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Berlin, October 2007

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Abstract

In a series of experimental games, each of two players may choose between remuneration based on either private or team effort. Although at least one of the players has the subgame perfect equilibrium strategy to choose remuneration based on private effort, we frequently observe team remuneration chosen by both players. Team remuneration allows for high pay-off for each player for cooperation, but at the same time provides individual incentives to take a free ride on the other player's effort. Due to significant cooperation we observe that in team remuneration participants make higher profits than in private remuneration. We also observe that, when participants are not given the option of private remuneration, they cooperate significantly less.

Keywords: Team effort, voluntary collaboration, experimental economics

JEL classification: C72, C90, H41, J33

Contents

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The mere mention of teams and team compensation can make a human resources manager quiver with emotion. (Lazear 1996, p. 47)

1 Introduction

The study of the performance of incentive schemes is crucial for the understanding how organizations form and function (Holmstrom 1982). To foster team effort, many firms use team incentive schemes that account for a small portion of employee income (Milgrom and Roberts 1992). Following Lazear (1996), there are good reasons to suppose that team incentive schemes are more effective than individual incentive schemes in inducing high employee effort, in particular when the measurement of individual contributions is impossible or very costly. On the other hand, team incentive schemes are likely to induce free-riding behavior (e.g., Alchian and Demsetz 1972, Holmstrom 1982).

Team incentive schemes are typically based on profit sharing: employees are paid annual bonuses that vary with profitability defined at the overall corporate level or at the level of an individual division. Several empirical studies find evidence that profit sharing is associated with higher productivity (for an overview see OECD 1995) and better financial performance of firms (e.g., Mitchell, Lewin and Lawler 1990 for the US, Zhuang and Xu 1996 for China, Bhargava 1994 for the UK, and Kraft and Ugarkovic 2006 for Germany.)

An extreme form of profit sharing is when employees own all of the company as, for example, in partnerships that are typical in law, medicine, management consulting or architecture, or in production cooperatives. There is a huge body of literature on worker-owned firms, both theoretical and empirical. The latter suggests that producer cooperatives tend to enjoy higher levels of productivity than conventional firms (e.g., Bonin, Jones and Putterman 1993.)

Putterman and Skillman (1992) present a theoretical model of effort choice in a cooperative firm in which they examine the role of exit costs in order to reconcile the seemingly contradictory lines of reasoning by MacLeod (1988) and Lin (1990). MacLeod argues that repetition of the production relationship in a cooperative allows for the use of trigger strategies to punish deviations from efficient output. He points out that worker mobility might hamper threats of future punishment and thus calls for exit costs as an important criterion for a successful cooperative. Lin, on the other hand, suggests that effective cooperation depends on the freedom to exit. She argues “that high-effort outcomes were achieved in Chinese farm cooperatives prior to 1958 because members enjoyed the right to return to private farming at will, and could thus credibly use the threat of exit to deter shirking by fellow team members. When, by Lin’s account, individual rights of withdrawal were removed in 1958, productivity dropped sharply” (Putterman and Skillman 1992, page 598.)

Another aspect, implicit in Lin’s argument, is that prior to 1958 participation was voluntary, while later on it was enforced. In psychology, reactance is defined as an emotional reaction in direct contradiction to rules and/or regulations that threaten or eliminate specific behavioral freedoms (e.g., Baron, Byrne and Branscombe 2006, page 152, and Brehm 1966). In the case of enforced cooperation without any option of exit, this kind of reaction could arise and hamper the cooperative effort. This could have been one of the reasons for the failure of the labor-managed firm created in former Yugoslavia, which has attracted of lot of attention in the 1960s and 1970s.

In this paper, we examine the behavioral difference in voluntary versus enforced collaboration in a series of experiments on team effort under profit sharing. In the voluntary collaboration experiments we allow, in keeping with Lin’s line of reasoning, the choice to renounce team effort. We address several questions. Our major interest is whether teaming should be voluntary or enforced by management. Thus, we compare an environment where employees can choose between private and team remuneration to one where they have no choice but to work under team remuneration. We hypothesize that voluntary team effort is greater than enforced team effort because when subjects voluntarily choose team remuneration they signal interest in cooperation. Note that we do not examine whether team incentive schemes are more effective than private incentive schemes.

In our experiments, pairs of participants have to provide costly effort over 30 periods. In each period, each participant individually chooses an effort as an integer number between 0 and 100. Effort costs are represented by a quadratic function. In an environment where teaming is enforced, a participant’s remuneration is based on the average of the participant's own effort and the effort of the participant he or she is paired with. In an environment where teaming is voluntary, each participant chooses between private or team remuneration before deciding on the effort in each period. While private remuneration is based on the participant's individual effort only, team remuneration is based on the average of the participant's own effort and the effort of his or her team member.

In the case of team remuneration, each of the two participants faces an individual incentive to take a free ride on the other's effort. The effort of each participant may be considered a voluntary contribution to the public good team effort. We have modeled the situation such that through cooperation the team can realize higher profits than the maximum sum of profits that the two players can realize under private remuneration. This is based on the assumption of a higher payment per effort unit under team remuneration than under private remuneration, reflecting that in the case of team remuneration the firm has a cost advantage relative to the case of private remuneration due to reduced monitoring costs. In real life, effort can hardly be measured so that incentive payment has to be based on a surrogate, typically an output variable. In a work team it is often very hard to measure an individual's contribution to the team output.

While there is a large theoretical literature on team incentives when individual effort is not observable (e.g., Holmstrom 1982, Rasmusen 1987, Itoh 1991, 1992, McAfee and McMillan 1991), only few empirical studies have examined the impact of teams on output (e.g., Weitzman and Kruse 1990 and Hamilton, Nickerson and Owan 2003, and the references therein). While data at the firm level may be available, they might not allow for the comparison of outcomes with and without team incentives, or of voluntary and enforced teaming. Comparisons across firms are likely to suffer from issues of worker self-selection and distorting factors due to additional differences in human resource and production processes. Thus, controlled laboratory experiments are a valuable method to collect data.

Nalbantian and Schotter (1997), for example, present an experimental analysis of the functionality of various team incentive schemes. Their revenue sharing scheme is very similar to our team remuneration scheme with profit sharing, except for a stochastic element in their experiment. More concretely, their participants face a moral hazard problem, while in our experiment effort is observable and verifiable. Both experiments, however, involve a free-riding incentive. Nalbantian and Schotter observe declining effort over time, i.e., an increase in free riding behavior.

In the experimental economics literature, we find a large number of studies on voluntary contributions to finance a public good to which our experiment relates (e.g., Isaac, Walker and Williams 1994, Andreoni 1988, 1995). These studies provide a good picture of the kind of environments that are needed to facilitate cooperation and of the behavioral dynamics. The most important finding is that people do make voluntary contributions above those that are in their egoistic individual interest and that their contribution decisions tend to be based on the reciprocity principle or, in other words, conditional cooperation (e.g., Keser and van Winden 2000, Keser 2000, 2002, Fehr and Gächter 2000a, Fischbacher, Gächter and Fehr 2001).

In the majority of experiments, including those by Nalbantian and Schotter, participants are told that they are members of a team or a group. They cannot choose whether to be in a group or select the group or individual group members (with the exception of Ehrhart and Keser 1999, Hauk and Nagel 2001, Hauk 2003, Coricelli, Fehr and Fellner 2004, Page, Putterman and Unel 2005, Charness and Yang 2007). It is an important point of our investigation whether participants, when they have the choice of either private or team remuneration, will choose team remuneration at all. We have parameterized our experimental games such that in the subgame-perfect equilibrium participants choose private remuneration although social efficiency would require them to choose team remuneration.

The subsequent question then is whether participants do provide cooperative efforts when they have chosen team remuneration. The above mentioned signaling argument would say yes. Theoretically, signaling relates to a forward induction argument rather than the backward induction on which the subgame perfect equilibrium is built. The next question then pertains to dynamics in the decision making, which could not only affect effort but also remuneration choices.

To evaluate the robustness of our observations with respect to the choice of the remuneration mode and effort, we examine both a symmetric and an asymmetric parameterization of our game. Asymmetry in the players' effort costs makes the definition of a cooperative goal more difficult (e.g., Selten, Mitzkewitz and Uhlich 1997). It reflects heterogeneity of the team members, an aspect that is often neglected in experimental investigations that tend to focus on symmetric situations. Different effort costs can reflect diverse abilities or skills among team members. They can also reflect diverse organizational cultures coming together after merger. The understanding of divergent behavior in symmetric and asymmetric team situations is an important human capital management issue. Abramson et al. (2002), for example, argue that increased attention to differences and how individuals from different backgrounds work together is necessary to create workplaces in which employees work together in a cooperative, productive manner.[1]

[1] It is sometimes argued that worker heterogeneity in teams leads to better team outcomes due to mutual learning and complementarities (Hamilton, Nickerson and Owan 2003, Surwiecki 2005). Our experimental design, however, does not allow for such effects.

