Limiting the Leader: Fairness Concerns and Opportunism in Team Production

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Abstract

We use a laboratory experiment to investigate the extent to which leaders—faced with opportunistic incentives—employ monitoring to improve team production. Participants are assigned to teams, with one person appointed as the leader. The leader has the power to commit to a monitoring option, which replaces the default equal sharing rule with one that distributes team revenue in proportion to individual investments. Additionally, the leader can announce a claim to a portion of the team revenue, which is paid before shares are distributed. The resulting game possesses multiple equilibria involving monitoring and full investment, characterized by the largest claim the non-leaders are willing to tolerate by the leader. We appeal to behavioral considerations in order to select among the multiple equilibria, providing sharper predictions that pivot around the notion that non-leaders limit the leader to a 'fair claim'. In the experiments, leaders are only moderately successful at increasing team production as they claim too much or forgo the monitoring option too often, especially when it is costly to monitor. Still, when there is no cost of monitoring, nearly half of the leaders successfully increase team production towards full investment, by relying on constant monitoring and resisting the temptation to issue unfair claims. These results highlight the potential for opportunistic incentives to undermine efficiency-enhancing leadership, even when the leader can commit to her decisions.

Keyword: leader, monitoring, team production, fairness, free-riding, experiment

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1 Introduction

A fundamental feature of most organizations is that they rely in some way on teams. Accordingly, team production has occupied a prominent position as part of the classical theory of the firm (Alchian and Demsetz, 1972). The benefits of organizing production in teams may be the result of complementarities, specialization, or economies of scale. However, much of the interest in team production focuses on the classical incentive problem that arises when team output is observable, but individual efforts are not. More specifically, individual team members face the incentive to free ride if they are compensated based on team output rather than individual effort (Alchian and Demsetz, 1972; Holmstrom, 1982).

There is a vast literature that has offered and analyzed various solutions to this moral hazard problem in teams. Alchian and Demsetz (1972) argue that the problem can be resolved by hiring a principal (or manager), who becomes a residual claimant, to monitor the individual effort of the team members. This allows the organization to condition rewards on individual effort, thereby resolving the free-rider problem. However, if the residual claimant lacks the power to commit to a specific incentive scheme, there is a second-order problem; the principal may be tempted to limit the distribution of proceeds among team members, so as to retain a larger residual claim. The mere possibility of such opportunistic behavior by the principal may undermine team members' investment incentives. Moreover, even when the principal can commit to an incentive scheme, the potential efficiency gains from proportional sharing may bestow enough bargaining power on her to support the retention of a larger residual claim.

In this paper, we study behavior in a team production environment where one of the team members, designated as the team leader, can unilaterally invest in monitoring. The monitoring technology, which may be costly, alters the distribution of team revenue among group members, from an equal sharing rule to a proportional sharing rule. This transforms the team production environment from a classical social dilemma (or collective action problem) into one where team members have strong incentives to supply full effort. At the same time, the leader can also claim or appropriate funds out of the team revenue prior to the distribution of proceeds. This introduces an obstacle to successful self-governance within teams, even with monitoring in place, as the leader is faced with the temptation to claim a larger part of the surplus gain for herself, while the non-leaders would prefer to limit the leader's claim.

We model the problem as a two-stage game played by a team with an exogenously appointed leader. In a series of laboratory experiments, we examine the extent to which leaders successfully use monitoring to improve team production. In the first stage of the game, the leader announces a claim to a portion of the team's revenue and chooses whether or not to adopt the monitoring option that implements proportional rather than equal sharing of the remaining revenue. In principle, the claim allows the leader to use some of the revenue to cover the cost of the monitoring option (when it is adopted), but the leader is not restricted in her claim. In the second stage, aware of the leader's monitoring and claim decisions (as well as the implications of those decisions for how revenue is shared), each of the team members (including the leader) chooses how much of an endowment to invest in team production, keeping the remainder for their own private consumption. Investments are amplified by a multiplier term, generating surplus gains relative to the total endowment of resources.

In the model and experiments, we endow the leader with a certain degree of commitment power, by making both the monitoring and claim decisions enforceable in the second stage. As such, the interaction also resembles a bargaining situation, in which the leader proposes a lump-sum payment for herself and a sharing rule for any remaining proceeds. When monitoring is not chosen, team revenue is distributed equally among the team members and the second stage takes the familiar form of a linear public goods game with strong free-riding incentives for the non-leaders. In contrast, provided the cost of monitoring is not too large, the proportional incentives facilitated by the monitoring option provide team members with strong individual incentives to invest the full endowment in team production. As such, there are potentially large surplus gains that can be generated by shifting to the proportional sharing rule through monitoring, even if the monitoring option is costly to adopt.

Matters are potentially more complicated by the leader's ability to appropriate a portion of the team revenue before it is distributed. This appropriation power captures the essence of the residual claimant status of the central monitor in Alchian and Demsetz (1972). On the one hand, because the leader is uniquely responsible for choosing the incentive structure, there is a case to be made that she is entitled to a larger share of the surplus gain than the other members of the team. From a bargaining perspective, the leader may lay claim to a significantly larger cut than the others, who lack the authority to invest in the monitoring option. On the other hand, the other team members are not entirely without bargaining power. In particular, non-leaders may collectively attempt to limit the leader's claim to a level that is closer to the cost of monitoring.

We derive theoretical predictions for the two-stage game, assuming that players are standard, own-payoff maximizing agents. The formal details are provided in Appendix A. The main challenge is that there is a continuum of equilibria, with different equilibria corresponding to how large a claim the non-leaders are willing to accede to the leader. For instance, at one extreme, there is an equilibrium in which the leader extracts all of the surplus gain; at the other extreme, there is an equilibrium in which the non-leaders restrain the leader's claim considerably, resulting in a more equitable division of the surplus gain. Nevertheless, there are salient behavioral considerations that we appeal to as a means of selecting from the set of multiple equilibria. We concentrate on considerations of fairness as the basis for equilibrium selection and examine the issue empirically, by means of a controlled laboratory experiment.

In the experiment, subjects are placed into teams consisting of four members, then play 20 periods of the two-stage linear team production game. We implement two main treatments—NoCost (where the cost of monitoring is $c = 0$) and Cost-20 (where $c = 20$)—in which one team member is randomly assigned to the role of team leader before the first period. In addition, we conduct a third treatment (Threshold), in which there is no explicit leader and thus no first stage monitoring or claim decisions to be made. Instead, the monitoring option is automatically implemented whenever the revenue generated exceeds the *threshold* that is sufficient to cover the cost, $c = 20$.[1] In this treatment, both full investment and full free-riding

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[1] Our Threshold treatment can be viewed as a sort of "idealized" setting where there is an "unseen" leader

are equilibrium investment profiles, although the former is Pareto superior to the latter. Since this third treatment alters two features of the environment at once, we refrain from referring to it as a *control* or *baseline* treatment. Nevertheless, it serves as a point of comparison for our two main treatments, since the setup represents a sort of "idealized" institution in which high levels of investment are the most likely outcome.

Our main experimental findings are as follows. First, team leaders in our two main treatments are only moderately successful at increasing team production, especially when monitoring is costly. Fairness considerations appear to play a pivotal role in determining how high a claim the non-leaders are willing to tolerate. Average group investment is significantly higher with monitoring than without it, in line with the incentives provided by the respective sharing rules. However, there are striking differences between investment levels under monitoring based on the fairness of the leader's claim. When the claim exceeds the relevant "fair" threshold, investment by the non-leaders collapses relative to the level of investment supplied when the claim is below the fair threshold, suggesting that fairness concerns empower the non-leaders to limit the leader's claim.

In our NoCost treatment, just below half of the team leaders successfully increase investment in team production towards the efficient level. In these "successful" groups, leaders nearly always use monitoring and issue claims that are strictly positive, but below the fair threshold. In contrast, leaders in "unsuccessful" groups either claim too much or forgo the monitoring option too often. In contrast, less than a quarter of the teams in our Cost-20 treatment are successful at increasing team production. In this case, the main reason for the lack of success is that many of the team leaders rarely adopt the (costly) monitoring option. In part, this may also reflect the strategic uncertainty faced by the leader when monitoring is costly; if the leader does not correctly anticipate how large a claim the non-leaders are willing to permit, her payoff may be substantially reduced by selecting the costly monitoring option, steering behavior towards an inefficient equilibrium in which the leader elects to forgo the monitoring option in favor of a lucrative outside option.

As expected, in the Threshold treatment, average investment increases rapidly towards the Pareto-superior, full investment prediction. Thus, when the team members can dictate the adoption of the monitoring option themselves (via their collective investment), the fact that monitoring is costly and reduces their team revenue does not impede convergence to the provision of full investment. The comparison with the main treatments helps to highlight that allowing the leader to appropriate funds beyond the cost of monitoring can prevent teams from taking advantage of the efficiency-enhancing properties of the proportional sharing rule.

Related Literature. Our study is related to a rich body of work examining institutions designed to improve efficiency in collective action problems. These include communication (Dawes et al., 1977; Isaac and Walker, 1988; Bochet et al., 2006), monitoring (Carpenter et al., 2018;

(whether a member of the team or an external actor) who has pre-committed to an enforceable contract specifying the automated implementation of the monitoring option (given sufficient revenue) and specifying a claim equal to the cost.

Nicklisch et al., 2021), sanctions and rewards (Ostrom et al., 1992; Fehr and Gächter, 2000; Bochet et al., 2006; Carpenter, 2007; Sefton et al., 2007; Nikiforakis and Normann, 2008; Egas and Riedl, 2008; Gürerk et al., 2009), taxes and subsidies (Falkinger, 1996; Falkinger et al., 2000; Guillen et al., 2015), rank-order competition (Nalbantian and Schotter, 1997; Angelovski et al., 2019), electoral delegation (Hamman et al., 2011), team contests (Bandiera et al., 2013; Guillen et al., 2015), and "leading-by-example" (Hermalin, 1998; Meidinger and Villeval, 2002; Moxnes and van der Heijden, 2003; Güth et al., 2007; Levati et al., 2007; Potters et al., 2007; Gächter et al., 2012; Cappelen et al., 2016).[2] A related recent study by Cappelen et al. (2016) examines the voluntary provision of public goods in a setting where participants can volunteer to be a leader-by-example. They exogenously manipulate the level of compensation awarded to the leader and find that moderate compensation is most beneficial for the group; if the leader's compensation is too large, it results in more free-riding and leads to a "social crowding-out effect". Our study is differentiated from theirs in (at least) two important ways; (i) the leader does not "lead-by-example" (choosing her investment before others), but rather determines the sharing rule for team revenue, and (ii) the compensation is effectively chosen by the leader, rather than being determined exogenously by the experimenter.[3] However, our finding that non-leaders collectively respond with low investment to excessive or unfair claims by the leader complements the crowding out effect observed by Cappelen et al. (2016) when leader compensation is (exogenously) higher.

Of equal relevance to our setting is the literature investigating team production (and other collective action environments) with a leader who controls the allocation of team output. Early examples of this kind of leadership are examined in Güth et al. (2007) and Rivas and Sutter (2009). In Güth et al. (2007), the leader had the power to exclude one member from the group in the next round after observing individual contributions. Rivas and Sutter (2009) compared the same to a setting where the leader could reward one of the team members (at the expense of all others). More recent work has allowed the leader more direct control over the distribution of team revenue. For instance, Stoddard et al. (2014) and Stoddard et al. (2021) examine an "allocator mechanism" in which a third party allocator has discretion to assign shares of the collective good among the team members.[4] However, the allocators in their settings are not residual claimants and as such, do not face any opportunistic incentives.[5] In these studies, the authors examine whether the allocators are able to implement efficiency-enhancing allocation rules (including those that make full investment a dominant strategy). In contrast, the motivation behind our investigation concerns the potential impact of opportunism on the leader's ability to improve team performance.

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[2] Also related to these institutional remedies is the literature studying leadership in coordination games, (see, e.g., Brandts et al., 2015, who compare leader communication with incentive increases in a weak-link coordination game, with both elected and randomly appointed leaders.).

[3] We also do not allow players to volunteer to be the leader. Furthermore, teams interact for multiple periods in our experiment, in contrast with the one-shot nature of the interactions (via random rematching between periods) in Cappelen et al. (2016).

[4] Stoddard et al. (2014) allow the allocator to choose from among a set of alternative allocations, while Stoddard et al. (2021) allow, in addition, for the leader to choose any distribution.

[5] Instead, the allocator's compensation is tied to, but separate from, the level of team output.

More closely related to this motivation, van der Heijden et al. (2009) show that in a game with binary actions (work or shirk) and effort complementarities, team leaders resist the temptation to over-appropriate team output for themselves. Thus, relative to a setting with equal sharing of team revenue, the introduction of a team leader with the power to distribute revenue significantly curtails free-riding and improves team performance. Drouvelis et al. (2017) also compares an equal sharing mechanism with a hierarchical mechanism in which team output is allocated by a leader. They find similar improvements in the performance of teams with a leader—both with homogenous and heterogeneous worker types—but the efficiency gains accrue almost entirely to the leader. In a follow-up study, they show that when team members are able to determine how much of the team revenue the leader controls, they tend to restrict the leader to less than half of the proceeds.

Most of the studies mentioned above provide the leader with full discretion to determine the allocation of team revenue. This flexibility allows for a wide range of distribution schemes, with varying incentive properties.[6] One drawback of this flexibility is that it widens the scope for leaders to implement unusual or even perverse incentive structures that complicate the team production decisions. In order to avoid the possibility that leaders fail to identify productivity-enhancing incentive schemes or implement perverse incentives,[7] we simplify the leader's decision. In our model, the leader simply makes a binary decision, to invest in the monitoring option or not. Thus, the effect of the monitoring option is simply to make individual efforts contractible, thereby permitting the implementation of a proportional sharing rule in place of the default equal sharing rule. This allows us to focus more directly on the leader's claim decisions, and the response to such claims by the non-leaders, both with and without monitoring.

Moreover, the particular sharing rule in place is known to the team members before they choose their effort investments.[8] Likewise, the claim is announced *before* investment decisions, rather than made contingent on the team revenue. The timing of decisions in our model is more closely related to Grosse et al. (2011) and Balafoutas et al. (2013). The focus in Balafoutas et al. (2013) is very different from ours. They assign unequal endowments to group members in order to examine the conflict between the equal sharing rule, which promotes equality but does not provide incentives for full investment, and the proportional sharing rule, which promotes efficiency through incentives, but results in highly unequal earnings. Their main objective is to investigate the tradeoff between concerns for equity and efficiency.[9] There is, however, no leader in their teams, nor do the ideas of costly monitoring or appropriation factor into their environment.

In Grosse et al. (2011), the authors examine a team production game where players can vote on whether to employ an external monitor (who retains a fixed share of team output) or rely

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[6] For instance, a leader with full discretion could choose to reward low contributors and punish high contributors, or assign different shares to team members who contributed the same amount of effort. This would obviously not promote the provision of effort.

[7] For instance, see the discussion of "rogue" allocators in Stoddard et al. (2021).

[8] The leader commits to the sharing rule, which is typically not the case in other experimental studies where the leader observes investment decisions first, then chooses how to allocate the resulting team revenue.

[9] They also provide some evidence that the source of endowment inequality - whether it is earned or arbitrarily assigned - affects subjects' preferences for equality over efficiency.

on peer monitoring, which suffers from a second-order free-riding problem. Monitoring is costly, but provided players (or the external monitor) invest in enough monitoring, team members are compensated based on their individual efforts, as in a proportional sharing rule. As such, when the teams rely on the external monitor, they know precisely how the team revenue will be distributed, as well as the cost (the share of revenue) that must be paid to the external monitor. Two main features differentiate our model from theirs; (i) the leader in our setting is an exogenously appointed team member, rather than an external monitor, and (ii) our leader is permitted to choose their claim, whereas Grosse et al. (2011) assumes that the external monitor receives a fixed share of team output. Furthermore, our objectives are, while complementary, different from theirs. While Grosse et al. (2011) focuses on whether or not teams can successfully rely on peer monitoring, rather than an external monitor, we focus on the effect of the leader's opportunistic incentives on the team's ability to improve cooperation.

To summarize, while there is an excellent mixture of prior work examining leader-determined monitoring and variation in group incentives, our study is novel in several dimensions. We simplify one aspect of the leader's decision, allowing her to select *and commit to* one of two predefined incentive schemes (equal sharing or proportional sharing), in order to focus on the other aspect—her restraint in the face of opportunism. In conjunction with this focus, we are also able to prioritize our understanding of the extent to which other team members act as a check upon the leader's assumed power. Indeed, it seems that non-leaders do not typically stand for exploitative claims by their leaders, although they are generally willing to tolerate claims that result in higher payoffs for the leader, provided those claims are consistent with considerations of fairness.

The remainder of the paper is organized as follows. Section 2 describes the experiment, briefly outlines the theoretical framework, and derives our main experimental hypotheses. The results are reported and discussed in Section 3, focusing first on aggregate treatment comparisons, then on the role of fairness concerns, and finally on group-level heterogeneity. We provide concluding remarks in Section 4.

