers' individual performances instead of the team's output. Second, we show that the firm optimally discriminates among (possibly homogeneous) workers with respect to total rent granted, type of bonus offered, and how closely they are monitored. Third, we show that Winter (2004)'s conclusion that robustness concerns have no effect in free-riding contexts, where teammates' efforts are substitutes, crucially hinges on the lack of individual signals; in our context, robustness concerns introduce pay discrimination among homogeneous agents even when efforts are substitutes rather than complements. Fourth, we show that, even if the firm's monitoring ability harms workers overall, the competition for better contracts triggers a race to facilitate monitoring even if the firm cannot commit to punishing or rewarding them. As a result of this transparency race, firm and workers obtain the same payoffs as in the firm-preferred equilibrium, albeit with a very different contract structure (favoring individual bonuses) and better monitoring. Thus, unlike the classical benchmark, our model is consistent with the evidence that workers commonly engage in practices that increase their effort's transparency, like self-promotion. Finally, we show that workers' monitorability harms their colleagues, suggesting a novel reason why unions typically oppose monitoring and casting doubts on the effectiveness of delegating monitoring to other workers, especially the team manager.

Lastly, in the appendix, we extend the model in different directions. First, we show that our conclusions about the contract structure are robust to the presence of heterogeneity in workers' skills and to the possibility for the firm to condition workers' wages on their colleagues' individual signals (however, the full characterization of these two cases is well beyond the scope of this paper). Second, we show that strong inequality aversion on the side of the workers, leads to even less frequent use of team performance bonuses (in favor of individual performance bonuses) and result in a larger information waste on the side of the firm.

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5 Appendix

5.1 Extensions

For simplicity, in the extensions, we focus on cases where efforts are complements.

5.1.1 More Flexible Contracts: Include Third Party performances

An important assumption of our model is that a worker's contract cannot depend on the private signals that the firm receives from her colleagues. Considering such a possibility significantly complicates the analysis without changing the main messages of the paper. In particular, since strategic uncertainty significantly affects also every contract that depends on such third-party signals, the trade-off between strategic insurance rents and information rents continues to bite. As a result we can still prove that team performance bonuses would be lower-powered when the firm is concerned about trust than when trust is not a concern (our benchmark case).

Proposition 9. *Trust concerns strictly decrease the weight of team performance bonuses.*

Moreover, we can show that the firm would never provide a larger bonus to a worker upon observing the positive individual signal of a colleague. If the wage does not depend on the team performance, conditioning on coworkers' individual signal would be useless: it would just add variance to the salary without changing the expectation.[40] Indeed, when not combined with team performance, colleagues' individual signals are uninformative for the worker's effort, and thus ineffective in reducing information rents.[41] On the other hand, if a worker's wage positively depends on the team performance, granting higher bonus when the colleagues' performance is positive would be counterproductive: doing so would just increase strategic uncertainty and thus strategic insurance rents. However, granting higher wages when some of the colleagues' individual signal are negative might help in reducing the negative impact of strategic uncertainty. Intuitively, denote by h the highest-ranked worker, who needs to be made indifferent between working and shirking when she expects all other workers in NW to shirk. The firm benefits from introducing for h an extra bonus when the signal of one of his colleague is negative. Indeed such occurrence is unlikely in equilibrium, given that all workers exert effort, but is able to reduce strategic insurance rents that need to be granted to h.[42]

However, creating direct competition among workers can easily backfire when cooperation is crucial. Workers might not cooperate and even sabotage each other

[40] Recall that both the firm and the workers are risk-neutral.

[41] Conditioning bonuses on colleagues' individual signals' would not reduce information rents.

[42] Given the out of equilibrium beliefs, the impact on the h's participation constraint is bigger than the impact on the firm's objective function.

as a result of such competition (e.g., Dai and Toikka (2017),Chowdhury and Gürtler (2015)). Workers might also suffer from the so-called "discouragement effect" when the workers are pessimistic about their own abilities; see Sheremeta (2016) for a review of pros and cons of relative performance bonuses in the workplace.

5.1.2 Inequality Aversion

This section studies the effects of inequality concerns on the optimal contract structure that robustly implements teamwork. For simplicity, consider homogeneous workers.

While low inequality aversion does not affect the optimal contract structure, strong inequality aversion penalizes discrimination and the use of ranking mechanisms, potentially challenging our result. However, our main result about information waste may become even sharper in this case. To illustrate this, we consider a setting where workers' inequality aversion is so strong that the firm cannot implement teamwork unless it provides equal expected pay to all teammates (otherwise, they all shirk). We show that if $m > 0$ workers would be in IW absent inequality aversion, then at least m workers are in IW in this setting with inequality aversion; actually, the firm is indifferent among all $|IW| \in m, m+1, ...n$ and, if there were any aversion or cost in having different bonus compositions, then all workers will receive b_i^{ind} only.

Proposition 10 (Inequality Aversion). *If p and F are such that the optimal ranking scheme that RITW features $|IW| = m \geq 1$ in absence of inequality aversion, then in the presence of strong inequality aversion $IW = N$.*

Intuitively, since the firm needs to grant all workers the same expected wage, it would only care to minimize the rents of the highest-paid worker to robustly implement teamwork. So, if it is cheaper to induce the highest-paid worker to exert effort using b^{ind} then the firm would find it optimal to reward all workers that way.

In a nutshell, we conclude that strong inequality aversion leads to even less frequent use of team performance bonuses (in favor of individual performance bonuses) and result in a larger information waste on the side of the firm.

5.1.3 Heterogeneous Skills

Assume that each worker i has skill $\theta_i \in \mathbb{R}^+$, identifying the impact of i's effort on the success probability $F\left(\sum_i \theta_i e_i\right)$. For simplicity, we assume all workers have the same monitorability p and contracts are additively separable.

Proposition 11. *The optimal mechanism that RITW splits workers into IW and NW, creating a full ranking in NW. In NW, higher-skilled workers are ranked higher and paid more. Moreover, if the highest-skilled worker is in IW, then $IW = N$.*

5.1.4 Endogenous monitoring by workers: Substitutes.

While the main text focused on teams of sufficiently complementary workers, this section explores the impact on workers' monitoring incentives when their efforts are not sufficiently complementary (C1 violated). One challenge in this context is the absence of a clear-cut characterization of how workers are ranked within NW as a function of $\mathbf{p}$. Even in such cases, higher monitorability unambiguously reduces workers' information rents (as in the high-trust benchmark), but it also affects strategic insurance rents, potentially introducing a trade-off. This trade-off, however, may not manifest when workers are substitutes. For instance, we can demonstrate that when affecting monitoring is cheap (e.g., free), the equilibrium outcome may remain the same with or without trust concerns.

Proposition 12. *Suppose the firm aims to RITW. If efforts are substitutes and $g(p_i) = 0$ for all p_i, then $E(W_i|e_i = 1) = \frac{F(n)c}{F(n)-F(n-1)}$ and the high-trust equilibrium (with $\mathbf{p}=\frac{\mathbf{1}}{\mathbf{2}}$) is robust to trust concerns.*

In essence, each worker can set $p_i = \frac{1}{2}$, compelling the firm to rely solely on b^{team}. By doing so, the worker guarantees herself at least $b_i^{team} = \underline{b}_i^{team} := \frac{c}{F(n)-F(n-1)}$, which renders i indifferent between working and shirking when all colleagues work. However, if efforts are substitutes, workers have the least impact on team success, i.e., their chance to obtain $\underline{b}_i^{team}$, when all colleagues work. Thus, $\underline{\mathbf{b}}^{team}$ makes working dominant for every worker and is sufficient for RITW. As a result, each worker's expected wage must be $F(n)\underline{b}_i^{team}$ and $\mathbf{p} = \frac{\mathbf{1}}{\mathbf{2}}$ is part of a subgame-perfect equilibrium.

Conversely, trust concerns significantly impact workers' monitoring incentives and the resulting equilibrium when efforts are complementary. In that case, $\underline{b}_i^{team}$ no longer suffices for RITW; workers are less incentivized when expecting more colleagues to shirk.

5.2 Mathematical Appendix

5.2.1 High-Trust (firm-preferred) equilibrium benchmark

Proof of Proposition 1

The firm chooses $\boldsymbol{b} = \left(b_i^{ind}, b_i^{team}, b_i^{both}\right)$ to solve

$$\min_{\boldsymbol{b}} \sum_{i \in N} \left(p_i b_i^{ind} + F(n) b_i^{team} + p_i F(n) b_i^{both}\right) \qquad \text{subject to:}$$

$$(2p_i - 1) b_i^{ind} + \Big(F(n) - F(n-1)\Big) b_i^{team} + \Big(p_i F(n) - (1-p_i) F(n-1)\Big) b_i^{both} = c, \quad \forall i \in N.$$

Since $p_i > \frac{1}{2}$, we have

$$\frac{F(n)}{F(n) - F(n-1)} > \frac{p_i F(n)}{p_i F(n) - (1-p_i) F(n-1)}$$

and thus the firm always prefer to use b^{both} rather than b^{team}.