Finally, we point out that our experiments are based on games that have a social optimum in the interior of the strategy space. This is different from the typical experiment on public-goods provision where the efficient solution lies at the upper end of the strategy space. It has been neglected in the literature that this design issue renders the observation of an aggregate outcome close to the efficient solution almost impossible.

In Section 2, we present the model and its theoretical solutions. Section 3 develops behavioral predictions. Section 4 describes the experimental design. In Sections 5 and 6, we present the experimental results. Section 7 concludes the article.

2 The model

Our experiments with voluntary choice of the remuneration mode are based on the *effort game* presented in Section 2.1. This game has a unique subgame-perfect equilibrium (Section 2.2) that is different from the joint profit-maximizing solution (Section 2.3).

2.1 The effort game

Consider a game with two players i = 1, 2 and two decision stages. Let us start by describing the second decision stage in which each of the two players chooses an effort level, before we consider the first stage in which the players decide on their remuneration mode.

In the *second decision stage*, each player i knows the remuneration mode and independently chooses an effort level, e_i, where $e_i \in [0,100]$. Effort is costly. Player i's cost function C_i depends on his individual effort e_i and a constant k_i, and is quadratic:

$$C_i = k_i \, e_i^2 \, .$$

In the *first decision stage*, each player i independently chooses between *private remuneration* or *team remuneration*. If both players choose team remuneration, *team remuneration* is applied: each player i is paid, at the end of the second decision stage, based on both players' average effort multiplied by a constant, t. The team remuneration T_i for each player i is

$$T_i = t\left(\frac{e_1 + e_2}{2}\right).$$

If at least one of the players chooses private remuneration, *private remuneration* is applied: each player *i* is paid at the end of the second decision stage, based on his private effort multiplied by a constant, *p*. The private remuneration P_i for each player *i* is

$$P_i = p\, e_i \,.$$

Note that we assume $t > p$. This reflects that in the case of team remuneration the firm has a cost advantage relative to the case of private remuneration due to reduced monitoring costs.

The effort game ends at the conclusion of the second decision stage. Player *i*'s profit Π_i is determined by his remuneration minus his individual cost of effort:

$$\Pi_i = P_i - C_i \quad \text{in the case of private remuneration}$$

$$\Pi_i = T_i - C_i \quad \text{in the case of team remuneration}$$

2.2 The subgame-perfect equilibrium

The subgame-perfect equilibrium of the effort game can be found by backward induction. We start by considering the second decision stage in which each player chooses a profit-maximizing effort level. We have to distinguish whether private or team remuneration applies, which depends on the players' choices in the first stage.

In the case of *private remuneration*, each player *i* solves an individual profit-maximization problem that is independent of the other player's effort choice:

$$\underset{e_i}{Max} \quad P_i - C_i \quad = \quad p\, e_i - k_i\, e_i^2 \,.$$

The resulting optimal effort

$$e_i * = \frac{p}{2\, k_i}$$

implies the profit

$$\Pi_i * = \frac{p}{2}\, e_i * \,.$$

In the case of *team remuneration*, each of the two players, $i = 1, 2$, independently chooses his effort to maximize his individual profit, taking the other player's effort into account:

$$\underset{e_i}{Max} \quad T_i - C_i \quad = \quad t\left(\frac{e_1 + e_2}{2}\right) - k_i \, e_i^2 \, .$$

The solution is independent of the other player's effort and, thus, implies the following dominant strategy for each player *i*:

$$e_i ** = \frac{t}{4 k_i}$$

The resulting equilibrium profit for player *i* is:

$$\Pi_i ** = \frac{t}{4} e_i ** + \frac{t}{2} e_j **, \qquad \text{with } i = 1, 2 \text{ and } j = 3 - i.$$

Consider, now, the first stage of the effort game taking the above solutions into account. If $\Pi_i** > \Pi_i*$, then player *i* chooses team remuneration; if $\Pi_i ** < \Pi_i*$, then player *i* chooses private remuneration. If player *i* is indifferent regarding team and private remuneration, we assume that player *i* chooses private remuneration. Only when both players choose team remuneration does the subgame-perfect equilibrium predict team remuneration; in all other cases, it predicts private remuneration.

2.3 Joint profit maximization

In the case of team remuneration, the two players find themselves in a kind of prisoner's-dilemma situation: their efforts represent voluntary contributions to the public good *team effort*. To some extent, each player has an incentive to take a free ride on the effort of the other player. The effort levels predicted by the equilibrium in dominant strategies are not optimal for the team. We find Pareto-optimal team-effort levels by solving the joint profit-maximization problem:[2]

$$\underset{e_1, e_2}{Max} \quad t\,(e_1 + e_2) - k_1\, e_1^2 - k_2\, e_2^2$$

For each player *i*, the optimal effort is given by:

$$e_i ' = \frac{t}{2 k_i}$$

[2] We equally weigh both players' profits. By using different weights we find other Pareto optimal solutions.

which implies the profit:

$$\Pi_i' = \frac{t}{2} e_j' \quad \text{with } i = 1, 2 \text{ and } j = 3 - i.$$

As $t > p$, it follows that $e_i' > e_i^*$ and $\Pi_i' > \Pi_i^*$. Thus, we have a Pareto-optimal solution for the effort game in which both players choose team remuneration and the effort e_i'.

3 Predictions

We develop a number of theoretical and behavioral predictions to be tested in the experiments.

Prediction 1: ***Participants do not choose the team remuneration mode when it is in their egoistic self-interest to choose private remuneration.***

This follows directly from the subgame perfect equilibrium prediction derived above.

Prediction 2: ***Under private remuneration, participants choose the optimal effort level.***

Under private remuneration, participants make an individual decision without strategic interactions. Their profit-maximizing effort can be directly read from a table in the instructions, which provides the respective cost and profit for each effort level (see Appendix).

The following three behavioral predictions relate to cases in which, contrary to the theoretical prediction 1, both participants have chosen team remuneration.

Prediction 3: ***Under team remuneration, participants choose an effort above the equilibrium prediction.***

Under team remuneration, participants are in a decision situation that is strategically equivalent to making a voluntary contribution to the provision of a public good. Over-provision relative to the dominant strategy prediction is a stylized fact (e.g., Ledyard 1995).

Prediction 4: ***Participants choose higher team effort under voluntary teaming than under enforced teaming where participants do not have the choice of private remuneration.***

This is due to a forward-induction argument (Kohlberg and Mertens 1986, Cho and Kreps 1987, Van Damme 1989) rather than the backward-induction argument on which the subgame perfect equilibrium is built. Participants who choose team remuneration are assumed to signal an interest in earning more than under private remuneration. In the case that the subgame-perfect equilibrium predicts private remuneration, this implies that participants who choose team remuneration intend to choose a higher effort than the equilibrium effort, or in other words, they intend to play more cooperatively than predicted. Assume that the population of participants consists of a constant proportion of “free riders”—participants who prefer to play the equilibrium strategy under team remuneration—and “cooperators”—participants who prefer to cooperate under team remuneration. This implies a self-selected group of cooperators in voluntary teaming, while the participants in enforced teaming are represented by the entire population that includes the constant proportion of free riders. Thus, we expect a higher level of cooperation in voluntary teaming than in enforced teaming.

Prediction 5: ***Participants’ behavior is driven by reciprocity.***

A motivational definition of reciprocity has been given by Rabin (1998). If somebody is nice to you or others, you are inclined to be nice to him; if somebody is mean to you or others, you are inclined to be mean to him. Many public-goods experiments provide evidence in favor of reciprocity. In our game, reciprocity can show both in the level of team effort and in the choice of the remuneration mode. In particular, the choice of private remuneration after teaming can be a kind of negative reciprocity (punishment) in response to uncooperative team effort by the other player.

4 Experimental design

To test the above predictions we design several experimental treatments that are specified in Section 4.1. Section 4.2 describes the organization of the experiments.

4.1 Treatments

In a 2 x 2 treatment design, we examine the four combinations resulting from two different parameterizations and two structural variants of the effort game. The two parameterizations are symmetric (*SYM*), where the two players have the same parameters, and asymmetric (*ASYM*), where the two players have different effort costs. Most public-goods experiments examine symmetric parameterizations. The asymmetric parameterization allows us to examine the robustness of the behaviors with respect to the five predictions.