2 Experimental Design & Procedures

2.1 Design

In the experiment, subjects were randomly divided into teams with $n = 4$ members. At the beginning of the game, one player in each team was randomly assigned to the role of the *team leader*. Then each team played 20 periods of the two-stage linear team production game, described below, according to a partners matching protocol with fixed roles.

The Linear Team Production Game. Each of the $n = 4$ members of the team receive an endowment of resources (think "time" or "effort"), $\omega = 20$. Team members decide simultaneously how much to invest in the production process, e_i, and consume anything not invested. Total group investments, equal to the sum of each team member's investment, are multiplied by a return factor $A \in (1, n)$, such that team revenue is given by $R = A \cdot \sum_{i=1}^{n} e_i$. In the experiment, we set $A = 1.6$.[10] Let $i = L$ denote the *team leader*. We refer to the other players as *non-leaders*. The game proceeds in two stages. Investment decisions are made in the second stage, by all four members of the team (including the leader, L). Only the leader makes any decisions in the first stage.

In Stage 1 of the game, the leader makes two decisions. The first is to choose a claim, $x \geqslant 0$, to be subtracted from the team revenue *before* it is distributed among the team members.[11] The second decision is whether or not to adopt a (possibly costly) monitoring option. Let $m \in \{0,1\}$ denote the leader's monitoring decision. If the monitoring option is selected ($m = 1$), team revenue (after paying the leader's claim, x) is distributed according to a proportional sharing rule, with each player's share of the remaining revenue being proportional to his own investment as a share of the total investment of all players. If the monitoring option is not selected ($m = 0$), each team member receives an equal share of the remaining revenue, regardless of how much he invests in team production. The team leader has full commitment power so that the claim x and the monitoring decision m are both credible and enforceable in the second stage.

At the beginning of Stage 2, all players observe the team leader's Stage 1 decisions, (x, m). Then, each team member i (including $i = L$) chooses an investment $e_i \in [0, \omega]$.[12] Total investment and team revenue are calculated as above and, before anything else, the team leader's claim x is paid out of the team revenue. If $R < x$, then the claim is only partially paid, by allocating all of the revenue to the leader. Otherwise, the remaining team revenue, $R - x$, is distributed according to the revenue sharing rule dictated by the leader's monitoring decision, m. That is, if $m = 0$, each team member receives an equal share, $S_i^0(e_i, e_{-i}) = 1/n$ of the remaining team revenue; if $m = 1$, each team member receives a share proportional to her own investment, $S_i^1(e_i, e_{-i}) = e_i/(\sum_j e_j)$.

Players' payoffs include any endowment not invested and their share of the revenue generated by the team (after paying the leader's claim). In addition, the team leader receives the claim (partial if it exceeded actual team revenue) and pays a cost of c if she chose to monitor. We assume that c is fixed and common knowledge among all players. Formally, the material payoff for each non-leader $i \neq L$ is given by

$$\pi_i = \begin{cases} 20 - e_i & \text{if } R < x \\ 20 - e_i + S_i^m(e_i, e_{-i})(R - x) & \text{if } R \geqslant x \end{cases}. \qquad [1]$$

Meanwhile, for the team leader, $i = L$, the material payoff is given by

$$\widehat{\pi}_L = \begin{cases} 20 - e_L + R - mc & \text{if } R < x \\ 20 - e_L + x - mc + S_i^m(e_L, e_{-L})(R - x) & \text{if } R \geqslant x \end{cases}. \qquad [2]$$

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[10] This return corresponds to a marginal per capita return of 0.4 under the equal sharing rule, which is comparable to the usual assumption in linear public goods experiments.

[11] Given the parameters of the game in the experiment, the maximum possible team revenue is $R_{max} = 128$. Therefore, we allowed team leaders to choose any integer claim, $x \in [0, 128]$.

[12] In the experiment, subjects could choose any integer investment from 0 to 20, inclusive.

Feedback and timing. At the end of the period, all subjects were given feedback about their own investment, the total group investment and the resulting team revenue, the team leader's claim and the remaining team revenue (if any), their share of the remaining team revenue, and their overall payoff for the period. Importantly, to avoid any informational differences between the players, the team leader was *not shown* the individual investments of other team members when she selected the monitoring option.[13] Thus, the decision to adopt the monitoring option served only to change the revenue sharing rule from equal sharing to proportional sharing.

2.2 Treatments

We consider two main treatments in our experiment. In the NoCost treatment, the cost of the monitoring option is $c = 0$, while in the Cost-20 treatment, $c = 20$. In both treatments, c is common knowledge among players and fixed across all periods. In addition to these two main treatments, we also consider a third treatment, Threshold, in which there is no explicit leader. Treatment variation is between subjects.

In the Threshold treatment, we simulate a setting where the monitoring option is automatically implemented whenever total investment generates team revenue above a *threshold* that is sufficient to cover the cost c. That is, if $R \geqslant c$, the monitoring option is automatically implemented, the cost c is paid out of team revenue, and the remaining team revenue, $R - c$, is distributed proportionally to individuals' investments. However, if $R < c$, the monitoring option is not implemented, the cost c is not incurred, and all team members receive an equal share of the team revenue, R, regardless of their investment. For the Threshold treatment, the cost, $c = 20$, is common knowledge and fixed across all periods.

2.3 Session Procedures

We conducted a total of 9 sessions at the XS/FS Laboratory at Florida State University (FSU). A summary of the sessions and independent groups for each treatment is provided in Table 1. The experiment was programmed and implemented using z-Tree (Fischbacher, 2007). A total of 176 subjects (63.1% of them female, 24/48 in Threshold, 42/64 in NoCost, 45/64 in Cost-20) were randomly recruited via ORSEE (Greiner, 2015) from a subpopulation of FSU students pre-registered to receive announcements about upcoming experiments. Each session lasted approximately 75 minutes and participants earned, on average, \$16.39 (including a \$7.00 show-up fee).

There were two main parts to each session. In Part 1, which was the same across all treatments, we elicited a basic measure of each subject's preference for fairness using a standard Dictator game. Each subject was given an endowment of \$2.00 and asked to decide how much to allocate to a randomly selected other participant.[14] Then in Part 2, the subjects played the

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[13] This is consistent with a setting where the leader can hire an outside party to monitor and implement the sharing rule, without observing individual efforts herself.

[14] While all subjects made the decision as the dictator, they were also the random recipient for another subject's decision. Each subject was informed that the participant choosing how much to give to him was different from the recipient to his own decision, and that the probability that he would be paid as the dictator vs. as the recipient

Table 1. Summary of experimental treatments.

Treatment	Leader	Cost, c	Sessions	Groups	Subjects
NoCost	Yes	0	4	16	64
Cost-20	Yes	20	3	16	64
Threshold	No	20	2	12	48
Total	–	–	9	44	176

two-stage team production game for 20 periods. Instructions for Part 2 were distributed and read only after Part 1 was completed. At the end of the instructions, subjects participated in two practice stages (with no interaction) to familiarize themselves with the interface and the calculation of payoffs.[15] A copy of the instructions is provided in Appendix C.

2.4 Theoretical Framework

In this section, we first provide a characterization of the equilibrium predictions for the two-stage linear team production game. A more detailed treatment is relegated to Appendix A. We then describe several potential behavioral concerns that we anticipate may influence subject behavior in the experiments and which allow us to formulate more precise experimental hypotheses.

Equilibrium predictions. Since the game consists of two stages with perfectly observed Stage 1 actions, we use subgame perfect equilibrium (SPE) as our solution concept. Each pair of first-stage decisions by the leader generates a distinct subgame. Thus, we first characterize sequentially rational (Nash equilibrium) play in each such subgame.

Observation 1. *In any subgame where $m = 0$, all of the non-leaders invest zero.*

Observation 1 follows from the fact that non-leaders have a dominant strategy incentive to free ride when the equal sharing rule is in place ($m = 0$). In turn, the leader should invest her full endowment, $\omega = 20$, and claim all of the revenue resulting from her own investment, meaning $x \geqslant A\omega = 32$. Therefore, assuming sequentially rational play, the leader's payoff from $m = 0$ is given by $\widehat{\pi}_L = A\omega = 32$.

The case of $m = 1$ is more complicated. This may seem surprising given that, standing on its own, the proportional sharing rule has a simple dominant strategy of full contribution by all players. The wrinkle in our game comes from the a priori claim, x, the leader is entitled to make on the team revenue. Intuitively, by making this claim—which must be paid first—the

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was 0.5. Information and payoffs from this part were withheld until the end of the experiment, so as to avoid any wealth effects.

[15] In each practice stage, a subject could enter hypothetical choices for all of the players in a group (including a claim for the leader). For the first practice stage, we simulated the leader's decision NOT to select the monitoring option. The second practice stage implemented the monitoring option. After entering their hypothetical choices, subjects were shown the full calculation of earnings for each of the hypothetical group members. In the Threshold treatment, the practice stages simply allowed the subjects to enter hypothetical choices for all of the players in a group, with no mention of claims or leaders.

leader is setting the parameters for a type of endogenous threshold game. It is not surprising that threshold public goods games have multiple equilibria. However, as we will show below, this is not everywhere a problem. If the leader claims “too much”, the claim swamps any possible gains from cooperation, and a single equilibrium results in the associated subgame. Likewise, if x is modest enough, it has no effect and the standard full contribution equilibrium is unique in the associated subgame. However, in a critical intermediate range, the endogenous threshold nature of the claim has traction, and indeed multiple equilibria are the result. We explain these cases in more precise detail in the next three observations.

Observation 2. *In any subgame where* $m = 1$ *and* $x > 48$*, there is a unique Nash equilibrium (NE) in which* $e_L^* = 20$ *and* $e_i^* = 0$ *for* $i \neq L$*.*

Intuitively, whenever the leader claims more than the maximum possible surplus gain generated by monitoring, $n(A-1)\omega = 48$, the dominant strategy for any non-leader is similarly to invest zero. Again, the leader should invest her entire endowment (which grows to $A\omega = 32$) since it is less than her claim, and all of the revenue accrues (via the claim) to the leader. The resulting payoffs are $\widehat{\pi}_L = 32 - c$ (since $m = 1$) for the leader and $\pi_i = 20$ for all $i \neq L$.

Observation 3. *In any subgame where* $m = 1$ *and* $x \leqslant 24$*, there is a unique NE in which* $e_i^* = 20$ *for all* i*.*

At the other extreme, when the leader’s claim is sufficiently low—such that $x \leqslant 2\omega(A-1) = 24$—the effort incentives provided to the non-leaders by the proportional sharing rule motivate full investment, $e_i = 20$. It’s straightforward to show that the leader’s payoff, in this case, is equal to $\widehat{\pi}_L = 32 - c + 0.75x$, which is increasing in x. As such, a claim of $x = 24$ dominates any lower claim whenever the monitoring option is selected ($m = 1$).

The remaining case to consider is the one in which $m = 1$ and the claim x is between 24 and 48. In this case, due to the linearity of the team production problem, there are two NE in the corresponding subgame.

Observation 4. *For any subgame in which* $x \in [24, 48]$ *and* $m = 1$*, there are two NE.*

(i) *Full investment, where* $e_i = 20$ *for all* i*;*

(ii) *Non-leader free-riding, where* $e_i = 0$ *for all* $i \neq L$ *and* $e_L = 20$*.*

Since there are multiple NE in this last case, the characterization of subgame perfect equilibria in the two-stage game depends on how we specify the NE at these Stage 2 subgames. Key to the characterization is to pin down the *highest claim for which the non-leaders play according to the full investment NE*, which we denote by $\widehat{x}$. Note that by the above observations, $\widehat{x} \in [24, 48]$.

Conditional on specifying the full investment NE at some claim x, the leader’s payoff, $\widehat{\pi}_L = 32 - c + 0.75x$, is strictly increasing in x. Therefore, the leader will always prefer to increase her claim, provided that the non-leaders continue to invest their endowments at the higher claim. It follows that, whenever $m = 1$, the leader’s optimal claim is to choose $x^* = \widehat{x}$.

The final step to characterizing the subgame perfect equilibrium predictions is to consider the optimal monitoring decision in the first stage. As noted above, sequentially rational play implies payoffs to the leader of $\widehat{\pi}_L = 32$ when choosing $m = 0$ (coupled with a claim $x \geqslant 32$), and payoffs of $\widehat{\pi}_L = 32 - c + 0.75\widehat{x}$ when choosing $m = 1$. It's clear to see that the latter dominates the former if and only if $c \leqslant 0.75\widehat{x}$, or $\widehat{x} \geqslant 4c/3$. We formalize these results in the following proposition.

Proposition 1. *Fix any* $\widehat{x} \in [24, 48]$.

- *(a) If* $\widehat{x} \geqslant \frac{4c}{3}$*, there is a subgame perfect equilibrium in which*
    - *(i) the team leader chooses the claim* $x^* = \widehat{x}$*, and chooses the monitoring option,* $m = 1$*;*
    - *(ii) all players choose investments* $e_i^* = \omega$ *on the equilibrium path and in all subgames with* $m = 1$ *and* $x < \widehat{x}$*;*
    - *(iii) non-leaders invest nothing in subgames with* $m = 0$ *and in subgames with* $m = 1$ *and* $x > \widehat{x}$.
- *(b) In contrast, if* $\widehat{x} < \frac{4c}{3}$*, there is a subgame perfect equilibrium in which*
    - *(i) the team leader claims* $x^* = 32$*, chooses not to monitor,* $m = 0$*, and invests* $e_L^* = 20$ *in all subgames;*
    - *(ii) non-leaders invest*
        - ∗ *nothing on the equilibrium path, and nothing in any subgame corresponding to* $x > \widehat{x}$*,*
        - ∗ *everything* ($e_i^* = 20$) *at off-path subgames where* $x \leqslant 24$*, and*
        - ∗ *either all invest nothing, or all invest everything for* x *between* 24 *and* $\widehat{x}$.

Summarizing, there exists a continuum of SPE in the two-stage game, corresponding to the different possible values of $\widehat{x}$. Intuitively, if non-leaders are extremely permissive, meaning $\widehat{x}$ is close to the upper bound of 48, the leader will extract much more of the efficiency gains generated by introducing proportional sharing in place of the equal sharing rule. Conversely, if non-leaders are strict in limiting the leader's claim, meaning $\widehat{x}$ is closer to the lower bound of 24, then the leader will enjoy a lower share of the surplus gain in equilibrium. Indeed, when the non-leaders are especially strict, such that $\widehat{x}$ is below $4c/3$, the leader finds it more profitable to forgo the monitoring option altogether, taking her effective outside option of 32, which she obtains by investing her own endowment and claiming all of the resulting surplus for herself.

In our NoCost treatment ($c = 0$), every SPE involves full investment, with the team leader choosing $m = 1$, and claiming $x = \widehat{x}$.[16] In the Cost-20 treatment ($c = 20$), there are two cases. When $\widehat{x} \in [26.66, 48]$, the same class of SPE arise as in NoCost (i.e., $m = 1$, $x = \widehat{x}$, full investment). However, when $\widehat{x} \in [24, 26.66]$, the SPE involves the team leader choosing $m = 0$, claiming $x \geqslant 32$, and investing everything, while all non-leaders invest nothing. Despite the multiplicity problem, we provide below considerably sharper predictions for our experiments, by appealing to behavioral concerns for fairness as a basis for equilibrium selection.

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[16] This follows from the fact that $3\widehat{x}/4 > c = 0$ for all $\widehat{x} \in [24, 48]$.

2.4.1 Predictions for the Threshold treatment

Before presenting our more specific experimental hypotheses, we also describe predictions for the Threshold treatment. Recall that there is no explicit team leader in Threshold. Instead, the monitoring option is automatically implemented when total investment exceeds the cost, $c = 20$. Thus, the resulting game consists of just one stage, in which each team member simultaneously chooses how much to invest.

In this setting, there are two Nash equilibria. First, there is a free-riding equilibrium in which every team member invests zero.[17] Nevertheless, there is another Nash equilibrium, in which every player invests the full endowment. To see this, note that investing everything becomes a best response as long as there is at least one other player who invests everything, due to the return $A = 1.6$ and the automatic introduction of proportional incentives. Furthermore, this Nash equilibrium Pareto dominates the free-riding equilibrium, generating symmetric equilibrium payoffs of $\pi_i^* = A\omega - \frac{c}{n} = 27$, rather than $\pi_i^* = \omega = 20$. As such, we predict that subjects in the Threshold treatment will play the Pareto superior Nash equilibrium.

Hypothesis 1. In the Threshold treatment, every player invests the full endowment. As a result, the monitoring option is always triggered.

2.4.2 Behavioral Considerations for the Main treatments

Due to the multiplicity of equilibria for our two main treatments, the equilibrium analysis outlined above does not provide much guidance with regard to forming experimental hypotheses. However, as we discuss next, there are behavioral considerations that may be invoked as a basis for selecting among the various equilibria.