Moreover, since $F(n) - F(n-1) > 0$, we have

$$\frac{p_i}{(2p_i - 1)} > \frac{p_i F(n)}{p_i F(n) - (1-p_i) F(n-1)}$$

and thus the firm always prefer to use b^{both} rather than b^{ind}. Therefore

$$\left(b_i^{ind}, b_i^{team}, b_i^{both}\right) = \left(0, 0, \frac{p_i F(n)}{p_i F(n) - (1-p_i) F(n-1)}\right). \qquad \blacksquare$$

5.2.2 Robust implementation of teamwork

As a first step to characterize the optimal compensation scheme with trust concerns, we want to prove that we can focus on $W^* : \{0,1\} \times \{0,1\} \to \mathbb{R}^+$ such that

$$W_i^*\left(S_i^{ind}, S^{team}\right) = b_i^{both} \mathbb{I}\left(S_i^{ind} = 1, S^{team} = 1\right) + b_i^{ind} \mathbb{I}\left(S_i^{ind} = 0\right),$$

To this end, we first establish the following lemma.

Lemma 2. *The optimal compensation scheme $W^* : \{0,1\} \times \{0,1\} \to \mathbb{R}^+$ that RITW is such that, $\exists$ a permutation $O : N \leftrightarrow \{1, ..., n\}$ such that $\forall i \in N$, W_i^* solves*

$$\min_{W_i} E_S \left(W_i(S) \,|\mathbf{e} = \mathbf{1}\right) \qquad \textit{subject to:}$$

$$\min_{\mu^i \in \Delta\{0,1,\ldots,n-1\}} E_{S,\mu} \Big(W_i(S) \,| e_i = 1, \mathbf{e}_{<O(i)} = \mathbf{1}\Big) - E_{S,\mu^i} \Big(W_i(S) \,| e_i = 0, \mathbf{e}_{<O(i)} = \mathbf{1}\Big) = c$$

where $\mathbf{e}_{<O(i)}$ is the vector of efforts exerted by workers with $O(j) < O(i)$, and $\mu^i(h)$ is the probability that exactly h of i's colleagues exert effort.

Proof. First, note that $\forall s \in \{1, ..., n\}$ W^* must be such that when $s-1$ workers are guaranteed to work at least another worker $i \in N$ is willing to work independently of what the rest of her colleagues do; otherwise there would be a rationalizable outcome where at most $s-1$ workers work. Set $O(i) := s$. Moreover, note that if working is dominant for j such that $O(j) = 1$ and iteratively dominant for all $O(i) > 1$, there cannot be a rationalizable outcome where some workers shirk.

So, the firm's problem can be rewritten as

$$\min_O \min_W \sum_{i=1}^{n} E_S \left(W_i \left(S \right) | \mathbf{e} = \mathbf{1} \right) \qquad \text{subject to: } \forall i \in N$$

$$\min_{\mu^i \in \Delta\{0,1,\ldots,n-1\}} E_{S,\mu^i} \left(W_i \left(S \right) | e_i = 1, \mathbf{e}_{<O(i)} = \mathbf{1} \right) - E_{S,\mu^i} \left(W_i \left(S \right) | e_i = 0, \mathbf{e}_{<O(i)} = 1 \right) \geq c$$

For every given O, the second minimization can then be split into n sub-problems, one for every $i \in N$:

$$\min_{W_i} E_S \left(W_i \left(S \right) | \mathbf{e} = \mathbf{1} \right) \qquad \text{subject to:}$$

$$\min_{\mu^i \in \Delta\{0,1,\ldots,n-1\}} E_{S,\mu^i} \left(W_i \left(S \right) | e_i = 1, \mathbf{e}_{<O(i)} = \mathbf{1} \right) - E_{S,\mu^i} \left(W_i \left(S \right) | e_i = 0, \mathbf{e}_{<O(i)} = \mathbf{1} \right) \geq c$$

Finally, note that, in this sub-problem, the constraint must hold with equality; otherwise, the firm can save on W_i while still incentivizing worker i's effort.[43] □

We then exploit the previous lemma to prove the following proposition.

Proposition 13. *The optimal compensation scheme W^* that RITW is such that*

$$W_i^* \left(S_i^{ind}, S^{team} \right) = b_i^{both} \mathbb{I} \left(S_i^{ind} = 1, S^{team} = 1 \right) + b_i^{ind} \mathbb{I} \left(S_i^{ind} = 0 \right),$$

with $b_i^{both}, b_i^{ind} \geq 0$ for all $i \in N$.

Proof. First, we show $W_i^* (0,0) = 0$. Suppose, by contraposition, $W_i^* (0,0) > 0$ and consider an alternative compensation W_i': $W_i' (0,0) = 0$ and $W_i' (S_i) = W_i^* (S_i)$ for all $S_i := \left(S_i^{ind}, S^{team} \right) \neq (0,0)$. Note that W_i' is cheaper than W_i^* but still satisfies

$$\min_{\mu^i \in \Delta\{0,1,\ldots,n-1\}} E_{S_i,\mu^i} \left(W_i \left(S_i \right) | e_i = 1, \mathbf{e}_{<O(i)} = \mathbf{1} \right) - E_{S_i,\mu^i} \left(W_i \left(S_i \right) | e_i = 0, \mathbf{e}_{<O(i)} = \mathbf{1} \right) \geq c.$$

Indeed, worker i's effort always reduces the probability of $S = (0,0)$, independently of her colleagues' efforts.Then it must be that $W_i^* (0,0) = 0$. Thus for all $i \in N$

$$W_i^* \left(S_i \right) = b_i^{both} \mathbb{I} \left(S_i^{ind} = 1, S^{team} = 1 \right) + b_i^{ind} \mathbb{I} \left(S_i^{ind} = 0 \right) + b_i^{team} \mathbb{I} \left(S^{team} = 0 \right)$$

with $b_i^{team}, b_i^{ind} \geq 0$ and $b_i^{both} \geq - \left(b_i^{team} + b_i^{ind} \right)$. As a result, we can rewrite the firm's problem for every $i \in N$ as

$$\min_{\left(b_i^{both}, b_i^{ind}, b_i^{team} \right)} p_i F(n) b_i^{both} + p_i b_i^{ind} + F(n) b_i^{team} \qquad \text{subject to:}$$

$$\min_{\mu^i \in \Delta\{0,\ldots,n-1\}} (2p_i - 1) b_i^{ind} + E_{\mu^i} \left(F(k+1) \left(p_i b_i^{both} + b_i^{team} \right) - F(k) \left((1-p_i) b_i^{both} + b_i^{team} \right) | \mathbf{e}_{<O(i)} = \mathbf{1} \right) = c.$$

Finally, note that, since $p_i \in (\frac{1}{2}, 1)$, then for all $\mu^i \in \Delta\{0,1,\ldots,n-1\}$,

$$\frac{p_i F(n)}{E_{\mu^i} \left(F(k+1) \right) p_i - E_{\mu^i} \left(F(k) \right) (1 - p_i)} < \frac{F(n)}{E_{\mu^i} \left(F(k+1) \right) - E_{\mu^i} \left(F(k) \right)}.$$

[43] Recall that we assume workers exert effort when indifferent between working and shirking.