The two structural variants are voluntary teaming (*VOLUNTARY*), which is exactly the effort game described above, and enforced teaming (*ENFORCED*), where the players play only the second stage of the game in enforced team remuneration. This allows us to investigate Prediction 4, which says that participants choose higher team effort under voluntary teaming than under enforced teaming. For each of the four treatments we have eight independent observations, based on eight pairs of two participants each.

Table 1 presents the parameters used in the *SYM* and *ASYM* treatments and the theoretical predictions for the second stage of the game in each of the two parameterizations. Note that in the case of team remuneration the second stage has the nature of a voluntary-contribution-to-a-public-good game where both the dominant strategy solution and the optimum (joint profit-maximizing solution) lie in the interior of the strategy space.

Table 1
Parameter values and theoretical predictions for the second stage of the game

Treatment	k_i	e_i*	e_i**	e_i'	Π_i*	Π_i**	Π_i'
SYM *i* = 1, 2 p = 9, t = 10	1/10	45	25	50	202.5	187.5	250
ASYM							
i = 1 (low cost)	1/10	35	20	40	122.5	104	128
i = 2 (high cost)	1/8	28	16	32	98	112	160
p = 7, t = 8							

e_i* player *i*'s optimal effort under private remuneration
e_i** player *i*'s equilibrium effort (dominant strategy) under team remuneration
e_i' player *i*'s joint profit-maximizing effort under team remuneration
Π_i* player *i*'s maximum profit under private remuneration
Π_i** player *i*'s equilibrium profit under team remuneration
Π_i' player *i*'s profit in the joint profit-maximizing solution under team remuneration
p factor of private remuneration
t factor of team remuneration
k_i individual cost factor

In the *SYM* parameterization, each player's maximal profit in the case of private remuneration is larger than his equilibrium profit in the case of team remuneration. It follows that in the subgame perfect equilibrium solution of the symmetric effort game both players choose private remuneration and an effort of 45. This yields a profit of 202.5 to each player. However, if both players choose team remuneration and an effort of 50 they can make a profit as high as 250 each. This solution maximizes the sum of profits of both players in the group.

In the *ASYM* parameterization, the player with the lower effort cost, player 1, makes a maximum profit in the case of private remuneration that is larger than his equilibrium profit in the case of team remuneration, while the opposite is true for the player with the higher effort cost, player 2. Thus, in the subgame perfect equilibrium solution private remuneration will be realized. The low-cost player chooses an effort of 35 and makes a profit of 122.5, while the high-cost player chooses an effort of 28 and makes a profit of 98. Each of the two players can do better by choosing team remuneration and an effort of 40 by the low-cost player and 32 by the high-cost player. In this Pareto optimal solution, the low-cost player's profit is 128 while the high-cost player's profit is 160, which implies that the high-cost player makes a higher profit than the low-cost player. As each of the two players has an incentive to individually deviate, this Pareto optimal solution does not describe an equilibrium of the second stage subgame.

4.2 Organization

In the experiments, participants played 30 repetitions, called *periods*, of the effort game in two-player groups that remained unchanged during the entire experiment ("partners" design). Based again on the backward induction principle, the subgame perfect equilibrium prediction of the finitely repeated effort game prescribes in each period the subgame perfect equilibrium prediction presented above. Behaviorally, however, the repetition opens up room for reciprocal behavior or conditional cooperation.

In the beginning of the second decision stage, in the *VOLUNTARY* treatments, each participant was informed of the actual remuneration mode, depending on both players' decisions in the first stage. At the end of each period, each participant was informed about his or her individual profit. In the case of team remuneration also the average effort level (and, thus, implicitly the effort level chosen by the other player) was communicated to each participant. A participant's sum of profits in all 30 periods determined his or her individual earnings in the experiment.

The computerized experiments were run at the experimental economics laboratory at CIRANO-LUB (Centre Interuniversitaire de Recherche en Analyse des Organisations – Laboratoires Universitaires Bell) in Montréal. We conducted sessions with eight participants each.

In the beginning of a session, the participants were randomly and anonymously assigned into four two-player groups, and, in the *ASYM* treatments, they were also randomly allocated the role of either a low-cost or a high-cost player for the entire experiment.

Participants received written instructions (an English translation can be found in the Appendix, the French version is available upon request), which were also read aloud to them. Before the experiment could start, each participant had to provide correct answers to a number of questions regarding the understanding of the instructions. Participants were not allowed to communicate with each other during the entire experiment. They did not know with whom they interacted among the other participants. After the experiment, each participant was paid in privacy based on his or her individual earnings in the experiment plus a show-up fee. The individual earnings were converted into Canadian dollars with a factor announced in the experiment instructions. On average, participants earned 30 Canadian dollars, including the show-up fee, for a session that lasted about 90 minutes.

5 Experimental results

In this section we evaluate, based on non-parametric data analysis, the five predictions made in Section 3 above. Each pair of participants forming a two-player group represents an independent observation. Unless mentioned otherwise, all non-parametric tests are two-sided. If no significance level is given, we require significance at the 10-percent level. We denote the Wilcoxon signed ranks test as Wilcoxon test and the Man-Whitney u-test as u-test.

Prediction 1: ***Participants do not choose the team remuneration mode when it is in their egoistic self-interest to choose private remuneration.***

In the *VOLUNTARY SYM* treatment, team remuneration is chosen by both players and thus realized in 45 percent of all periods.[3] This is in sharp contrast to the subgame-perfect equilibrium of the game with its specific paremeterization. Comparing the first set of 15 periods to the final set of 15 periods, the relative frequency of team remuneration exhibits no tendency to increase or decrease over time (Wilcoxon test).

[3] In 34 percent of all periods both players choose private remuneration, while in 21 percent of all periods private remuneration is realized due to one player choosing team remuneration but the other player choosing private remuneration.

In the *VOLUNTARY ASYM* treatment, team remuneration is chosen by both players and thus realized in as many as 72 percent of all periods. Again, this is in sharp contrast to the subgame-perfect equilibrium of the game with its specific parametrization. The relative frequency of team remuneration in this treatment exhibits a tendency to increase over time. When we compare the first set of 15 periods to the last set of 15 periods, we observe an increase that is significant at the 5-percent level (Wilcoxon test).

In the subgame-perfect equilibrium of the *VOLUNTARY ASYM* treatment only the high-cost player has an interest in choosing team remuneration. Thus, we hypothesize that high-cost players tend to choose team remuneration more often than low-cost players. We find support for this hypothesis in that the high-cost players chose team remuneration in 89 percent of all periods while the low-cost players chose team remuneration in 78 percent of all periods. In six of the eight independent groups the high-cost player chooses team remuneration more often than the low-cost player. This replicates the empirical finding of Hamilton, Nickerson and Owan (2003).

Conclusion 1: *Participants do choose team remuneration, contradictory to the subgame-perfect equilibrium solution of the game.*

Prediction 2: *Participants choose the optimal effort level under private remuneration.*

In the *VOLUNTARY SYM* treatment, the average effort over all periods with private remuneration is 45.27 (standard deviation of 16.81) and is not significantly different from 45, the optimal effort in the case of private remuneration (binomial test). This might be interpreted as evidence in favor of the participants' rationality. However, only about one half (52 percent) of all individual decisions under private remuneration are exactly 45. Participants tend to learn the optimal effort, though: the percentage of optimal private-effort choices increases from 47 in the first set of 15 periods to 63 in the last set of 15 periods. This increase is significant at the 10-percent level (Wilcoxon test).

In the *VOLUNTARY ASYM* treatment, the average private effort of the low-cost players is 34.87 (standard deviation of 9.88), which is not significantly different from the optimal level of 35 (binomial test), and the average private effort of the high-cost players is 27.22 (standard deviation of 15.58), which is not significantly different from the optimal level of 28 (binomial test). However, on the aggregate, only 51 percent of the effort choices by the low-cost players and 46 of those by the high-cost players are optimal. Pooling low-cost and high-cost players due to only four independent observations in each category, we observe that participants learn the optimal private effort: from the first set of 15 periods to the last set of 15 periods, the percentage of optimal choices significantly increases (Wilcoxon test, 10-percent significance).

Conclusion 2: *On the aggregate, participants choose the optimal private effort. However, only about 50 percent of the individual choices are optimal. The percentage of optimal choices shows a significant tendency to increase over time.*

Prediction 3: *Under team remuneration, participants choose an effort above the equilibrium prediction.*

In the *VOLUNTARY SYM* treatment, the average effort over all periods with team remuneration is 50.10 (standard deviation of 17.34) and significantly above 25, the dominant strategy in the case of team remuneration (binomial test, 5-percent significance).[4] Thus, in the case of team remuneration, our experimental evidence is similar to the results in public-goods experiments: effort is higher than predicted by the game-theoretical solution.

