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Team Incentives and Leadership

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Abstract
We study, experimentally, how two alternative incentive mechanisms affect team performance, and how a team chooses between alternative mechanisms. We study a group incentive mechanism, where team output is shared equally among team members, and a hierarchical mechanism team output is allocated by a team leader. Our experiment examines these mechanisms in both homogeneous teams, where workers have identical productivities and in heterogeneous teams, where workers vary in their productivity. Our results are robust to whether teams are homogeneous or heterogeneous. We find that output is higher when a leader has the power to allocate output, but this mechanism also generates large differences between earnings of leaders and other team members. When team members can choose how much of team output is to be shared equally and how much is to be allocated by a leader, they tend to restrict the leader's power to distributing less than half of the pie.

Keywords: Team Production, Leadership, Reward Power, Delegation, Experiment

JEL codes: C92, H4, D7

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1. Introduction

Group incentive schemes in team production environments are vulnerable to well-known free-rider problems. In this paper we investigate, experimentally, whether team performance can be improved by empowering a leader to distribute team output among team members, as an alternative to a simple revenue-sharing arrangement.

Our starting point is an environment where team members incur individual effort costs from making contributions to team output, but share team output equally with all team members. As is well-known, since the benefits of a team member's efforts are shared with the rest of the team, this introduces an externality that in theory, if decisions are guided by a comparison of private costs and benefits, will result in excessive shirking and welfare loss (Holmstrom, 1982). A substantial experimental literature finds that efforts in such environments are prey to free-riding incentives, falling short of efficient levels and decreasing with repetition (see for example the early study by Nalbantian and Schotter, 1997, or the recent review in Camerer and Weber, 2012). In line with these previous findings, we also observe substantial free-riding in this benchmark treatment.

We then focus on two research questions. First, we ask whether installing a leader who allocates rewards to team members improves team performance. Second, we ask whether team members will voluntarily cede such power to a leader, and whether this affects the leader's performance, in terms of encouraging team production.

To answer the first question we conduct treatments where all team output accrues to a leader, who can then decide how to distribute it. Importantly, any output not allocated to other team members is retained by the leader. In this setting, a leader might induce efficient team production by compensating team members appropriately for the costs they incur from their productive efforts, and furthermore she has an incentive to do so as efficient team production will increase her residual claim. Such a solution to the free-riding problem may, however, be vulnerable to other sorts of incentive problems. Most obviously, a selfish leader has an incentive to appropriate all the team output for herself. In theory, assuming standard selfish preferences, a leader will keep all team output and, in anticipation of this team members supply minimum effort.

In contrast to this theoretical prediction, in our experiment we find that installing a leader does indeed promote effort and increase efficiency. Leaders use simple strategies that reward workers who supply high effort and withhold rewards from shirkers. This in turn encourages effort and results in substantial increases in team production and earnings. Team earnings are substantially higher than in our benchmark treatment without a leader, and amount to almost 90% of the maximum possible earnings.

Successful leadership may be more challenging when, as in many natural team settings, workers vary in their productivity. What constitutes "compensating team members appropriately" may then be less straightforward. If workers are concerned about equity and fairness, and if there are competing notions of fairness, it may be particularly difficult to provide the correct incentives. Thus, we also ran treatments with heterogeneous worker productivities. Again, we find low effort in the absence of a leader and substantially higher effort and efficiency with a leader. Thus, just as in the case of homogeneous teams, with heterogeneous teams we find that installing a leader with power to distribute the proceeds of team production is successful in promoting efficiency.

A feature of these treatments is that the institutional setting – either a group incentive scheme or a leader reward scheme – is exogenously imposed on a team as part of our experimental design. Since, in practice, authority is often not absolute but instead is granted, we conducted further treatments to investigate our second question: whether teams will voluntarily cede discretionary reward power to a leader, and whether endogenously empowering leaders affects team performance.

To answer this question, in a second set of experiments we allowed team members to repeatedly decide on the leader's power through a voting mechanism. Team members can decide what proportion of team output will be given to the leader to distribute, with the remainder shared equally among the team members.

Making the leader's power endogenous in this way could represent an obstacle to successful leadership. Even if a leader would be willing and able to compensate workers, team members may not vote for leadership because they fail to anticipate the leader's behavior, or because they prefer to retain some control over part of their earnings from providing effort. This may reflect a non-pecuniary benefit from partially controlling incentives, similar to the desire to retain authority seen in other studies of principal-agent relationships (e.g., Bartling and Fischbacher, 2012; Fehr et al., 2013). On the other hand, the voting mechanism may facilitate successful leadership. First, the voting mechanism gives team members an opportunity to punish leaders who abuse their power, and so it may be a useful mechanism for constraining opportunistic leaders. Second, as seen in other studies of endogenous institutions (e.g., Dal Bó et al., 2010; Sutter et al., 2010) giving agents a voice in the institution may in and of itself foster a more cooperative environment.

We find that, as in our previous treatments, team production and earnings are higher when leaders are given more power. However, despite the success of the leadership institution when it emerges, we find that team members delegate too little power to leaders and so the potential gains from leadership are not realized. The main reason for this appears to be the way the benefits of leadership are shared. Although the leaders' rewarding strategies are well-calibrated to make it pay to work rather than shirk, the rents from work go mainly to the leader. That is, the leader rewards enough to compensate team members for their effort costs, but takes the lion's share of any remaining output. Given that team members do slightly better than predicted under group incentives, the leaders' rewarding strategies do not make leadership an attractive proposition.

Our experiment adds to a recent experimental literature examining the potential for leadership to overcome the free-rider problem. However, most of this literature examines how a leader may influence followers by their own effort choice (i.e. "leading-by-example", as studied in, e.g., Gächter and Renner, 2003; Güth et al., 2007; Potters et al., 2007; Drouvelis and Nosenzo, 2013), or by communication (e.g., Wilson and Sell, 1997; Levy et al., 2011; Houser et al., 2014). This literature has also studied endogenous leadership, either through allowing the sequential move structure of leading-by-example to emerge endogenously (e.g., Potters et al., 2005; Haigner and Wakolbinger, 2010; Rivas and Sutter, 2011; Arbak and Villeval, 2013), or by using voting mechanisms to select communicators (e.g., Brandts et al., 2014). Our leaders are different in that they control the remuneration of team members and can use this to motivate self-interested team members. That is, we study what has been termed "transactional leadership" (Burns, 1978), where leaders allocate tangible rewards to obtain compliance from followers.

There have been relatively few studies of transactional leadership in experimental economics. Gürerk et al. (2009) and Nosenzo and Sefton (2014) study team production games where, after all team members have made a contribution to team production and received an equal share of team output, one team member (the team leader) receives a monetary budget that she can use to inflict punishment or rewards. Their main interest is on the relative effectiveness of punishments versus rewards (punishments turn out to be more effective) and the endogenous choice of incentive instrument (teams learn to use punishment incentives). Our study differs from these previous papers in that our leaders can only yield incentives through decisions on how to distribute output, with the leader's earnings determined by her residual claim. More closely related are studies by Heijden et al. (2009) and Abeler et al. (2010), who study settings where agents generate revenues from which a principal can reward agents and retain residual earnings.[1] Like us, Heijden et al. (2009) show that this institution raises effort and efficiency significantly compared to a revenue sharing institution. However, their study differs in numerous ways, e.g. their leaders have a productive as well as allocative role, effort decisions are binary, there are complementarities in team production. Most importantly, they do not consider asymmetries in productivity or endogenous incentive mechanisms. Abeler et al. (2010) study a game between two agents, who exert efforts, and a principal who chooses wages. They find that efforts are low when the principal is constrained to pay equal wages, but higher when the principal can pay different wages to different workers. Again, they do not consider asymmetries in productivity or endogenous authority.

The remainder of the paper is organized as follows. In section 2 we present our initial study where we compare team production under a leaderless group incentive scheme with a leader reward-based incentive scheme. In section 3 we present our second study, where the leader's reward power is delegated by team members. Concluding comments are provided in section 4.

2. Study 1: The effectiveness of exogenously imposed leadership

2.1 Experiment design

In our initial study we examine the effectiveness of exogenously imposed leadership using a ten-round, five-person team production game. Teams are randomly formed in the first round of the game and remain fixed across rounds. Within each team, four subjects are randomly assigned the role of "worker" and one subject the role of "leader", and these roles are kept fixed across rounds.[2] Subjects earned points in each round and at the end of the game were paid based on their accumulated point earnings from all rounds.

Each round consists of two stages. In stage one each worker is endowed with 10 units of effort and chooses how many units to contribute to team production. Worker choices are made simultaneously. Leaders are also endowed with 10 units of effort but they cannot

[1] Also related is the experiment by Stoddard et al. (2014), who study a common-property resource game where groups of four agents make provision decisions, and a leader decides the shares of output to allocate to each agent. They find that this mechanism increases provision relative to a revenue sharing mechanism. Differently from our study, their leader is not a residual claimant of the common-property resource. Moreover, Stoddard et al. (2014) do not study settings with asymmetric productivities or endogenous incentive mechanisms.

[2] We did not use the labels "worker" and "leader" in the instructions. Instead, subjects were identified through letters A to E and group members A to D acted as workers and group member E as leader in the experiment. In our NoLeader treatments group member E had no decision-making role and simply observed the decisions of the other group members. We included this "dummy" player in our design to enhance comparability with the Leader treatment. The instructions are reproduced in Appendix A.

contribute these to team production in the experiment. Each unit of effort that a team member does not contribute to team production yields 30 points to that member, whereas each unit of effort contributed to team production by worker i generates θ_i points of "team output". In stage two of each round the team output is redistributed among team members according to the following rules: a share γ of the team output ($0 \leq \gamma \leq 1$) is transferred to the team leader who decides how to redistribute the output among all team members (including the leader), and the remaining share $1 - \gamma$ of team output is equally redistributed among the four workers. The leader is informed of the individual efforts in stage one before making her redistribution decisions by assigning reward points to workers. The point earnings of the team members are as follows:

$$\pi_{Leader} = 300 + \gamma \cdot \sum_{i=1}^{4} \theta_i e_i - \sum_{i=1}^{4} r_i$$

$$\pi_{Worker\,i} = 300 - 30e_i + \frac{1-\gamma}{4} \cdot \sum_{i=1}^{4} \theta_i e_i + r_i$$

where $e_i \in \{0, 1, \ldots, 10\}$ denotes worker i's effort in stage one and r_i denotes the reward points assigned by the leader to worker i in stage two. The leader cannot assign negative rewards, $r_i \geq 0$, and total rewards cannot exceed the share of team output controlled by the leader, $\sum_{i=1}^{4} r_i \leq \gamma \cdot \sum_{i=1}^{4} \theta_i e_i$. At the end of each round all team members are informed of all stage one and stage two choices, and the resulting payoffs.

This initial study has four treatments in a 2x2 between-subject design where we vary:

i) the share of team output γ transferred to the leader, and

ii) workers' productivity parameter θ_i, i.e. the number of points of team output generated by a unit of worker i's effort.

In our **NoLeader** treatments leaders have no reward power: no share of team output is transferred to the leader (i.e., $\gamma = 0$) and all team output is equally shared by the four workers. In our **Leader** treatments leaders have instead full reward power as they receive the whole team output to redistribute (i.e., $\gamma = 1$). In our **Homogeneous** treatments productivity is homogenous within a team, i.e. for all workers each unit of effort generates $\theta_i = 60$ points of team output. In our **Heterogeneous** treatments workers are heterogeneous in their productivity: two workers have high productivity ($\theta_i = 80$), while the other two have low productivity ($\theta_i = 40$). Table 1 summarizes the design of the experiment.

Table 1 – Study 1 experimental design

Treatment	Share of team output redistributed by leader (γ)	Workers' productivity (θ_i)
NoLeader_Homogeneous	$\gamma = 0$	$\theta_i = 60$ for $i = \{1, 2, 3, 4\}$
Leader_Homogeneous	$\gamma = 1$	$\theta_i = 60$ for $i = \{1, 2, 3, 4\}$
NoLeader_Heterogeneous	$\gamma = 0$	$\theta_i = 80$ for $i = \{1,2\}$ and $\theta_i = 40$ for $i = \{3,4\}$
Leader_Heterogeneous	$\gamma = 1$	$\theta_i = 80$ for $i = \{1,2\}$ and $\theta_i = 40$ for $i = \{3,4\}$

2.2 Theoretical considerations

In all treatments team output is maximized when workers supply maximum effort. However, if team members are rational and exclusively motivated by self-interest, workers have no incentive to supply effort in any of the treatments. Consider a one-round version of our team production game. In the NoLeader treatment the cost of contributing a unit of effort (30 points) exceeds the benefit ($\theta_i/4$ points) and so a self-interested worker has a dominant strategy to provide zero effort. The presence of a leader with reward power in our Leader treatments does not change this prediction: in stage two of the game, a rational self-interested leader will keep any team output produced by the workers. Anticipating this, workers do not supply any effort in stage one. Thus the unique subgame perfect equilibrium, assuming that it is common knowledge that players maximize own earnings, has all workers contribute zero effort to team production. These predictions for a single round game also carry over to the ten round repeated game: in the unique subgame perfect equilibrium workers provide zero effort.