Thus $b_i^{team} = 0$, which, due to limited liability, implies $b_i^{both} \geq 0$. Thus it must be that $W_i^* \left(S_i^{ind}, S^{team}\right) = b_i^{both} \mathbb{I}\left(S_i^{ind} = 1, S^{team} = 1\right) + b_i^{ind} \mathbb{I}\left(S_i^{ind} = 0\right)$ with $b_i^{both}, b_i^{ind} \geq 0$. $\square$

Proof of Theorem 1

By Lemma 2 and Proposition 13, for every worker $i \in N$, the optimal W_i^* solves

$$\min_{\left(b_i^{both}, b_i^{ind}\right)} p_i F(n)\, b_i^{both} + p_i b_i^{ind} \qquad \text{subject to}$$

$$\min_{x \in \{O(i)-1,\ldots,n-1\}} (2p_i - 1)\, b_i^{ind} + \left(p_i F(x+1) - (1-p_i) F(x)\right) b_i^{both} = c, \text{ for all } i \in N.$$

for some optimal permutation O. So, if $\frac{p_i F(n)}{\min_{x\in\{O(i)-1,\ldots,n-1\}} \Delta_{p_i,x}^{both}} \geq \frac{p_i}{\Delta_{p_i}^{ind}}$, i is assigned to IW and rewarded with $b_i^{ind} = \frac{c}{\Delta_{p_i}^{ind}}$. Otherwise, i is assigned to NW and rewarded with

$$b_i^{both} = \frac{c}{\min_{x\in\{O(i)-1,\ldots,n-1\}} \Delta_{p_i,x}^{both}}.$$

First, note that, given $\mathbf{p}$ and an optimal bonus scheme $\mathbf{b}^*$, there must be a permutation of N, say O, that generates $\mathbf{b}^*$ in the above problem, such that $O(i) < O(j)$ for all $i \in IW$ and $j \in NW$. Indeed, placing IW workers at the top (lower $O(i)$) while keeping them in IW has no effect on their bonuses but (weakly) decreases the ones of NW workers. Thus, given IW, we can focus on NW *permutations*, $O' : NW \leftrightarrow \{1, ..., n - |IW|\}$, such that $\forall i \in NW$

$$\Psi_i(O'(i), b_i^{both}) := \min_{x\in\{|IW|+O'(i)-1,\ldots,n-1\}} \Delta_{p_i,x}^{both} b_i^{both} = c. \tag{2}$$

If workers are complements (F is convex), then $\Delta_{p_i,x}^{both}$ increases in x. Therefore, $\arg\min_{x\in\{|IW|+O'(i)-1,\ldots,n-1\}} \Delta_{p_i,x}^{both} = |IW| + O'(i) - 1$ and $\mathcal{T} := O'$, where O' is the optimal permutation, is a complete ranking. On the other hand, when efforts are not complements (F, at least in part, concave), $\Delta_{p_i,x}^{both}$ may not be increasing in x. However, even in this case, we can have pay discrimination. Suppose, for example, $\forall i, j \in NW$ $p_i = p_j = p$ (so that we do not need to worry about the optimal permutation O). Then, $\Psi_i(O'(i), b_i^{both}) = c$ implies that $\exists i, j \in NW$ such that $b_i^{both} \neq b_i^{both}$ if and only if $\exists y \in \mathbb{N}_+$, $|IW| \leq y < n-1$, such that $pF(y+1) - (1-p) F(y) < pF(n) - (1-p) F(n-1)$, i.e., such that $p > \frac{F(n-1) - F(y)}{(F(n)+F(n-1)) - (F(y+1)+F(y))}$. Note that this is always true for p sufficiently high (even if F is concave or not convex).

Finally, we want to show that a tier structure always arises. We recursively define $\mathcal{T} : NW \to \mathbb{N}_+$ as follows. First, given $\mathbf{p}$, IW, and the optimal bonus scheme $\mathbf{b}^*$, call $\mathbf{O}_{\mathbf{b}^*}^{\mathbf{0}}$ the set of all NW permutations that generate $\mathbf{b}^*$ through (2). Consider $O' \in \mathbf{O}_{\mathbf{b}^*}^{\mathbf{0}}$

and set $\mathcal{T}(i)=1$ if $\Psi_i\left(O'(i), b_i^{both\,*}\right)=\Psi_i\left(1, b_i^{both\,*}\right)$ and $\mathcal{T}(i)>1$ otherwise. Call $\mathbf{O^1_{b^*}}$ the set of all NW permutations O'' that maintain the same order as O' but place workers with $\mathcal{T}(i)=1$ at the top (lower $O''(i)$); i.e., such that for any $i, j_1, j_2 \in NW$ with $\mathcal{T}(j_1)>1$, $\mathcal{T}(j_2)>1$, and $\mathcal{T}(i)=1$, if $O'(j_2)>O'(j_1)$ then $O''(i)<O''(j_1)<O''(j_2)$. Then it must be that $\mathbf{O^1_{b^*}} \subseteq \mathbf{O^0_{b^*}}$; placing workers with $\mathcal{T}(i)=1$ at the top of NW has no effect on their bonus, but (weakly) decreases the ones of the other NW workers. Analogously, recursively consider $O' \in \mathbf{O^{t-1}_{b^*}}$ and, for all $i \in NW$ such that $\mathcal{T}(i)>t-1$, set $\mathcal{T}(i)=t$ if $\Psi_i\left(O'(i), b_i^{both\,*}\right)=\Psi_i\left(1+|\{j \in NW : \mathcal{T}(i)<t\}|, b_i^{both\,*}\right)$ and $\mathcal{T}(i)>t$ otherwise. Call $\mathbf{O^t_{b^*}}$ the set of all NW permutations O'' such that for any $i, r, j_1, j_2 \in NW$ with $\mathcal{T}(j_1)>t$, $\mathcal{T}(j_2)>t$, $\mathcal{T}(r)<t$, and $\mathcal{T}(i)=t$, if $O'(j_2)>O'(j_1)$ then $O''(r)<O''(i)<O''(j_1)<O''(j_2)$. Then it must be that $\mathbf{O^t_{b^*}} \subseteq \mathbf{O^{t-1}_{b^*}}$; placing workers with $\mathcal{T}(i)=t$ above those with $\mathcal{T}(j)>t$ has no effect on their bonus, but (weakly) decreases the ones of j with $\mathcal{T}(j)>t$. Proceeding recursively, until reaching $t=T$ such that $\{i \in NW : \mathcal{T}(i) \leq T\}=NW$, we fully define $\mathcal{T}: NW \rightarrow \{r \in \mathbb{N}_+ : r \leq T\}$ as originated by the optimal $\mathbf{b}^*$ (and the associated optimal permutation $O' \in \mathbf{O^t_{b^*}}$).

Defined in this manner, $\mathcal{T}$ constitutes a tier structure in NW. Indeed, by construction, (i) $\mathcal{T}$ is surjective, (ii) when $p_i=p_j$, $b_i^{both\,*} \geq b_j^{both\,*}$ if and only if $\mathcal{T}(i) \leq \mathcal{T}(j)$, and (iii) combining $\Psi_i\left(O'(i), b_i^{both\,*}\right)=c$ with the optimal $O' \in \mathbf{O^t_{b^*}}$, we obtain $\min\limits_{x \in \mathbb{N}_+ : |\mathcal{D}_\mathcal{T}(i)| \leq x \leq n-1} \Delta^{both}_{p_i,x}\, b_i^{both}=c$, where $\mathcal{D}_\mathcal{T}(i):=N \setminus \{j \in A : \mathcal{T}(j) \geq \mathcal{T}(i)\}$. ■

Proof of Corollary 1

As noted, the firm optimally offers to every $i \in IW$ a bonus $b_i^{ind}=\frac{c}{2p_i-1}$. As for $i \in NW$, her optimal bonus depends on the tier structure. For every fixed $x_\mathcal{T}$, using Proposition 13 and Theorem 1, we can write the firm's problem as

$$\min_{(\boldsymbol{b_i})_{i \in NW}} \sum_i \left(p_i b_i^{ind}+p_i F(n) b_i^{both}\right) \qquad \text{subject to:}$$

$$(2p_i-1)\, b_i^{ind}+\Big(p_i F\left(x_{\mathcal{T},i}+1\right)-(1-p_i)\, F\left(x_{\mathcal{T},i}\right)\Big) b_i^{both}=c \qquad \forall i \in NW\ .$$

Note that, if $i \in NW$ then it must that $\frac{p_i F(n)}{p_i F\left(x_{\mathcal{T},i}+1\right)-(1-p_i)F\left(x_{\mathcal{T},i}\right)}<\frac{p_i}{2p_i-1}$, otherwise the firm would optimally switch i to IW. Thus, $\forall i \in NW$, $b_i^{ind}=0$ and $b_i^{both}=c/\Big(p_i F\Big(x_{\mathcal{T},i}+1\Big)-(1-p_i)\, F\Big(x_{\mathcal{T},i}\Big)\Big)$

Finally, since, by definition, $\Delta^{both}_{p_i,x_{\mathcal{T},i}} \leq \Delta^{both}_{p_i,n-1}$, then every worker i in the lowest tier T must have $\Delta^{both}_{p_i,x_{\mathcal{T},i}}=\Delta^{both}_{p_i,n-1}$, otherwise the firm could create an extra tier $T+1$ where placing only i, saving on her bonus without affecting the others. ■

Proof of Proposition 2

Suppose all workers $j \in N \setminus \{i\}$ are in IW, then the firm can save on $i's$ expected payment by placing her in NW. Indeed, since $p < 1$ and $\frac{F(n-1)}{F(n)} < 1$, then

$$\frac{pF(n)}{pF(n) - (1-p)F(n-1)} = \frac{p}{p - (1-p)\frac{F(n-1)}{F(n)}} < \frac{p}{2p-1}.$$