Interestingly, the observed effort is not significantly different from the Pareto optimum of 50 (Wilcoxon test). Note that in our experimental game, in contrast to most public-goods experiments, the optimum lies in the interior of the strategy space. If the Pareto optimum lies at the upper limit of the strategy space, participants can never err around it: deviations from the Pareto optimum are always below. This raises the concern whether it is due to this design issue that in most public-goods experiments contributions, although higher than in equilibrium, are still far below the Pareto optimum (see the related discussion on corner equilibria in Andreoni 1995, Ledyard 1995, Keser 1996, and Sefton and Steinberg 1996). Our experimental results give support to this concern as they show that, on the aggregate, participants make efforts right at the Pareto-optimal level. This implies that effort levels above the optimum have been chosen to the same extent as those below.

Over all periods, the resulting average profit in team remuneration is 220.08 and significantly higher than in private remuneration, where it is 174.35 (Wilcoxon test, 10-percent signifi-

[4] From the first set of 15 periods to the last set of 15 periods, we observe no significant increase or decrease in the team effort, but a decrease in its standard deviation from 20.54 to 11.91 (Wilcoxon test, 5-percent significance) signaling a larger cooperative consensus over time.

cance).[5] The average profit in team remuneration is significantly below the optimal profit of 250 (Wilcoxon test) and not significantly different from the equilibrium profit of 187.5.

In the *VOLUNTARY ASYM* treatment, the average team effort of the low-cost players is 34.51 (standard deviation of 11.09), while the average team effort of the high-cost players is 30.14 (standard deviation of 8.01).[6] Both effort levels are significantly above the respective dominant strategy of 20 or 16 (binomial test, 1-percent significance). Requiring significance at the 10-percent level (Wilcoxon test), both effort levels are not significantly different from the Pareto optimum of 40 and 32, respectively. Furthermore, neither the low-cost players' average effort nor its standard deviation is significantly different from the respective value of the high-cost players (Wilcoxon test).

The resulting average profit of the low-cost players (127.26, standard deviation of 74.05) is not significantly different from the one of the high-cost players (137.1, standard deviation of 59.85) in team remuneration (Wilcoxon test).[7] While the high-cost players' average profit is significantly above their equilibrium profit (Wilcoxon test, 5-percent significance), the low-cost players' average profit is not significantly different from their equilibrium profit (Wilcoxon test). Both low-cost and high-cost players' profits are not significantly different from their respective joint profit-maximizing profit (Wilcoxon test): the low-cost players realize 99 percent and the high-cost players realize 86 percent of it.

The high-cost players' average profit is significantly higher in team remuneration than in private remuneration, where it is 68.06 (Wilcoxon test, 2-percent significance). The low-cost players' average profit is in six of the eight groups higher in team remuneration than in private remuneration. However, this difference is statistically not significant (Wilcoxon test). The low-cost players' profit under private remuneration is 112.89 on average.

[5] We observe no significant increase or decrease of profit from the first set of 15 periods to the last set of 15 periods, neither in team nor in private remuneration. The standard deviation, however, decreases from 165.34 to 81.31 in team remuneration (Wilcoxon test, 10-percent significance) and from 51.89 to 22.25 in private remuneration (Wilcoxon, 5-percent significance).

[6] Comparing the average team effort in the first set of 15 periods to that in the final set of 15 periods, we observe a decrease both for the low-cost and the high-cost players. Neither is statistically significant (Wilcoxon test) although the decrease of the low-cost players' effort just fails significance.

[7] The profit of the low-cost players tends to increase from the first set of 15 periods to the last set of 15 periods under team remuneration (Wilcoxon test, 5-percent significance). The profit of the high-cost players shows no tendency to increase or decrease under team remuneration (Wilcoxon test).

Conclusion 3: *Participants do choose team effort that is above the equilibrium prediction. They do not realize profits, though, that are significantly higher than the equilibrium profits—with the exception of the high-cost players.*

Prediction 4: ***Participants choose higher team effort under voluntary teaming than under enforced teaming.***

Comparing average effort in the *ENFORCED SYM* to that in the *VOLUNTARY SYM* treatment, we observe that under enforced teaming effort is 35.68 (standard deviation of 19.45) and, thus, significantly lower than under voluntary teaming where it is 50.10 (u-test, 5-percent significance).[8] Initially, however there is no statistically significant difference: enforced team effort in the first period is 41.88; whereas, voluntary team effort in the first period that team remuneration is realized is 45.00 (u-test).

Enforced team effort is significantly above the equilibrium effort of 25 (Wilcoxon test, 5-percent significance) and significantly below the joint profit-maximizing effort of 50 (Wilcoxon test, 2-percent significance). Recall that, in contrast to this latter result, voluntary team effort is not significantly different from 50.

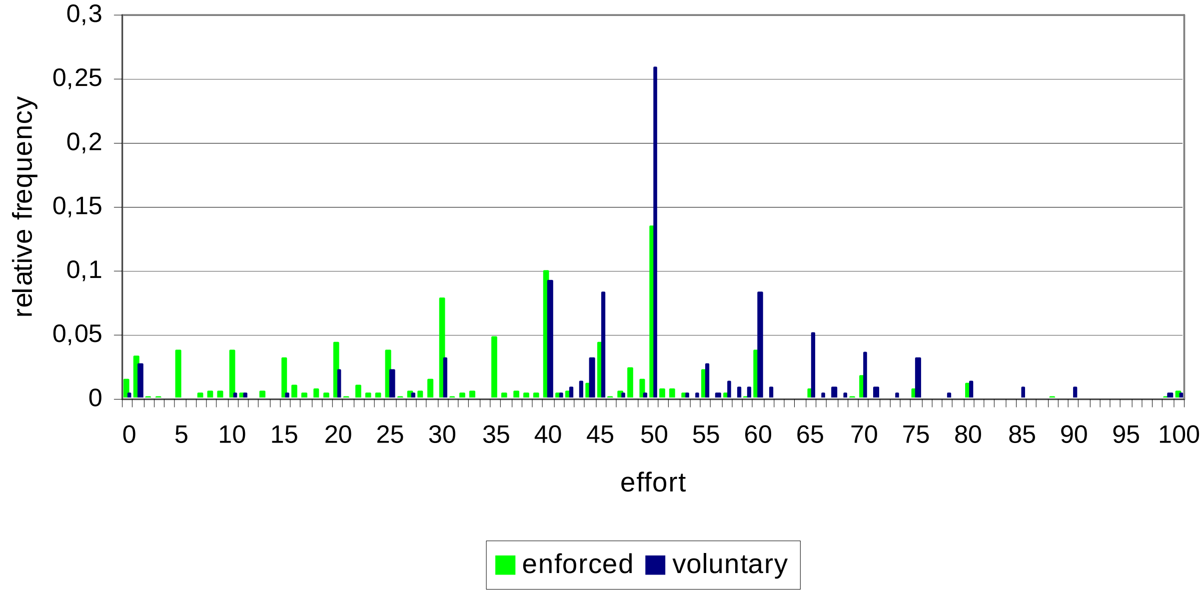
Figure 1 compares the density of voluntary and enforced team effort. While we rarely observe enforced effort above the joint profit-maximizing level of 50 (15 percent of all observations above 50, 72 percent below), voluntary effort seems to be allocated around 50 (37 percent of all observations above, 38 below). Effort levels above 50 might be used as a signal for one’s willingness to cooperate with the other, in particular if one expects the other to make an effort below 50 in the current period.[9] But, they could also simply be due to random decision making and/or misunderstanding of the payoff function. The latter is unlikely to account for the majority of the observations above 50 in the voluntary teaming treatment as we observe only relatively few effort choices above 50 in the enforced teaming treatment. It could be seen as an unfortunate drawback of our experimental design that the middle of the strategy space coincides with the joint profit-maximizing effort, as in some cases participants might have just gone toward the middle of the strategy space. However, as will be seen below, this midd-

[8] Similar to the voluntary team effort, enforced team effort shows neither a statistically significant decrease nor a statistically significant increase from the first set of set of 15 periods to the second set of set of 15 periods, nor does its standard deviation (Wilcoxon tests).

[9] The payoff function is relatively flat around the optimum so that the cost of going slightly above it is not very high.

le point was not chosen in the asymmetric cases. Note that when the Pareto optimum lies at the border of the strategy space so that participants have no opportunity to go above, either intentionally or erroneously, this might cause the observed cooperation level to lie much further below the Pareto optimum than it would otherwise.