However, there is by now abundant evidence that not all individuals are exclusively motivated by their self-interest (see, e.g., Camerer, 2003; Fehr and Schmidt, 2006 for reviews of the experimental literature). Individuals with other-regarding preferences may have an incentive to supply effort to team production. Moreover, this incentive to supply effort may vary across treatments. To illustrate this, consider the case of inequality averse players, as modeled by Fehr and Schmidt (1999).[3] According to their model, player *i*'s utility is given by:

$$U_i = \pi_i - \frac{\alpha_i}{n-1}\sum_{j \neq i} max\{\pi_j - \pi_i, 0\} - \frac{\beta_i}{n-1}\sum_{j \neq i} max\{\pi_i - \pi_j, 0\}$$

[3] We use the Fehr and Schmidt model as a simple and tractable illustration of theoretical predictions when individuals display other-regarding preferences. Several other models of other-regarding preferences have been proposed in the literature (see Fehr and Schmidt, 2006 for an overview of these models), but it is beyond the scope of this paper to consider the predictions of these models.

where π_i is the player's material payoff from the game, the parameter α_i measures her aversion to disadvantageous payoff inequality, and the parameter β_i measures her aversion to advantageous payoff inequality. Fehr and Schmidt assume that $\beta_i \leq \alpha_i$ and $0 \leq \beta_i < 1$.

In the single round game of our NoLeader treatment there is an equilibrium where all workers supply maximal effort if they are sufficiently averse to advantageous inequality. For our homogeneous productivity treatment this requires that each worker has $\beta_i \geq \frac{4}{7} \approx 0.57$, for our heterogeneous treatment it requires that each high productivity worker has $\beta_i \geq 0.4$ and each low productivity worker has $\beta_i \geq \frac{8}{11} \approx 0.73$.[4] In the game of our Leader treatments the leader's aversion to advantageous inequality is critical. If $\beta_{Leader} < 0.8$, then in stage two of the game the Leader will keep all team output and so the unique subgame perfect equilibrium has all workers supply zero effort in stage one. On the other hand, if leaders are sufficiently averse to advantageous inequality ($\beta_{Leader} > 0.8$) they will redistribute team output in order to equalize material payoffs across players, and anticipating this workers will supply maximal effort. In this latter case the unique subgame perfect equilibrium of the game has all workers supply full effort to team production.

This simple analysis illustrates how the presence of individuals with other-regarding preferences may generate interesting interactions between leadership and incentives to contribute to team production. On the one hand, teams can achieve fully efficient outcomes even in the absence of leaders with reward power as long as all workers are sufficiently inequality averse. On the other hand, with a sufficiently inequality averse leader teams can overcome the free-rider problem even if workers are purely self-interested.

2.3 Experiment procedures

The experiments were carried out at the University of Birmingham with 230 subjects recruited from a campus-wide distribution list.[5] Three sessions were conducted for each treatment, with either 20 or 15 subjects per session. No subject participated in more than one session. We had 60 subjects participate in each of our Homogeneous treatments, and 55 subjects participate in each of our Heterogeneous treatments.

At the beginning of a session, subjects were randomly allocated to visually-isolated computer terminals. They received written instructions that the experimenter read aloud. The

[4] When this condition holds there are also other equilibria where workers supply identical efforts. For any inequality aversion parameter values, there is also an equilibrium where all workers supply zero effort. For details see Appendix B.

[5] Subjects were recruited through the online recruitment system ORSEE (Greiner, 2004). The experiment was computerized using the software z-Tree (Fischbacher, 2007).

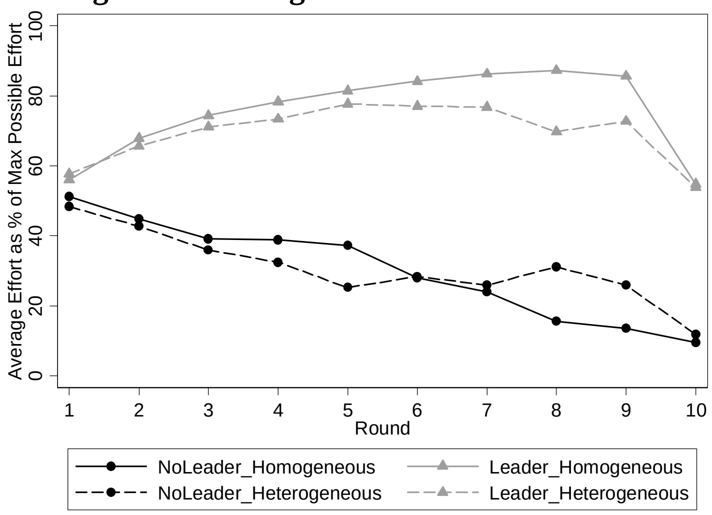
instructions contained a set of control questions to test subjects' understanding of the experimental setting. Answers were checked in private by the experimenter. Once all subjects had answered all questions correctly, they were randomly allocated to teams and randomly assigned a role within the team. Subjects then played 10 rounds of the team production game described above.

At the end of round 10, subjects filled in a short questionnaire eliciting basic socio-demographic information. Subjects were then paid in cash and in private according to the sum of their earnings across the 10 rounds at a rate of £0.10 per 100 points, plus a £3.50 show-up fee. Earnings ranged between £6.18 and £14.47, averaging £7.76. On average sessions lasted about 75 minutes.

2.4 Results

Figure 1 shows the average effort supplied by workers across our four treatments. In round 1 efforts range from 48% to 58% across treatments, but these differences are not statistically significant (Kruskal-Wallis test: p = 0.588).[6] Marked differences between treatments then emerge from round 2 onwards: efforts gradually decrease over rounds in our NoLeader treatments, whereas they increase in our Leader treatments. This pattern is observed both in the Homogeneous and Heterogeneous treatments. In round 10 of all treatments we observe an end-game drop in effort, which is particularly sharp in our Leader treatments.

Figure 1 - Average effort across treatments



[6] This test is based on 48 individual observations in each of our NoLeader_Homogeneous and Leader_Homogeneous treatments, and 44 individual observations in each of our NoLeader_Heterogeneous and Leader_Heterogeneous treatments. Unless otherwise stated, all other tests in Study 1 use team averages as the independent unit of observation and are therefore based on 12 (Homogeneous treatments) and 11 (Heterogeneous treatments) observations per treatment. All reported p-values are two-sided.

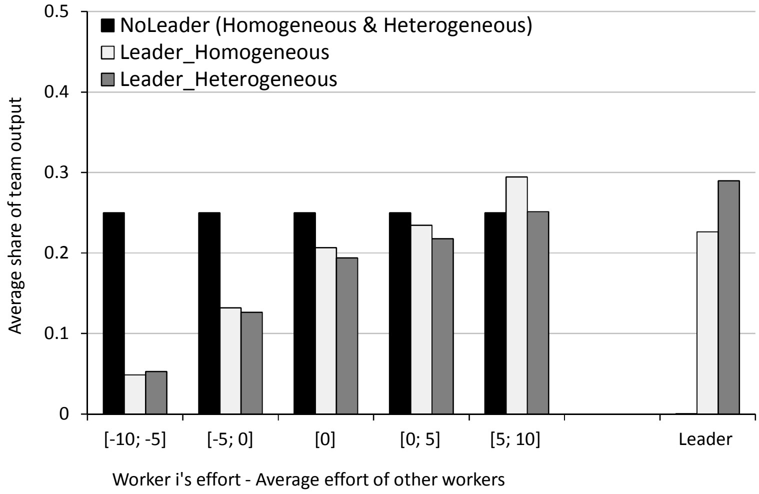
Averaging across all rounds, subjects supply about 30% and 31% of maximum possible effort in NoLeader_Homogeneous and NoLeader_Heterogeneous, respectively. In contrast, average effort is substantially higher in the treatments with leader: 76% of maximum possible effort in Leader_Homogeneous and 70% in Leader_Heterogeneous. These differences between treatments with and without leaders are statistically significant (Mann-Whitney tests: NoLeader_Homogeneous vs. Leader_Homogeneous p = 0.000; NoLeader_Heterogeneous vs. Leader_Heterogeneous p = 0.001). The effectiveness of leadership does not seem to be diminished in the treatments with heterogeneous worker productivities. In fact, we observe very similar efforts in homogeneous and heterogeneous teams, both in the NoLeader and Leader treatments (Mann-Whitney tests: NoLeader_Homogeneous vs. NoLeader_Heterogeneous p = 0.580; Leader_Homogeneous vs. Leader_Heterogeneous p = 0.853).

Within the Heterogeneous treatments, we observe only small differences in effort between workers with high and low productivity. Averaging across rounds of our NoLeader treatment high productivity workers supply 34% of maximum possible effort while low productivity workers supply 28%. High productivity workers supply more effort in our Leader treatment as well, 73% compared with 66% by low productivity workers. However, none of these differences are statistically significant (Wilcoxon tests: high vs. low productivity workers p = 0.477 in NoLeader_Heterogeneous and p = 0.286 in Leader_Heterogeneous).[7]

These findings suggest that in our Leader treatments leaders use their reward power effectively and adopt redistribution strategies that incentivize workers to contribute to team output. Figure 2 illustrates leaders' use of their reward power across the different treatments. The figure shows the average share of team output received by leaders and workers in the four treatments. For workers, this is disaggregated based on how their efforts relate to the average effort of the rest of their team.

[7] There is mixed evidence on the impact of heterogeneity in contributions to public goods. See the summary of the literature in Reuben and Riedl (2013). Most of this evidence comes from experiments where players differ in their endowments or marginal return from the public good. Two exceptions are Tan (2008) and Kölle (2015), who also study heterogeneity in productivities. Tan (2008) finds homogeneous groups contribute more than heterogeneous groups, whereas Kölle (2015) finds the opposite. Both studies find that within heterogeneous groups high productivity players contribute more than low productivity players.

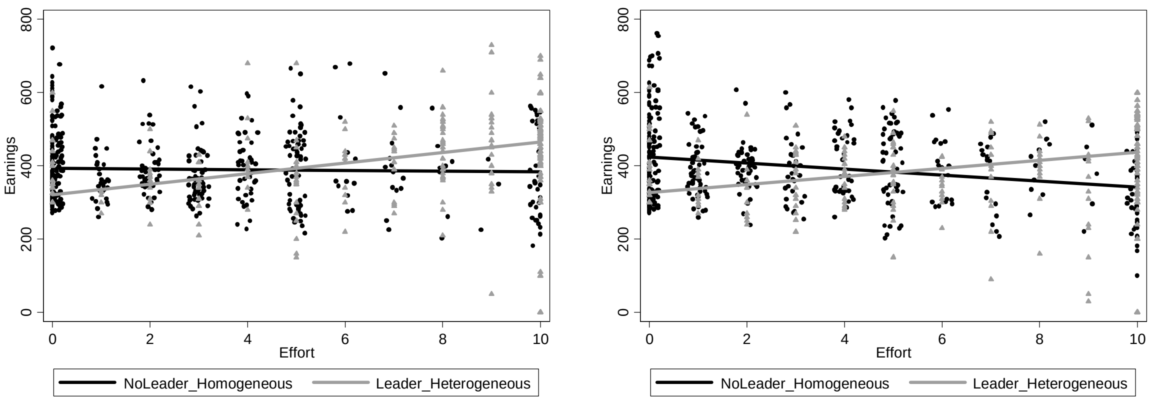
Figure 2 – Share of team output received



In the NoLeader treatments each worker automatically receives a quarter of the team output, irrespective of their effort, while the leader receives no share of the team output. In the Leader treatments the leader decides how to share team output. Figure 2 shows that leaders follow a strategy that rewards contributions and punishes free-riding in both Leader treatments. In the Homogeneous treatment workers who supply effort at or above the average of their team in a period receive on average 23% of team production, while those supplying effort below the average receive 12% of team production. These differences are highly significant (Wilcoxon test, p = 0.002). The same pattern is observed in the Heterogeneous treatment. Here, workers who supply effort at or above the team average receive on average 21% of team production, while those supplying effort below the team average receive 11% of team production (Wilcoxon test, p = 0.004).