In our experiments, the question of how large a claim the non-leaders are willing to allow the leader, $\widehat{x}$, before withdrawing their investments, is an empirical one. Higher values of $\widehat{x}$ correspond to more permissive equilibrium behavior by the non-leaders, and thus the equilibrium payoffs are increasing in $\widehat{x}$ for the leader, and decreasing in $\widehat{x}$ for the non-leaders. In this respect, the setting resembles a bargaining situation in which the leader proposes a division of the potential surplus gain (from full investment) between herself and the non-leaders. Unlike many standard bargaining situations (e.g., the ultimatum game), the leader does not necessarily hold all the bargaining power in our setting. Non-leaders have some power to coordinate on a relatively low $\widehat{x}$, limiting the disparity between the surplus gain that accrues to the leader and the gains that accrue to the non-leaders. That is, the collective decision to "reject" a particular claim $x \in [24, 48]$ is sequentially rational, without needing to augment players' intrinsic preferences with any form of inequality aversion, efficiency concern, or reciprocity.

In the laboratory setting, team leaders may be faced with considerable strategic uncertainty regarding the highest claim that the non-leaders are willing to tolerate before withdrawing their

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[17] Consider an individual player i and suppose everyone else is investing nothing. It is straightforward to show that investing any amount strictly between 0 and 20 is strictly dominated, either by investing nothing, or by investing everything (20). However, the payoff from investing everything when others invest nothing is $A\omega - c = 12$, while investing nothing guarantees a payoff of 20. Thus, there can be no equilibrium in which only one team member invests a positive amount.

investment. For instance, if a leader claims too much, such that the non-leaders decline to invest, and if monitoring is costly, then the leader's payoff may fall below what she could obtain by choosing not to monitor in the first place. In other words, claiming too much—even with proportional incentives in place—may harm the leader's payoff as she discourages the non-leaders from contributing to the potential surplus gains in the first place.

Some of the associated strategic uncertainty may be alleviated by repeated interaction. In the experiment, subjects play the two-stage game in fixed groups across multiple periods. With repeated play, non-leaders may be able to more effectively discipline the leader's claim, as it becomes easier to coordinate on a lower $\widehat{x}$. Likewise, leaders may be able to better calibrate their conjectures about the largest tolerated claim, $\widehat{x}$.

The arguments raised above naturally suggest one salient behavioral concern in the form of a *preference for fairness*. Fairness concerns among the non-leaders may facilitate coordination on a lower value of $\widehat{x}$, since it reduces the leader's equilibrium payoff and increases the non-leaders' payoffs. Similarly, fairness concerns on the part of the leader, or else anticipation by the leader that unfair claims will be met with low (or zero) investment, may drive her to issue lower, relatively more fair claims. Note that we appeal here to fairness concerns as a basis for equilibrium selection (among the set of SPE described above), rather than as an underlying influence on primitive preferences.[18] Even so, what constitutes a fair claim among the set of SPE claims?

One salient candidate for a fair claim is $x = c$. That is, the leader claims just enough from the total revenue to cover the cost of the monitoring option. The costs are then shared equally among all team members (including herself). This ensures complete equality in equilibrium payoffs between the leader and the non-leaders ($\widehat{\pi}_L = \pi_i = 32 - 0.25c$). However, in light of Observation 3, this is not sequentially rational for the leader if $c < 24$. Holding the leader to such a claim does not take into account the leader's option to eschew the monitoring option altogether (saving on the cost) and secure a higher payoff of $\widehat{\pi}_L = 32$ by investing her endowment and claiming at least the resulting revenue it generates. In other words, although cost sharing is a salient notion of fairness, it is not an equilibrium arrangement. Perhaps an equally serious issue with cost sharing is that, relative to their outside options, the leader does not receive any of the additional net surplus gain generated by switching from equal sharing to proportional sharing (even when $c = 0$).

Thus, we propose an alternative notion of a fair claim that considers the equal distribution of the net surplus gain relative to the total payoffs generated without monitoring ($m = 0$) in equilibrium. Recall that the Nash equilibrium in any subgame where $m = 0$ is for the leader to invest her full endowment and claim $x \geqslant 32$, while all non-leaders invest zero.[19] The resulting total (aggregated) payoffs are equal to $(32 + 3(20)) = 92$. With monitoring, $m = 1$, under the

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[18] Another approach would be to model the agents as having some form of social preferences, incorporating things like inequality aversion, efficiency concern, or reciprocity. Rather than having to take a stance on a particular model specification, we take a simpler approach of invoking fairness considerations as a means of equilibrium selection.

[19] This NE is unique up to the amount of the claim $x \geqslant 32$. In particular, any claim higher than 32 is redundant, since in equilibrium total revenue is capped at 32, as only the leader invests.

full investment equilibrium, total payoffs are increased to $128 - c$, resulting in a net surplus gain of $36 - c$.

Equal division of this net surplus gain corresponds to payoffs of $\widehat{\pi}_L = 41 - 0.25c$ and $\pi_i = 29 - 0.25c$ for each $i \neq L$. Given the differences between payoffs, this implies that equal division of the net surplus gain is secured by a claim equal to $12 + c$. However, among the set of SPE, the lowest equilibrium claim is 24. As such, if we maintain the requirement that subjects are sequentially rational (and maximize their own material payoffs), the corresponding notion of a fair *equilibrium* claim, based on the above arguments, is a claim of 24 for any $c < 12$, and a claim of $12 + c$ for any $c \geqslant 12$.

An appealing feature of this alternative approach is that the corresponding "fair claims" coincide with standard solutions to a bargaining problem. To see this, consider a stylized version of the model that takes the form of a multilateral bargaining game between the leader and the non-leaders. With monitoring in place ($m = 1$), the leader issues a claim $x \in [24, 48]$. The non-leaders can perfectly coordinate on either *accepting* the leader's claim (by playing the full investment equilibrium) or *rejecting* the leader's claim (by playing the free-riding equilibrium). The outside option for the non-leaders is to consume their endowment, meaning $\pi_i = 20$, whereas the outside option for the leader is to forgo the monitoring option ($m = 0$), invest her endowment, and claim the resulting revenue, yielding $\widehat{\pi}_L = 32$.

We can consider these outside options as the threat point (or disagreement point) for the multilateral Nash Bargaining game. It's then straightforward to show that, assuming the agents all have equal bargaining power, the Nash bargaining solution is the claim $x_{NB} = (A-1)\omega + c = 12 + c$. However, for a sufficiently low cost ($c < 12$), this implies $x_N B$ is in the range of claims for which the non-leaders have a dominant strategy to invest the full endowment ($x < 24$). In these cases, the relevant threat point for the non-leaders should actually be higher than $\pi_i = 20$, since free-riding is not an equilibrium strategy profile among the non-leaders for such claims.[20] As such, the Nash bargaining solution for this stylized interpretation of the model also suggests a 'fair' claim equal to $x_{NB} = 24$ for $c < 12$ and a 'fair' claim equal to $x_{NB} = 12 + c$ for $c \geqslant 12$.

2.5 Experimental Hypotheses

Based on the preceding theoretical framework, we introduce the following as our main hypothesis.

Main Hypothesis (Equilibrium Prediction)**.** In the NoCost treatment, leaders claim $x = 24$ and choose to monitor ($m = 1$). In the Cost-20 treatment, leaders claim $x = 32$ and choose to monitor ($m = 1$). In both treatments, all team members invest their full endowment.

This Main Hypothesis is a prediction about behavior in equilibrium. Comparing across the three treatments (i.e., including the Threshold treatment), equilibrium play entails no differences in total investment or monitoring frequency.

Hypothesis 2. Total group investment is the same (full investment) for all three treatments.

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[20] Instead, the relevant (credible) outside option payoff for the non-leaders when $x < 24$ is $\pi_i = A\omega - x/n = 32 - 0.25x$, implying a Nash product equal to 0.

Hypothesis 3. The frequency of monitoring is the same (100%) for all three treatments.

Furthermore, according to our Main Hypothesis, the team leaders claim higher amounts in the Cost-20 treatment ($x = 32$) than in the NoCost treatment ($x = 24$).

Hypothesis 4. The average leader claim when monitoring is higher in Cost-20 ($x = 32$) than in NoCost ($x = 24$).

The hypotheses above are very demanding. Indeed, it would be extremely surprising to see such equilibrium play in every round by every group. Even allowing for groups to converge over time, there is no guarantee that groups will converge to this particular equilibrium (or any equilibrium at all). In addition, for the Cost-20 treatment, there also exist equilibria, corresponding to $\widehat{x} \in [24, 26.6\bar{6}]$, in which $m = 0$, the leader claims $x \geqslant 32$ and invests 20, while the non-leaders invest nothing. Thus, it would not necessarily be surprising to see fewer instances of monitoring in the Cost-20 treatment, if non-leaders are particularly strict about limiting their leaders.

Nevertheless, our main equilibrium hypotheses (where $m = 1$) are also supported by particular predictions about behavior off the equilibrium path, which we use to form additional hypotheses. Our next hypothesis reflects the fact that, on aggregate, total investment in both NoCost and Cost-20 ought to be higher with monitoring than without monitoring.

Hypothesis 5. Total group investment is significantly higher when the monitoring option is selected than when it is not.

Next, recall that the precise patterns of investment are predicted to depend not just on the monitoring decision, but also on the accompanying claims. Thus, we decompose the predictions about investment under monitoring, based on whether or not the claim is "fair".

Hypothesis 6. When the team leader selects the monitoring option ($m = 1$),

(i) non-leaders in NoCost invest significantly less if $x > 24$ than if $x \leqslant 24$, while

(ii) non-leaders in Cost-20 invest significantly less if $x > 32$ than if $x \leqslant 32$.

This hypothesis is based on the fairness-driven behavioral prediction that $\widehat{x} = 24$ when $c = 0$ and $\widehat{x} = 32$ when $c = 20$. For claims that are above the relevant $\widehat{x}$, non-leaders are predicted to play the free-riding equilibrium, while for claims at or below $\widehat{x}$, they are predicted to play the full investment equilibrium.

When the leader does not select the monitoring option (which is off the equilibrium path except in Cost-20 when $\widehat{x} < 26.6\bar{6}$), the theoretical predictions suggest that the leader should invest everything and claim $x \geqslant 32$, while the non-leaders invest nothing.

Hypothesis 7. When the team leader does not select the monitoring option ($m = 0$), she claims $x \geqslant 32$ and invests her full endowment, whereas each non-leader invests nothing.

Finally, we consider an alternative hypothesis for the Cost-20 treatment, where the leader is faced with arguably more severe consequences when they claim too much. In this case, if the team leader incorrectly conjectures the value of $\widehat{x}$, and claims more than the non-leaders are willing to tolerate, she is left to bear the full cost of the monitoring option, leading her payoff to fall to $A\omega - c = 12$ (if the non-leaders withhold all of their investment as predicted). This is much lower than the outside option payoff of 32 that she can secure by choosing $m = 0$, investing all 20 tokens and claiming $x = 32$. Similarly, if the non-leaders coordinate on a sufficiently low $\widehat{x}$ (in the range of SPE claims between 24 and $26.\bar{6}\bar{6}$), the leader's equilibrium strategy is to not select the monitoring option. This contrasts with the NoCost treatment, where the consequences of choosing too high of a claim are less severe, since there is no cost subtracted from the leader's payoff in any outcome (and in which every equilibrium entails monitoring). As a result, we formulate the following alternative hypothesis for the Cost-20 treatment.

Hypothesis 8. Leaders in the Cost-20 treatment opt to forgo the monitoring option, invest their endowment, and claim the resulting revenue. As such, the frequency of monitoring and correspondingly, total group investment, are lower in Cost-20 than in NoCost.

3 Results

We organize our results as follows. In Section 3.1, we examine the aggregate differences between treatments in terms of group investment, monitoring frequency, the team leader's claim, and payoffs. In Section 3.2, we examine more closely the impact of the team leader's claim on investment levels both with and without monitoring. In particular, we compare investment levels in response to *fair* and *unfair* claims when monitoring is in place. Finally, Section 3.3 examines the heterogeneous performance of teams in the main treatments, comparing claim and monitoring decisions between teams classified as *successful* and those classified as *unsuccessful*. We then address whether or not leaders' decisions in the dictator game are correlated with successful group performance in the team production game.

3.1 Aggregate treatment comparisons

Table 2 provides group-level summary statistics for the key variables of interest. In the following subsections, we examine group investment, monitoring, leader claims, payoffs, and the comparison of investment levels by monitoring decision.

3.1.1 Group Investment

We start by comparing team production levels over time and across treatments. Table 2 reports the mean, standard deviation, and median for group-level investment, where an observation is the group investment averaged across all 20 periods. Group investment levels are significantly different between the three treatments (Kruskal-Wallis (KW) test, $p < 0.001$, Mann-Whitney Wilcoxon (MWW) Ranksum tests: $p = 0.013$ for Threshold v. NoCost; $p < 0.001$

Table 2. Group-level summary statistics across treatments.

	THRESHOLD	NOCOST	COST-20
Investment			
Mean	63.25	47.17	32.03
(*s.d.*)	(19.53)	(19.79)	(16.46)
Median	66.03	51.10	29.88
Monitoring Frequency			
Mean	0.93	0.79	0.35
(*s.d.*)	(0.20)	(0.19)	(0.30)
Leader's Claim			
$m = 1$	–	21.52	38.14
$m = 0$	–	24.77	35.12
Observations	12	16	16

for THRESHOLD v. COST-20; and $p = 0.0317$ for NOCOST v. COST-20).[21] Importantly, in the THRESHOLD treatment, groups invest heavily in team production, even knowing that a portion of the revenue will automatically be deducted to pay the cost of the monitoring option if investment exceeds the threshold.

Figure 1 illustrates that although they begin at similar levels, average group investment differs across treatments. Investment is highest in the THRESHOLD treatment, where it increases quickly and reaches approximately 70 (out of a possible 80) tokens, on average, in the last five periods. This suggests that, at least by the end of the interaction, behavior in THRESHOLD is consistent with Hypothesis 1.

In the NOCOST treatment, average group investment hovers between 40 and 55 tokens throughout the experiment. Team production is lowest in the COST-20 treatment, where average group investment is below 40 tokens in all periods. Consequently, we find clear evidence contradicting Hypothesis 2, which is summarized by the following result.

Result 1. *Group investment is significantly higher in the* THRESHOLD *treatment (where there is no team leader) than in the two treatments with a leader; and significantly higher in the* NOCOST *treatment than in the* COST-20 *treatment.*

3.1.2 Monitoring

Table 2 also reports the mean (group-level) frequency of monitoring for each treatment. In THRESHOLD, monitoring was automatically implemented whenever group investment exceeds the cost threshold (20 tokens). Thus, given the high level of investment, it's not surprising that the mean frequency of monitoring is 93% across groups. In contrast, when monitoring is determined by the team leader, the mean frequency of monitoring is 79% in NOCOST, and just 35% in COST-20. Thus, the frequency of monitoring decreases substantially as the cost of

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[21] As with the summary statistics, a unit of observation for these tests is the average across all 20 periods for one group.

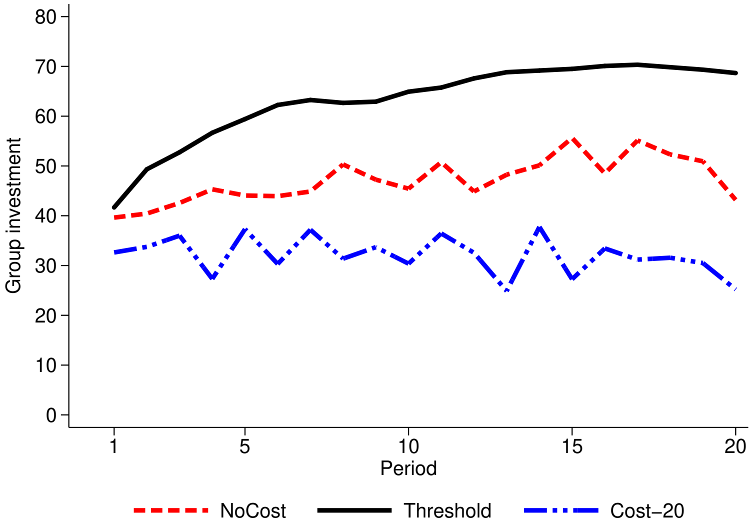

Figure 1. Average group investment over time.

monitoring increases. These differences are also supported by non-parametric tests (KW test, $p < 0.001$; MWW tests, $p = 0.004$ for Threshold v. NoCost, $p < 0.001$ for Threshold v. Cost-20, and $p < 0.001$ for NoCost v. Cost-20).[22] Consequently, we also find clear evidence contradicting Hypothesis 3.

Result 2. *The frequency of monitoring decreases significantly when it is determined by a team leader and, within the team leader treatments, decreases significantly with the cost of the monitoring option.*

While they contrast with the equilibrium prediction of our Main Hypothesis, these first two results are more consistent with the alternative Hypothesis 8, which better accounts for the potential impact of misjudgment by the leader when monitoring is more costly.