Figure 1
Density of team effort in the *VOLUNTARY* and *ENFORCED SYM* treatments



The average profit under enforced teaming is 191.73 (standard deviation of 120.56). It is significantly higher than the team equilibrium profit of 187.5 (Wilcoxon test, 5-percent significance), but lower than the joint profit-maximizing profit of 250 (Wilcoxon test, 2-percent significance). It is also lower than the average profit of 220.08 under voluntary teaming; but this difference is statistically not significant (u-test). The standard deviations of effort and profit, such as the absolute difference between the two players' effort levels are not significantly different between the two treatments.

Comparing average effort and profit levels in the *ENFORCED ASYM* treatment to those in the *VOLUNTARY ASYM* treatment, we observe that the profit of 75.98 (standard deviation of 151.41) of the high-cost player in the *ENFORCED ASYM* treatment is significantly lower than in the *VOLUNTARY ASYM* treatment (u-test, 2-percent significance). Also, the standard deviation of the high-cost players' team effort is higher in the enforced treatment (21.67) than in the voluntary treatment (u-test, 10-percent significance). All other variables in the *ENFORCED ASYM* treatment, the low-cost players' effort (31.14) and its standard deviation

(17.78), the high-cost players' effort (29.32), the low-cost players' profit (113.38), its standard deviation (98.53), and the difference of the low-cost minus the high-cost players' effort are not significantly different from the respective value in the *VOLUNTARY ASYM* treatment. Effort and profit of the low-cost players are not significantly different from those of the high-cost players (Wilcoxon tests).

The low-cost players' effort is significantly above their equilibrium effort and significantly below their joint profit-maximizing effort (Wilcoxon tests, 5-percent significance). Recalling that in voluntary teaming the low-cost players' effort is not significantly different from their joint profit-maximizing effort, we have thus got **indirect** evidence for higher effort by the low-cost players in voluntary teaming compared to enforced teaming. The high-cost players' effort is significantly above their equilibrium effort but not significantly different from their joint profit-maximizing effort. This is similar to what we observe under voluntary teaming.[10]

Figures 2a and 2b show the density of team effort of the low- and the high-cost players, respectively, under enforced and voluntary teaming. We see that under voluntary teaming the observed effort levels are much less spread out than under enforced teaming.

The low-cost players' profit is significantly different neither from their equilibrium profit nor from their joint profit-maximizing payoff, while the high-cost players' payoff is not significantly different from their equilibrium payoff but significantly below their joint profit-maximizing payoff (Wilcoxon test, 2-percent significance). In contrast to this, under voluntary teaming the high-cost players' payoff is not significantly different from their joint profit-maximizing payoff.

Conclusion 4: *In the SYM treatment, we observe voluntary team effort that is higher than enforced team effort. In the ASYM treatment, we observe less standard deviation of the team effort choices by the high-cost players if teaming is voluntary rather than enforced. It is only the high-cost players in the ASYM treatment who gain a higher profit under voluntary teaming than under enforced teaming.*

Prediction 5: ***Participants' behavior is driven by reciprocity.***

[10] When we compare the first set of 15 periods to the last set of 15 periods, for neither player type, neither effort nor profit shows a significant tendency to decrease or increase over time (Wilcoxon tests). The decrease in the low-cost players' effort, however, just fails significance. This is similar to voluntary teaming.

Figure 2a
Density of team effort in the *VOLUNTARY ASYM* treatment

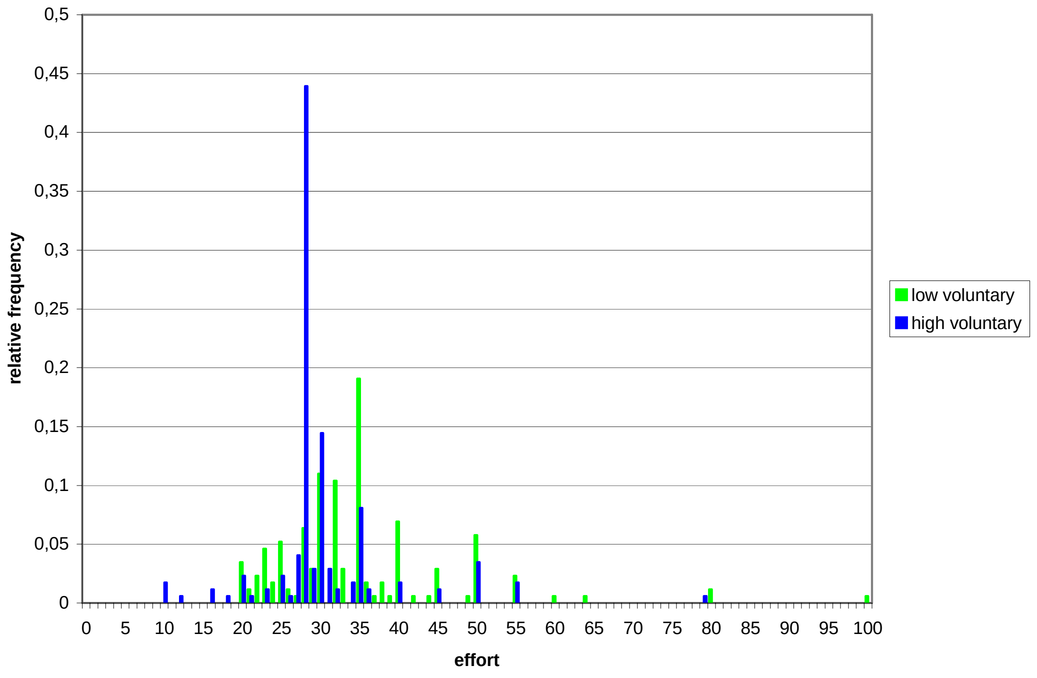
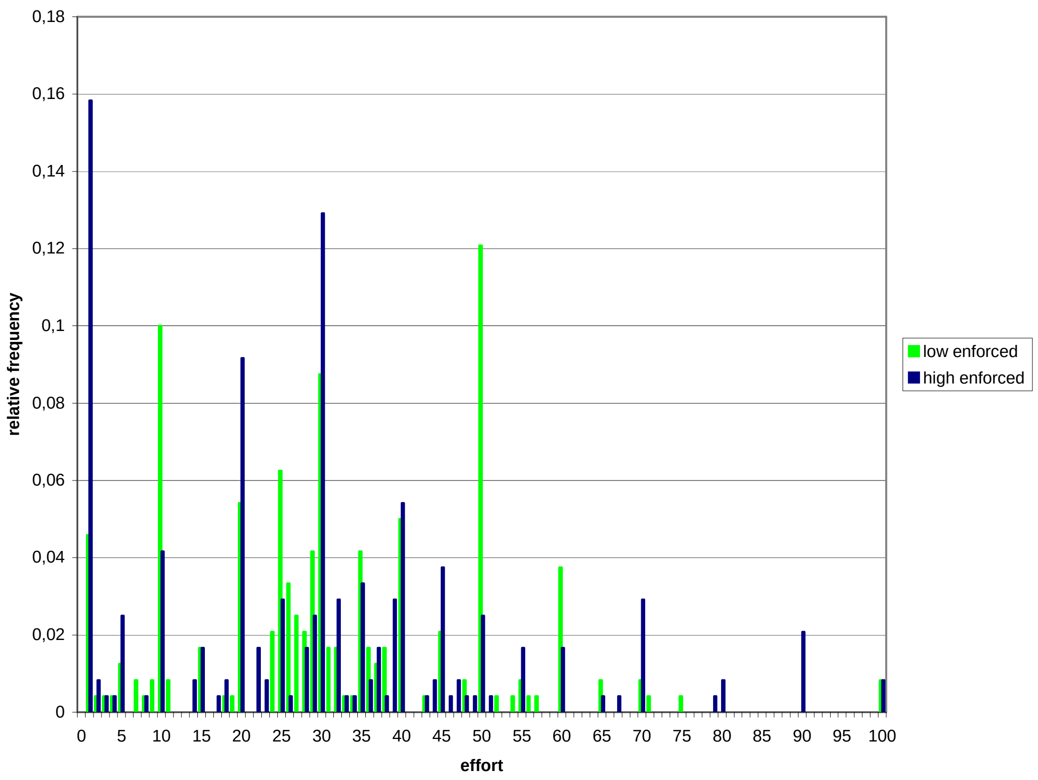


Figure 2b
Density of team effort in the *ENFORCED ASYM* treatment



Reciprocity can show both in the choice of the team-effort level and in the choice of the remuneration mode. For the choice of team effort, we define reciprocity as in the public-goods literature. Specifically, we interpret participants' voluntary contributions in terms of conditional cooperation, following Keser and van Winden (2000): when a player changes his effort from one period to the next, he increases the effort if in the previous period he contributed a lower effort than the other player but decreases it if in the previous period he contributed a higher effort than the other player.