This reward strategy creates strong incentives to supply effort in the Leader treatments. Figure 3 shows a scatterplot of the relation between workers' earnings and efforts between treatments with and without leaders in the Homogeneous (left panel) and Heterogeneous treatments (right panel). Lines of best fit obtained through linear regressions are also shown in the figure.

Figure 3 – Relation between workers' earnings and effort



When leaders have no reward power, workers who supply more effort tend to earn less than those who free-ride. This is particularly evident in the NoLeader_Heterogeneous treatment where, on average, supplying zero effort leads to 429 points whereas maximal effort leads to 315 points. In contrast, when leaders have full reward power, the relation between earnings and efforts is positive, and workers who supply effort tend to earn more than free-riders. For example in the Leader_Heterogeneous treatment, on average, free-riders earn 335 points whereas workers who supply maximum effort earn 447 points.

A simple regression analysis confirms that the presence of leaders with reward power substantially changes the incentives to supply effort relative to the NoLeader treatments. Table 2 reports OLS regressions of workers' earnings on effort, a dummy variable assuming value 1 for observations from the Leader treatments and 0 otherwise, an interaction term between the effort and treatment variables, and a round trend variable. We report separate regressions for the Homogeneous and Heterogeneous treatments. The Heterogeneous regression also includes a dummy variable assuming value 1 for a high productivity worker and 0 for a low productivity worker.

Table 2 – Regression of workers' earnings on effort

	Homogeneous	Heterogeneous
Effort	-5.43 *(5.41)*	-10.73*** *(2.78)*
Leader	-94.26*** *(23.95)*	-106.03*** *(24.82)*
Effort * Leader	20.96*** *(5.80)*	22.02*** *(4.58)*
High Productivity	-	-11.98 *(7.68)*
Round	-11.22*** *(2.15)*	-11.29*** *(2.23)*
Constant	468.73*** *(26.52)*	499.39*** *(23.66)*
N. of observations	960	880
R^2	.223	.167

Notes: OLS regressions with robust standard errors clustered at the team level reported in parentheses. Dependent variable is workers' earnings. Significance levels: *** = 1%.

The regressions confirm that in the NoLeader treatments there is a negative relation between earnings and effort, although this is statistically significant only in the Heterogeneous treatment. This relation becomes positive in the two Leader treatments. In Leader_Homogeneous each unit of effort supplied to team production increases earnings by approximately 15 points (F-test, p = 0.000). In Leader_Heterogeneous each additional unit of effort increases earnings by approximately 11 points (F-test, p = 0.005).

Our results so far have shown that leadership is very effective in incentivizing effort, both in our Homogeneous and Heterogeneous treatments. We conclude our analysis by studying the impact of leadership on earnings and efficiency. For a measure of efficiency we use attained team earnings as a percentage of 2700, the maximum possible team earnings.[8] Table 3 reports individual earnings, combined earnings, and efficiencies per round across treatments.

[8] Note that in the standard theoretical outcome where team effort is zero, combined earnings are 1500, implying an efficiency of 56%.

Table 3 – Individual earnings and efficiency

	NoLeader Homogeneous	Leader Homogeneous	NoLeader Heterogeneous	Leader Heterogeneous
Leader's Earnings	300 *(0.0)*	686.8 *(203.4)*	300 *(0.0)*	746.0 *(190.8)*
Workers' Earnings	390.6 *(38.9)*	430.2 *(57.1)*	-	-
Low Productivity			407.1 *(62.8)*	406.4 *(68.4)*
High Productivity			389.5 *(38.6)*	401.2 *(60.2)*
Combined Earnings	1862.5 *(155.6)*	2407.5 *(193.7)*	1893 *(174.1)*	2361.3 *(220.5)*
Efficiency	69%	89%	70%	88%

Notes: "Combined Earnings" are the sum of leader's and workers' earnings. "Efficiency" is combined earnings as a percentage of maximum possible earnings (in all treatment maximum possible combined earnings are 2700). Standard deviations based on team averages in parentheses.

The earnings analysis confirms the effectiveness of leadership in promoting efficiency in our team production setting. In the Homogeneous treatment combined earnings increase from 1862.5 when leaders have no reward power (an efficiency of 69%) to 2407.5 when leaders have reward power (an efficiency of 89%). This difference is statistically significant according to a Mann-Whitney test (NoLeader_Homogeneous vs. Leader_Homogeneous p = 0.000). Similarly, in the Heterogeneous treatment combined earnings increase from 1893 when leaders have no reward power (an efficiency of 70%) to 2361.3 when leaders have reward power (an efficiency of 88%). This difference is statistically significant (Mann-Whitney test: NoLeader_Heterogeneous vs. Leader_Heterogeneous p = 0.001).[9]

Table 3, however, also shows that the efficiency gains of leadership are redistributed very unequally between leaders and workers: most of the efficiency gains accrue to leaders, whereas workers' earnings are not very different between NoLeader and Leader. For leaders, both in Homogeneous and Heterogeneous, we detect a statistically significant difference between earnings in NoLeader and Leader (Mann-Whitney tests: NoLeader_Homogeneous vs. Leader_Homogeneous p = 0.000; NoLeader_Heterogeneous vs. Leader_Heterogeneous p = 0.000). For workers, instead, we do not find that earnings are significantly higher under NoLeader than under Leader (Mann-Whitney tests:

[9] We do not detect statistically significant differences in efficiency between our Homogeneous and Heterogeneous treatments (Mann-Whitney tests: NoLeader_Homogeneous vs. NoLeader_Heterogeneous p = 0.975; Leader_Homogeneousvs. Leader_Heterogeneous p = 0.460).

NoLeader_Homogeneous vs. Leader_Homogeneous p = 0.106; NoLeader_Heterogeneous vs. Leader_Heterogeneous low productivity p = 0.974; high productivity p = 0.577).

2.5 Discussion

In summary, our initial study shows that leaders with reward power are successful in encouraging contributions to team production and promoting efficiency. This is observed even in environments where workers are heterogeneous in their productivity. However, while the team as a whole is better off with than without leaders, the efficiency gains of leadership are distributed asymmetrically. Leaders reap most of the efficiency gains, whereas workers are no better off with leaders than without.

This raises a natural question about whether leadership will emerge in environments where leaders are not exogenously imposed on a team, but are endogenously appointed by team members. In such environments, the success of leadership may be hindered: team members may refuse to vote for leadership if leaders behave too opportunistically and do not share enough of the proceeds of team production. On the other hand, the voting mechanism may constrain the leaders' opportunism and thus facilitate the emergence of successful leadership. In the next section, we discuss a follow-up study which addresses these questions by studying a setting where leadership is not imposed on teams but instead may emerge endogenously through a voting mechanism.

3. Study 2: The emergence of endogenous leadership

3.1 Experiment design and procedures

The follow-up study is based on the same ten-round, five-person team production game that we used in our initial study and that we described above. However, differently from the initial study, at the beginning of the game the four workers simultaneously vote on the leader's reward power, i.e. on the share γ of team output that will be redistributed by the leader. Workers can vote for one of six possible levels of γ: 0, 0.2, 0.4, 0.6, 0.8, or 1, one of which will be implemented across all ten rounds. For example, with $\gamma = 0.4$, in each round 40% of team output is transferred to the leader, whereas 60% of team output is evenly distributed among workers. Note that when leaders are granted no reward power ($\gamma = 0$) or full reward power ($\gamma = 1$) we have cases that correspond to the NoLeader and Leader treatments of the initial study. The level of γ implemented in a team is decided using a "random dictator" rule:

after each worker has submitted a vote, one worker from each team is selected at random and his/her vote is implemented.

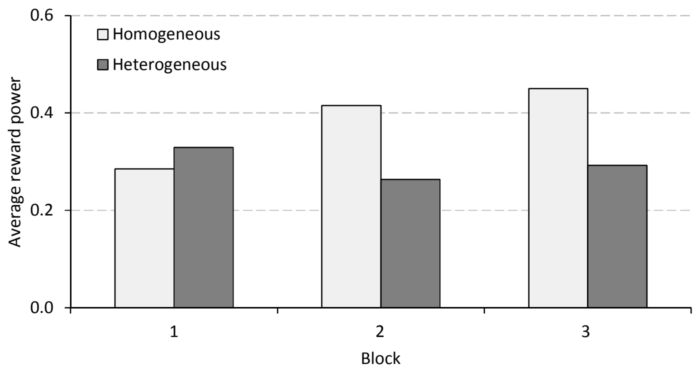
We study a repeated version of this game across three blocks of 10 rounds each. Group composition and roles are kept fixed across blocks and rounds. As in the initial study, we have two treatments varying the homogeneity of workers' productivity. In the **Homogeneous** treatment all workers have the same productivity ($\theta_i = 60$). In the **Heterogeneous** treatment two workers have high productivity ($\theta_i = 80$), while the other two have low productivity ($\theta_i = 40$).

The experiments were carried out at the University of Birmingham using the same procedures as in the initial study. We had 195 subjects in total, 100 in the Homogeneous treatment and 95 in the Heterogeneous treatment. Subjects were paid according to their accumulated earnings across the 30 rounds of the experiment at a rate of £0.10 per 100 points. Earnings ranged between £12.23 and £24.89, averaging £16.04, including a £3.50 show-up free. On average session lasted about 150 minutes.

3.2 Results

Figure 4 shows the reward power that workers are willing to delegate to leaders in each of the three blocks of the experiment in the Homogeneous and Heterogeneous treatments. The figure is based on all votes submitted at the beginning of each block, and not only on the votes that were actually implemented in the experiment.

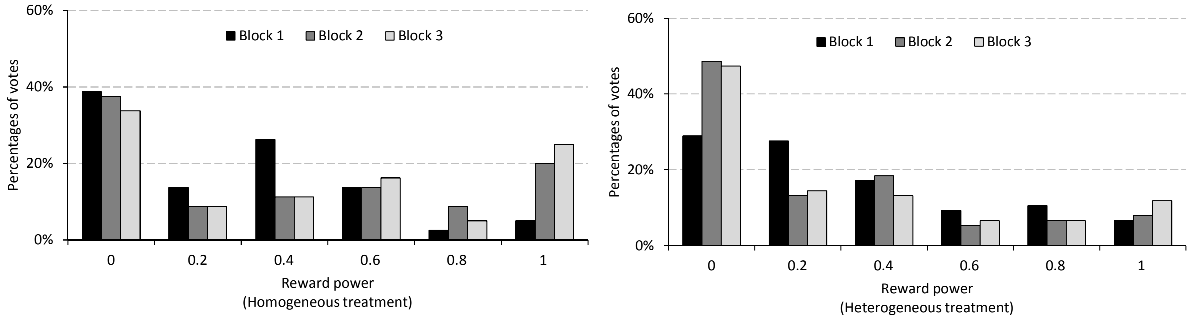
Figure 4 – Average reward power delegated by workers



Initially, delegation of reward power is similar across our two treatments: in block 1 of both treatments workers are willing to delegate about one-third of team output to leaders, 29% in Homogeneous and 33% in Heterogeneous. This difference between treatments is not significant (Mann-Whitney test: p = 0.422).[10] In the Homogeneous treatment the share of team output delegated to leaders increases to 42% in block 2 and 45% in block 3.[11] In contrast, in Heterogeneous workers delegate less in blocks 2 and 3 than in block 1: 26% in block 2 and 29% in block 3.[12] As a consequence, the reward power delegated to leaders is higher in Homogeneous than in Heterogeneous in blocks 2 and 3 of the experiment (Mann-Whitney tests: block 2 p = 0.034; block 3 p = 0.026).

Figure 5 shows the distribution of delegation votes across the three blocks of the experiment in the Homogeneous (left panel) and Heterogeneous (right panel) treatments.