3.1.3 Leader Claims

Table 2 also reports the mean (group-level) claim made by the leader with and without monitoring in the NoCost and Cost-20 treatments. On average, the claims made by the team leaders when monitoring are higher than the cost. In NoCost, the mean claim when $m = 1$ is only slightly below the 'fair' claim of $x = 24$ predicted in Hypothesis 4, and the difference is not statistically significant (Wilcoxon signed-rank test, $p = 0.234$, using the average claim when $m = 1$ across all periods by a given leader as one unit of observation). In contrast, in Cost-20, the mean claim when $m = 1$ is higher than the 'fair' claim of $x = 32$, although again, the difference is not statistically significant (Wilcoxon signed-rank test, $p = 0.551$).

When team leaders do not select the monitoring option, the claims are also high, given that the leader does not incur any cost when forgoing the monitoring option. In fact, for both

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[22] One unit of observation is the average frequency of monitoring over all 20 periods for a single group.

Table 3. Mean payoff per person, per period, across treatments.

	Treatment		
	THRESHOLD	NOCOST	COST-20
Overall	24.84	27.07	23.05
Leader	–	37.11	29.71
Non-leader	–	23.73	20.84
With Monitoring ($m = 1$)	24.71	27.43	22.21
Leader	–	37.85	23.87
Non-leader	–	23.96	21.65
Without Monitoring ($m = 0$)	21.11	23.72	22.93
Leader	–	32.87	30.90
Non-leader	–	20.67	20.27
Observations	12	16	16

treatments, leader claims when $m = 0$ are not significantly different from claims when $m = 1$ (Wilcoxon signed-rank test, $p = 0.972$ in NOCOST, $p = 0.638$ in COST-20). This is especially noteworthy for the COST-20 treatment, since it implies a significantly higher *net claim* (claim − cost) when not monitoring, as the leader does not incur the cost.

Comparing across the two treatments, claims are higher in COST-20 than in NOCOST when $m = 1$ (MWW Ranksum test, $p = 0.048$), consistent with Hypothesis 4. In contrast, without monitoring, the difference between treatments is not statistically significant (MWW Ranksum test, $p = 0.236$), despite a fairly sizable difference between means.

Result 3. *Team leaders claim more than the cost of monitoring, and claim similar amounts whether or not they select the monitoring option. Consistent with Hypothesis 4, mean claims with monitoring are higher in* COST-20 *than in* NOCOST.

3.1.4 Payoffs

Table 3 reports the mean payoff per person, per period for each treatment, both overall and broken down by role and by monitoring decision. In all three treatments, the mean payoff is significantly greater than 20 tokens. In the THRESHOLD treatment, in line with the patterns of investment, payoffs are relatively close to, albeit lower than the theoretical optimum (27 tokens) obtained when every player invests everything.[23] For the two main treatments, the leaders obtain significantly higher average payoffs than the non-leaders (Wilcoxon signed-rank test, $p < 0.001$ for both treatments).

Average payoffs for the leader are higher than for non-leaders in both of our main treatments, but with very different underlying patterns. In NOCOST, both the average leader's payoff and average non-leaders' payoffs are higher with monitoring (37.85 for the leader, 23.96 for non-leaders) than without monitoring (32.87 for the leader, 20.67 for non-leaders). That is, leaders

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[23] Recall that in this case, the total surplus to be split is 108 tokens, since the cost of monitoring, 20 tokens, is automatically subtracted from team revenue.

are able to secure an average payoff of almost 38 tokens while improving the non-leaders' average payoffs to roughly 24 tokens. Furthermore, when they don't select the monitoring option, the leader and the non-leaders each get, on average, roughly their outside options (32.87 vs. 30 and 20.67 vs. 20 tokens, respectively).

This is in stark contrast with the COST-20 treatment, where the average payoff is *lower* with monitoring than without monitoring for the leader (23.87 for $m = 1$, 30.90 for $m = 0$) and only marginally higher for the non-leaders (21.65 with $m = 1$, 20.27 with $m = 0$). In particular, the average payoffs for the leader with monitoring (23.87 tokens) are well below the outside option of 32 tokens, and the empirical average payoff secured when not selecting the monitoring option (30.90 tokens). This provides a compelling explanation for the low frequency of monitoring in COST-20. As we observed earlier, the leaders tend to claim too much—issuing claims that exceed the fair claim (38.14 vs. 32 tokens)—and the non-leaders respond by withdrawing their investment, leaving the leader to cover the cost of monitoring with lower team revenue. In fact, even if the leader does not claim more than the fair claim, if she is concerned about the non-leaders being less tolerant of claims that exceed the cost of monitoring, she faces incentives to forgo the (costly) monitoring option in order to secure her outside option (32 tokens). The resulting patterns of (i) low investment, (ii) low monitoring frequency, and (iii) high claims are consistent with the equilibria associated to Hypothesis 8, in which the leader does not select the monitoring option.

3.1.5 Investment by Monitoring Decision

Next, we examine how investment levels differ based on the monitoring decisions of the team leaders in the NOCOST and COST-20 treatments. Figure 2 shows the mean (group-level) investment with and without monitoring for each treatment. Similarly, Table 4 reports the mean and standard deviation of group investment for each treatment and each monitoring decision. Groups invest significantly more when monitoring is selected than when it is not (Signed rank test, $p = 0.0037$ in NOCOST and $p = 0.0015$ in COST-20). We thus find support for Hypothesis 5.

Result 4. *In both* NOCOST *and* COST-20*, group investment is significantly higher when the leader selects the monitoring option.*

Comparing between the two treatments with leaders we find that, when monitoring is not selected, there is no significant difference between group investment levels (MWW Ranksum test, $p = 0.405$). Likewise, conditional on the leader selecting the monitoring option, group investment does not differ between NOCOST and COST-20 (MWW Ranksum test, $p = 0.561$). This suggests that the difference between NOCOST and COST-20 in Figure 1 is driven almost entirely by the difference in monitoring frequency. A breakdown of group investment by role is also informative. Absent monitoring, the leaders invest, on average, only around half of their endowment (8.20 in NOCOST; 10.82 in COST-20), contrary to the prediction of full investment (cf. Hypothesis 7). The non-leaders invest very little (sum totals of 16.59 tokens in NOCOST; 8.72 in COST-20), close to the dominant strategy prediction of zero investment. With monitoring, the leaders invest significantly more, although still less than their full endowment, while the

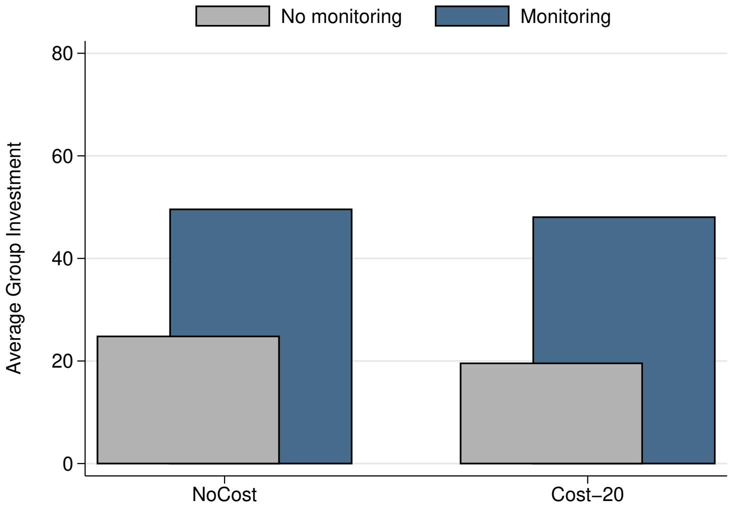

Figure 2. Average group investment by monitoring decision

Table 4. Group-level investment by monitoring decision.

	NoCost		Cost-20	
	$m = 0$	$m = 1$	$m = 0$	$m = 1$
Investment				
Mean	24.79	49.57	19.54	48.04
(*s.d.*)	(12.40)	(20.78)	(6.50)	(17.44)
Leader	8.20	14.13	10.82	15.91
Non-leaders	16.59	35.44	8.72	32.13
Observations	13	16	16	14

non-leaders invest substantially more.

Nevertheless, group investment with leader-determined monitoring remains below the level of group investment observed in the Threshold treatment. Thus, while the lower group investment illustrated in Figure 1 can be largely attributed to infrequent monitoring by the team leaders, it is also partly driven by lower investment even when monitoring is in place. A key potential explanation for these differences is that the leaders often claim too much, causing the non-leaders to play the free-riding Nash equilibrium in the second stage, even with the proportional incentives provided by the monitoring option. We turn next to a closer inspection of the impact that the leader's claim has on investment under monitoring.

3.2 Fairness, Leader Claims, and Investment

In this section, we examine investment by non-leaders when the claim is *fair* versus when it is *unfair*, using the discussion in Section 2.4.2 as the basis for characterizing claims as such. However, before doing so, we provide some preliminary analysis to guide the subsequent discussion.

Table 5. Dynamic Panel-Data Regression (One-Step System GMM) of Non-leaders' Investment on Monitoring and Claim, by Treatment

Dependent variable: Non-leaders' investment

	NoCost		Cost-20	
	(1)	(2)	(3)	(4)
$E^{NL}_{i,t-1}$	0.167* (0.085)	0.191** (0.085)	–0.079 (0.062)	–0.017 (0.065)
m (monitoring)	18.461*** (5.173)	19.139*** (5.091)	26.924*** (5.164)	28.259*** (4.541)
x (claim)	–0.026 (0.076)	–0.012 (0.076)	–0.192** (0.078)	–0.193** (0.077)
$x \times m$	–0.308*** (0.077)	–0.307*** (0.077)	–0.203*** (0.042)	–0.227*** (0.039)
Constant	19.124*** (4.823)	15.283** (5.351)	19.739*** (3.769)	18.986*** (5.266)
Period Dummies	✗	✓	✗	✓
Arellano-Bond test for AR(2)	0.232	0.307	0.545	0.348
Hansen test	0.323	1.000	0.097	1.000
Instruments	13	31	13	25
Groups	16	16	16	16
Observations	304	304	304	304

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
We report p-values for the AR(2) test and the Hansen test.

In Table 5, we report the results of a dynamic panel regression estimating the following linear model,

$$E^{NL}_{i,t} = \beta_0 + \alpha E^{NL}_{i,t-1} + \beta_1 m_{i,t} + \beta_2 x_{i,t} + \beta_3 (x_{i,t} \times m_{i,t}) + u_i + \varepsilon_{it} \qquad [3]$$

where $E^{NL}_{i,t}$ is the sum of non-leaders' investments in group i in period t, $m_{i,t}$ is the monitoring decision and $x_{i,t}$ is the leader's claim for group i in period t, and u_i captures group-level fixed effects. There are two potential endogeneity problems to address—first, the lagged dependent variable $E^{NL}_{i,t-1}$ is likely to be correlated with the unobserved heterogeneity, u_i; and second, the explanatory variables $x_{i,t}$ and $m_{i,t}$ (along with their interaction) may also be correlated with the unobservable fixed effect, u_i. We estimate a one-step system GMM to deal with these potential endogeneity problems.[24] The first two columns report the coefficient estimates for the NoCost treatment, without period dummies in column (1), and including period dummies in column (2). The corresponding estimations for the Cost-20 treatment are reported in columns (3) and (4), respectively.

It is important to note that the coefficients are very similar with and without period dummies. Including period dummies increases the number of instruments above the number of groups,

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[24] We use first and second lags of $E^{NL}_{i,t-1}$, $x_{i,t}$, $m_{i,t}$, and the interaction term as instruments, and collapse the instrument set to mitigate instrument proliferation.

weakening the Hansen test (and raising some concern about the implausible p-values of 1.000), but the estimates are very similar to those obtained without period dummies, both in terms of significance and magnitudes. Moreover, none of the period dummies are significant in either treatment. In all four regressions, the Arellano-Bond test for no autocorrelation in first-differences is not rejected, as desired.

As expected, monitoring has a strongly significant, positive effect on the level of non-leaders' investment in both treatments. Somewhat surprisingly, the lagged dependent variable is either weakly significant (in the NoCost treatment) or not significant at all (in the Cost-20 treatment). The main effects of interest are the impact of the claim on non-leaders' investment with and without monitoring. In NoCost, columns (1) and (2) indicate that when monitoring is not selected ($m = 0$), an increase in the leader's claim does not affect non-leaders' investment. The intuition for this is straightforward—when $m = 0$, the non-leaders already face free-riding incentives, and so there is little scope for further reduction in investment. In contrast, when monitoring is selected ($m = 1$), an increase in the claim has a strongly significant negative effect on non-leaders' investment.[25] Thus, when the leader selects the monitoring option, non-leaders are sensitive to how much the leader claims. These results are robust to a restriction of the sample to the last 10 periods of the interaction (see Table B.1).

The results are similar for the Cost-20 treatment. In this case, an increase in the claim has a significant negative effect on investment even when $m = 0$. Nevertheless, as in NoCost, the negative effect of an increase in the claim on non-leaders' investment is significantly stronger when $m = 1$.[26] Furthermore, when we restrict the sample to the last 10 periods (see Table B.1), the effect of the claim without monitoring is not statistically significant, while the negative effect of the leader's claim with monitoring remains strongly significant.

3.2.1 Fair and Unfair Claims

Next, we classify claims by whether or not they exceed the *fair* claim proposed in Section 2.4.2. Thus, in the NoCost treatment, a claim is classified as "*fair*" if it is less than or equal to 24. In the Cost-20 treatment, claims less than or equal to 32 are classified as "*fair*". All other claims are classified as "*unfair*".

Figure 3 plots the mean (group-level) investment by all *non-leaders* for three types of leader decisions: no monitoring, monitoring with an unfair claim, and monitoring with a fair claim.[27] The difference between non-leaders' investment under fair and unfair claims is striking, especially in the NoCost treatment. In both treatments, mean non-leader investment in response to 'fair' claims is close to 40 (out of a possible 60) tokens, while the average drops below 15 in NoCost and below 20 in Cost-20 in response to 'unfair' claims.

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[25] A test for the significance of the sum of the coefficients on x and $x \times m$ returns a p-value < 0.001 for both specifications (1) and (2).

[26] We reject the hypothesis that the sum of coefficients on x and $x \times m$ is equal to 0, with $p < 0.001$, in both specifications (3) and (4).

[27] In the Appendix, we include similar figures that separate non-leader investments under no monitoring by whether or not the claim is fair (Figure B.1) and by whether or not the claim is zero (Figure B.2).

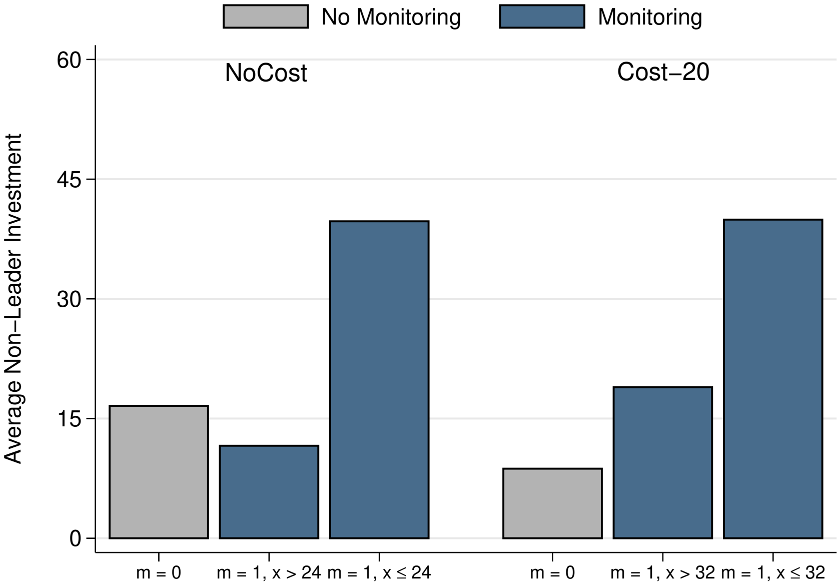

Figure 3. Average non-leader investment by monitoring decision: fair vs. unfair claims

The picture conveyed by Figure 3 is also supported by regression analysis. In Table 6, columns (1) and (3) report the results of a dynamic panel-data regression, by treatment, for the following equation:

$$E_{i,t}^{NL} = \beta_0 + \alpha E_{i,t-1}^{NL} + \beta_1 m_{i,t} + \beta_2 \text{Unfair}_{i,t} + \beta_3 (m_{i,t} \times \text{Unfair}_{i,t}) + u_i + \varepsilon_{it} \quad [4]$$

where the new variable $\text{Unfair}_{i,t}$ takes a value of one if the leader's claim is classified as unfair, and zero if the leader's claim is classified as fair. In columns (2) and (4), we include period dummies in the corresponding regressions. However, since the coefficient estimates and relevant tests are all extremely similar whether period dummies are included or not, we concentrate on the regressions without them—columns (1) and (3)—for which the number of instruments is less than the number of groups.