Thus $NW \neq \emptyset$. Finally, consider $|IW|$. Define $\psi_s = \frac{pF(n)}{\min\limits_{y \in \{s,\ldots,n-1\}} (pF(y+1) - (1-p)F(y))}$. It cannot be that $\frac{p}{2p-1} < \psi_{|IW|}$, otherwise the firm would optimally switch to IW all tier one workers (who are currently granted the expected bonus $\psi_{|IW|}$). Second, it cannot be that $\frac{p}{2p-1} \geq \psi_{|IW|-1}$, otherwise the firm would optimally switch one worker to NW.[44] Thus, $|IW|$ must be such that $\psi_{|IW|} \leq \frac{p}{2p-1} < \psi_{|IW|-1}$. As a result, $\psi_{|IW|-1} = \frac{pF(n)}{pF(|IW|) - (1-p)F(|IW|-1)}$ and, since ψ_s decreases in s, $|IW|$ is uniquely pinned down: $|IW| = 0$ if and only if $\frac{p}{2p-1} \geq \psi_0$, otherwise $|IW| = \max\{s \in \{1, ..., n\} : \psi_{s-1} > \frac{p}{2p-1}\}$. The latter can be rewritten as

$$|IW| = \max\left\{ s \in \{1, ..., n\} : \frac{2p-1}{p} > \frac{F(s) - F(s-1)}{F(n) - F(s-1)} \right\}.$$

Note that $|IW| \neq \emptyset$ if and only if $\exists s \in \{1, ..., n\}$ such that $\frac{2p-1}{p} > \frac{F(s)-F(s-1)}{F(n)-F(s-1)}$. ■

Proof of Lemma 1

Suppose by contradiction that $j \in IW$, i is NW with $x_{\mathcal{T},i} = x$, but $p_i > p_j$, i.e., $Z_i := \frac{1-p_i}{p_i} < \frac{1-p_j}{p_j} := Z_j$. Since the firm cannot prefer switching i to IW, then

$$\frac{1}{1 - Z_i} \geq \frac{F(n)}{F(x+1) - Z_i F(x)};$$

otherwise, the firm could save both on i and (weakly) on all other workers (who would have weakly higher incentives to work following the switch). Thus, we get

$$Z_j > Z_i \geq \frac{F(n) - F(x+1)}{(F(n) - F(x))}. \tag{3}$$

Moreover, as the firm cannot prefer switching the workers i and j, (which would keep all the others indifferent), then it must be that

$$\frac{1}{1 - Z_j} + \frac{F(n)}{F(x+1) - Z_i F(x)} \leq \frac{1}{1 - Z_i} + \frac{F(n)}{F(x+1) - Z_j F(x)}$$

Rearranging and using the notation $F_2 := F(x+1)$ and $F_1 := F(x)$, we get

$$\frac{1}{1 - Z_j} - \frac{F(n)}{F_2 - Z_j F_1} \leq \frac{1}{1 - Z_i} - \frac{F(n)}{F_2 - Z_i F_1}$$

[44] Recall that, without loss, we break ties favor of NW.

Thus, $\frac{1}{1-Z}-\frac{F(n)}{F_2-ZF_1}$ must be decreasing in Z for some $Z\in[Z_i,Z_j]$, i.e.,

$$\exists Z\in[Z_i,Z_j] \text{ such that } \left(\frac{F_2-F_1Z}{1-Z}\right)\leq\sqrt{F(n)F_1}.$$

Rearranging, and using $Z_i\leq Z$, we obtain

$$Z_i\leq Z\leq\frac{\sqrt{F(n)F_1}-F_2}{\left(\sqrt{F(n)F_1}-F_1\right)}. \tag{4}$$

Combining inequalities 3 and 4, we get

$$\frac{F(n)-F(x+1)}{(F(n)-F(x))}\leq Z_i\leq\frac{\sqrt{F(n)F(x)}-F(x+1)}{\left(\sqrt{F(n)F(x)}-F(x)\right)}.$$

However, $\frac{F(n)-F(x+1)}{F(n)-F(x)}-\frac{\sqrt{F(n)F(x)}-F(x+1)}{\left(\sqrt{F(n)F(x)}-F(x)\right)}=\frac{(F(x+1)-F(x))}{F(x)(F(n)-F(x))}\sqrt{F(n)F(x)}>0$, reaching a contradiction. Thus, if $j\in IW$ and $p_i>p_j$, then it must be that $i\in IW$. ■

Proof of Proposition 3

Point 0: Since $\frac{(F(x+1)-F(x))^2}{F(x)}$ is increasing in x then F must be convex (complementary efforts), thus the tier structure $\mathcal{T}$ is a complete ranking.

Point 1: Consider $i,j\in NW$, $p_i>p_j$, assigned to two consecutive ranks. We want to show that, ranking i higher than j is cheaper for the firm. First, note that switching i and j ranks has no impact on their colleagues. Thus, we can focus on i's and j's expected wages only. The firm prefers ranking i higher if and only if

$$\frac{p_iF(n)}{F_1p_i-F_0(1-p_i)}+\frac{p_jF(n)}{F_2p_j-F_1(1-p_j)}<\frac{p_jF(n)}{F_1p_j-F_0(1-p_j)}+\frac{p_iF(n)}{F_2p_i-F_1(1-p_i)}, \tag{5}$$

where $F_0:=F(x)$, $F_1:=F(x+1)$, $F_2:=F(x+2)$. Define $Z_i=\frac{1-p_i}{p_i}\in[0,1]$. Inequality 5 holds for all $Z_i<Z_j$ (i.e., $p_i>p_j$) if and only if $\frac{1}{F_1-F_0Z}-\frac{1}{F_2-F_1Z}$ is increasing in Z (decreasing in p), i.e., if and only if $F_0(F_2-F_1Z)^2-F_1(F_1-F_0Z)^2\geq 0$. To show that this is indeed the case, first note that, since F is convex and $Z\in[0,1]$,

$$\frac{\partial\left(F_0(F_2-F_1Z)^2-F_1(F_1-F_0Z)^2\right)}{\partial Z}=2F_0F_1\left((F_1-F_0)Z-(F_2-F_1)\right)<0$$
$$\implies F_0(F_2-F_1Z)^2-F_1(F_1-F_0Z)^2\geq F_0(F_2-F_1)^2-F_1(F_1-F_0)^2.$$

Finally, since $\frac{(F(x+1)-F(x))^2}{F(x)}$ is increasing in x (by assumption), then $\frac{(F(x+1)-F(x))^2}{F(x)}<\frac{(F(x+2)-F(x+1))^2}{F(x+1)}$ and thus $F_1(F_1-F_0)^2<F_0(F_2-F_1)^2$. As a result,

$$F_0(F_2-F_1Z)^2-F_1(F_1-F_0Z)^2\geq F_0(F_2-F_1)^2-F_1(F_1-F_0)^2\geq 0,$$

which is what we needed to prove that i is ranked above j. Iterating this argument, we obtain that, the firm optimally ranks more monitorable NW workers higher.

Point 2. Without loss, relabel workers s.t. $p_1 \geq p_2 \geq ... \geq p_n$. By point 1 and Lemma 1, $\exists i \in N$ s.t. $\forall j \in N$, $j \in IW$ if $j < i$, and $j \in NW$ (with $x_{\mathcal{T},l} = \mathcal{D}(l) = l-1$) if $j \geq i$.[45] Thus, every $i \in NW$ in equilibrium receives an expected wage of $\frac{p_i F(n)}{p_i F(i) - (1-p_i) F(i-1)}$.

Note that, $\forall s \in \{1, ..., n\}$, if $\frac{p_s F(n)}{F(s) p_s - F(s-1)(1-p_s)} \leq \frac{p_s}{2p_s - 1}$, i.e., $p_s \leq \frac{F(n) - F(s-1)}{2F(n) - F(s-1) - F(s)}$, then $|IW| \leq s-1$. Indeed, by Lemma 1, $|IW| > s-1$ would imply $s \in IW$, but adding s to the highest rank of NW reduces s's expected wage with no effect on her colleagues.[46] Conversely, if $p_s > \frac{F(n) - F(s-1)}{2F(n) - F(s-1) - F(s)}$ then $|IW| \geq s$. Indeed, by Lemma 1 and point 1, $|IW| < s$ would imply $s \in NW$ and $\mathbb{E}[W_s | \mathbf{e} = \mathbf{1}] = \frac{p_s F(n)}{F(s) p_s - F(s-1)(1-p_s)} \leq \frac{p_s}{2p_s - 1}$; thus, switching s to IW would reduce her expected wage with no effect on her colleagues. Finally, since $NW \neq \emptyset$, we can conclude that $IW = \left\{ i \in N : \frac{2p_i - 1}{p_i} > \frac{F(i) - F(i-1)}{F(n) - F(i-1)} \right\}$.