Figure 5 – Distribution of delegation votes in Homogenous (left panel) and Heterogeneous (right panel)



In both treatments, and in all blocks, the modal vote delegates no power to the leader. In the Homogeneous treatment the proportion of workers who vote against delegation is stable across blocks and varies between 34% and 39%. In Heterogeneous this proportion is more volatile across blocks: in block 1 29% of workers vote against delegation, and this proportion increases to 49% in block 2 and 47% in block 3. The votes in favor of delegation also vary across blocks. In both treatments, workers are initially cautious in delegating reward power: the most popular votes in favor of delegation in block 1 are for a reward power of 0.2 or 0.4. In later blocks workers tend to delegate more power to the leader, especially in the Homogeneous treatment where the fraction of votes in favor of full delegation ($\gamma = 1$) increases from 5% in block 1 to 25% in block 3.

Overall, these results show that workers delegate some power to leaders, but they do not fully exploit the potential for delegation. In both treatments, and in all blocks, workers

[10] This test of initial voting behavior is based on 80 individual observations in Homogeneous and 76 individual observations in Heterogeneous. Unless otherwise stated, all other tests in Study 2 use team averages as the independent unit of observation and are therefore based on 20 (Homogeneous) and 19 (Heterogeneous) observations per treatment. All reported p-values are two-sided.

[11] Delegation of power is significantly higher in block 2 than in block 1 (Wilcoxon signed-rank test p = 0.045), whereas the difference between block 2 and 3 is not significant (Wilcoxon signed-rank test p = 0.443).

[12] However, these differences in delegation of power are not significant (Wilcoxon signed-rank tests: block 2 vs. block 1 p = 0.150; block 3 vs. block 2 p = 0.467).

transfer less than half of the team output to the leader. Moreover, a substantial fraction of team members (between one-third and one-half) are opposed to any amount of delegation and vote against transferring power to the leader.

One possible explanation for the reluctance to delegate power to leaders might be that leadership is not as effective in these endogenous treatments as it was in our initial study where γ is exogenous. In other words, in the treatments with endogenous leadership, leaders may not make effective use of their reward power and may fail to adopt the redistribution strategies observed in our initial study resolved the free-riding problem.

Our data, however, suggest that this is not the case. Figures 6 and 7 show the average effort supplied in each of the three blocks of the Homogeneous (Figure 6) and Heterogeneous (Figure 7) treatments, disaggregated by the realized level of the leader's reward power.

Figure 6 – Average effort in Homogenous

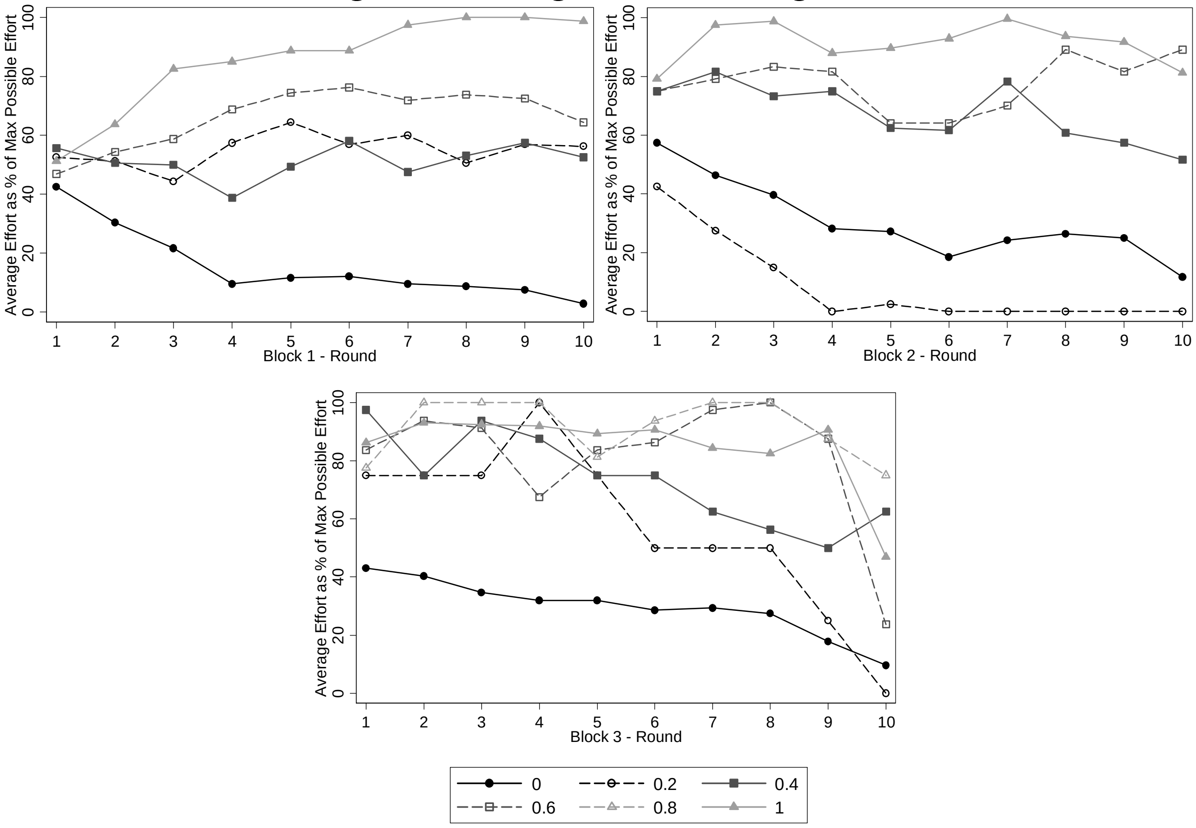
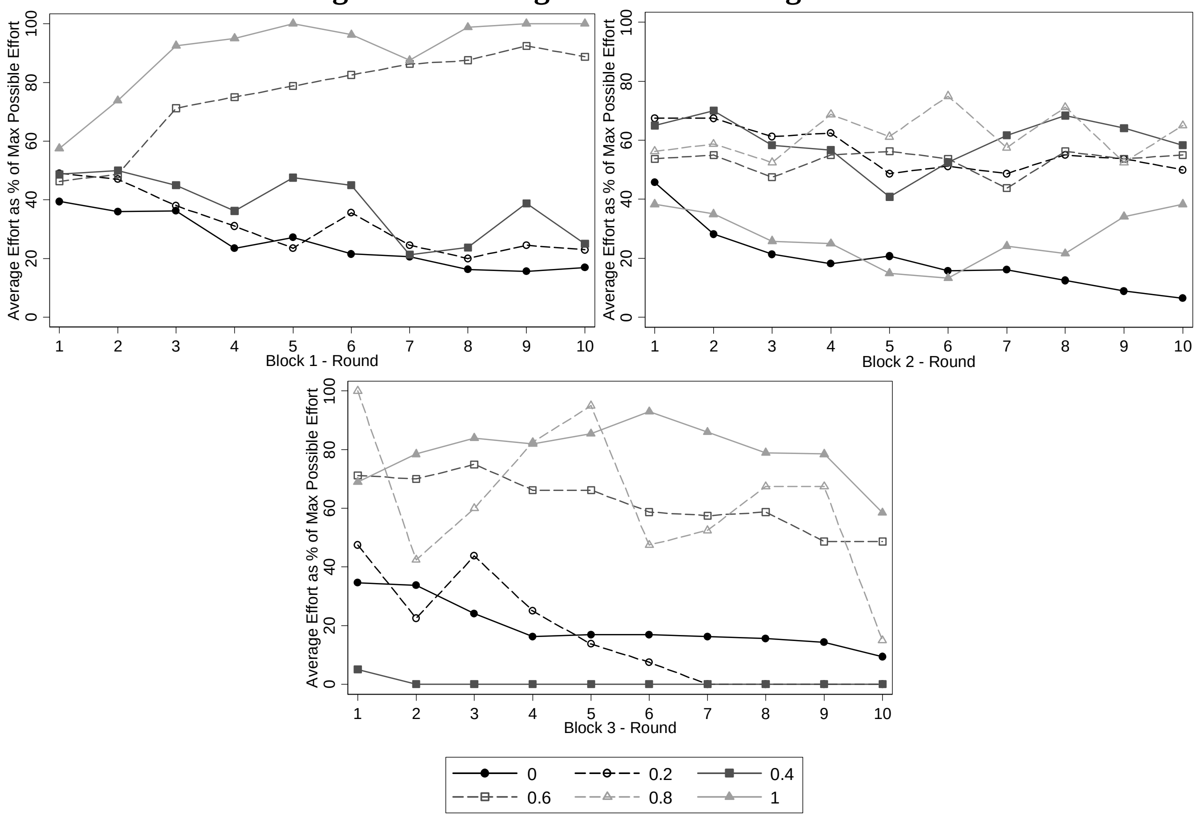


Figure 7 – Average effort in Heterogeneous



In both treatments, and in nearly all blocks, teams with powerful leaders supply more effort than teams with powerless leaders. The separation between teams with powerful and powerless leaders is clearer in the Homogeneous than in the Heterogeneous treatment, although this partly reflects the low numbers of observations in some cases.[13] We explore the effect of leader power on effort more formally in Table 4, where we report OLS regressions of effort on dummy variables for the level of reward power delegated to the leader (note that the benchmark category is the case where $\gamma = 0$, i.e. the team has no leader). We report separate regressions for the Homogeneous and Heterogeneous treatments. The regressions also include round and block variables, and, for the Heterogeneous treatment, a dummy variable for high productivity workers.

Table 4 – Regression of workers' effort

	Homogenous	Heterogeneous
0.2	24.92** *(11.09)*	11.07 *(8.62)*
0.4	37.49*** *(12.30)*	20.47 *(12.22)*
0.6	49.21*** *(6.86)*	42.03*** *(13.35)*
0.8	61.10*** *(7.62)*	41.68*** *(8.43)*
1	61.95*** *(6.58)*	45.17*** *(10.65)*
High productivity	-	7.72 *(4.75)*
Round	-1.62*** *(0.49)*	-1.68*** *(0.41)*
Block	5.05 *(3.55)*	-3.07 *(2.03)*
Constant	24.18** *(9.34)*	33.14*** *(6.11)*
N. of observations	2400	2280
R^2	.370	.239

Notes: OLS regressions with robust standard errors clustered at the team level reported in parentheses. Dependent variable is workers' effort expressed as percentage of maximum possible effort. Significance levels: *** = 1%; ** = 5%.

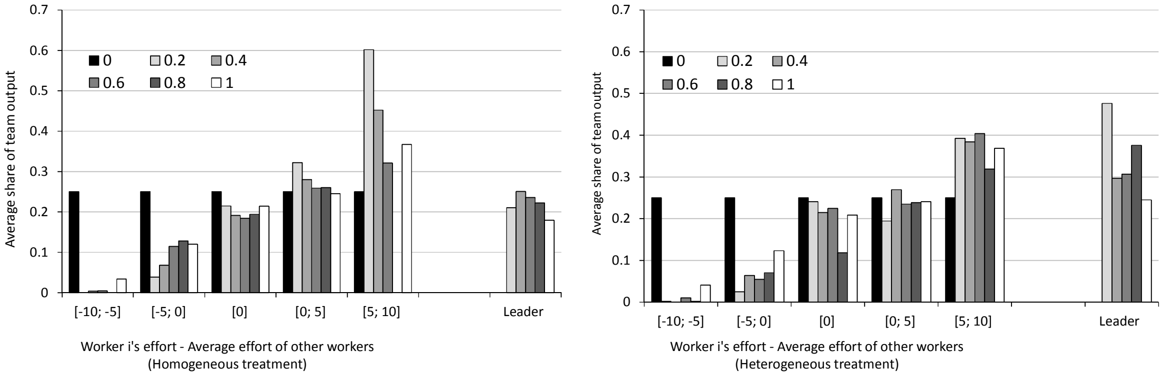
The regressions confirm that delegation of reward power increases effort provision. The effect is particularly strong in Homogeneous where even delegating a small amount of power

[13] For example, Figure 7 shows that in block 3 of the Heterogeneous treatment teams with $\gamma = 0$ perform better on average than teams with $\gamma = 0.4$. However, this is based on observations from 8 teams with $\gamma = 0$ and only 1 team with $\gamma = 0.4$. Similarly, in block 2 of the Heterogeneous treatment the low average efforts in teams with $\gamma = 1$ are based on just 3 teams.

to the leader ($\gamma = 0.2$) increases effort by about 25 percentage points relative to the case where leaders have no reward power. Delegating full reward power to leaders ($\gamma = 1$) increases productivity by about 62 percentage points relative to teams without a leader. In Heterogeneous the effect of delegation is statistically significant only when team delegate more than half of the team output to the leader.