In the *VOLUNTARY SYM* treatment, considering all the observations where the realization of team remuneration followed team remuneration and where the two players' efforts were different in the previous period, we identify seven groups that obeyed this reciprocity rule in the majority of cases; only one group did not follow this rule of reciprocity in the majority of cases. Similarly, in the *ENFORCED SYM* treatment, we identify seven of the eight groups that follow the rule of reciprocity in the majority of cases. Thus, participants show in both SYM treatments a significant tendency to follow this specific rule of reciprocity (binomial tests, 10 -percent significance).

In the *VOLUNTARY ASYM* treatment, considering all cases where team remuneration followed team remuneration and where the two players' efforts were different in the previous period, we observe that the low-cost players, if they change their effort from one period to the next, show a significant tendency to increase their effort if they contributed less in the previous period and to decrease it if they contributed more in the previous period (binomial test, 5 - percent significance). The high-cost players do not show this kind of reciprocal behavior. In the *ENFORCED ASYM* treatment, we find that neither the low nor the high-cost players show a significant tendency for reciprocal behavior under enforced teaming. Thus, only when teaming is voluntary, do we observe reciprocity in the low-cost players' effort choices.

With respect to the remuneration choice, our hypothesis is that participants tend to choose private remuneration after having chosen a higher effort than the other player in previous team remuneration. In other words, the choice of private remuneration can be used strategically as a kind of punishment—by ostracism or a simple rejection to interact—with the intention to enforce future cooperation. The experimental results by Fehr and Gächter (2000a) and Masclet et al. (2003) show that participants in public-goods experiments make use of costly opportunities to punish uncooperative others. Hirshleifer and Rasmusen (1989) show in a theoretical paper that a way to enforce cooperation in a finitely repeated n-person prisoners' dilemma game is ostracism: players who defect are expelled. Closely related to that theoretical paper, Cinyabugama, Page and Putterman (2005) show in an experiment that the threat of costly expulsion (through majority vote in the group) can induce cooperation in a public-goods game. While these two papers consider models that allow players to expel uncooperative others, Hauk 2003 examines a game that, perhaps more closely related to our paper, provides the opportunity to opt out of a finitely repeated prisoners' dilemma game. She finds that defection in early periods is punished by opting out.

In the *VOLUNTARY SYM* treatment, we observe a tendency (just failing significance) to choose team remuneration after team remuneration was realized, or inertia with respect to the choice of team remuneration.[11] However, after private remuneration, there is a weak tendency (again, just failing significance) to choose team rather than private remuneration.[12] In other words, there is some tendency not to stay with private remuneration. This suggests that the choice of private remuneration can be a temporary threat rather than intended to be a long-run situation.

Similarly, in the *VOLUNTARY ASYM* treatment, we observe a tendency to choose team remuneration after team remuneration was realized in the previous period. This is true for low-cost and for high-cost players (binomial test, 10-percent significance). In the 15 cases in which private remuneration was chosen (in ten of these cases it was the low-cost player, and in five of these cases it was the high-cost player), the player had contributed more effort than the other player in the previous period. After private remuneration was realized, there was no clear-cut tendency to choose either remuneration.

Further support for our punishment hypothesis is given in the *VOLUNTARY SYM* treatment by the fact that in 21 out of the 30 cases in which a participant chose private remuneration after having experienced team remuneration in the previous period, the participant had contributed more effort than the other player. In six of the groups the majority of choices of private remuneration after team remuneration were made after the player had contributed a higher effort than the other player. In one group the players who chose private remuneration after team remuneration had contributed a lower effort than the other player. In another group the

[11] After team remuneration, five groups chose team remuneration while only one group chose private remuneration in more than half of all cases and one group chose team and private remuneration equally often. The latter two groups account for only 6.73 percent of all the cases in which team remuneration was observed in *t*-1.

[12] After private remuneration, five groups chose team remuneration while only two groups chose private remuneration in more than half of all cases and one group chose private and team remuneration equally often.

situation never occurred. We conclude that the choice of private remuneration after team remuneration tends (just failing statistical significance) to be due to the fact that the participant had contributed a higher effort than the other player.

Conclusion 5: *In both SYM treatments, we observe reciprocity in the effort choice. In the VOLUNTARY ASYM treatment, only the low-cost player observes the reciprocity rule. The choice of private remuneration can be interpreted as a signal of disapproval of the low effort of the other player in the previous team remuneration mode.*

6 Regression analysis

In this section we complement the non-parametric data analysis presented above by a regression analysis. In Section 5.1, we examine the choice of remuneration for the *VOLUNTARY SYM* and *VOLUNTARY ASYM* treatments. In Section 5.2, we examine the effort choice for all treatments. We shall see that the parametric regression results are quantitatively and qualitatively consistent with our non-parametric observations.

6.1 Remuneration mode

We examine the participants' choice of the remuneration mode in a parsimonious random effect probit model on the decision to choose team remuneration. The decision variable "voluntary teaming" is equal to "1" if the participant chooses team remuneration and "0" otherwise. Explanatory variables are "1st period", which is equal to "1" for the first period and "0" otherwise, and "last 5 periods", which is equal to "1" for the last five periods and "0" otherwise. These two dummy variables account for first-period and end-game effects.

We also construct the explanatory variables "partner's effort below a strategic level" and "partner's effort above a strategic level" based on the following hypothesis. A participant chooses team remuneration if he expects to earn a higher payoff than under private remuneration. Assume that he chooses his dominant strategy in team remuneration and, thus, to achieve a higher or equal payoff than in private remuneration, he needs a minimum effort from his team partner. In the symmetric cost situation, the partner's minimum required effort is 28.[13] In the asymmetric cost situation, the low-cost player requires from his partner a minimum effort of 20, while the high-cost player requires a minimum effort of 17.[14] The latter requirement is likely to be satisfied as the low-cost player's dominant strategy in team remuneration is 20 and thus above the required minimum.

We do not expect participants to be able to compute exactly those numbers and therefore create the following two binary variables. "Partner's effort above a strategic level" takes a value of "1" if the last time that team remuneration was realized the partner chose an effort larger or equal to 6 units above the required effort as determined above, or "0" otherwise. "Partner's effort below a strategic level" takes a value of "1" if the last time that team remuneration was realized the partner chose an effort smaller or equal to six units below the required effort as determined above, or "0" otherwise. The choice of six units around the required minimum is arbitrary. However, analyses with other numbers around 6 have not substantially changed the results.

The random effects probit regression results are presented in Table 2. In both the *VOLUNTARY SYM* and the *VOLUNTARY ASYM* treatment and for both cost types, we observe that "partner's effort above a strategic level" significantly increases the probability of choosing team remuneration. The coefficient of "partner's effort below a strategic level," however, is not statistically significant. These results indicate some kind of reciprocity, which shows in the participants' choice of the remuneration mode.

In the *VOLUNTARY SYM* treatment, we observe a negative end-game effect: in the final periods of the game, participants are more likely than before to choose private remuneration.

In the *VOLUNTARY ASYM* treatment, we observe a significant negative first period effect in one specification for the low-cost player, while the variable "1st period" is insignificant for the high-cost players. The latter is not surprising as the high-cost players have, according to the game-theoretical solution, an interest in team remuneration that is independent of the other

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[13] The participant's dominant strategy in the case of team remuneration is 25. We solve the following equation to determine the partner's effort X that makes the participant indifferent to team and private remuneration: $203 = 10(25 + X)/2 - (25^2/10)$, where 203 is the (rounded) maximum profit in private remuneration.

[14] The following equations are solved for X, respectively: (1) $123 = 8(20 + X)/2 - (20^2/10)$, where 123 is the low-cost player's (rounded) maximum profit in private remuneration and 20 his dominant strategy in team remuneration. (2) $98 = 8(16 + X)/2 - (16^2/8)$, where 98 is the high-cost player's maximum profit in private remuneration and 16 his dominant strategy in team remuneration.

player's effort. This is also reflected in the relatively high and statistically significant (one-tail test) constant for the high-cost players. While high-cost players always have an interest in team remuneration, it is interesting for the low-cost players only if they manage to cooperate with the high-cost player.