Point 3 Suppose efforts are complements (F convex). We show that if $\exists x$ such that $\frac{(F(x+1) - F(x))^2}{F(x)} > \frac{(F(x+2) - F(x+1))^2}{F(x+1)}$, then $\exists (p_i)_{i \in N}$ such that $i, j \in N$, are assigned to two consecutive tiers in NW, with j ranked higher even if $p_i > p_j$. Since all colleagues are unaffected by a switch between i and j, it is sufficient to show that

$$\frac{p_i F(n)}{F_1 p_i - F_0 (1-p_i)} + \frac{p_j F(n)}{F_2 p_j - F_1 (1-p_j)} > \frac{p_j F(n)}{F_1 p_j - F_0 (1-p_j)} + \frac{p_i F(n)}{F_2 p_i - F_1 (1-p_i)}, \quad (6)$$

where $F_s = F(x+s)$. Inequality 6 holds for some $p_i > p_j$ if and only if $\frac{1}{F_1 - F_0 \frac{(1-p)}{p}} - \frac{1}{F_2 - F_1 \frac{(1-p)}{p}}$ is increasing in p for some p, i.e., if and only if

$$F_0 \left(F_2 - F_1 \left(\frac{1-p}{p} \right) \right)^2 - F_1 \left(F_1 - F_0 \left(\frac{1-p}{p} \right) \right)^2 < 0.$$

Note that, if $p_j = \frac{1}{2}$, then the LHS is $F_0 (F_2 - F_1)^2 - F_1 (F_1 - F_0)^2$, which is indeed lower than 0 if $\frac{(F(x+2) - F(x+1))^2}{F(x+1)} < \frac{(F(x+1) - F(x))^2}{F(x)}$. By assumption, the latter is true for some x. This implies that if $p_j = \frac{1}{2}$, $p_i = \frac{1}{2} + \varepsilon$, with $\varepsilon > 0$ sufficiently small, j would be ranked above i if they were optimally placed in ranks $x+1$ and $x+2$ where $\frac{(F(x+2) - F(x+1))^2}{F(x+1)} < \frac{(F(x+1) - F(x))^2}{F(x)}$. Moreover if $max_{i \in N}(p_i) \leq \frac{F(n) - F(0)}{2F(n) - F(0) - F(1)}$, all workers are assigned to NW. Thus, if $\frac{(F(x+2) - F(x+1))^2}{F(x+1)} < \frac{(F(x+1) - F(x))^2}{F(x)}$ in a team with $x+1$ workers with $p_j = 0.5$ and one worker, i, with $p_i = 0.5 + \epsilon$, where $\epsilon > 0$ small enough, then i would be ranked lower than some of the less monitorable ones.

Finally, if efforts are substitutes and $p_j = \frac{1}{2}$, then incentivizing j is most costly when j expects all colleagues to work. Thus, to implement $j's$ effort in equilibrium, the firm must place j in NW and make it dominant for j to work. Thus, $\mathcal{T}(j) = 1$

[45]Without loss, if $p_i = p_j$ and $i > j$, assume that either $j, i \in NW$ with j ranked higher, or $i \in IW$.

[46]Note also that $\frac{F(n) - F(s-1)}{2F(n) - F(s-1) - F(s)}$ is increasing in s.

(the highest tier), regardless of her colleagues' precisions. Moreover, assume that the other $n-1$ teammates have precision $p_i = 1-\epsilon$ with $\epsilon > 0$ arbitrarily small. Then, at least one of those would be placed in NW and assigned $\mathcal{T}(i) = 2$, delivering our result: Indeed, once ensured the work of the $n-1$ colleagues, using b_i^{both} is cheaper than b_i^{ind} and $p_i F(x+1) - (1-p_i)F(x)$ increases in x for p_i sufficiently high. Finally, proceed similarly when F is in part concave and in part convex (exploiting the fact that colleagues with $p_j = 1$ are always placed in IW). ■

Proof of Proposition 4

Following the same steps of Lemma 2, we show that we can split the firm's problem into n individual sub-problems for some (optimal) $O : N \leftrightarrow \{1, ..., n\}$ s.t. W_i^* solves

$$\min_{\left(b_i^{both}, b_i^{ind}\right)} F(n)\, b_i^{team} + p_i b_i^{ind} \qquad \text{subject to}$$

$$\min_{x\in\{O(i)-1,\dots,n-1\}} (2p_i - 1)\, b_i^{ind} + \left(F\left(x_{O,i}+1\right) - F\left(x_{O,i}\right)\right) b_i^{team} = c, \text{ for all } i \in N,$$

where $x_{O,i} = \underset{x\in\{O(i)-1,\dots,n-1\}}{\arg\min} \left(F(x+1) - F(x)\right)$.

Thus $b_i^{team} = \frac{c}{F\left(x_{O,i}+1\right)-F\left(x_{O,i}\right)}$ and $b_i^{ind} = 0$ if and only if $\frac{F(n)}{F\left(x_{O,i}+1\right)-F\left(x_{O,i}\right)} < \frac{p_i}{(2p_i-1)}$ and, otherwise, $b_i^{ind} = \frac{c}{(2p_i-1)}$ and $b_i^{team} = 0$. Moreover, since b_i^{team} is independent of p_i, the ranking O within NW is arbitrary. Thus, optimally selecting O only requires to optimally partition workers into IW and NW, where IW receives b_i^{ind} and NW receives b_i^{team}. Note that, if $j \in IW$ and $i \in NW$ in the optimal $\mathbf{b}$, then $O(j) < O(i)$. Finally, note that $x_{O,i} = O(i)-1$ if efforts are complements and $x_{O,i} = n-1$ if efforts are substitutes. Thus, we have a complete ranking within NW if efforts are complements, and all NW workers are assigned to tier 1 if efforts are substitutes.

To fully characterize the optimal incentive scheme, note that if $i \in IW$ and $p_j > p_i$ then $j \in IW$. Indeed, if j is in NW and i in IW, switching them strictly benefits the firm as $\frac{p_i}{2p_i-1} + \frac{F(n)}{F(x+1)-F(x)} > \frac{p_j}{2p_j-1} + \frac{F(n)}{F(x+1)-F(x)}$. Finally, following the same logic as Point 2 in the proof of Proposition 3 and using the fact that the ranking within NW is arbitrary, we conclude that, $IW = \left\{ i \in N : \frac{2p_i-1}{p_i} > \frac{F(z(i))-F(z(i)-1)}{F(n)-F(z(i)-1)} \right\}$, where $z : N \leftrightarrow \{1, .., n\}$ such that $z(i) < z(j)$ if $p_i < p_j$. ■

Proof of Proposition 6

First, note that, if $\mathbf{p}^*$ is optimal for the firm then, every component p_i^* must be optimal for the contract assigned to i in the equilibrium of the sub-game following

$\mathbf{p}^*$. Thus, if $i \in IW$, then p_i^* solves $\min_{p_i} \left(\frac{p_i}{2p_i - 1}\right) c + k(p_i)$. Since $\lim_{p_i \to 1/2} k'(p_i) = 0$ and $\lim_{p_i \to 1} k'(p_i) = +\infty$ and k convex, then $\frac{c}{(2p_i-1)^2} = k'(p_i)$.

If instead $i \in NW$, then the firm's problem $\min_{p_i} \frac{p_i F(n) c}{p_i F(x+1) - F(x)(1-p_i)} + k(p_i)$ is solved by the unique p_i such that $\frac{F(x)F(n)c}{(p_i F(x+1) - F(x)(1-p_i))^2} = k'(p_i)$. For every x, denote this optimal signal precision by $\mathcal{P}(x)$. Since $\left(\frac{p_i F(n) c}{p_i F(x+1) - F(x)(1-p_i)} + k(p_i)\right)$ is strictly supermodular in p_i, x when $\frac{(F(x+1)-F(x))^2}{F(x)}$ is increasing in x, then $\mathcal{P}(x)$ is strictly decreasing in x. In the case of complementary efforts, where creating a complete NW ranking is optimal and $x_{\mathcal{T},i} = |IW| + \mathcal{T}(i) - 1$, this implies that the firm monitors higher tiers (lower $\mathcal{T}(i)$) more closely. As a result, we also have that higher tiers are paid more in this case. Indeed, suppose i is ranked above j, then $\frac{p_i F(n) c}{p_i F(x_{\mathcal{T},i}+1) - F(x_{\mathcal{T},i})(1-p_i)} > \frac{p_j F(n) c}{p_j F(x_{\mathcal{T},j}+1) - F(x_{\mathcal{T},j})(1-p_j)}$ if and only if $\frac{F(n)c}{F(x_{\mathcal{T},i})} p_i^2 k'(p_i) > \frac{F(n)c}{F(x_{\mathcal{T},j})} p_j^2 k'(p_j)$, which follows from $x_{\mathcal{T},j} > x_{\mathcal{T},i}$ and our previous result that $p_i > p_j$. On the other hand, when efforts are not complement the optimal p_i still varies with $x_{\mathcal{T},i}$, but we may have no complete ranking, and workers in higher tiers may be monitored less closely.