In the NoCost treatment, there is no significant impact of an unfair claim on non-leaders' investments when the monitoring is not selected. This is not necessarily so surprising, because in the absence of monitoring, non-leaders should already be investing relatively little, regardless of the nature of the leader's claim. In contrast, when the leader selects the monitoring option, and also chooses an unfair claim, virtually all of the positive impact of monitoring is negated. Choosing an unfair claim while monitoring has a large and significant negative effect on non-leaders' investment in the NoCost treatment ($p = 0.0046$).

In the Cost-20 treatment, the results are slightly different when the monitoring option is not selected. Even without monitoring, an unfair claim has a significant negative effect on non-leaders' investments. Nevertheless, as is the case in the NoCost treatment, when the leader selects the monitoring option and chooses an unfair claim in Cost-20, the negative effect on

Table 6. Dynamic Panel-Data Regression (One-Step System GMM) of Non-leaders' Investment on Monitoring and Fairness of the Claim, by Treatment

Dependent variable: Non-leaders' investment

	NoCost		Cost-20	
	(1)	(2)	(3)	(4)
$E^{NL}_{i,t-1}$	0.154**	0.175**	−0.002	0.056
	(0.068)	(0.072)	(0.052)	(0.062)
m (monitoring)	18.326***	19.003***	21.752***	21.483***
	(5.212)	(4.969)	(5.103)	(4.592)
Unfair	1.290	2.844	−11.235**	−13.223***
	(6.929)	(7.154)	(4.707)	(4.504)
$m \times$ Unfair	−18.479***	−18.569***	−7.118	−5.286
	(5.981)	(5.876)	(6.549)	(7.067)
Constant	17.177***	17.090***	15.591***	15.459***
	(4.890)	(5.077)	(3.369)	(3.692)
Period Dummies	✗	✓	✗	✓
Arellano-Bond test for AR(2)	0.084	0.141	0.435	0.342
Hansen test	0.590	1.000	0.130	1.000
Instruments	13	31	13	31
Groups	16	16	16	16
Observations	304	304	304	304
Wald test: Unfair + ($m \times$ Unfair) = 0	$p = 0.0046$	$p = 0.0101$	$p = 0.0197$	$p = 0.0177$

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
We report p-values for the AR(2) test and the Hansen test.

non-leaders' investment is large and statistically significant ($p = 0.0197$).

To summarize, we find very strong support for Hypothesis 6.

Result 5. *When the monitoring option is selected, investment by the non-leaders is significantly lower if the claim is unfair than if the claim is fair.*

3.3 Heterogeneity in Team Performance

In this section, we examine in greater detail the effects of monitoring and claim decisions on the performance of teams. The aggregate results in the previous section suggest a fairly robust pattern of behavior. Average investment increases substantially with monitoring, provided the team leader does not claim too much. However, the aggregate results do little to highlight the heterogeneity in team performance across different groups.

To address this heterogeneity across groups, we introduce a binary measure of group-level performance. Specifically, we calculate the total non-leaders' investment in each period and take the average across the last 10 periods (periods 11–20). A group is classified as *"successful"* if and only if the average non-leaders' investment over the last 10 periods is at least 40 tokens,

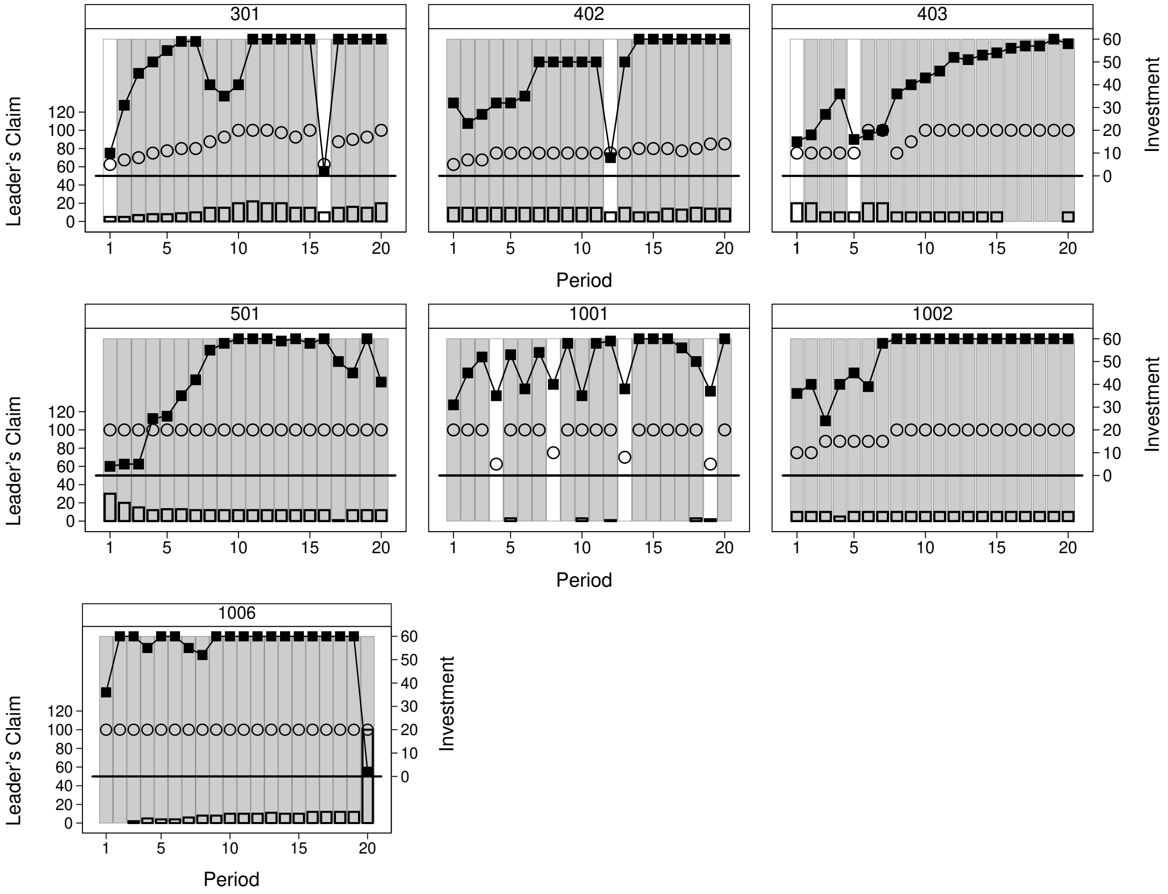

Figure 4. Investment, monitoring, and claims in *"successful"* groups—NoCost treatment. *Notes:* Gray (white) columns indicate $m = 1$ ($m = 0$); Bars in the lower panel indicate leader's claim (left axis); Hollow circles indicate leader's investment (right axis); Connected squares indicate total non-leaders' investment (right axis).

which corresponds to two-thirds of their total endowment.[28] By this metric, we classify 7 out of 16 groups as successful in NoCost and just 3 out of 16 groups as successful in Cost-20.

Figures 4 and 5 illustrate the investment, monitoring, and claim decisions for successful groups in NoCost and Cost-20, respectively. For each group, we plot the total non-leaders' investment (the black line with square markers) and the leader's investment (hollow circles) in the top panel of the graphs. The gray background is used to indicate those periods in which monitoring was selected by the leader. In the bottom panel of the graphs, the hollow bars indicate the size of the leader's claim.

The graphs highlight several important features of successful groups. **First**, all of the successful groups exhibit extremely high monitoring frequency. Indeed, for NoCost, there are just 9 out of 140 periods in which the monitoring option is not selected by the team leader, while for

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[28] We chose the two-thirds threshold to be consistent with the early classification of highly cooperative behavior ("Lindahl" behavior) in Isaac et al. (1984).

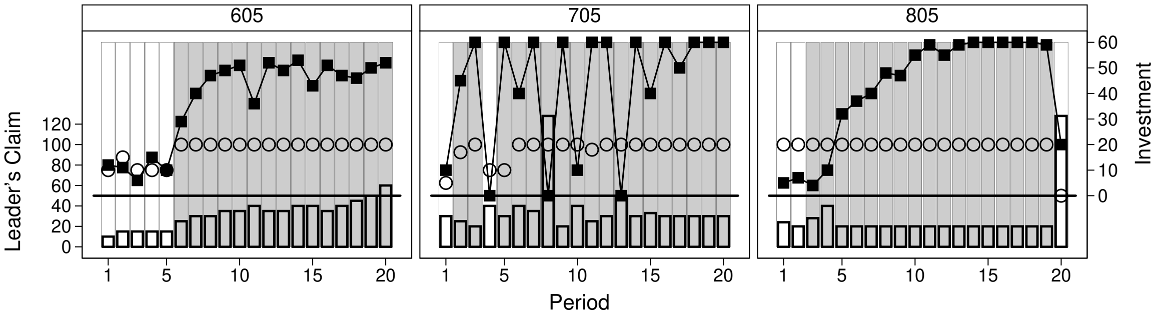

Figure 5. Investment, monitoring, and claims in *"successful"* groups—Cost-20 treatment. *Notes:* Gray (white) columns indicate $m = 1$ ($m = 0$); Bars in the lower panel indicate leader's claim (left axis); Hollow circles indicate leader's investment (right axis); Connected squares indicate total non-leaders' investment (right axis).

Cost-20, there are 10 out of 60 such periods, with only one coming after the first five periods. **Second**, in all of those periods without monitoring, non-leaders' investment falls dramatically relative to previous periods with monitoring. Similarly, when the group plays the first few periods without monitoring (for example, the first five periods for group 605 in Cost-20), non-leaders' investment is very low and increases only once the monitoring option is selected.

Third, the claims made by leaders in successful groups are relatively low. For instance, in the NoCost treatment, virtually every claim made by the leaders in successful groups is below the *fair* claim of 24 predicted by Hypothesis 4, with a mean claim of 10.73 for $m = 1$. In Cost-20, the claims are more comparable with the predicted *fair* claim of 32 tokens, with a mean claim of 31.98 tokens. Of the 50 periods with $m = 1$ in Cost-20, there are 17 instances in which the leader claimed exactly 20 tokens (a net claim of 0), 17 instances of claims between 30 and 35 tokens, and 12 instances of claims at or above 40 tokens.[29] Furthermore, as illustrated by Figure 5, non-leaders' investment also dips noticeably whenever the team leader increases the claim by a non-trivial amount relative to the fair claim.

Result 6. *In successful groups, the leader virtually always selects the monitoring option and chooses a claim at or below the fair level.*

Nevertheless, in both treatments, just as intriguing as the downward response to the removal of monitoring or the elevation of the claim is the near-immediate return to high investment once monitoring or the previous (acceptable) claim is restored. For example, in group 301 (NoCost), when the leader removed monitoring in period 16, non-leaders' investment plummeted from 60 tokens (full investment) to just 2 tokens. Yet, when the leader restored monitoring *and maintained the previously tolerated claim* in period 17, non-leaders' investment immediately jumped back up to full investment.[30] For another example, in group 705 (Cost-20), there are multiple periods in which the leader increased the claim substantially and the non-leaders responded by

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[29] Leaders in successful groups never claimed less than the cost when selecting the monitoring option in Cost-20.

[30] Other similar examples occurred in group 402, period 12; group 1001, periods 4, 8, 13, and 19; and group 705, period 4.

decreasing from full investment to low or even zero investment. Yet, in each case, when the leader lowered the claim back down in the next period, the non-leaders returned immediately to full investment. Together, these observations underscore that, at least in successful groups, the non-leaders respond strongly to the incentives faced both with and without monitoring. Moreover, they are willing to tolerate positive *net* claims, but only if the resulting claims do not exceed the *fair* claim.

For completeness, we also present similar graphs for the groups that are not classified as successful (see Figures B.3 and B.4 in Appendix B). In the NoCost treatment, unsuccessful groups still exhibit a relatively high frequency of monitoring, with only one leader choosing the monitoring option in fewer than half of the periods. However, the chances of successful team production in these groups are seemingly thwarted by a combination of excessive claims and inconsistency in the monitoring decision. In particular, the average claim made by the leader when monitoring in NoCost is 29.08 tokens for the unsuccessful groups, compared with 10.73 tokens for successful groups. Moreover, 53 out of 122 claim decisions (when monitoring) were above the fair claim of 24 tokens, and an additional 43 of the 122 decisions were 15 tokens or more.[31] In contrast, in the Cost-20 treatment, the primary obstacle to successful team production is that the leaders rarely exercise the monitoring option. Indeed, 11 out of the 13 unsuccessful groups selected the monitoring option in fewer than three of the last ten periods. For many of these groups, non-leaders' cooperation collapses very quickly, while others find some moderate early success under monitoring, only to be undone by a claim that is too high or by the removal of the monitoring option by the leader.

Result 7. *Unsuccessful groups in the* NoCost *treatment exhibit a combination of inconsistent monitoring and excessive, often "unfair" claims when the monitoring option is selected. In the* Cost-20 *treatment, the leaders of unsuccessful groups are more consistent in their monitoring decisions, but the consistent decision is not to select the monitoring option.*

4 Concluding Remarks

In this paper, we report the results from a series of controlled laboratory experiments, designed to examine the impact of an exogenously appointed leader on team production. The leader is given the power to adopt a monitoring option, which may be costly, that transforms the revenue sharing rule from equal sharing—which generates strong free-riding incentives for the non-leaders—to proportional sharing, under which each individual is compensated according to the proportion of total investment he contributes. The main tension is that the leader can also make (and commit to) a claim to a portion of the resulting team revenue, which is paid *before* distributing shares to the team members.

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[31] Note that four of the groups—302, 502, 1003, and 1004—fell just short of being classified as successful, with average non-leader investments in the last 10 periods equal to 34, 33.8, 31.5, and 33.4 tokens, respectively. In all four cases, the leader maintained monitoring in at least eight of the last ten periods, and in the first three groups, the claims when monitoring were all relatively low (below the fair claim). Nevertheless, the few instances in which monitoring was revoked, combined with inconsistency in the claim amounts, appear to have disrupted these groups' attempts to move towards full investment.

The game consists of two stages. In the first stage, the leader announces a claim and chooses whether or not to adopt the monitoring option. In the second stage, having observed the leader's first stage decisions, all team members (including the leader) choose investments in team production. Out of the resulting team revenue, the leader's claim (or part thereof) is paid, and anything that remains is distributed according to the implemented sharing rule. Since there are multiple equilibria, which depend on how large a claim the non-leaders are willing to tolerate while still investing, we draw on fairness concerns as a basis for equilibrium selection. We identify a *fair threshold claim* below which non-leaders provide full investment, and above which the non-leaders withdraw their investment, limiting the leader to a more equitable equilibrium claim.

A key takeaway from our experiment is that the leaders are not always so successful at improving team performance. The results from our THRESHOLD treatment affirm the hypothesis that in a kind of idealized world—where sufficient investment guarantees the implementation of proportional incentives at exactly the cost of monitoring (i.e., without any scope for a leader's opportunism)—subjects routinely and rapidly converge towards full investment. Yet, in our COST-20 treatment, leaders are generally reluctant to adopt the monitoring option, and many claim too much when they do, resulting in little group investment and leaving potential surplus gains on the table. In contrast, when monitoring is not costly (our NOCOST treatment), leaders are somewhat more successful, with nearly half achieving a gradual increase towards sustained high investment. Consistent with our hypotheses, those leaders who are more successful *nearly always adopt the monitoring option and make claims below the corresponding fair threshold*, while those who are less successful either claim too much (above the fair threshold), forgo the monitoring option too often, or both. Thus, fairness considerations appear to play a powerful role in our main treatments.

Our study is not without its limitations, especially because the setup of the model and experiment is very stylized. However, this goes hand in hand with the power of controlled laboratory experiments to isolate alternative mechanisms that might influence behavior in the real-world firms and organizations the model is designed to simulate. In this respect, lab experiments can be powerful complements to, and provide guidance for, larger-scale field studies (Falk and Heckman, 2009). Nonetheless, there are a couple of ways in which the setup we studied here may be generalized. First, note that there is no direct communication or negotiation between the team members in our setting. Incorporating communication would likely help to alleviate both (i) coordination problems among the non-leaders,[32] and (ii) strategic uncertainty faced by the leader, in regards to the largest claim the non-leaders might be willing to tolerate. Given the potential for misunderstanding between parties, creating an open dialog between leader and non-leaders may improve the chances of sustained efficiency improvements.

Second, the leader in our game does not face the possibility of being removed or replaced. This may be an acceptable assumption for many examples in management or organizational contexts—especially if there must be legal grounds for such replacement—but in others, the

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[32] See Brandts et al. (2015) for evidence regarding the powerful impact of leader communication on coordination in a turnaround game.

threat of removal is a natural feature to incorporate. Moreover, such considerations would likely play an important disciplinary role for the leader, regarding how large a claim they can reasonably appropriate. Relatedly, a leader who is elected or otherwise endogenously appointed may be granted more legitimacy than an exogenously chosen leader (similarly to the findings reported by Levy et al., 2011; Kocher et al., 2013; Brandts et al., 2015).