As in our initial study, the positive effect of leadership on effort is driven by the redistribution strategies adopted by leaders, which reward workers who supply effort and withhold rewards from those who shirk. Figure 8 shows the average share of team output received by leaders and workers disaggregated by level of reward power of the leader. The left panel contains data from the Homogeneous treatment whereas the right panel contains data from the Heterogeneous treatment. Workers' output shares are disaggregated based on how their efforts relate to the average effort of the rest of their team.

Figure 8 – Share of team output received



Notes: When $\gamma = 0$ the leader is assigned no share of the team output and all output is redistributed in equal proportions among workers. When $\gamma > 0$ the figure shows how the share of team output assigned to the leader is redistributed among workers and leaders.

In both treatments, when the leader has no reward power ($\gamma = 0$) each worker automatically receives a quarter of the team output and the leader receives nothing. When leaders are granted some reward power ($\gamma > 0$), leaders redistribute output by giving higher rewards to those who supply more effort. In the Homogeneous treatment workers who supply effort at or above the average effort in their team receive on average 25% of the team output assigned to the leader. In contrast, those who provide less effort than the team average receive only 7% of team output. The difference is highly significant (Wilcoxon test, p = 0.000). As in the initial study, these patterns are similar in the Heterogeneous treatment: workers supplying effort at or above the team average receive 23% of team output, whereas workers supplying effort below the team average receive 5% of team output (Wilcoxon test, p = 0.001).

As in our initial study, the reward strategy creates a stronger incentive to supply effort when leaders are granted some power relative to the case where leaders are powerless. Table 5 reports OLS regressions of workers' earnings on effort, dummy variables for the level of reward power delegated to the leader, and interaction terms between the effort and reward power variables. The regressions also contain block and round trend variables. We report separate regressions for the Homogeneous and Heterogeneous treatments.

Table 5 – Regression of workers' earnings on effort

	Homogeneous	Heterogeneous
Effort	8.40** *(3.21)*	-7.09** *(2.51)*
Effort * 0.2	-0.71 *(4.10)*	15.28* *(8.12)*
Effort * 0.4	1.96 *(5.19)*	15.65* *(8.08)*
Effort * 0.6	3.59 *(3.89)*	30.61*** *(4.02)*
Effort * 0.8	2.61 *(3.21)*	12.11* *(6.92)*
Effort * 1	12.48*** *(3.05)*	20.09*** *(3.70)*
0.2	40.56 *(33.13)*	-24.94 *(30.35)*
0.4	31.54 *(30.07)*	-16.24 *(31.74)*
0.6	19.30 *(24.93)*	-76.04** *(30.03)*
0.8	15.89 *(16.96)*	-31.66 *(36.27)*
1	-65.73*** *(21.33)*	-64.14** *(26.00)*
High Productivity	-	-1.65 *(12.98)*
Round	-4.69*** *(1.12)*	-6.21*** *(1.73)*
Block	4.23 *(6.60)*	-13.10* *(7.02)*
Constant	373.02*** *(24.29)*	448.68*** *(30.99)*
N. of observations	2400	2280
R^2	.333	.226

Notes: OLS regressions with robust standard errors clustered at the team level reported in parentheses. Dependent variable is workers' earnings. Significance levels: *** = 1%; ** = 5%; * = 10%.

The regressions show that delegating power to leaders strengthens the incentives to supply effort. This is particularly evident in the Heterogeneous treatment where, when leaders are powerless, there is a negative relation between earnings and effort. The presence of leaders, even with minimal reward power (e.g., $\gamma = 0.2$), reverses the relation between earnings and effort. In fact, this relation becomes significantly positive in the cases where leaders have full reward power or reward power equal to 0.6 (F-tests, $p < 0.000$). In the Homogeneous treatment, the relation between earnings and effort is positive already when the leaders have no power. The presence of powerful leaders increases the steepness of this relation, particularly in the case where leaders have full power.

These results suggest that workers' reluctance to delegate power is not due to the ineffectiveness of endogenous leadership. As in the initial study with exogenous leadership, endogenously empowered leaders also adopt reward strategies that incentivize effort provision. Workers also respond to these incentives by providing more effort in the presence of more powerful leaders.

Although leaders assign sufficient rewards to provide strong incentives to encourage team production, they may not be sufficient to induce workers to be willing to delegate. Recall that in the initial study leaders appropriate large fractions of the proceeds from team production and leave workers no better off than without a leader. Our data suggest that this is also the case in the endogenous leadership study. Figure 8 above shows that leaders tend to appropriate about 20% of the team output in Homogeneous, and about 30% in Heterogeneous. Table 6 shows that this generates strong asymmetries between leaders' and workers' earnings.

In both treatments, combined earnings and efficiency are positively related with leaders' power. However, in both treatments the leaders reap most of these efficiency gains. Leaders' earnings increase by about 119% from 300 points in the case where they are powerless ($\gamma = 0$) to 658 points in the case where they have full reward power ($\gamma = 1$). Workers' earnings also tend to be higher when leaders have more reward power, but the impact of leadership on workers' earnings is not nearly as strong as in the leaders' case. In Homogeneous workers' earnings increase on average by 26% between the $\gamma = 0$ and $\gamma = 1$ cases. In Heterogeneous, high productivity workers' earnings increase by 16% while low productivity workers' earnings increase by just 2%.

Table 6 – Individual earnings and efficiency

	Homogeneous treatment					
	γ					
	0	0.2	0.4	0.6	0.8	1
Leader's Earnings	300 *(0.0)*	350 *(31.6)*	439.8 *(89.4)*	533 *(112.6)*	691.9 *(18.5)*	658.7 *(153.9)*
Workers' Earnings	378.1 *(65.1)*	430.8 *(72.7)*	450.2 *(66.8)*	462.1 *(50.6)*	476.5 *(26.9)*	474.6 *(64.8)*
Combined Earnings	1812.6 *(260.6)*	2073 *(316.9)*	2240.7 *(340.7)*	2381.3 *(217.2)*	2598 *(89.1)*	2557.8 *(158.2)*
Efficiency	67%	77%	83%	88%	96%	95%
	Heterogeneous treatment					
	γ					
	0	0.2	0.4	0.6	0.8	1
Leader's Earnings	300 *(0.0)*	365.4 *(30.5)*	437.9 *(115.5)*	464 *(100.9)*	772.5 *(193.2)*	658.4 *(192.3)*
Low Productivity Worker	383.3 *(97.3)*	399.6 *(94.0)*	413.8 *(86.2)*	439.3 *(106.0)*	353.9 *(44.3)*	390.1 *(59.9)*
High Productivity Worker	361.1 *(33.4)*	389.5 *(77.4)*	406.1 *(80.4)*	482.9 *(123.2)*	411.7 *(63.8)*	420 *(88.6)*
Combined Earnings	1788.8 *(238.8)*	1943.7 *(341.1)*	2077.7 *(401.4)*	2308.5 *(413.3)*	2303.7 *(198.3)*	2278.6 *(361.9)*
Efficiency	66%	72%	77%	86%	85%	84%

Notes: "Combined Earnings" are the sum of leader's and workers' earnings. "Efficiency" is combined earnings as a percentage of maximum possible earnings (in all treatment maximum possible combined earnings are 2700). Standard deviations based on team averages per block in parentheses.

Table 7 reports OLS regressions of individual earnings on a set of dummy variables for the level of reward power delegated to the leader as well as block and round trend variables. We report separate regressions for the Homogeneous and Heterogeneous treatments, and for leaders and workers.

The regressions confirm that leader power has a strong, positive effect on leaders' earnings. In both treatments, leaders earn significantly more when they are granted reward power, even if this is minimal ($\gamma = 0.2$). In the Homogeneous treatment leaders' power is also positively associated with workers' earnings, albeit the effect is small, if compared with the leaders' case. Moreover, workers' earnings when leaders have power greater than 0.4 (i.e. for $\gamma = 0.6$, $\gamma = 0.8$, and $\gamma = 1$) are not significantly different from earnings when leaders have a power of 0.4 (F-tests, all p > 0.515). Thus while delegating some power to the leader may be profitable, it does not seem to pay to delegate a lot of power.

Leadership is not beneficial for low productivity workers in heterogeneous teams: earnings are not significantly different between the $\gamma = 0$ case and any of the cases where leaders have reward power. For high productivity workers, leadership has no impact on workers' earnings when leader power is low ($\gamma = 0.2$ or $\gamma = 0.4$), whereas it has a small, positive effect when leaders have high power ($\gamma \geq 0.6$).

Table 7 – Regression of earnings on leaders' power

	Homogeneous		Heterogeneous		
	Leaders	Workers	Leaders	Low Productivity. Workers	High Productivity. Workers
0.2	65.19*** *(18.00)*	58.45* *(31.91)*	73.25*** *(15.38)*	13.86 *(39.87)*	21.05 *(26.83)*
0.4	148.52*** *(37.69)*	75.33** *(29.74)*	141.83*** *(46.38)*	29.27 *(33.45)*	41.30 *(29.62)*
0.6	241.78*** *(38.46)*	87.18*** *(19.49)*	164*** *(37.32)*	56.00 *(49.99)*	121.84** *(48.29)*
0.8	370.85*** *(13.82)*	90.58*** *(23.78)*	464.72*** *(89.17)*	-27.06 *(36.11)*	58.00** *(27.01)*
1	358.00*** *(44.21)*	96.34*** *(24.79)*	351.34*** *(53.94)*	8.93 *(36.65)*	65.58** *(28.14)*
Round	4.90 *(3.056)*	-6.09*** *(1.41)*	2.08 *(3.14)*	-4.99** *(1.79)*	-6.39*** *(1.77)*
Block	24.37** *(10.88)*	9.04 *(10.35)*	23.45 *(15.48)*	-7.16 *(10.00)*	-22.20*** *(5.78)*
Constant	220.98*** *(9.34)*	392.30*** *(27.15)*	241.66*** *(43.18)*	425.11*** *(32.57)*	440.62*** *(20.38)*
N. of observations	600	2400	570	1140	1140
R^2	.452	.187	.362	.045	.167

Notes: OLS regressions with robust standard errors clustered at the team level reported in parentheses. Dependent variable is earnings. Significance levels: *** = 1%; ** = 5%.

3.3 Discussion

In summary, our study of endogenous leadership shows that there are important obstacles to the emergence of leadership in our setting. Team members are reluctant to delegate to leaders the power to redistribute team output, despite the fact that granting leaders this power makes the team as a whole substantially better off.

Our data show that this reluctance to delegate is not due to the fact that endogenous leaders are unable to provide appropriate incentives for team members to supply effort. In fact, effort and efficiency are considerably higher in teams with than without leaders. However, these efficiency gains are distributed unequally. Leaders are substantially better off when they are granted reward power whereas workers are only marginally better off, if at all. Moreover, in terms of absolute levels of earnings, there is substantial inequality between leaders and workers when leaders are granted high redistribution power. This also may reduce the incentives for workers to delegate power to leaders if they care about relative earnings.

4. Conclusion

Our studies investigate a team production game that exhibits the fundamental incentive problems facing teams when agents are purely self-interested. When the benefits of team production are distributed using group incentive schemes, such as the simple revenue-sharing scheme we employ, there are well-known free-riding incentives and we observe substantial levels of shirking. When a leader can allocate the benefits this creates a possibility for the leader to incentivize workers by allocating benefits to those who contribute the most and withholding them from those who free-ride. However, in theory this hierarchical solution to the free-rider problem introduces further incentive problems. In particular, a self-interested leader has an incentive to keep all the benefits for herself. Indeed, this is identified by Miller (1992, p.154) as the central dilemma in a hierarchy: "*how to constrain the self-interest of those with a stake in the inevitable residual generated by an efficient incentive system*".

Our research suggests that self-restraint by leaders can resolve this dilemma. We find that leaders do reward those who contribute to team output, and do so in a way that incentivizes efficient effort provision. To this extent, our research suggests that hierarchical institutional structures can resolve free-rider problems in teams. However, our research also identifies another problem. Leaders who calibrate rewards so as to maximize their residual claim while giving away just enough to incentivize work will tend to distribute the benefits of leadership unevenly. Workers are (just) compensated for their efforts, and the majority of the rents accrue to the leader. Given this, workers are barely better off in a well-functioning, hard-working team than in a dysfunctional team of shirkers. This asymmetric distribution of the leadership rents limits the benefits that workers get from a hierarchical structure. Thus we find that when the leader's reward power requires the acquiescence of workers, workers are less willing to empower the leader. Thus, endogenously arriving at an efficient incentive scheme is a more difficult challenge.