Moreover, the firm optimally monitors IW strictly more closely than NW. Indeed: First, by Proposition 3, the firm monitors IW at least as much as NW. Second, if (by contraposition) $i \in NW$, $j \in IW$, but $p_i = p_j$, then $\frac{p_j}{(2p_j-1)} = \frac{p_i}{(2p_i-1)} \geq \frac{p_i F(n)}{\left(p_i F\left(x_{\mathcal{T},i}+1\right) - (1-p_i) F\left(x_{\mathcal{T},i}\right)\right)}$, otherwise the firm would switch i to IW; then $\frac{c}{(2p_j-1)^2} \geq \frac{F(n)^2 c}{\left(p_i F\left(x_{\mathcal{T},i}+1\right) - (1-p_i) F\left(x_{\mathcal{T},i}\right)\right)^2} > \frac{F(x_{\mathcal{T},i}) F(n) c}{\left(p_i F\left(x_{\mathcal{T},i}+1\right) - (1-p_i) F\left(x_{\mathcal{T},i}\right)\right)^2}$. However, if p_i and p_j were optimal, we must have $k'(p_j) = \frac{c}{(2p_j-1)^2}$ and $k'(p_i) = \frac{F(x_{\mathcal{T},i}) F(n) c}{\left(p_i F\left(x_{\mathcal{T},i}+1\right) - (1-p_i) F\left(x_{\mathcal{T},i}\right)\right)^2}$, contradicting the hypothesis that $p_i = p_j$. Thus $p_i^* < p_j^*$.

Finally, recall that for all $\mathbf{p}$, $NW \neq \emptyset$. Instead, IW may be empty (e.g. if monitoring is too expensive), but $IW \neq \emptyset$ is very possible. For example, suppose $c = 1$ and $k(1-\delta) < \varepsilon_\delta$ with δ arbitrarily small, $\varepsilon_\delta > 0$. Then, the cost of assigning j to IW while optimally monitoring her is $\frac{p_j^*}{\left(2p_j^*-1\right)} + k\left(p_j^*\right) < 1 + \varepsilon_\delta$. In contrast, the cost of assigning the last worker l to NW is $\frac{p_l F(n)}{(p_l F(1) - (1-p_l) F(0))} + k(p_l) > \frac{F(n)}{F(1)} > 1$. Thus, for $\varepsilon_\delta < \frac{F(n)}{F(1)} - 1$, the firm optimally assigns at least one worker to IW. ■

Proof of Proposition 12

Each worker can set $p_i = \frac{1}{2}$, compelling the firm to rely solely on b^{team}. By doing so, the worker can guarantee herself a team bonus of at least $b_i^{team} = \underline{b}_i^{team} := \frac{c}{F(n) - F(n-1)}$, which renders i indifferent between working and shirking when all colleagues work.

However, if F is concave, $F(x) - F(x-1)$ decreases in x. Thus, $\underline{\mathbf{b}}^{team}$ makes working dominant for every worker and is sufficient for RITW. Hence, each worker's expected wage must be $F(n)\underline{b}_i^{team}$ and $\mathbf{p} = \mathbf{\frac{1}{2}}$ is part of a subgame-perfect equilibrium. ■

Proof of Theorem 2

Note that the wage of worker $i \in IW$ continuously (and strictly) decreases in p_i. On the other hand, since workers with higher monitorability are ranked higher (by Proposition 3) the wage of worker $i \in NW$ is non-monotonic in p_i. In particular, when p_i increases, i's wage continuously (and strictly) decreases at every given rank but jumps up when p_i becomes higher than p_j for some $j \in NW$ so that i is granted a higher rank. Also, the workers' cost of adjusting their monitorability to p_i, $g(p_i)$, is continuous in p_i. From these observations we can conclude:

Step 1 *All workers get the same expected payoff.* Consider an equilibrium where $i, j \in N$ select (possibly degenerate) distributions over signal precisions $\pi_i^{LT}, \pi_j^{LT} \in \Delta\left[\frac{1}{2}, 1\right]$. Suppose, by contraposition, that i gets an expected payoff of u_i higher than j. Then j could ensure an expected payoff of at least u_i^- by deviating to $p_j' = p_i^{max} + \varepsilon$, with $p_i^{max} := \max_{p_i \in Supp\left(\pi_i^{LT}\right)} p_i$ and $\varepsilon \to 0^+$. Indeed, (i) if $p_i^{max} \geq \frac{F(n)}{2F(n)-(F(|NW|)-F(|NW|-1))}$, then p_i^{max} granted a place in IW in the proposed equilibrium, then also p_j' would, [47] and (ii) if $p_i^{max} < \frac{F(n)}{2F(n)-(F(|NW|)-F(|NW|-1))}$ granted rank r in NW in the proposed equilibrium, then also p_j' would guarantee j at least rank r within NW. In all these cases, j would get a payoff at least infinitesimally close to the one obtained in the proposed equilibrium by i when choosing p_i^{max}. Finally, since $\pi^{LT}(p_i^{max}) > 0$, then it must be the case that p_i^{max} delivered the expected payoff of u_i and thus that p_j' delivers an expected payoff of at least u_i^-.

Step 2 $\exists\, i \in N$ *such that* $p^{HT} \in Supp\left(\pi_i^{LT}\right)$ *and at most one worker has an atom in* p^{HT}. Define $p_i^{min} := \min_{p_i \in Supp(\pi_i^{LT})} p_i$. Suppose, by contraposition, $\min_{i \in N} p_i^{min} = x > p^{HT}$ and $x \in Supp\left(\pi_i^{LT}\right)$. First, if no other π_j^{LT} has an atom in x, then, by choosing x, i obtains the lowest rank in NW with probability 1 (recall that $NW \neq \emptyset$). However, in this case, i would benefit from switching to $p_i = p^{HT} < x$: i would still get the lowest rank in NW, but at least it would maximize his payoff at this lowest rank. Second, if instead both i and j were to assign atomistic probabilities to $x \geq p^{HT}$, then:

[47] Note that, if $p_i^{max} = \frac{F(n)}{2F(n)-(F(|NW|)-F(|NW|-1))}$, i in equilibrium could be assigned to NW; however, even in that case p_j would grant j a place in IW

(i) It cannot be that both i and j are assigned to NW when they both select x. Otherwise, one (say, i) would obtain a higher rank with positive probability, so the other (say j) would strictly benefit from deviating to $p_j = x+\varepsilon$, with $\varepsilon \to 0^+$, and ensuring to be always ranked higher than i when i selects x.

(ii) It cannot be that i is assigned to IW when selecting x. Otherwise, another worker selecting x (say j) must receive the lowest rank in NW with positive probability when both i and j select x (x is the lowest signal precision). However, in this case, j would strictly benefit from deviating to $p_j = x + \varepsilon$, with $\varepsilon \to 0^+$, and ensuring to be assigned to IW whenever i selects x; indeed, $\frac{x}{2x-1} > \frac{xF(n)}{xF(n)-(1-x)F(n-1)}$.

Therefore, at most one worker assigns atomistic probability to x. Together with the previous point, this implies $\min\limits_{i \in N} p_i^{min} \leq p^{HT}$. Finally, note that $p_i^{min} \geq p^{HT}$. Indeed, since $p^{HT} \leq \bar{p}$ (by Corollary 2), any marginal increase from $p_i^{min} < p^{HT}$ leads to strictly lower cost and higher wage for every worker who obtains the lowest NW rank with positive probability when selecting p_i^{min} (higher information rent if kept in the lowest rank or switched to IW, and higher strategic insurance rent if moved up in the ranks).