Finally, it is important to note that from an efficiency standpoint, relying on costly monitoring to achieve full investment is not first-best. Even in the THRESHOLD setting, the monitoring option that implements proportional incentives is costly. This raises a natural question: if teams are able to develop a "culture of cooperation" with the aid of the monitoring option, could they continue to do so even after monitoring is removed as an option? In our experiment, we have seen that the non-leaders are highly responsive to changes in incentives; even if the team is investing at very high levels under monitoring, if the leader removes the monitoring, investment crashes. At face value, this suggests that sustaining high investment after monitoring is taken away might be unlikely. However, the leaders in our experiment could and did still claim substantial amounts when they chose not to adopt the monitoring option, which would seem to be a stronger reason for non-leaders' reluctance to continue to invest. In order to better understand the persistence of any kind of "culture of cooperation", further work is needed. For instance, one might consider restricting claims to zero when monitoring is not selected. Alternatively, one could exogenously remove the leader at the end of an initial interaction and investigate whether the leaderless teams are able to sustain high investment in subsequent periods. We consider these to be potentially interesting avenues for further research.

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A Theoretical Framework

A.1 Model

We consider the following linear team production environment. A team consists of n members each with an endowment of (time or effort) resources, ω. All team members decide simultaneously on the amount of resources they wish to invest in the production process and consume anything not invested. Let e_i denote the investment of player i. Total group investments, which are the sum of each team member's investment, are multiplied by a return factor $A \in (1, n)$, such that team revenue is given by $R = A \sum_{i=1}^{n} e_i$. While this describes the general linear team production environment, the game actually proceeds in two stages. In each team, player $i = L$ is designated as the *team leader*, while all other players are referred to as *non-leaders*.

Stage 1—Leader's claim & monitoring decisions. In the first stage, the team leader makes two decisions. The first is to choose a claim, $x \geqslant 0$, that will be subtracted from the team revenue before it is distributed among the team members. The second decision is whether or not to adopt a (possibly costly) monitoring option. Let $m \in \{0, 1\}$ denote the leader's monitoring decision and $c \geqslant 0$ denote the cost of the monitoring option. If the monitoring option is selected ($m = 1$), team revenue (after paying the leader's claim) is distributed according to a proportional sharing rule, with each player's share being proportional to her own investment. If it is not selected ($m = 0$), each team member receives an equal share of the remaining revenue, regardless of how much she invests in team production. We assume the team leader has full commitment power, so that the claim x and the monitoring decision m are both credible and enforceable in the second stage.

Stage 2—Team production decisions. At the beginning of the second stage, all players observe the team leader's first-stage decisions, (x, m). Then, each team member i (including the team leader, $i = L$) chooses $e_i \in [0, \omega]$. Total investment and team revenue are calculated as above and, before anything else, the team leader's claim x is paid out of the team revenue. If $R < x$, then the claim is only partially paid, by allocating all of the revenue to the leader. Otherwise, the remaining team revenue, $R - x$, is distributed according to the revenue sharing rule dictated by the leader's monitoring decision. That is, if $m = 0$, each team member receives an equal share, $S_i^0(e_i, e_{-i}) = 1/n$ of the remaining team revenue. If $m = 1$, each team member i receives a share proportional to her own investment, $S_i^1(e_i, e_{-i}) = e_i/(\sum_j e_j)$.

Payoffs. Let $v_i(x, m, e_i, e_{-i})$ denote player i's payoff from team production. When $R < x$, all of the team revenue is used to (partially) pay the team leader's claim and so $v_i(x, m, e_i, e_{-i}) = 0$. If $R \geqslant x$, then $v_i(x, m, e_i, e_{-i}) = S_i^m(e_i, e_{-i})(R - x)$. Since each player consumes any resources not invested, the material payoff for each non-leader, $i \neq L$, is given by

$$\pi_i(e_i, e_{-i}, x, m) = \omega - e_i + v_i(x, m, e_i, e_{-i}), \tag{A.1}$$

while for the team leader, L, the material payoff is

$$\widehat{\pi}_L(e_L, e_{-L}, x, m, c) = \omega - e_L + v_L(x, m, e_L, e_{-L}) + \min\{x, R\} - mc. \tag{A.2}$$

That is, non-leaders' payoffs are the sum of their retained endowment and their share of any team revenue remaining after the leader's claim is paid. The leader's payoff consists of the same terms, plus the (possibly partial) claim, minus the cost c if they select the monitoring option.

A.2 Equilibrium analysis

Overview. In this section, we first derive predictions under the standard assumption that individuals are self-interested material payoff-maximizers. Since the game consists of two stages with perfectly observed Stage 1 actions, we use subgame perfect equilibrium (SPE) as our solution concept. Thus, we begin by characterizing the Nash equilibria (NE) for each subgame that may be reached in the second stage. Each pair of first stage decisions by the leader, (x, m), lead to a distinct subgame. Before proceeding to the analysis, we provide a description of the resulting equilibria and highlight the underlying intuition.

One of the main challenges of deriving predictions for the model is that there are multiple subgame perfect equilibria (in fact, a continuum of SPE) in our two-stage game. The different equilibria hinge on different specifications for how large a claim the non-leaders are willing to tolerate (or relinquish to the leader, while still investing full effort) when monitoring is selected. Thus, after presenting the standard equilibrium analysis, we turn to the question of equilibrium selection.

Some preliminary comments are straightforward to show. First, in any equilibrium, the team leader always invests the full endowment, $e_L^* = \omega$. Second, when the leader forgoes the monitoring option, the non-leaders all invest nothing, since they face the standard dominant strategy incentive to free ride. The rest of the analysis then concerns behavior when the monitoring option is in place.

When the leader exercises the monitoring option, the optimal behavior by the non-leaders depends on how much the leader claims in the first stage. For very high claims, non-leaders again have a dominant strategy to invest nothing. For sufficiently low (although still positive) claims, the proportional incentives instituted by the monitoring technology ensure a dominant strategy to invest full effort. It's straightforward to show that the leader should never choose a claim from one of these two ranges - if the claim is too low or too high, the leader can increase her payoff by increasing or decreasing the claim, respectively. Instead, the optimal claim always falls somewhere in the intermediate range between these two extremes.

For intermediate claims, there are two equilibrium profiles (in terms of non-leaders' investments). In one, the non-leaders coordinate on the *free-riding profile*, $e_i = 0$ for all $i \neq L$. In the other, they coordinate on the *full-investment profile*, $e_i = \omega$. With monitoring in place, the leader's payoff is maximized by choosing the largest claim for which the non-leaders coordinate on the *full-investment profile*. We let $\widehat{x}$ denote the largest such claim; i.e., the highest claim the non-leaders are willing to tolerate. Then the equilibrium entails the leader selecting the monitoring option and claiming $\widehat{x}$, except in cases where the cost of monitoring is high and $\widehat{x}$ is very low.[33] Thus, there exist a whole continuum of SPE, corresponding to the intermediate range of possible values taken by $\widehat{x}$.

Formal Analysis. Consider the optimal behavior in the second stage, for different subgames characterized by (x, m). We first consider subgames corresponding to $m = 0$, i.e., those in which the team leader did not choose the monitoring option. In this case, it is straightforward to show that there is a unique NE with $e_L^* = \min\{\omega, x/A\}$ and $e_i^* = 0$ for all $i \neq L$. That is, non-leaders face the standard free-riding incentive to invest nothing, while the team leader, taking her claim x as given, either invests exactly enough to generate team revenue equal to x, if $x \leqslant A\omega$, or else invests her full endowment (since the resulting revenue, $A\omega < x$ will be used to pay the claim in part).

Notice then that the leader's payoff in these subgames is increasing in x, such that in the first stage, choosing $(x, m) = (A\omega, 0)$ dominates $(x', 0)$ for any $x' < A\omega$. Furthermore, any claim higher than $A\omega$ with $m = 0$ generates the same payoff. Thus, the best possible payoff to the leader from choosing $m = 0$ is $\widehat{\pi}_L = A\omega$.

A graphical illustration is provided by Figure A.1, which shows the leader's expected payoffs as a function of the claim x and monitoring decision m, assuming sequentially rational (i.e., Nash equilibrium) play in Stage 2. The case where $m = 0$ is captured by the dashed (red) line in each panel of Figure A.1. As explained above, the expected payoff for the leader when $m = 0$ begins at ω when $x = 0$, increases with x up until $x = A\omega$, then remains constant at $\widehat{\pi}_L = A\omega$ for all higher claims, $x \geqslant A\omega$.

Next, consider the class of subgames corresponding to $m = 1$, i.e., those in which the team leader chose the monitoring option. In this case, for any claim x, it is straightforward to see that the leader invests $e_L^* = \omega$ (her entire endowment) in any NE of the subgame pertaining to x. In contrast, the equilibrium behavior for the non-leaders depends on the claim. We can divide the analysis into three cases.

The first case is when the claim is very large. If $x > n(A-1)\omega$, there is a unique NE with $e_L^* = \omega$ and $e_i^* = 0$ for all $i \neq L$. That is, if the leader claims more than the maximal net return on group investments, non-leaders have no incentive to invest at all because they cannot obtain any of the surplus gain generated by the return factor. Thus, an excessively large claim counteracts the effort incentives provided by the proportional sharing rule. The resulting payoff for the leader is $A\omega - c$. This case is represented in Figure A.1 by the flat portions of the solid (blue) line for claims larger than $n(A-1)\omega$.

The second case is when the claim is very small. Specifically, if $x \leqslant 2\omega(A-1)$, then the unique equilibrium involves all players (leader and non-leaders) investing everything, $e_i^* = \omega$. Essentially, provided the leader does not claim too much, she does not undermine the effort incentives provided to the non-leaders by the proportional sharing rule. In this case, the leader's payoff is $\frac{n-1}{n}x + A\omega - c$, which is increasing in x (see the upward sloping solid blue line in each

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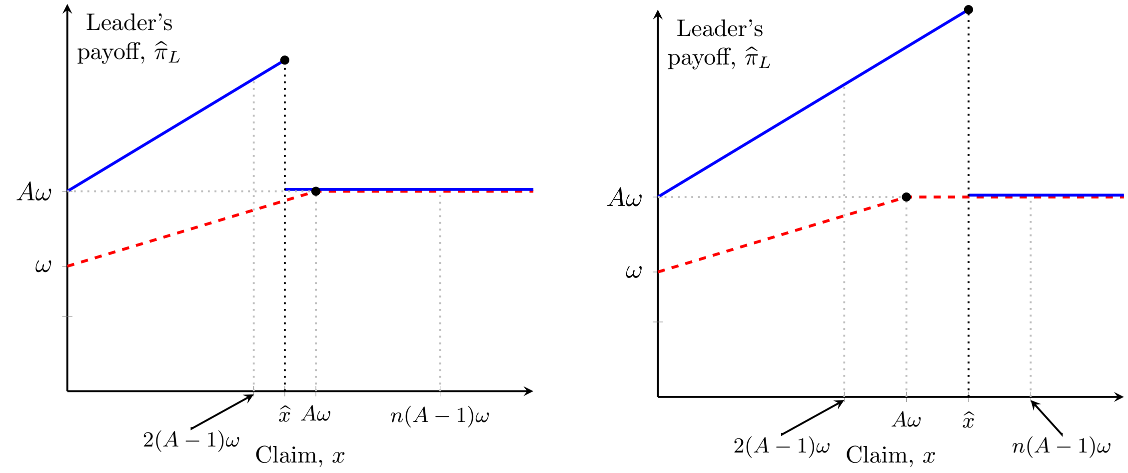
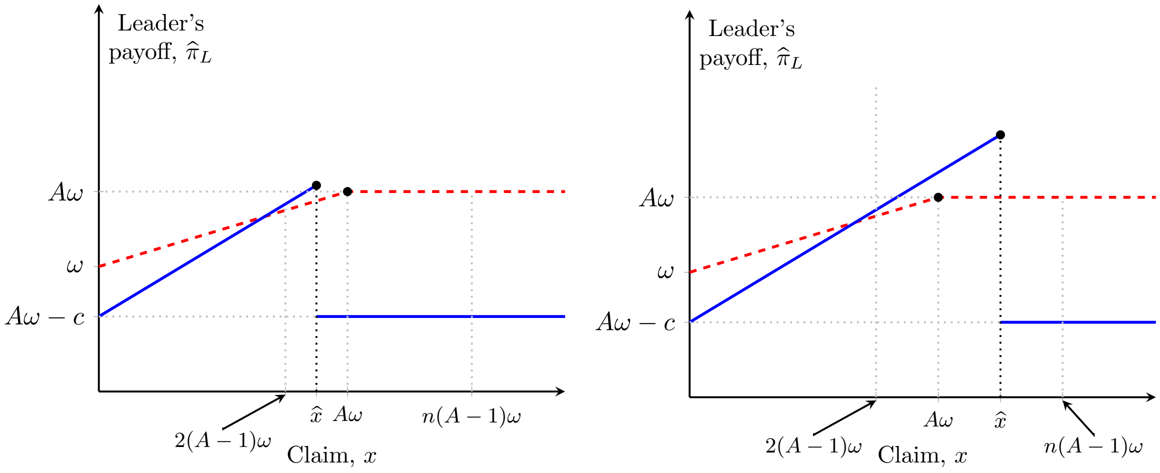
[33] For the exceptional cases, if the non-leaders are only willing to tolerate very low claims, and the cost of monitoring is high, the leader is better off not selecting the monitoring option in equilibrium.



(a) Lower $\widehat{x}$ with $c = 0$

(b) Higher $\widehat{x}$ with $c = 0$



(c) Lower $\widehat{x}$, with $c > 0$

(d) Higher $\widehat{x}$, with $c > 0$

Figure A.1. Leader's payoff for alternative Stage 1 decisions (x, m). Monitoring $(m = 1)$ shown by solid blue line, No monitoring $(m = 0)$ shown by dashed red line. In panels (a) and (b), we set $c = 0$, while for panels (c) and (d), we consider a strictly positive cost of monitoring, $c > 0$. Panels (a) and (c) show a case where $\widehat{x}$ is relatively low, while panels (b) and (d) show a case where $\widehat{x}$ is relatively high.

panel of Figure A.1 for $x \leqslant 2(A-1)\omega)$. As such, a claim of $x = 2(A-1)\omega$ dominates any lower claim, whenever the monitoring option is selected $(m = 1)$.

The third and final case is when $2\omega(A-1) < x \leqslant n\omega(A-1)$. In this case, there are two NE in the corresponding subgame, coinciding with those for the previous two cases; that is, either (1) $e_L = \omega$ and $e_i = 0$ for $i \neq L$, or (2) $e_i = \omega$ for all i. Working backwards to the first stage thus requires us to consider alternative specifications of the NE in each of the corresponding subgames. To this end, let $\widehat{x} \in [2\omega(A-1), n\omega(A-1)]$ be the largest claim for which the specified equilibrium investments in the second stage (with $m = 1$) are everyone investing $e_i = \omega$. Then the optimal claim, given $m = 1$, is $x^* = \widehat{x}$, which results in leader payoff $\widehat{\pi}_L = (n-1)\widehat{x}/n + A\omega - c$.

In Figure A.1, this is captured by the increasing portion of the graph for x between $2(A-1)\omega$ and $\widehat{x}$.[34] As $\widehat{x}$ shifts left or right, the resulting payoff from $x = \widehat{x}$ decreases and increases, respectively. Moreover, for any claim $x > \widehat{x}$, the non-leaders invest nothing (by construction), leaving the leader with a payoff of $\widehat{\pi}_L = A\omega - c$.

Accounting for the three cases, observe that as long as $(n-1)\widehat{x}/n > c$, the payoff from $x = \widehat{x}$ (when monitoring) is greater than the highest leader payoff achievable by choosing $m = 0$ (which is $A\omega$), in which case the leader will choose $(x, m) = (\widehat{x}, 1)$ in Stage 1 of the game. As such, there exists a continuum of SPE in the game, corresponding to different values of $\widehat{x}$.[35] A formal statement of the equilibrium characterization is provided by Proposition 1 in the main text.

Due to the multiplicity of equilibria, the standard analysis does not provide much guidance with regard to forming experimental predictions. Thus, we also introduce some behavioral assumptions to form more concrete predictions about behavior. In particular, we consider the effect of fairness concerns on behavior.

A.3 Fairness concerns and equilibrium selection

There are natural reasons to expect that behavior in the two-stage game might be influenced by fairness concerns. First, the multiplicity of equilibria described above turns on the value of $\widehat{x}$, which is the largest claim at which the non-leaders are willing to (collectively) contribute their full endowment. It is straightforward to show that the difference between equilibrium payoffs for the leader and the non-leaders increases with $\widehat{x}$. For instance, if $\widehat{x} = n(A-1)\omega$, the leader extracts all of the surplus generated by team production, maximizing the difference between leader and non-leader payoffs. In contrast, if $\widehat{x} = \max\{2(A-1)\omega, nc/(n-1)\}$, the payoff difference between leader and non-leaders is minimized among the set of subgame perfect equilibria.