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Appendix A: Instructions

[All treatments: Preliminary Instructions

Welcome! You are about to take part in a decision-making experiment. This experiment is run by the "Birmingham Experimental Economics Laboratory" and has been financed by various research foundations. Just for showing up you have already earned £3.50. You can earn additional money depending on the decisions made by you and other participants. It is therefore very important that you read these instructions with care.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your following of these rules.

We will first jointly go over the instructions. After we have read the instructions, you will have time to ask clarifying questions. We would like to stress that any choices you make in this experiment are entirely anonymous. Please do not touch the computer or its mouse until you are instructed to do so. Thank you.

]

[Exogenous treatments: Instructions

At the beginning of the experiment you will be matched with four other people, randomly selected from the participants in this room, to form a group of five. **The composition of your group will stay the same throughout the experiment**, i.e. you will form a group with the same four other participants during the whole experiment.

Each person in the group will be randomly assigned a role, either 'group member A', 'group member B', 'group member C', 'group member D', or 'group member E'. **Your role will stay the same throughout the experiment**. You will not learn the identity of the other participants in your group. Participants will be identified simply as 'group member A', 'group member B' etc..

When we have finished reading the instructions you will be informed of your role. **The experiment will then consist of 10 periods**. In each period you can earn points. Your point earnings will depend on the decisions made within your group, and will not be affected by decisions made in other groups.

At the end of the experiment your accumulated point earnings from all periods will be converted into cash at the exchange rate of **10 pence per 100 points**. You will be paid, in cash and in private, this amount in addition to the show-up fee of £3.50.

Decisions and Earnings

The experiment consists of ten periods in which you can earn points. Every period has the same structure and has two stages.

Stage One

At the beginning of Stage One each group member will be given 10 tokens.

Group members A, B, C and D must choose how many of these tokens to invest in a group project and how many to keep in their private accounts. Group member E has no choice to make: the computer will place all ten of his or her tokens in his or her private account.

Each token a group member keeps in his or her private account yields a return of thirty points to that group member.

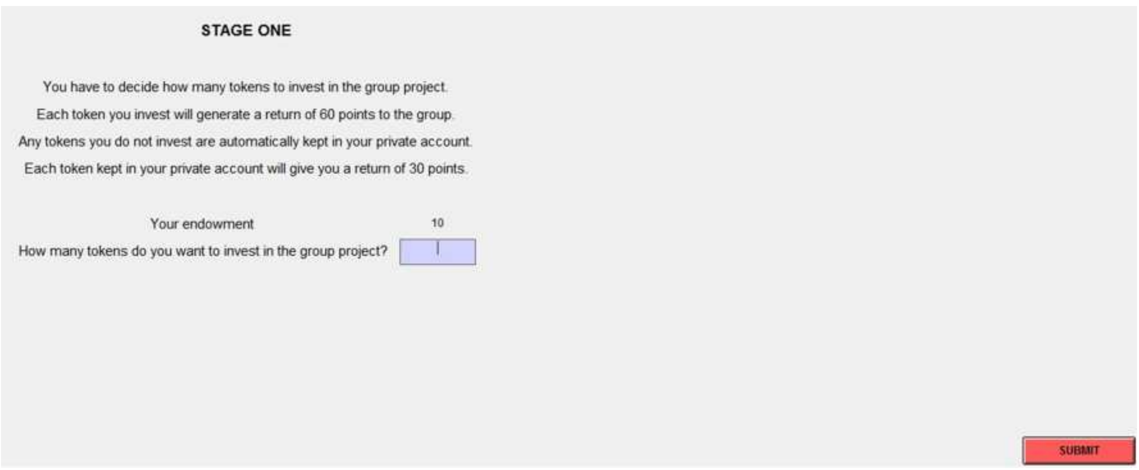
[Homogeneous: Each token a group member invests in the group project yields a return of sixty points to the group. How these points are allocated among group members will be determined in Stage Two.**]**

[Heterogeneous: Each token group member A or B invests in the group project yields a return of forty points to the group. Each token group member C or D invests in the group project yields a return of eighty points to the group. How these points are allocated among group members will be determined in Stage Two.**]**

Your point earnings for the period will be your point earnings from your private account plus your point earnings from the group project.

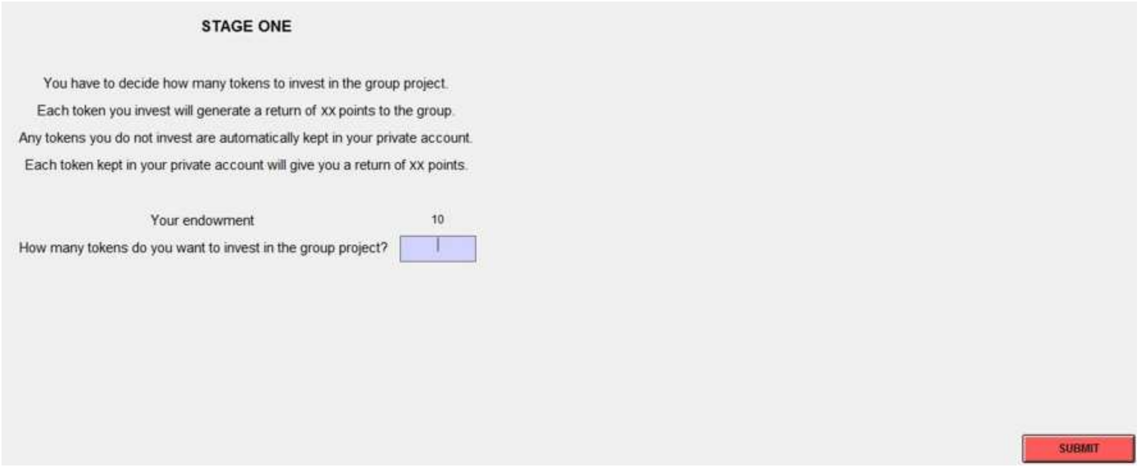
If you are one of group members A, B, C or D, you will make your decision by entering the number of tokens you invest in the group project. Any tokens you do not invest will automatically be kept in your private account. You will enter your decisions on a screen like the one shown below.

[Homogeneous:



]

[Heterogeneous:



]

When you have made your decision you must click on the *SUBMIT* button. Once group members A, B, C and D have submitted their decisions Stage Two will begin.

Stage Two

[Homogeneous: Remember, each token invested in the group project generates a return of sixty points to the group. Thus, the total return from the group project will be 60 times the total number of tokens invested in the group project. How this return is distributed among group members is determined as follows.**]**

[Heterogeneous: Remember, each token invested in the group project by group member A or B yields a return of forty points to the group. Each token invested in the group project by group member C or D yields a return of eighty points to the group. How this return is distributed among group members is determined as follows.**]**

[NoLeader_Homogeneous: Each of group members A, B, C, and D will receive an equal share of the total return from the group project. This means that each group member receives 60 / 4 = 15 points per token for each token invested in the group project.

Thus, **if you are group member A, B, C or D**, your earnings for the period will be:

> **Your point earnings = 30 x (number of tokens kept in your private account) + 15 x (total number of tokens invested in the group project by your group).]**

[NoLeader_Heterogeneous: Each of group members A, B, C, and D will receive an equal share of the total return from the group project. This means that for each token invested in the group project by A or B each group member receives 40 / 4 = 10 points per token, and for each token invested in the group project by C or D each group member receives 80 / 4 = 20 points per token.

Thus, **if you are group member A, B, C or D**, your earnings for the period will be:

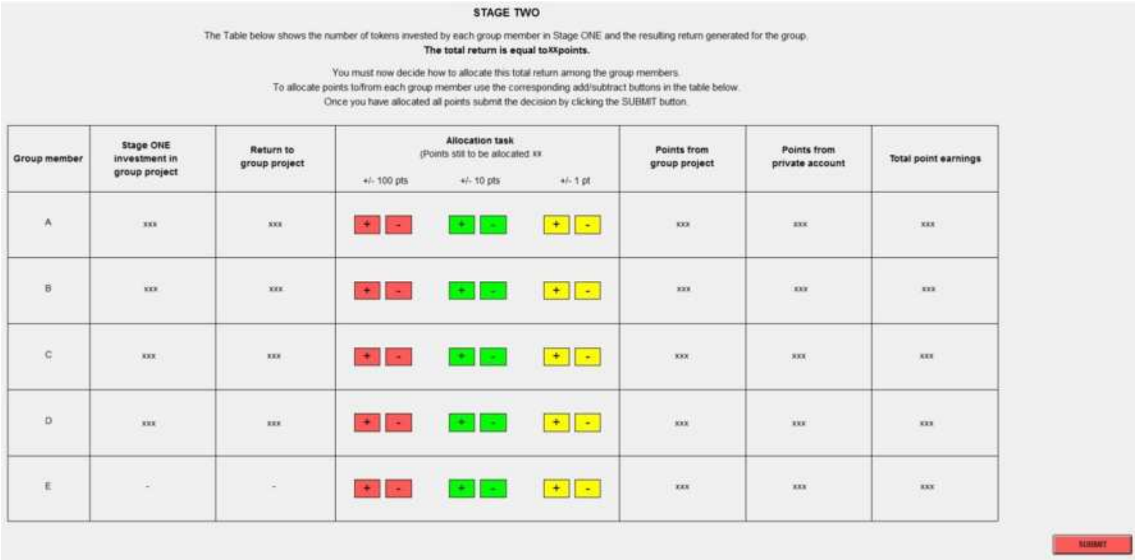
> **Your point earnings = 30 x (number of tokens kept in your private account) +**
>
> **10 x (total number of tokens invested in the group project by A and B) +**
>
> **20 x (total number of tokens invested in the group project by C and D).]**

[NoLeader: If you are group member E you do not get any of the return from the group project. Thus, **if you are group member E** your earnings for the period will be

Your point earnings = 30 x 10 = 300.]

[Leader: Group member E will be informed of the decisions of the other group members and must decide how to allocate the total return from the group account among all group members, including himself or herself. Group member E is free to choose any allocation he or she wants, as long as each group member receives at least zero points from the group project and the total received by all group members is equal to the total return from the group project.

To do this Group Member E will complete a screen like the one shown below.

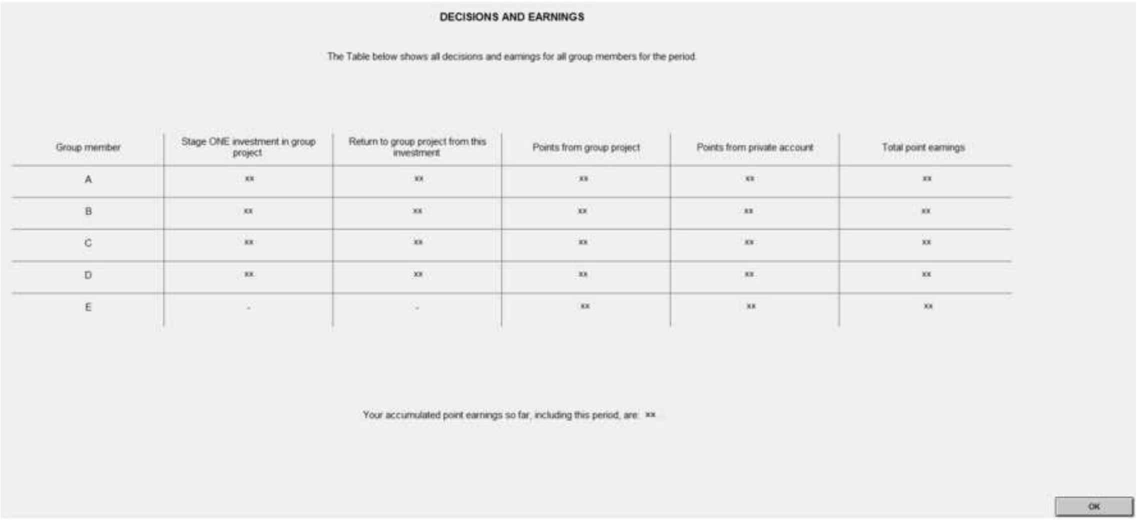


The first column shows the group member ID and the second column shows how many tokens this group member invested in the group project in Stage One. The third column shows the resulting return to the group from this investment decision. We will explain the fourth column in a moment. The fifth column is to be completed by group member E and shows how many points from the group project that this group member receives. The sixth column shows this group member's point earnings from his or her private account and the last column shows this group member's point earnings for the period.