Table 2
Choice of team remuneration in *VOLUNTARY SYM* and *ASYM* treatments
(Random effects probits)

	SYM	*ASYM*		
		Low cost		High cost
		[1]	[2]	[1]
Constant	0.216 (0.375)	0.550 (0.577)	0.151 (0.367)	1.219* (0.725)
1st period	-0.187 (0.505)	-1.225* (0.687)		
Last 5 periods	-0.581* (0.273)	-0.037 (1.05)		
Partner's effort below a strategic level	0.293 (0.347)	-0.244 (0.615)		-0.976 (0.727)
Partner's effort above a strategic level	1.325** (0.387)	0.867* (0.293)	1.225** (0.146)	0.999* (0.475)
ρ^a	0.618**	0.385^{a} **	0.338**	0.231^{a*}
Loglikelihood	-195.045	-82,647	-85.409	-52.606
Nobs	*480*	*240*	*240*	*240*

*Significant at 5%; ** Significant at 1%; one- or two-tail tests, whenever appropriate.
( ) Standard-error.
a: Likelihood ratio test.

6.2 Effort

The determinants of the effort level (in the range of 0 to 100) are reported using panel regressions with fixed effects for individuals and periods. Assuming fixed effects for periods and strategic first-period and end-game effects being unlikely to play a role in private remuneration, we disregard the "1st period" and "last 5 periods" dummies from these regressions. To take the remuneration mode into account, we include the dummy variable "team mode" which is equal to "1" if the group is in the team remuneration mode when the effort is chosen or "0" otherwise. We also include the variable “effort of the partner” which is the effort chosen by the partner the last time that the group was in the team remuneration mode. This variable reflects a specific type of reciprocity, where reciprocity is defined in a strict quantitative way. In the non-parametric analysis of our data we used a qualitative definition for reciprocity based on the difference between the two players’ effort levels in the previous period. One difficulty with this definition in the parametric analysis of panel data would be the inclusion of a lagged dependent variable.

The regression results are reported in Table 3 for *VOLUNTARY* teaming and in Table 4 for *ENFORCED* teaming. In the *VOLUNTARY* teaming treatments, nothing, except for the constant term, is significant at the 1 -percent or 5-percent level. The constant represents the participants’ effort choice in private remuneration. With 47.6 in the *SYM* case, 32.3 for the low-cost players and 29.8 for the high-cost players in the *ASYM* case, these values are close to the respective optimal values of 45, 35 and 28. In the team mode, by using all coefficients, we can show that the players are closer to the Pareto optimum than their respective dominant strategy, but the non-significant coefficients of the “team mode” and “effort of the partner” variables make this result relatively imprecise. In the *ASYM* case this is particularly true for the high-cost players.

Table 3
Choice of effort level in the *VOLUNTARY SYM* and *ASYM* treatments
(Least squares with fixed effects for individuals and periods)

	SYM	*ASYM*	
		Low cost	High cost
Constant	47.600** (1.07)	32.286** (1.48)	29.772** (1.35)
Team mode	-4.023 (3.11)	2.724 (2.87)	-4.144 (2.67)
Effort of the partner	0.0771 (0.059)	0.0175 (0.0856)	0.107 (0.0589)
R^2	0.341	0.367	0.462
Nobs	*480*	*240*	*240*

* Significant at 5%; ** Significant at 1%; (   ) Standard-error.

Table 4
Choice of effort level in the *ENFORCED SYM* and *ASYM* treatments
(Least squares with fixed effect for individuals and periods)

	SYM	*ASYM*	
		Low cost	High cost
Constant	35.339** (0.7463)	26.872* (2.046)	15.954** (2.419)
Effort of the partner	0.2482** (0.0483)	0.1486* (0.0626)	0.4380** (0.0722)
R^2	0.297	0.395	0.563
Nobs	*480*	*240*	*240*

* Significant at 5%; ** Significant at 1%; ( ) Standard-error.

The fact that players do not reciprocate the previous team effort of their partner probably results from the first step of the game: once the players have decided for team remuneration, this has a signaling effect implying that they cooperate at a level they think is a reasonable point of cooperation.

The results in the *ENFORCED* teaming treatments support this explanation. When teaming is enforced, the reciprocity variable "effort of the partner" has a significantly positive effect on the effort. Note that this result does not necessarily contradict the non-parametric result that reciprocity is mostly insignificant in the *ASYM* treatments (with the exception of the low-cost players under *VOLUNTARY* teaming). The non-parametric tests are conservative and concern the direction rather than the intensity of the reaction to other's effort. Thus, the increase (decrease) in units of effort given an increase (decrease) in the partner's effort appears to be significant although we observe almost equal numbers of increases and decreases.

The predicted team effort levels, taking the partner's previous team effort at mean values, are in all enforced treatments lower than in the respective voluntary teaming treatment. For example, the predicted effort in the regression for the *ENFORCED SYM* treatment is 44.2 and, thus, lower than the effort level predicted for the *VOLUNTARY SYM* treatment.

7 Conclusion

In our experiments, we observe many instances of team remuneration: both players chose team remuneration in 45 percent of the periods in the symmetric specification of the game, where the two players have the subgame perfect equilibrium strategy to choose private remuneration, and in 72 percent of the periods in the asymmetric specification, where the player with the lower effort costs has the subgame-perfect equilibrium strategy to choose private remuneration. We also observe that under team remuneration the average effort is significantly higher than predicted by the subgame perfect equilibrium. Thus, participants make higher profits in team remuneration than in private. They tend to stay with their choice of team remuneration but choose private remuneration as a short-run punishment for uncooperative team effort by the other participant.

In a symmetric cost situation, we observe that voluntary teaming implies significantly higher effort levels than enforced teaming. However, this does not come along with a significantly higher efficiency, if we define efficiency as the realized percentage of the maximal team profit. The reason is that when teaming is voluntary participants choose effort levels above the efficient level significantly more often than when teaming is enforced. In both the voluntary and the enforced teaming environment, team effort is driven by a reciprocity principle: if a player intends to change his team effort from one period to the next, he increases (decreases) it if his own effort was lower (higher) than the other player's effort.

In an asymmetric cost situation, we do not observe statistically significant differences in the effort levels of the voluntary and the enforced teaming environment. We do, however, observe higher efficiency, due to larger payoffs for the high-cost players, in the voluntary teaming environment. The reciprocity principle defined above plays a minor role (only for the low-cost players when teaming is voluntary). It is not obvious for the two players in the asymmetric situation where to cooperate.

We observe that in contrast to the theoretical prediction people build teams. They do better in teams than if they make individually remunerated efforts. The degree of team cooperation, however, depends on whether teaming is enforced or voluntary. We observe more cooperation in voluntary teaming than in enforced teaming. This effect is most obvious in the symmetric cost situation where it is relatively obvious to the team members, who cannot communicate other than through their decision making, where to cooperate.

This is in keeping with the results by Ernst Fehr and his coauthors (e.g., Gächter and Fehr 1999, Fehr and Gächter 2000b). They provide experimental evidence that compared to complete labor contracts, incomplete contracts have an advantage in that they leave room for cooperation between the employer and the employee.

In our experiment there is room to "overdo" one's effort by going beyond the individual effort level that would be joint profit maximizing. We observe that participants often overdo effort in the voluntary symmetric treatment but not in the enforced symmetric treatment. Thus, simple error making cannot be the sole explanation for choosing effort levels above the joint profit-maximizing level. Another explanation could be that participants are signaling that they are interested in cooperation. A participant who expects the other to make a very low effort and who wants to send a very strong signal could have an interest in making an effort above the joint profit-maximizing level. In the bulk of experiments on voluntary contributions to finance a public good this is excluded by design.

In asymmetric experiments, where it is not so clear where cooperation should take place, the effort increase by voluntary teaming is not very significant. This is probably due to the relatively small number of independent observations. The effect shows more clearly in that the voluntary team effort levels are much more contained around and between the subgame perfect equilibrium and the joint profit-maximizing solution than in the case of enforced teaming, where effort levels are spread out over the entire strategy space. Obviously, voluntary teaming helps participants to better coordinate than enforced teaming. Once they have agreed on team remuneration, participants have already made some investment by giving up on their higher private remuneration rate. Similar evidence has been found by Cachon and Camerer (1996), who observe that a fixed entry fee for subjects participating in a coordination game improves coordination significantly. In our experiments, considering the game-theoretical solution, it is in particular the low-cost players who signal a commitment to attempt cooperation by their choice of team remuneration. Having made that choice, they are willing to make a somewhat higher effort than in enforced teaming (34.51 rather than 31.14). The difference is not statistically significant, probably due to the relatively low number of independent observations. But, while the enforced team effort is significantly lower than the joint profit-maximizing effort, we observe no significant difference between the voluntary team effort and the joint profit-maximizing effort.