From the team leader's perspective, there may be considerable strategic uncertainty regarding the value of $\widehat{x}$. For instance, it seems unlikely that the team leaders would anticipate being able to claim the entire net surplus from team production without attracting the ire of the other team members. Rather, the leader ought to contemplate the highest claim that non-leaders might be willing to tolerate if they are concerned about fairness in terms of the way the net surplus is distributed. There are a couple of ways to think about what might be considered *fair* by the non-leaders.

First, our setting bears some resemblance (though not a perfect fit) to the ultimatum game. There is an enormous amount of evidence that reciprocal behavior plays a key role in this game. Low offers are frequently rejected (see, e.g., Güth et al., 1982; Thaler, 1988; Güth, 1995; Camerer and Thaler, 1995; Roth, 1995) reflecting either a concern for fairness, or negative reciprocity towards offers that are perceived to be unkind (Falk and Fischbacher, 2006). These same considerations could be used to refine the set of subgame perfect equilibria in our environment and provide sharper predictions regarding behavior in the experiments.

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[34] For the purposes of the illustration, the graph is drawn assuming that non-leaders choose the full investment equilibrium for all $x < \widehat{x}$. However, this assumption is not at all important for the analysis.

[35] Note that, when $\widehat{x} < nc/(n-1)$, there are also equilibria with $m = 0$.

Suppose that we set aside any questions about coordination by non-leaders on a Nash equilibrium in Stage 2. That is, the non-leaders can perfectly coordinate on either the full investment equilibrium or the full free riding equilibrium after observing $m = 1$ and a claim $x \in [2(A-1)\omega, n(A-1)\omega]$. We can then interpret the actions of the non-leaders as the (collective) decision to accept (by playing the full investment equilibrium) or reject (by playing the free-riding equilibrium) the team leader's offer, which is precisely determined by x. An important difference is that, in our setting, rejecting the team leader's offer by playing the free-riding equilibrium does not rely on modifying the preferences of the agents; such behavior is an equilibrium in the corresponding subgame. Instead, it relies on the players being able to coordinate on a maximum claim, $\widehat{x}$, that they are willing to tolerate. It follows directly from the fact that the subgame perfect equilibrium payoffs for the non-leaders are decreasing in $\widehat{x}$, that the non-leaders would like to coordinate on $\widehat{x}$ as low as possible, subject to being sequentially rational.

The team leader thus faces considerable strategic uncertainty regarding the behavior of the non-leaders. Moreover, the consequences of claiming $x > \widehat{x}$ may be significant, since the leader's payoff would fall from $A\omega - c + (n-1)\widehat{x}/n$ to $A\omega - c$. Facing this uncertainty, team leaders may opt to eschew monitoring altogether (especially when the cost c is large), claim at least $A\omega$, invest the full endowment, and ensure a payoff of $A\omega$.

In the more general sense, our setting can also be viewed (like the ultimatum game) as a bargaining game between the team leader and the non-leaders. In particular, suppose the players bargain over a division of the *net surplus* generated by playing the full investment equilibrium instead of the free-riding equilibrium. Given the leader's outside option of choosing $(x, m) = (A\omega, 0)$, the disagreement point for the parties involves a payoff of $A\omega$ for the leader, and ω for the non-leaders. The net surplus gain (in equilibrium payoffs) from $m = 1$ rather than $m = 0$ is $(A-1)(n-1)\omega - c$.[36] It is useful then, to consider the type of agreements that might be reached if the parties could bargain about the division of the net surplus gain.

To that end, consider a multilateral version of the Nash Bargaining solution with equal bargaining power over the generated surplus gain. Using $\pi_L = A\omega$ and $\pi_i = \omega$ for $i \neq l$ as the threat point, the Nash product is

$$\begin{aligned}\mathcal{NP} &= \left(\left(A\omega + \frac{n-1}{n}x - c\right) - A\omega\right)\left(\left(A\omega - \frac{1}{n}x\right) - \omega\right)^{n-1} \\ &= \left(\frac{n-1}{n}x - c\right)\left((A-1)\omega - \frac{1}{n}x\right)^{n-1}. \qquad [A.3]\end{aligned}$$

Taking the natural logarithm and maximizing yields the first-order condition

$$\frac{n-1}{n}\left(\frac{1}{(A-1)\omega - x/n}\right) = \frac{(n-1)/n}{(n-1)x/n - c},$$

---

[36] Total payoffs in a SPE with $m = 1$ are $nA\omega - c$, while total payoffs with $m = 0$ are $(A + n - 1)\omega$.

which rearranges to

$$x = (A-1)\omega + c. \tag{A.4}$$

Note that for $c < (A-1)\omega$, this solution suggests a claim $x < 2(A-1)\omega$. However, as we argued above, when $x < 2(A-1)\omega$, non-leaders have a dominant strategy to invest their full endowment. Thus, if we add the constraint that the claim be part of a SPE, the constrained solution for cases where $c < (A-1)\omega$ is $x = 2(A-1)\omega$.

It follows that for sufficiently low cost of monitoring, a natural prediction is that non-leaders will coordinate on $\widehat{x} = 2(A-1)\omega$, which corresponds to the lowest $\widehat{x}$ among the set of all SPE. For higher costs, $c > 2(A-1)\omega$, the Nash bargaining approach suggests a critical claim of $\widehat{x} = (A-1)\omega + c$. The added appeal of this approach is that it reconciles with the idea that concerns about fair distribution of the net surplus gain can be used as a basis for equilibrium selection.

B Additional Figures & Tables

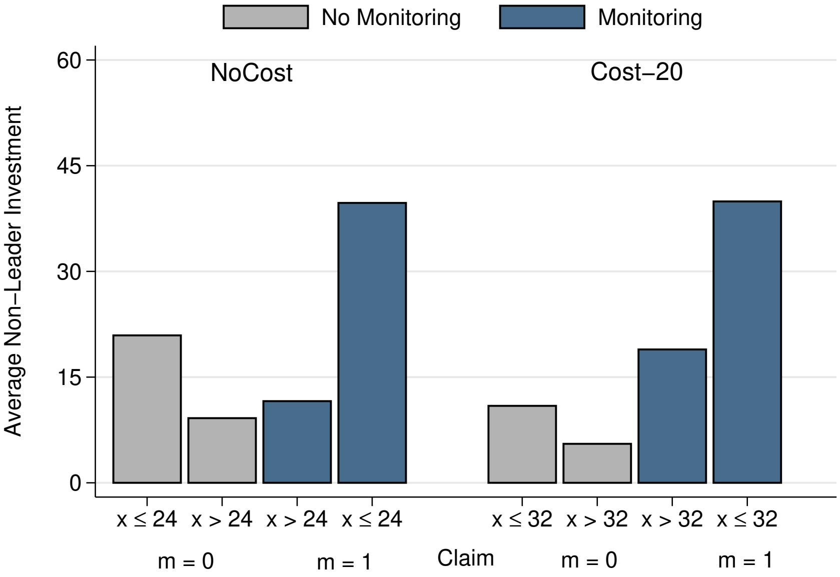

Figure B.1. Average non-leader investment by monitoring decision: fair vs. unfair claims

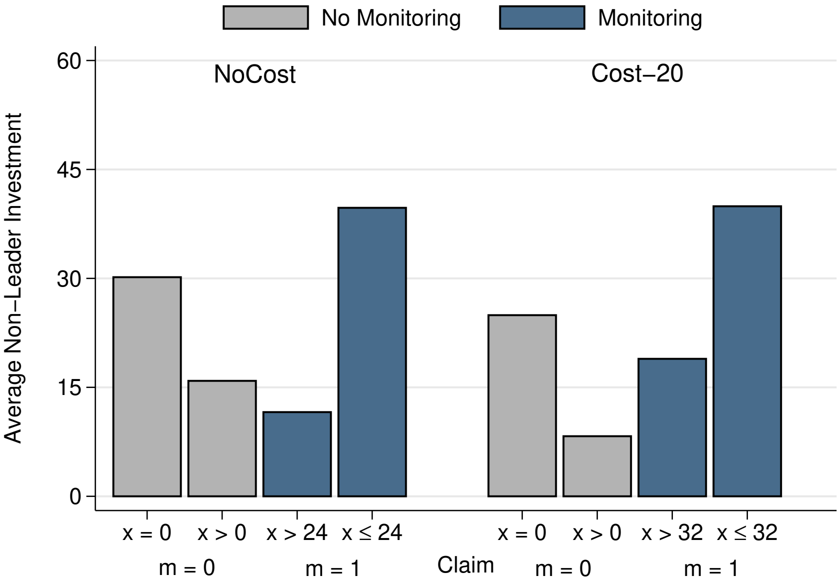

Figure B.2. Average non-leader investment by monitoring decision: fair vs. unfair claims ($m = 1$) and zero vs. non-zero claims ($m = 0$)

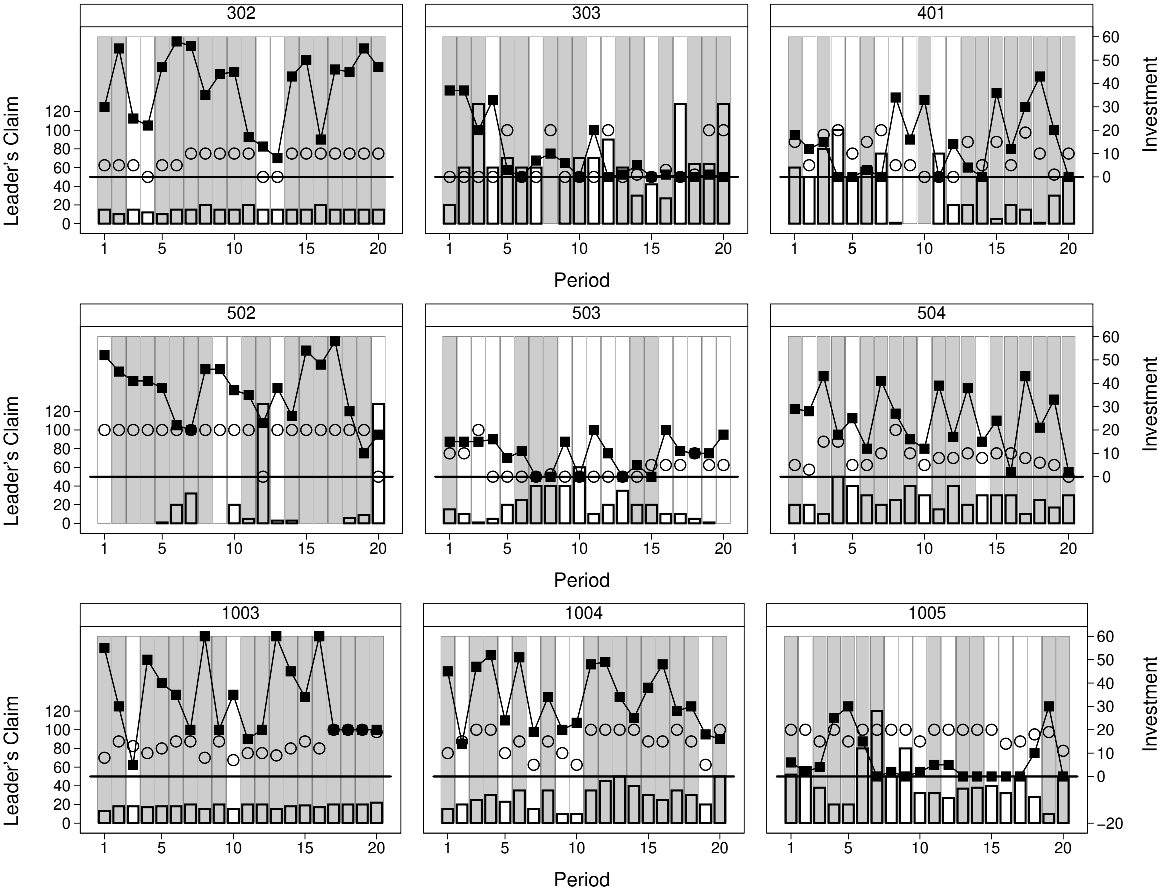

Figure B.3. Investment, monitoring, and claims in *"unsuccessful"* groups—NoCost treatment. *Notes:* Gray (white) columns indicate $m = 1$ ($m = 0$); Bars in the lower panel indicate leader's claim (left axis); Hollow circles indicate leader's investment (right axis); Connected squares indicate total non-leaders' investment (right axis).

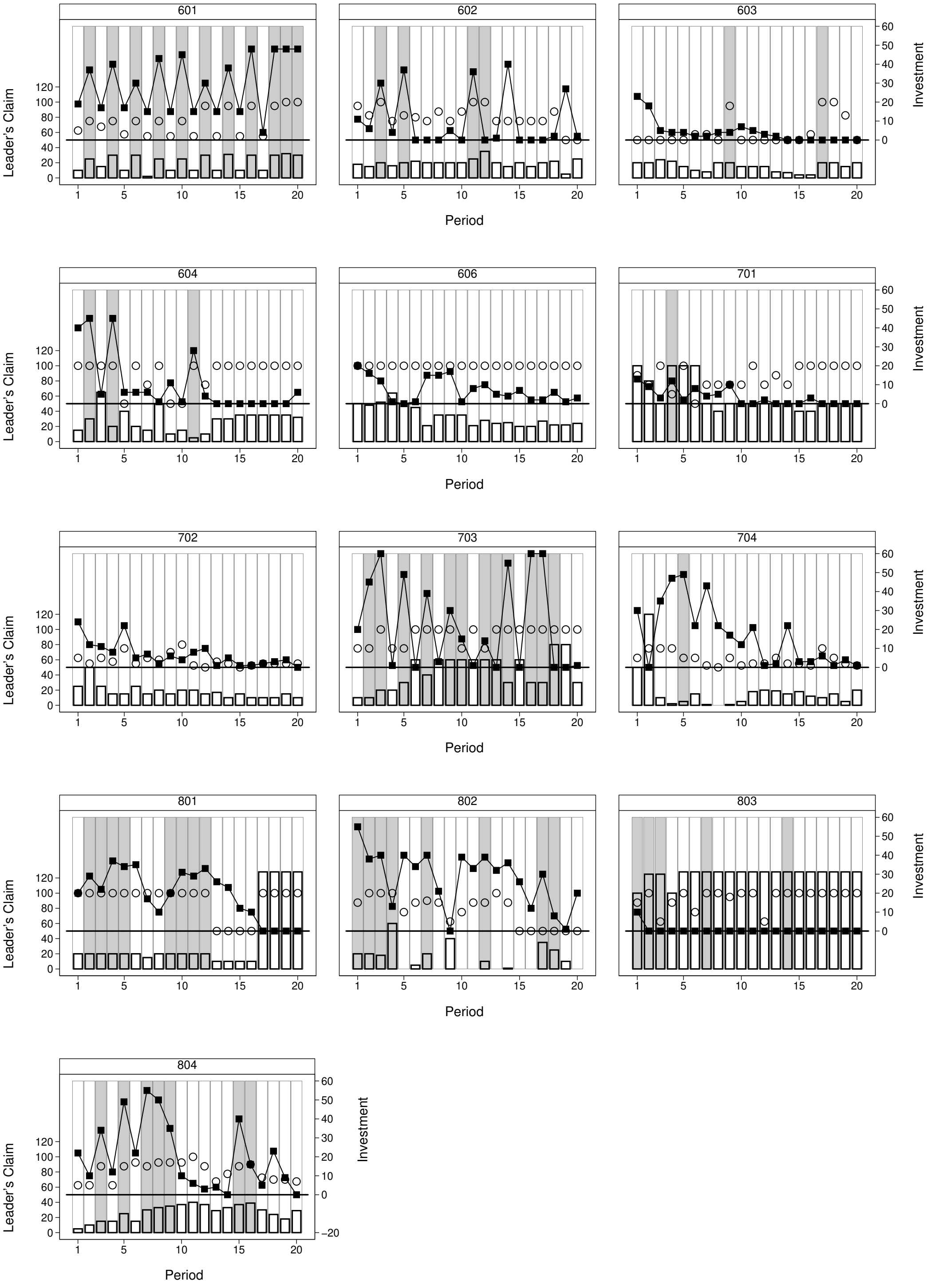

Figure B.4. Investment, monitoring, and claims in *"unsuccessful"* groups—Cost-20 treatment. *Notes:* Gray (white) columns indicate $m = 1$ ($m = 0$); Bars in the lower panel indicate leader's claim (left axis); Hollow circles indicate leader's investment (right axis); Connected squares indicate total non-leaders' investment (right axis).

Table B.1. Dynamic Panel-Data Regression (One-Step System GMM) of Non-leaders' Investment on Monitoring and Claim, by Treatment, using periods 11-20 (Table 5 using the last 10 periods only).