Together, steps 1 and 2 imply all workers attain the same expected payoff they would attain in the lowest NW rank with $p = p^{HT}$, i.e., as in the high-trust benchmark. ■

Proof of Corollary 3

Denote by $\Delta(p^{HT}, \pi_i^{LT}) := \sum_{i\in N} \left(g(p^{HT}) - \mathbb{E}_{\pi_i^{LT}}\left[(g(p_i^{LT})\right]\right)$, the difference between the expected adjustment costs paid, in equilibrium, by the workers in the high trust case and in the RITW case. Since, workers work and (under $C1$) obtain the same expected equilibrium payoffs as in the high-trust benchmark (Theorem 2), the firm's expected equilibrium payoff is (strictly) higher in the RITW case if and only if the expected adjustment costs paid, in equilibrium, by the workers are (strictly) greater, i.e., $\Delta(p^{HT}, \pi_i^{LT}) \geq 0$ (> 0). Conversely, the firm's expected equilibrium payoff is (strictly) higher in the high-trust benchmark if and only if $\Delta(p^{HT}, \pi_i^{LT}) \leq 0$ (< 0). Note indeed that, in equilibrium, the firm's wage schedule needs to compensate for these higher/lower costs. Moreover, by Theorem 2, we have that $p_{max}^{LT} \geq p_{min}^{LT} \geq p^{HT}$, with the first inequality holding strict whenever $p^{HT} < 1$. Thus, since the adjustment cost is convex and has its minimum at $\bar{p}$, we have

- $\Delta(p^{HT}, \pi_i^{LT}) \geq 0$ if $g(p_i) = 0 \; \forall p_i \geq \bar{p}$, or if $p_{max}^{LT} \leq \bar{p}$; they both imply $g(p^{HT}) \geq \max\limits_{m \in \bigcup_{i\in N} Supp(\pi_i^{LT})} g(m)$. $\Delta(p^{HT}, \pi_i^{LT}) > 0$ if we also have $g(p^{HT}) > 0$.

- $\Delta(p^{HT}, \pi_i^{LT}) \leq 0$ if $g(p_i) = 0$ $\forall p_i \leq \bar{p}$, or if $p^{HT} = \bar{p}$; they both imply $g(p^{HT}) = 0$. $\Delta(p^{HT}, \pi_i^{LT}) < 0$ if also $g(p_{max}^{LT}) > 0$.

- $\Delta(p^{HT}, \pi_i^{LT}) = 0$ if $g(p_i) = 0$ for all $p_i \in \left[\frac{1}{2}, 1\right]$ or if $p^{HT} = 1$ (indeed this latter implies $\bar{p} = 1$ and $\pi_i^{LT}(1) = 1$ $\forall i \in N$).

■

Proof of Proposition 5

For every $\boldsymbol{p} = (p_i)_{i \in N}$, let $IW(\mathbf{p})$ denote the equilibrium IW in the subgame following $\boldsymbol{p}$, and let $\bar{P}(z)$ denote the level at which a worker's expected payment is the same in IW and in the highest rank of NW when $|IW| = z$.

Lemma 3. *For any $\boldsymbol{p} = (p_i)_{i \in N}$ and any $i \in NW(\boldsymbol{p})$ that is not ranked highest, increasing i's p_i to $\bar{P}(|IW(\boldsymbol{p})|)^+$ results in a strictly higher expected payoff for i.*

Proof. Note that the expected wage of every $i \in NW$, is independent of p_i and decreasing in the ranking $O(i)$. Therefore, the highest rank in NW gains, in expectation, strictly more than all other workers in NW. If $i \in NW$ and $O(i) > 1$ then i gains, in expectation, discretely less than $F(n)\frac{c}{F(|IW|+1)-F(|IW|)} = \bar{P}(|IW|)\frac{c}{2\bar{P}(|IW|)}$. By increasing p_i slightly above $\bar{P}(|IW|)$, the worker can guarantee herself a place in IW and thus a payoff arbitrarily close to the one above. Indeed, the firm views ranks in NW as interchangeable, so it will switch a worker to IW whenever the expected wage needed to incentivize the worker is lower in IW than in the highest rank in NW. □

Hence, in any pure strategy equilibrium, there can be at most one worker in NW.

If in equilibrium there is exactly one worker l in NW, then for all $i \neq l \in N$, $p_i = \bar{P}(n-1) = p_l$. Indeed, (i) $p_l \leq \bar{P}(n-1)$, otherwise l would also be in NW; (ii) $p_i \geq \bar{P}(n-1)$, otherwise l would optimally deviate to p_i^+ and get switched to IW, obtaining $\frac{p_i^+ c}{2p_i^+ - 1} > \frac{\bar{P}(n-1)c}{2\bar{P}(n-1)-1} = \frac{F(n)c}{F(n)-F(n-1)}$; (iii) $p_l \geq \bar{P}(n-1)$, otherwise i would optimally select $p_i < \bar{P}(n-1)$ (contradicting point (ii)), indeed by choosing p_l^+, i would be placed in IW and obtain $\frac{p_l^+ c}{2p_l^+ - 1} > \frac{pc}{2p-1}$ for all $p \geq \bar{P}(n-1)$; (iv) $p_i \leq \bar{P}(n-1)$, otherwise i could decrease p_i to $\bar{P}(n-1)^+$, stay in IW and get higher payoff. Moreover, by the same logic as in point (iv), in any equilibria where $NW = \emptyset$, $p_i = \bar{P}(n-1)$ for all $i \in N$.

Finally, the two described above are indeed equilibria of the game, and they both deliver to all workers an expected payoff of $\frac{cF(n)}{F(n)-F(n-1)}$ as in the benchmark. ■

Proof of Proposition 8

The following proof holds both for the additively separable case and when we allow for more flexible contracts. First, note that any increase in p_j when $j \in IW$ would not affect any other worker. Second note that even if $j \in NW$ an increase in p_j would not affect any lower-ranked worker in NW. All workers in IW are also unaffected by such change, with the only exception of the worker in IW with $l \in \arg\min_{j \in NW} p_j$. In particular, if p_i increases above p_l, l might be switched to NW if j is switched to IW (and if l is cheaper to incentivize in the highest rank of NW given $|IW|$). Thus l can only be worse off. Finally, consider the possible increase of the signal precision p_i of a worker $i \in NW$ and denote by r a higher-ranked worker within NW. If p_i increases above p_r and contracts are flexible, then i's ranking would decrease. If p_i increases so much that i is switched to IW, then strategic insurance rent of r would decrease. As a result, r would be worse off.[48] ■

6 Online Appendix

6.1 Mathematical Appendix

Proof of Proposition 9

In the high-trust benchmark (i.e., firm-preferred equilibrium), workers expect all their colleagues to work. Thus the firm solves $\min_W \sum E_S (W_i(S) | \mathbf{e}=\mathbf{1})$ subject to $E(W_i(S)|\mathbf{e}=\mathbf{1}) - E(W_i(S)|e_i=0, \mathbf{e}_{-i}=\mathbf{1}) \geq c$, $\forall i \in N$, where $S = \left(S^{team}, (S_i^{ind})_{i \in N}\right)$. For all $i \in N$ the optimal W_i^* must satysfy the constraint with equality. Let $W_i^1(S_{-j}) := W_i^*\left(S^{team}, S_{-j}^{ind}, S_j^{ind}=1\right)$, $W_i^0(S_{-j}) := W_i^*\left(S^{team}, S_{-j}^{ind}, S_j^{ind}=0\right)$, and define $W_i'(S) := p_j W_i^1(S_{-j}) + (1-p_j) W_i^0(S_{-j})$, which is independent of S_j^{ind}. Note $E(W_i'(S)|\mathbf{e}=\mathbf{1}) = E(W_i^*(S)|\mathbf{e}=\mathbf{1})$ and $E(W_i'(S)|e_i=0, \mathbf{e}_{-i}=\mathbf{1}) = E(W_i^*(S)|e_i=0, \mathbf{e}_{-i}=\mathbf{1})$. Thus, if W_i^* respects the constraint, also W_i' does, and entails the same expected cost. As a result, the firm never needs to rely on S_{-i}^{ind} to incentivize worker i. Thus, using our analysis in Section 2.2 to conclude that, in equilibrium, $W_i(S) = b_i' S^{team} S_i^{ind}(Z(S))$, where $Z(S)$ is such that $E\left(b_i' S^{team} S_i^{ind}(R(S))|\mathbf{e}=\mathbf{1}\right) = E\left(b_i S^{team} S_i^{ind} | \mathbf{e}=\mathbf{1}\right)$. So, the power of team incentives in the contract W_i is

$$\pi^{team}(W_i) := \frac{E(W_i(S)|\mathbf{e}=\mathbf{1}, S^{team}=1)}{E(W_i(S)|\mathbf{e}=\mathbf{1}, S^{team}=1) + E(W_i(S)|\mathbf{e}=\mathbf{1}, S^{team}=0)} = 1.$$

[48] In the case of additively separable payoffs, we consider equilibria where the relative ranking among the workers in $NW \setminus \{i\}$ is unaffected by changes in p_i. The same result arise if r is the highest rank or if we focus on the sum of the expected wages of all coworkers in NW.