Group member E completes the fifth column by allocating the total return from the group project. The total return is shown above the table in bold, and the amount that still has to be allocated is shown at the top of the fourth column. In each row of the fourth column there are add (+) / subtract (-) buttons that group member E can use to allocate the total return. For example, if group member E clicks on the first add button 100 points will be added to group member A's point earnings from the group project. At the same time the entry in the final column for group member A will increase by 100 points and the amount still to be allocated will be reduced by 100 points. Thus, Group member E can easily see how total earnings and the amount left to be allocated change as he or she allocates the return. Group member E must allocate the total return from the group project among the five group members. Once group member E has allocated the total return he or she can either amend her decisions using the add/subtract buttons, or submit the decision by clicking the *SUBMIT* button.

]

At the end of the period all group members will be shown a *Decision and Earnings* screen like the one shown below.



DECISIONS AND EARNINGS

The Table below shows all decisions and earnings for all group members for the period.

Group member	Stage ONE investment in group project	Return to group project from this investment	Points from group project	Points from private account	Total point earnings
A	xx	xx	xx	xx	xx
B	xx	xx	xx	xx	xx
C	xx	xx	xx	xx	xx
D	xx	xx	xx	xx	xx
E	-	-	xx	xx	xx

Your accumulated point earnings so far, including this period, are: xx

OK

The screen shows all decisions and earnings for all group members for the period. At the bottom of the screen you will also see your total point earnings that you have accumulated from this and previous periods.

After you have read the information on the Decisions and Earnings screen you can click the *OK* button to continue. Once all group members have done this, the next period will begin.

At the end of period ten you will see your total point earnings from all periods and you will be paid 10p for every 100 points, in addition to your £3.50 show-up fee. You will be paid in private and in cash.

Questions

Please answer the questions below. The example in the questions is purely hypothetical. In the actual experiment the investments in the group project **[Leader:** and the allocation of the total return**]** will be determined by the decisions made in your group. In a couple of minutes someone will come to your desk to check your answers. When each participant has answered all questions correctly we will continue with the experiment.

1. How many periods will there be? __________

2. Will the people in your group be the same for period to period or change from period to period? Same / change

Suppose that in a period A invests 0, B invests 4 tokens, C invests 6 and D invests 10 tokens in the group project.

3. What will be the total return from the group project in that period? __________

[NoLeader:

4. How many points will each group member earn from the group project in that period?

A: __________

B: __________

C: __________

D: __________

E: __________

5. How many points will each group member earn from his or her private account in that period?

A: __________

B: __________

C: __________

D: __________

E: __________

6. What will be each group member's point earnings for the period?

A: __________

B: __________

C: __________

D: __________

E: __________

][Leader:

4. Suppose E distributes the total return from the group project as shown in the Table below. Complete the blanks in the last two columns.

Group member	Stage ONE investment in group project	Return to group project	Points from group project	Points from private account	Total point earnings
A	4	240 [160]	300		
B	6	360 [240]	100		
C	10	600 [800]	240		
D	0	0	360		
E	-	-	200		

]

[Endogenous: Instructions

At the beginning of the experiment you will be matched with four other people, randomly selected from the participants in this room, to form a group of five. **The composition of your group will stay the same throughout the experiment**, i.e. you will form a group with the same four other participants during the whole experiment.

Each person in the group will be randomly assigned a role, either 'group member A', 'group member B', 'group member C', 'group member D', or 'group member E'. **Your role will stay the same throughout the experiment**. You will not learn the identity of the other participants in your group. Participants will be identified simply as 'group member A', 'group member B' etc..

When we have finished reading the instructions you will be informed of your role. **The experiment will then consist of 3 blocks of 10 periods each**. In each period you can earn points. Your point earnings will depend on the decisions made within your group, and will not be affected by decisions made in other groups.

At the end of the experiment your accumulated point earnings from all periods will be converted into cash at the exchange rate of **10 pence per 100 points**. You will be paid, in cash and in private, this amount in addition to the show-up fee of £3.50.

Decisions and Earnings

The experiment consists of three blocks of ten periods in which you can earn points. Every period has the same structure and has two stages.

Stage One

At the beginning of Stage One each group member will be given 10 tokens.

Group members A, B, C and D must choose how many of these tokens to invest in a group project and how many to keep in their private accounts. Group member E has no choice to make: the computer will place all ten of his or her tokens in his or her private account.

Each token a group member keeps in his or her private account yields a return of thirty points to that group member.

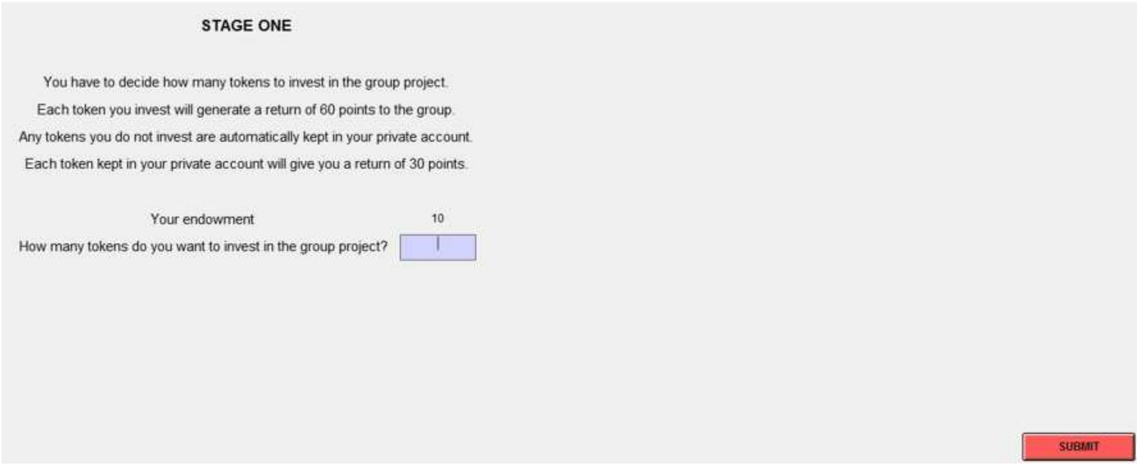
[Homogeneous: Each token a group member invests in the group project yields a return of sixty points to the group. How these points are allocated among group members will be determined in Stage Two.**]**

[Heterogeneous: Each token group member A or B invests in the group project yields a return of forty points to the group. Each token group member C or D invests in the group project yields a return of eighty points to the group. How these points are allocated among group members will be determined in Stage Two.**]**

Your point earnings for the period will be your point earnings from your private account plus your point earnings from the group project.

If you are one of group members A, B, C or D, you will make your decision by entering the number of tokens you invest in the group project. Any tokens you do not invest will automatically be kept in your private account. You will enter your decisions on a screen like the one shown below.

[Homogeneous:



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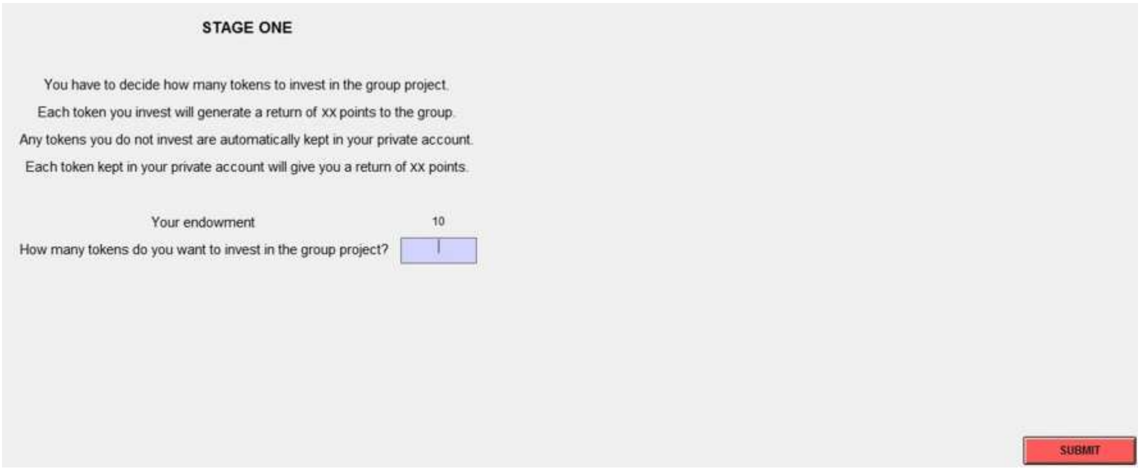
[Heterogeneous:



]

When you have made your decision you must click on the *SUBMIT* button. Once group members A, B, C and D have submitted their decisions Stage Two will begin.

Stage Two

[Homogeneous: Remember, each token invested in the group project generates a return of sixty points to the group. How this return is distributed among group members is determined as follows.**]**

[Heterogeneous: Remember, each token group member A or B invests in the group project yields a return of forty points to the group. Each token group member C or D invests in the group project yields a return of eighty points to the group. How this return is distributed among group members is determined as follows.**]**

The total return will be divided into two parts:

total return = automatic return + discretionary return.

The **automatic return** will be equally distributed among group members A, B, C and D. The **discretionary return** will be allocated by group member E. We will explain what part of the total return will be automatic and what part will be discretionary later.

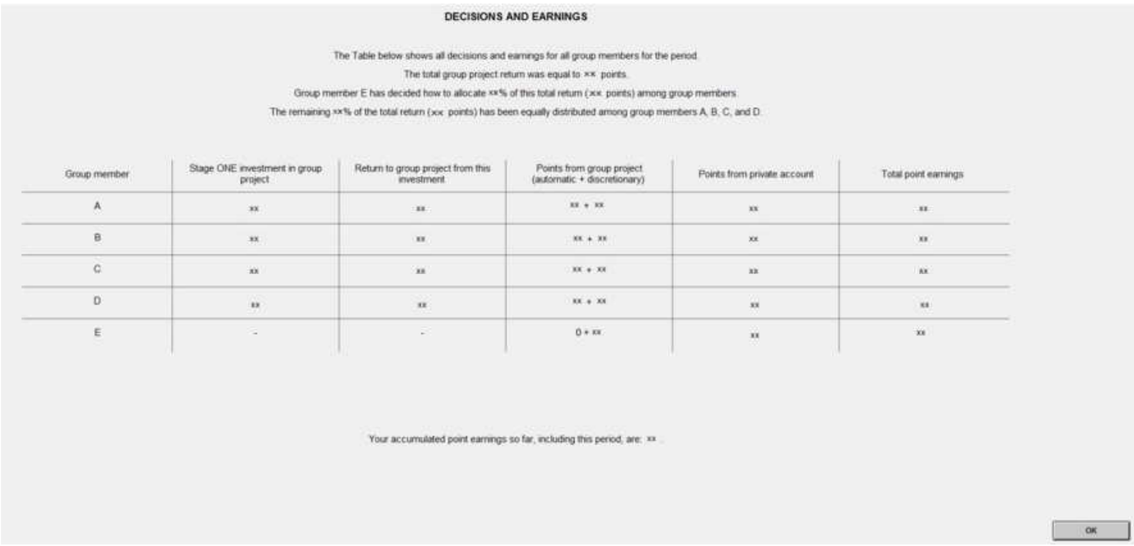
For the discretionary part, group member E will be informed of the decisions of the other group members and must decide how to allocate the discretionary return among all group members, including himself or herself. Group member E is free to choose any allocation he or she wants, as long as each group member receives at least zero discretionary points from the group project and the total discretionary points received by all group members equals the discretionary return.

To do this group member E will complete a screen like the one shown below.

The first column shows the group member ID and the second column shows how many tokens this group member invested in the group project in Stage One. The third column shows the resulting return to the group from this investment decision. We will explain the fourth column in a moment. The fifth column is to be completed by group member E and shows how many points from the group project that this group member receives. Note that in each row of this column there are two numbers, the first is the earnings from the group project this group member automatically receives, and the second is the discretionary earnings from the group project that this group member is allocated by group member E. The sixth column shows this group member's point earnings from his or her private account and the last column shows this group member's point earnings for the period.

Group member E completes the fifth column by allocating the discretionary return from the group project. The total return from the group project is shown above the table in bold, and the discretionary return that group member E must allocate is shown on the next line. The amount that still has to be allocated by group member E is shown at the top of the fourth column. In each row of the fourth column there are add (+) / subtract (-) buttons that group member E can use to allocate the return. For example, if group member E clicks on the first add button 100 points will be added to group member A's point earnings from the group project. At the same time the entry in the final column for group member A will increase by 100 points and the amount still to be allocated will be reduced by 100 points. Thus, group member E can easily see how total earnings and the amount left to be allocated change as he or she allocates the return. Group member E must allocate all of the discretionary return among the five group members. Once group member E has allocated all of the discretionary return he or she can either amend his or her decisions using the add/subtract buttons, or submit the decision by clicking the *SUBMIT* button.