Dependent variable: Non-leaders' investment

	NoCost		Cost-20	
	(1)	(2)	(3)	(4)
$E^{NL}_{i,t-1}$	0.057	0.132	−0.068	0.026
	(0.110)	(0.110)	(0.108)	(0.099)
m (monitoring)	23.067***	24.450***	28.934***	33.116***
	(7.886)	(7.317)	(9.554)	(9.515)
x (claim)	0.052	0.037	−0.094	−0.098
	(0.064)	(0.073)	(0.072)	(0.069)
$x \times m$	−0.501***	−0.490***	−0.265*	−0.345**
	(0.157)	(0.152)	(0.147)	(0.129)
Constant	21.844***	20.323***	15.419***	12.338**
	(5.448)	(4.829)	(4.069)	(4.586)
Period Dummies	✗	✓	✗	✓
Arellano-Bond test for AR(2)	0.816	0.663	0.570	0.584
Hansen test	0.237	0.873	0.374	0.745
Instruments	13	21	13	21
Groups	16	16	16	16
Observations	144	144	144	144

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We report p-values for the AR(2) test and the Hansen test.

C Experimental Instructions

In this section, we provide a copy of the experimental instructions for the three treatments. In all treatments, the Introduction and Part 1 were identical. The instructions for Part 2 differed across treatments. Below, we highlight the differences in the instructions for NoCost and Cost-20 using block paragraphs and italicized text for Cost-20. The instructions for Threshold are provided separately at the end.

C.1 Introduction (All treatments)

Thank you for participating in today's experiment. I will read through the script so that everyone receives the same information. Please remain quiet and do not communicate with other participants during the experiment. Raise your hand if you have any questions. Someone will come to you to answer the question privately.

For your participation in today's experiment, you will receive the show-up fee of $7. In addition, during the experiment, you will have the opportunity to earn more money. Your additional earnings will depend on the decisions you make and on the decisions made by other participants. At the end of the experiment, you will be paid anonymously by check. No other participant will be informed about your payment.

The experiment consists of multiple parts. The instructions for each part will only be distributed and read after previous parts have been completed.

C.2 Part 1 (All treatments)

In this part, you will participate in the following decision situations. All amounts are expressed in US Dollars for this part.

Decision Situation A

You will be randomly matched to one other person in the room. You will be given $2.00. Your task is to decide how much of the $2.00 (200 cents) to allocate to the other person and how much to keep for yourself.

In the space provided on the screen, you can allocate any integer number of cents from 0 to 200 to the other person and allocate the rest to yourself. After you have made your allocation decision, click the submit button on the screen.

Decision Situation B

While you are making your choice for Decision Situation A, you will also be randomly matched with a **different** other person in the room for Decision Situation B. This other person will be given $2.00 and asked to decide how much they wish to allocate to you and how much to keep for themselves.

Payment from Part 1

Only one of the two decision situations will be randomly selected and used to determine your payment from Part 1. Each situation is equally likely to be selected.

If Decision Situation A is the randomly selected option, then your earnings from Part 1 will be the amount you decided to keep for yourself and the earnings of the other person you are matched with for Decision Situation A will be the amount you allocated to him or her.

If Decision Situation B is the randomly selected option, then your earnings from Part 1 will be the amount allocated to you by the other person you are matched with for Decision Situation B. The earnings of that same other person will be the amount he or she decided to keep.

The results from this part of the experiment will not be revealed until the very end of the session, once all parts of the experiment are completed. On the Final Results screen, you will be shown which of the two decision situations was randomly selected and your earnings from that situation.

C.3 Part 2 (NoCost and Cost-20)

The Decision Situation

Before this part of the experiment begins, you will be randomly divided into groups consisting of four people. You will not be able to identify who is in your group, and nobody will be able to identify you. However, **the people in your group will stay the same throughout the experiment.**

In addition, one participant in each group will be randomly assigned to the role of **Team Leader**. The role of team leader will also be fixed for the entire experiment.

The experiment will consist of 20 periods. In each period, you can earn tokens, depending on the decisions made within your group. Your earnings will not be affected by the decisions made in other groups. At the end of the experiment, your earnings from each period will be added together and converted into US dollars according to the exchange rate of **60 tokens = 1 US Dollar**.

Every period has the same structure.

> NoCost The decision situation proceeds in two stages. In Stage 1, the team leader will make two decisions. The first decision is whether or not to select the monitoring option for the period. The second decision for the team leader is to choose an amount x that they would like to claim out of the team revenue generated in Stage 2 (explained below).
>
> Cost-20 *The decision situation proceeds in two stages. In Stage 1, the team leader will make two decisions. The first decision is whether or not to select the monitoring option for the period. If the team leader selects the monitoring option, he or she will automatically incur a cost of* **20 tokens** *at the end of the period. If the monitoring option is not selected, then no cost is incurred. The second decision for the team leader is to choose an amount x that they would like to claim out of the team revenue generated in Stage 2 (explained below).*

In Stage 2, each group member (including the team leader) will be given **20 tokens** and must decide how many tokens to invest in a **group project** and how many to keep in his or her private account. Any tokens that you do not invest into the group project will be automatically placed into your private account. For each token you keep in your private account, you will receive 1 token in earnings. Thus, if you keep 5 tokens in your private account, your earnings from the private account will be 5 tokens.

The team revenue for your group will be determined as follows. First, all of the tokens invested by you and your group members will be added together. This total (the sum of all investments in the group project) will then be multiplied by the return factor, which is **1.6**. For example, if the total number of tokens invested into the group project by you and your group members is 40, then your team revenue will be equal to $40 \times 1.6 = 64$ tokens.

Your earnings from your group's team revenue depend on the decisions made by your team leader. **First,** the team leader's claim x is paid out of the team revenue. If team revenue is not large enough to cover the entire claim, then all team revenue will be paid to the team leader, in partial payment of the claim.

Second, the remaining team revenue (if there is any) is shared among the four team members (including the team leader). However, the way that the remaining team revenue is shared depends on whether or not the team leader selected the monitoring option.

- If the team leader DID NOT SELECT the monitoring option, any remaining team revenue will be divided **EQUALLY** between the four members of your group, including the team leader.

For example, suppose you invested 5 tokens in the group project, while the other members of your group invested a total of 35 tokens into the group project. Then the total investment in the group project would be 40 tokens, which generates team revenue equal to 64 tokens ($40 \times 1.6 = 64$). Suppose the team leader claimed $x = 14$ tokens. Then the remaining team revenue would be $64 - 14 = 50$ tokens. If the team leader DID NOT SELECT the monitoring option, these 50 tokens would be divided EQUALLY between the four members of your group. That is, each group member (including the team leader) would receive 12.5 tokens in earnings from the group project ($0.25 \times 50 = 12.5$).

- If the team leader SELECTED the monitoring option, any remaining team revenue will be divided between the four members of your group in **PROPORTION** to each individual's investment in the group project. Specifically, each group member will receive a proportional share S of the remaining team revenue, where

$$S = \frac{\text{Group member's investment in the group project}}{\text{Total amount invested in the group project}}$$

As in the previous example, suppose you invested 5 tokens in the group project, while the other members of your group invested a total of 35 tokens into the group project. Then the total investment in the group project would be 40 tokens, which generates team revenue equal to 64 tokens. Suppose the team leader claimed $x = 14$ tokens. Then, as above, the remaining team revenue would be $64 - 14 = 50$ tokens. If the team leader SELECTED the monitoring option, these 50 tokens would be divided PROPORTIONALLY to individual investments among the four members of your group. Your proportional share of the remaining 50 tokens would be

$$S = \frac{5 \text{ tokens}}{40 \text{ tokens}} = \frac{1}{8}$$

which means you would receive $\frac{1}{8} \times 50 = 6.25$ tokens in earnings from the group project.

Earnings

If you are not the team leader in your group, your earnings for each period will be determined as follows.

Earnings from your Private Account

$$= 20 - \text{ Tokens you invested in the Group Project}$$

Earnings from the Group Project

- if the team leader DID NOT SELECT the monitoring option

$$= 0.25 \times \Bigg(\text{ Team Revenue} - x \Bigg)$$

- if the team leader SELECTED the monitoring option

$$= S \times \Bigg(\text{ Team Revenue} - x \Bigg)$$

where Team Revenue $= 1.6 \times ($ Sum of all Tokens invested in the Group Project), x is the amount claimed by the team leader, and S is your proportional share of the tokens invested in the Group Project. Notice also that if x is greater than the Team Revenue, your Earnings from the Group Project will be 0.

In each period, your total earnings will be the sum of your earnings from your private account and your earnings from the group project.

Total Earnings (non-leader)

$$= \text{ Earnings from your Private Account } + \text{ Earnings from the Group Project}$$

NoCost **If you are the team leader in your group,** your earnings for each period will be calculated the same way as above, with one additional term. Your earnings will be increased by the amount of the claim x you make in Stage 1, except if x is greater than the Team Revenue. In this case, your claim will be partially paid by allocating all of the Team Revenue to you.

Thus, in each period, your total earnings will be the sum of your earnings from your private account and your earnings from the group project, as calculated above, plus the minimum amount between your claim x and the Team Revenue.

Total Earnings (leader)

$$= \text{ Earnings from your Private Account } + \text{ Earnings from the Group Project}$$

$$+ \min\{x, \text{Team Revenue }\}.$$

Cost-20 **If you are the team leader in your group,** *your earnings for each period will be calculated the same way as above, with two additional terms. First, if you SELECTED the monitoring option, your earnings will be reduced by the amount of the cost of the monitoring option, which is* **20 tokens**. *Second, your earnings will be increased by the amount of the claim x you make in Stage 1, except if x is greater than the Team Revenue. In this case, your claim will be partially paid by allocating all of the Team Revenue to you.*

Thus, in each period, your total earnings will be the sum of your earnings from your private account and your earnings from the group project, as calculated above, plus the minimum amount between your claim x and the Team Revenue, minus the cost of selecting the monitoring option.

Total Earnings (leader)

$$= \text{ Earnings from your Private Account } + \text{ Earnings from the Group Project}$$

$$+\min\{x, \text{Team Revenue }\} - \begin{cases} 20 & \text{if you SELECTED the monitoring option} \\ 0 & \text{if you DID NOT SELECT the monitoring option} \end{cases} .$$

Feedback

At the beginning of each period, the team leader will decide whether or not to select the monitoring option and will choose a claim x (Stage 1).

After Stage 1 is completed, the team leader's choices will be shown on the screen before you make your investment decision. All group members (including the team leader) will simultaneously and privately make their investment decisions (Stage 2).

At the end of each period, the screen will display the team leader's Stage 1 choices, your own investment in the group project, the total investment in the group project, the team revenue for your group, and the calculation of your total earnings for the period.

Note that the team leader will not be shown the individual investments made by the other group members, even if the monitoring option is selected. That is, the only effect of the monitoring option is to change the way any remaining team proceeds are shared; from EQUAL among all four group members, to PROPORTIONAL to each group member's individual investment.

Practice Stages

Before the paid periods begin, you will have the opportunity to participate in two (unpaid) practice stages. **In these practice stages only**, you will not be matched with anyone else. Instead, you will each be able to make hypothetical choices for all of the players in a group consisting of a team leader and three others. After everyone has entered their choices, a summary of the results and the calculation of earnings will be displayed for all of the hypothetical group members. **However, as a reminder, you will not see the full calculation of earnings for anyone but yourself during the actual (paid) periods.**

In the first practice stage, you will be placed in a setting where the team leader DID NOT SELECT the monitoring option. Then you can choose a claim for the team leader and investments for all four group members. Once you click submit, please wait for others to finish making their choices. After everyone has finished, the screen will show the calculation of payoffs for each player in the group, based on the hypothetical decisions you entered for them. Note that since the team leader DID NOT SELECT the monitoring option, all group members will receive an equal share of any team revenue that remains after paying the team leader's claim.

In the second practice stage, you will be placed in a setting where the team leader SELECTED the monitoring option. Again, you can choose a claim for the team leader and investments for all four group members. Once you click submit, please wait for others to finish making their choices. After everyone has finished, the screen will show the calculation of payoffs for each player in the group, based on the hypothetical decisions you entered for them. Note that, in this case, since the team leader SELECTED the monitoring option, all group members will receive a share, in proportion to their individual investments, of any team revenue that remains after paying the team leader's claim.

No other participant will be shown the hypothetical decisions you enter in either practice stage.

C.4 Part 2 (Threshold)

The Decision Situation

Before this part of the experiment begins, you will be randomly divided into groups consisting of four people. You will not be able to identify who is in your group, and nobody will be able to identify you. However, **the people in your group will stay the same throughout the experiment.**

The experiment will consist of 20 periods. In each period, you can earn tokens, depending on the decisions made within your group. Your earnings will not be affected by the decisions made in other groups. At the end of the experiment, your earnings from each period will be added together and converted into US dollars according to the exchange rate of **60 tokens = 1 US Dollar**.

Every period has the same structure.

Each group member will be given **20 tokens** and must decide how many tokens to invest in a **group project** and how many to keep in his or her private account. Any tokens that you do not invest into the group project will be automatically placed into your private account. For each token you keep in your private account, you will receive 1 token in earnings. Thus, if you keep 5 tokens in your private account, your earnings from the private account will be 5 tokens.

The team revenue for your group will be determined as follows. First, all of the tokens invested by you and your group members will be added together. This total (the sum of all investments in the group project) will then be multiplied by the return factor, which is **1.6**. For example, if the total number of tokens invested into the group project by you and your group members is 40, then your team revenue will be equal to $40 \times 1.6 = 64$ tokens.

The total team revenue is shared among the four team members. However, the way that the revenue is shared depends on whether or not a **monitoring option** is in place. The cost of the monitoring option is **20 tokens**.

- If the total team revenue is **less than or equal to** the cost of the monitoring option, then the monitoring option will NOT be selected for the round. In this case, all the total team revenue will be divided **EQUALLY** between the four members of your group.

For example, suppose you invested 3 tokens in the group project, while the other members of your group invested a total of 7 tokens into the group project. Then the total investment in the group project would be 10 tokens, which generates team revenue equal to 16 tokens ($10 \times 1.6 = 16$). Since the total team revenue is less than the cost (20 tokens), the monitoring option will NOT be selected, and the 16 tokens in total team revenue would be divided EQUALLY between the four members of your group. That is, each group member would receive 4 tokens in earnings from the group project ($0.25 \times 16 = 4$).

- If the total team revenue is **greater than** the cost of the monitoring option, then the monitoring option will be SELECTED for the round. In this case, the cost will be deducted from the total team revenue, and the remaining team revenue will be divided between the four members of your group in **PROPORTION** to each individual's investment in the group project. Specifically, each group member will receive a proportional share S of the remaining team revenue, where

$$S = \frac{\text{Group member's investment in the group project}}{\text{Total amount invested in the group project}}$$

Suppose you invested 5 tokens in the group project, while the other members of your group invested a total of 35 tokens into the group project. Then the total investment in the group project would be 40 tokens, which generates team revenue equal to 64 tokens ($40 \times 1.6 = 64.$). Since the total team revenue is greater than the cost (20 tokens), the monitoring option WILL be selected and the cost deducted from team revenue. Therefore, the remaining team revenue would be $64 - 20 = 44$ tokens. These 44 tokens would then be divided PROPORTIONALLY to individual investments among the four members of your group. Your proportional share of the remaining 44 tokens would be

$$S = \frac{5 \text{ tokens}}{40 \text{ tokens}} = \frac{1}{8}$$

which means you would receive $\frac{1}{8} \times 44 = 5.5$ tokens in earnings from the group project.

Earnings

Your earnings for each period will be determined as follows.

Earnings from your Private Account

$$= 20 - \text{ Tokens you invested in the Group Project}$$

Earnings from the Group Project

- if Total Team Revenue <= 20, so that the monitoring option is NOT SELECTED,

$$= 0.25 \times \Bigg(\text{ Team Revenue} \Bigg)$$

- if Total Team Revenue > 20, so that the monitoring option is SELECTED,

$$= S \times \Bigg(\text{ Team Revenue} - 20 \Bigg)$$

where Team Revenue = $1.6 \times$ (Sum of all Tokens invested in the Group Project), and S is your proportional share of the tokens invested in the Group Project.

In each period, your total earnings will be the sum of your earnings from your private account and your earnings from the group project.

Total Earnings

$$= \text{ Earnings from your Private Account} + \text{Earnings from the Group Project}$$

Feedback

At the end of each period, the screen will display your own investment in the group project, the total investment in the group project, the team revenue for your group, and the calculation of your total earnings for the period.

Note that you will not be shown the individual investments made by the other group members, even if the monitoring option is selected. That is, the only effect of the monitoring option is to change the way any remaining team revenue after paying the cost is shared; from EQUAL among all four group members, to PROPORTIONAL to each group member's individual investment.

Practice Stages

Before the paid periods begin, you will have the opportunity to participate in two (unpaid) practice stages. **In these practice stages only**, you will not be matched with anyone else. Instead, you will each be able to make hypothetical choices for all of the players in a group consisting of you and three others. After everyone has entered their choices, a summary of the results and the calculation of earnings will be displayed for all of the hypothetical group members. **However, as a reminder, you will not see the full calculation of earnings for anyone but yourself during the actual (paid) periods.**

No other participant will be shown the hypothetical decisions you enter in either practice stage.