Finally, we want to show that, under **RITW**, it is sometimes optimal to set $\pi^{team}(W_i) < 1$. Consider a team of two workers, $n = 2$. Under **RITW**, the firm needs to provide one worker with a salary such that

$$\min_{\mu\in[0,1]} \left(\begin{array}{c} \mu\left(E_S\left(W_i\left(S\right)|e_i=1,e_j=1\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=1\right)\right)+ \\ +\left(1-\mu\right)\left(E_S\left(W_i\left(S\right)|e_i=1,e_j=0\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=0\right)\right) \end{array} \right) \geq c$$

and the other with a salary such that

$$\min_{\mu\in[0,1]} \left(\left(E_S\left(W_i\left(S\right)|e_i=1,e_j=1\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=1\right)\right)\right) \geq c.$$

The second worker will be rewarded as in the firm preferred equilibrium with b_i^{both}. In the following, we are interested in the first worker.

Lemma 4. *In the optimum no agent i is rewarded when the $S_i = 0$, i.e. for all $i \in N$*

$$W_i\left(S^{team}, S_i^{ind}=0, S_j^{ind}\right)=0$$

Proof. To see this consider the firm's minimization problem for the first worker

$$\min_{W_i} E_S\left(W_i\left(S\right)|\mathbf{e}=\mathbf{1}\right) \qquad \text{subject to:}$$

$$\min_{\mu\in[0,1]} \left(E_{\mu,S}\left(W_i\left(S\right)|e_i=1\right)-E_{\mu,S}\left(W_i\left(S\right)|e_i=0\right)\right) \geq c, \text{ for all } i \in N$$

i.e.

$$\min_{\mu\in[0,1]} \left(\begin{array}{c} \mu\left(E_S\left(W_i\left(S\right)|e_i=1,e_j=1\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=1\right)\right)+ \\ +\left(1-\mu\right)\left(E_S\left(W_i\left(S\right)|e_i=1,e_j=0\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=0\right)\right) \end{array} \right) \geq c,$$

i.e.

$$\min \left(\begin{array}{c} \left(E_S\left(W_i\left(S\right)|e_i=1,e_j=1\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=1\right)\right), \\ \left(E_S\left(W_i\left(S\right)|e_i=1,e_j=0\right)-E_S\left(W_i\left(S\right)|e_i=0,e_j=0\right)\right) \end{array} \right) \geq c.$$

Suppose $W_i\left(S^{team}, S_i^{ind}=0, S_j^{ind}\right)>0$ and consider W_i' such that $W_i'\left(S^{team}, S_i^{ind}=0, S_j^{ind}\right) = 0$ and $W_i'\left(S^{team}, S_i^{ind}=1, S_j^{ind}\right) = W_i\left(S^{team}, S_i^{ind}=1, S_j^{ind}\right)$. This would trivially lead to lower expected payment for the firm; so we just need to show that the constraint will still hold, which is true, indeed

$$
\begin{aligned}
&E_S\left(W_i'(S)\,|e_i=1,e_j\right)-E_S\left(W_i'(S)\,|e_i=0,e_j\right)\\
&=\left(\begin{array}{c} p_iE_S\left(W_i'(S)\,|S_i^{ind}=1,e_j\right)+(1-p_i)\,E_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right)+\\ -\left((1-p_i)\,E_S\left(W_i'(S)\,|S_i^{ind}=1,e_j\right)+p_iE_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right)\right)\end{array}\right)\\
&=\left(\begin{array}{c} p_iE_S\left(W_i(S)\,|S_i^{ind}=1,e_j\right)+(1-p_i)\,E_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right)+\\ -\left((1-p_i)\,E_S\left(W_i(S)\,|S_i^{ind}=1,e_j\right)+p_iE_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right)\right)\end{array}\right)\\
&=\left(\begin{array}{c} E_S\left(W_i(S)\,|e_i=1,e_j\right)-E_S\left(W_i(S)\,|e_i=0,e_j\right)+\\ +(1-2p_i)\left(E_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right)-E_S\left(W_i(S)\,|S_i^{ind}=0,e_j\right)\right)\end{array}\right)\\
&>E_S\left(W_i(S)\,|e_i=1,e_j\right)-E_S\left(W_i(S)\,|e_i=0,e_j\right),
\end{aligned}
$$

where the last inequality follows from $p_i > \frac{1}{2}$ and the fact that, by construction, $E_S\left(W_i'(S)\,|S_i^{ind}=0,e_j\right) < E_S\left(W_i(S)\,|S_i^{ind}=0,e_j\right)$. □

So we can focus on contracts where each worker i receives no bounus if $S_i^{ind}=0$.

Second, we want to show that $W_i\left(S^{team}=0,S_i^{ind}=1,S_{-i}^{ind}\right)\neq 0$ under some parameter. Indeed suppose by contraposition that we could restrict our attention to contract such that $W_i\left(S^{team}=0,S_i^{ind}=1,S_{-i}^{ind}\right)=0$, Then, in such restricted optimum, we can assume that the firm simply select bonuses $b_i:=\left(b_i^z,b_i^{jt}\right)$, where $b_i^z\geq 0$ is the bonus that the worker receive when $S^{team}=1,S_i^{ind}=1$, and $S_j^{ind}=0$, and $b_i^{jt}\geq 0$ is the bonus that the agent receives when $S^{team}=1,S_i^{ind}=1$, and $S_j^{ind}=1$. In this case we can rewrite the firm problem as

$$
\min_b p_iF(2)\left((1-p_j)\,b^z+p_jb^{jt}\right)\qquad\text{subject to:}
$$

$$
\min_{\mu_i}\left(\begin{array}{c}\mu_i\left(p_iF(2)-(1-p_i)\,F(1)\right)\left((1-p_j)\,b^z+p_jb^{jt}\right)\\ (1-\mu_i)\left(p_iF(1)-(1-p_i)\,F(0)\right)\left(p_jb^z+(1-p_j)\,b^{jt}\right)\end{array}\right)=c
$$

Lemma 5. *There exist F,p_i,p_j such that the firm prefers providing i with individual performance bonuses only, rather than setting $W_i\left(S^{team}=0,S_i^{ind}=1,S_{-i}^{ind}\right)=0$.*

Proof. Consider $F(0)=0, F(1)=\lim_{x\to\infty}\frac{1}{x}, F(2)=1$, and $p_i=p_j=p\in\left(\frac{1}{2},1\right)$. Then

$$
\min_b p_iF(2)\left((1-p_j)\,b^z+p_jb^{jt}\right)\qquad\text{subject to:}
$$

$$
\min_{\mu_i\in[0,1]}\left(\begin{array}{c}\mu_i\left(p_iF(2)-(1-p_i)\,F(1)\right)\left((1-p_j)\,b^z+p_jb^{jt}\right)\\ (1-\mu_i)\left(p_iF(1)-(1-p_i)\,F(0)\right)\left(p_jb^z+(1-p_j)\,b^{jt}\right)\end{array}\right)=c
$$

can be rewritten as

$$
\min_b p\left((1-p)\,b^z+pb^{jt}\right)\qquad\text{subject to:}
$$

$$\min \begin{pmatrix} \left(p-(1-p)\lim_{x\to\infty}\frac{1}{x}\right)\left((1-p)\,b^{z}+pb^{jt}\right), \\ \left(p\lim_{x\to\infty}\frac{1}{x}\right)\left(pb^{z}+(1-p)\,b^{jt}\right) \end{pmatrix} = c.$$

Note that $\left(p\lim_{x\to\infty}\frac{1}{x}\right)\left(pb^{z}+(1-p)\,b^{jt}\right) < \left(p-(1-p)\lim_{x\to\infty}\frac{1}{x}\right)\left((1-p)\,b^{z}+pb^{jt}\right)$. Thus, either b^{z} or b^{jt} need to go to infinity as $x \to \infty$, implying that also the expected payment $p_iF\,(2)\left((1-p_j)\,b^{z}+p_jb^{jt}\right)$ goes to infinity. As a result, the firm can be better off by inducing one of the two agents to work using individual performance bonus only. In that case, indeed, the expected payment would be $p\frac{c}{2p-1}$ which is less than infinity for any fixed $p \in (0,1)$. □

In light of this lemma we can conclude that setting $W_i\left(S^{team}=0, S_i^{ind}=1, S_{-i}^{ind}\right) = 0$ would be suboptimal under certain parameters. Thus, under trust concerns, there exist F, p_i, and p_j such that the optimal contract structure W is characterized by

$$\pi\left(W_i\right) := \frac{E\left(W_i\left(S\right)|\mathbf{e}=\mathbf{1}, S^{team}=1\right)}{E\left(W_i\left(S\right)|\mathbf{e}=\mathbf{1}, S^{team}=1\right)+E\left(W_i\left(S\right)|\mathbf{e}=\mathbf{1}, S^{team}=0\right)} < 1.$$

■