At the end of the period all group members will be shown a *Decision and Earnings* screen like the one shown below.


DECISIONS AND EARNINGS

The Table below shows all decisions and earnings for all group members for the period.
The total group project return was equal to xx points.
Group member E has decided how to allocate xx% of this total return (xx points) among group members.
The remaining xx% of the total return (xx points) has been equally distributed among group members A, B, C, and D.

Group member	Stage ONE investment in group project	Return to group project from this investment	Points from group project (automatic + discretionary)	Points from private account	Total point earnings
A	xx	xx	xx + xx	xx	xx
B	xx	xx	xx + xx	xx	xx
C	xx	xx	xx + xx	xx	xx
D	xx	xx	xx + xx	xx	xx
E	-	-	0 + xx	xx	xx

Your accumulated point earnings so far, including this period, are: xx

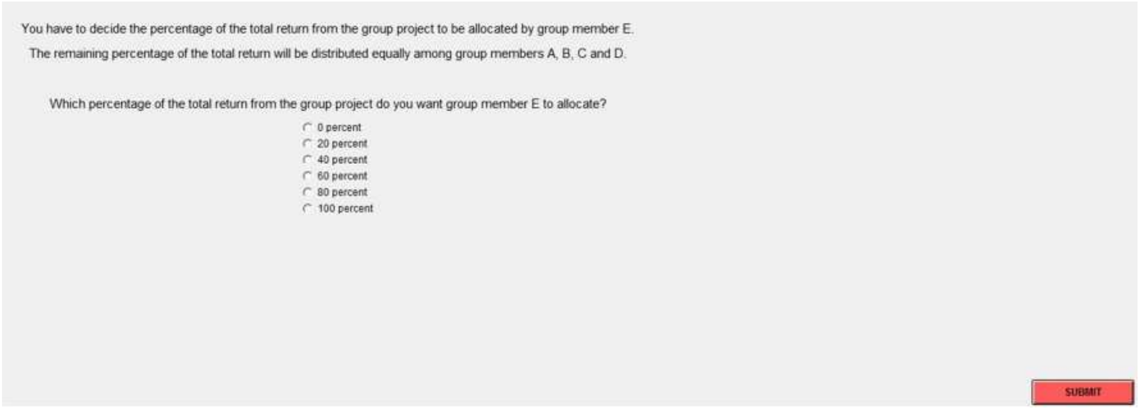
OK

The screen shows all decisions and earnings for all group members for the period. At the bottom of the screen you will also see your total point earnings that you have accumulated from this and previous periods.

After you have read the information on the Decisions and Earnings screen you can click the *OK* button to continue. Once all group members have done this, the next period will begin.

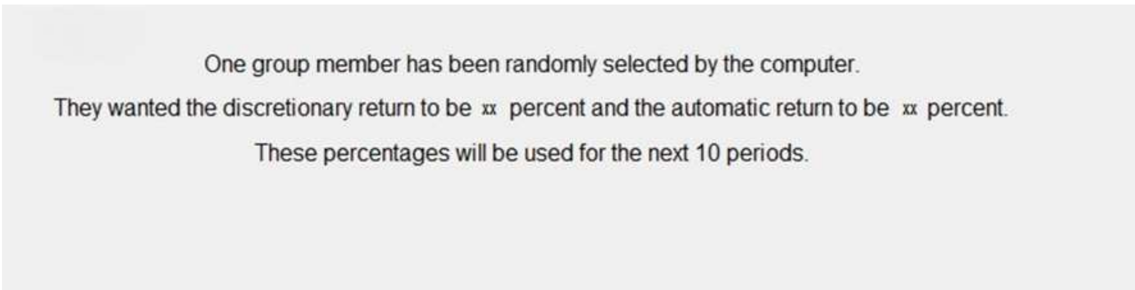
Beginning a Block

At the beginning of a block (that is, just before periods 1, 11 and 21), each of group members A, B, C and D will see the following screen.



Each group member has to indicate how he or she wants the total return from the group project to be divided between the discretionary return and automatic return. Each group member has to choose a percentage (out of 0%, 20%, 40%, 60%, 80% and 100%). This is the percentage of the total return from the group project that he or she wants to be the discretionary return, that is, the percentage to be allocated by group member E. The remaining percentage is the percentage of the total return from the group project that this group member wants to be distributed automatically.

After group members A, B, C and D have submitted their decisions, one of the four decisions will be selected at random by the computer and will be used to determine how the total return is distributed during the block of ten periods. The randomly selected group member's decision will be used for all ten periods in the block. All group members will be notified of the randomly selected decision on a screen like the one shown below.



Notice that if the discretionary return is 0% of the total return from the group project then group member E will have no decision to make. In this case group member E will still see the stage two decision screen, but he or she cannot change the entries in the table and he or she should just click on the *SUBMIT* button.

Ending the Experiment

At the end of period thirty you will see your total point earnings from all periods and you will be paid 10p for every 100 points, in addition to your £3.50 show-up fee. You will be paid in private and in cash.

Questions

Please answer the questions below. The example in the questions is purely hypothetical. In the actual experiment the investments in the group project and the allocation of the total return will be determined by the decisions made in your group. In a couple of minutes someone will come to your desk to check your answers. When each participant has answered all questions correctly we will continue with the experiment.

1. How many blocks will there be there be in this experiment? __________

2. How many periods will there be there be in each block? __________

3. Will the people in your group be the same from block to block or change from block to block? Same / change

4. Will the people in your group be the same from period to period or change from period to period? Same / change

5. Suppose that just before period 21 group member A chose the discretionary return 0%, B chose 20%, C chose 80%, and D chose 100%. Group member C's choice was randomly selected by the computer. What percentage of total return from the group project will be allocated by group member E in periods 21 to 30? __________

Suppose that for this block of periods the discretionary return is 0% and the automatic return is 100% of the total return from the group project. Suppose also that in a period A invests 4, B invests 6 tokens, C invests 10 and D invests 0 tokens in the group project.

6. What will be the return to the group project from each group member's investment in that period?

A: __________

B: __________

C: __________

D: __________

E: __________

7. What will be the total return from the group project in that period? __________

8. How many points will each group member earn from the group project in that period?

A: __________

B: __________

C: __________

D: __________

E: __________

9. How many points will each group member earn from his or her private account in that period?

A: __________

B: __________

C: __________

D: __________

E: __________

10. What will be each group member's point earnings for the period?

A: __________

B: __________

C: __________

D: __________

E: __________

Suppose that for this block of periods the discretionary return is 100% and the automatic return is 0% of the total return from the group project. Suppose also that in a period A invests 4, B invests 6 tokens, C invests 10 and D invests 0 tokens in the group project.

11. Suppose E allocates the total return from the group project as shown in the Table below. Complete the blanks in the last two columns.

Group member	Stage ONE investment in group project	Return to group project	Points from group project	Points from private account	Total point earnings
A	4	240 [160]	300		
B	6	360 [240]	100		
C	10	600 [800]	240		
D	0	0	360		
E	-	-	200		

]

Appendix B. Inequality aversion and equilibrium efforts.

In this appendix we derive the Fehr-Schmidt parameter conditions under which cooperation is possible in an equilibrium of the one-round game. Recall utilities are given by:

$$U_i = \pi_i - \frac{\alpha_i}{n-1}\sum_{j\neq i} max\{\pi_j - \pi_i, 0\} - \frac{\beta_i}{n-1}\sum_{j\neq i} max\{\pi_i - \pi_j, 0\}$$

where π_i denotes team member *i*'s material payoff.

The No Leader treatments

In the No Leader treatments material payoffs are given by

$$\pi_{Leader} = 300$$

$$\pi_{Worker\ i} = 300 - 30\ e_i + \frac{1}{4}\cdot\sum_{j=1}^{4}\theta_j e_j$$

where $e_i \in \{0, 1, \ldots, 10\}$ denotes worker i's effort and $\theta_i$denotes her exogenous productivity parameter. Recall that in all treatments $\sum_{j=1}^{4}\theta_j = 240$.

Suppose each worker supplies *e* units of effort. Then worker *i* earns $\pi_i = 300 - 30e + 60e = 300 + 30e$ and gets utility $U_i = 300 + 30e - \beta_i \frac{30e}{4}$.

If worker *i* were to unilaterally increase her effort by *t* units her material payoff would fall, she would incur disutility from disadvantageous inequality vis-à-vis the other workers, and this additional disutility would more than offset the reduction in disutility from the decrease in advantageous inequality vis-à-vis the leader. This is because (i) disadvantageous inequality weighs more heavily than advantageous inequality ($\alpha_i \geq \beta_i$), and (ii) each additional unit of effort supplied generates a 30 point difference in earnings vis-à-vis another worker, and a smaller, $30 - \frac{1}{4}t\theta_i$, difference in earnings vis-à-vis the leader. Thus it is not possible for worker *i* to increase her utility by increasing effort supply beyond *e*.

If worker *i* were to decrease her effort by *t* units her utility would be $U_i = 300 + 30e + 30t - \frac{1}{4}\theta_i t - \frac{\beta_i}{4}\left(30e + 30t - \frac{1}{4}\theta_i t + 90t\right)$. Thus the reduction in effort increases utility by $30t - \frac{1}{4}\theta_i t - \frac{\beta_i}{4}\left(120t - \frac{1}{4}\theta_i t\right)$. This is positive for small β_i and negative for large β_i. The critical value of β_i where the increase is zero is $\beta_i^* = \frac{480-4\theta_i}{480-\theta_i}$.

Thus if all workers have $\beta_i \geq \beta_i^*$ any symmetric effort profile is an equilibrium. For the homogeneous productivity treatment θ_i= 60 and so $\beta_i^* = \frac{4}{7} \approx 0.57$. For the heterogeneous treatment the critical value for low productivity workers (θ_i= 40) is $\beta_i^* \approx$ 0.73, and for high productivity workers (θ_i= 80) is $\beta_i^* = 0.4$.

The Leader treatments

In the No Leader treatments material payoffs are given by

$$\pi_{Leader} = 300 + \sum_{j=1}^{4} \theta_j e_j - \sum_{j=1}^{4} r_j$$

$$\pi_{Worker\ i} = 300 - 30\ e_i + r_i \cdot$$

where r_i is the leader's transfer to worker *i*.

If β_{leader} is small the leader maximizes utility by keeping all the team output, yielding utility

$$U_{leader}(keep) = 300 + \sum_{j=1}^{4} \theta_j e_j - \frac{\beta_{leader}}{4}\left(4\sum_{j=1}^{4} \theta_j e_j + 30\sum_{j=1}^{4} e_j\right).$$

If β_{leader} is large she maximizes utility by allocating rewards to equalize payoffs, yielding utility

$$U_{leader}(share) = 300 + \frac{1}{5}\sum_{j=1}^{4} \theta_j e_j - \frac{1}{5}\sum_{j=1}^{4} 30\ e_j.$$

The critical value of β_{leader} is where $U_{leader}(keep) = U_{leader}(share)$, or β_{leader}^*= 0.8.

If $\beta_{leader} < \beta_{leader}^*$ the leader will keep any team output in stage two. Anticipating this worker *i* maximizes utility by choosing zero effort in stage one. Increasing effort by a unit would reduce her material payoff by 30 points and increase disadvantageous payoff inequality vis-à-vis the leader by 30 + θ_i points. This would outweigh any possible utility gain from reducing advantageous inequality vis-à-vis the other workers (this reduction in disutility from advantageous inequality is at most $\frac{\beta_i}{4} 90 < 22.5$).

If $\beta_{leader} > \beta_{leader}^*$ the leader equalizes material payoffs in stage two. Given this strategy all workers will earn the same payoff and receive utility

$$U_{worker\ i} = 300 + \frac{1}{5}\sum_{j=1}^{4} \theta_j e_j - \frac{1}{5}\sum_{j=1}^{4} 30\ e_j.$$

Note that this is increasing in e_i. That is, by supplying an additional unit of effort in stage one worker *i* increases team earnings by $(\theta_i - 30)$. The leader's strategy ensures that as a result worker *i*'s material payoff and utility increases by $(\theta_i - 30)/5$. Thus, in the unique subgame perfect equilibrium all workers supply full effort.