Our results bear relevant implications for workforce management. Teams with a strong heterogeneity of abilities are likely to show a relatively large dispersion of efforts. Our experimental observations suggest that this dispersion can be reduced by allowing for voluntary teaming. In general, voluntary team effort will tend to be higher than enforced team effort. The effect is likely to be the stronger the less heterogeneity there is.

Of course, voluntary teaming is just one of many ways to enhance team cooperation. From many previous experiments on prisoners' dilemma type of situations, where individually rational behavior leads to inefficient outcomes for the group, we know that communication (e.g., Ostrom, Gardner and Walker 1992, 1994, Sally 1995, Brosig, Weimann, and Ockenfels 2003), and, as discussed in Section 5 above, the opportunity to punish uncooperative others either financially (e.g., Fehr and Gächter 2000a, 2002, Masclet et al. 2003) or by social exclusion (Hirshleifer and Rasmusen 1989, Hauk 2003, Cinyabugama, Page and Putterman 2005) are efficient ways to increase cooperation in teams.

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APPENDIX

Instructions *[VOLUNTARY ASYM]*

You are participating in a decision-making experiment where you have the opportunity to earn money. How much money you earn depends on your own decisions, but may also depend on those of other participants.

You will make individual decisions at your computer. From now on, please do not talk with other participants until the end of the experiment.

In the experiment, you will be anonymously paired with another participant to form a group of two. The experiment consists of 30 repetitions, called periods. You will stay in the same group with the same other participant during all 30 periods. In each of the periods, you will be in the same decision situation.

A period consists of two decision stages. We start by describing the second stage. In this stage, each participant has to choose an effort, which is an integer number between 0 and 100. The effort incurs a cost measured in Experimental Currency Units (ECU). The two members in each group have different effort costs. For one of the two group members, the effort cost is equal to the square of the chosen effort divided by 10, while for the other, it is equal to the square of the chosen effort divided by 8. Tables 1 and 1A below show for the two group members, respectively, the cost of each effort level between 1 and 100. Zero effort implies zero cost.

At the beginning of the experiment, you will find an envelope with your personal effort cost table at your computer terminal. One of the two members in each group will find Table 1 (cost equals squared effort divided by 10), while the other will find Table 1A (cost equals squared effort divided by 8).

In the first stage of each period, you have to choose between two modes of remuneration: a private remuneration mode and a joint remuneration mode. The remuneration mode will determine how you will be compensated for your effort.

- If you choose the private remuneration mode, you will be paid 7 ECU per effort unit that you individually choose in the second stage. The other group member will be paid 7 ECU per effort unit that he or she chooses in the second stage.

- If both you and the anonymous other group member choose the joint remuneration mode, each of you will be paid based on the average effort in your group in the second stage. Each of you will be paid 8 ECU per unit of the average effort by you and the other group member.
- If you choose the joint remuneration mode, but the anonymous other group member chooses the private remuneration mode, you will both adhere to the private remuneration mode. You will be paid 7 ECU per effort unit that you individually choose in the second stage. The other group member will be paid 7 ECU per effort unit that he or she chooses in the second stage.

Your earnings

Your profit (in ECU) in a period is determined as follows.

- If you are in the private remuneration mode, your profit is determined by your individual effort multiplied by 7 ECU minus the cost of your individual effort in ECU. Below you find Table 2 (cost equals squared effort divided by 10) and 2A (cost equals squared effort divided by 8) that show for each level of individual effort the corresponding cost and the profit under private remuneration. Those of you who will find Table 1 in the envelope at the beginning of the experiment will also be provided with Table 2 while those who will find Table 1a will also be provided with Table 2A.
- If you are in the joint remuneration mode, your profit is determined by the average effort by you and the other group member, multiplied by 8 ECU, minus the cost of your individual effort in ECU.

Your total profit for the experiment equals the sum of your profits over the 30 periods.

At the end of the experiment, your total profit will be converted to Canadian dollars with a conversion rate of 50 cents per 100 ECU.

Available information

At the end of the first stage of each period, you are told whether you are in private or joint remuneration mode.

At the beginning of each period (except for the first one), you are informed of your result in the previous period. This includes the remuneration mode that you chose, the remuneration mode that the other chose, the effective remuneration mode, your individual effort, the average effort in the joint remuneration mode (if applicable), your effort cost, your profit and your cumulated profit over all previous periods.

At any time, by clicking on the magnifying glass icon on your screen, you can access a table of your results in all previous periods. The table shows the results of the first period in the top line and the results of subsequent periods underneath.

Before we begin the experiment, we ask you to answer some comprehension questions regarding these instructions. Everybody must answer all of the questions correctly before we carry on.

Thank you for your participation!

Table A-1
Individual effort cost (Effort level squared and divided by 10)

Effort level	Effort cost	**Effort level**	Effort cost
1	0.10	**51**	260.10
2	0.40	**52**	270.40
3	0.90	**53**	280.90
4	1.60	**54**	291.60
5	2.50	**55**	302.50
6	3.60	**56**	313.60
7	4.90	**57**	624.90
8	6.40	**58**	336.40
9	8.10	**59**	348.10
10	10.00	**60**	360.00
11	12.10	**61**	372.10
12	14.40	**62**	384.40
13	16.90	**63**	396.90
14	19.60	**64**	409.60
15	22.50	**65**	422.50
16	25.60	**66**	435.60
17	28.90	**67**	448.90
18	32.40	**68**	462.40
19	36.10	**69**	476.10
20	40.00	**70**	490.00
21	44.10	**71**	504.10
22	48.40	**72**	518.40
23	52.90	**73**	532.90
24	57.60	**74**	547.60
25	62.50	**75**	562.50
26	67.60	**76**	577.60
27	72.90	**77**	592.90
28	78.40	**78**	608.40
29	84.10	**79**	624.10
30	90.00	**80**	640.00
31	96.10	**81**	656.10
32	102.40	**82**	672.40
33	108.90	**83**	688.90
34	115.60	**84**	705.60
35	122.50	**85**	722.50
36	129.60	**86**	739.60
37	136.90	**87**	756.90
38	144.40	**88**	774.40
39	152.10	**89**	792.10
40	160.00	**90**	810.00
41	168.10	**91**	828.10
42	176.40	**92**	846.40
43	184.90	**93**	864.90
44	193.60	**94**	883.60
45	202.50	**95**	802.50
46	211.60	**96**	921.60
47	220.90	**97**	940.90
48	230.40	**98**	960.40
49	240.10	**99**	980.10
50	250.00	**100**	1000.00

Table A-1A
Individual effort cost (Effort level squared and divided by 8)

Effort level	Effort cost	Effort level	Effort cost
1	0.13	**51**	325.13
2	0.50	**52**	338.00
3	1.13	**53**	351.13
4	2.00	**54**	364.50
5	3.13	**55**	378.13
6	4.50	**56**	392.00
7	6.13	**57**	406.13
8	8.00	**58**	420.50
9	10.13	**59**	435.13
10	12.50	**60**	450.00
11	15.13	**61**	465.13
12	18.00	**62**	480.50
13	21.13	**63**	496.13
14	24.50	**64**	512.00
15	28.13	**65**	528.13
16	32.00	**66**	544.50
17	36.13	**67**	561.13
18	40.50	**68**	578.00
19	45.13	**69**	595.13
20	50.00	**70**	612.50
21	55.13	**71**	630.13
22	60.50	**72**	648.00
23	66.13	**73**	666.13
24	72.00	**74**	684.50
25	78.13	**75**	703.13
26	84.50	**76**	722.00
27	91.13	**77**	741.13
28	98.00	**78**	760.50
29	105.13	**79**	780.13
30	112.50	**80**	800.00
31	120.13	**81**	820.13
32	128.00	**82**	840.50
33	136.13	**83**	861.13
34	144.50	**84**	882.00
35	153.13	**85**	903.13
36	162.00	**86**	924.50
37	171.13	**87**	946.13
38	180.50	**88**	968.00
39	190.13	**89**	990.13
40	200.00	**90**	1012.50
41	210.13	**91**	1035.13
42	220.50	**92**	1058.00
43	231.13	**93**	1081.13
44	242.00	**94**	1104.50
45	253.13	**95**	1128.13
46	264.50	**96**	1152.00
47	276.13	**97**	1176.13
48	288.00	**98**	1200.50
49	300.13	**99**	1225.13
50	312.50	**100**	1250.00

Table A-2
Profit in the private mode (Cost equals squared effort level divided by 10)

Effort level	Effort cost	Profit	**Effort level**	Effort cost	Profit
1	0.10	6.90	**51**	260.10	96.90
2	0.40	13.60	**52**	270.40	93.60
3	0.90	20.10	**53**	280.90	90.10
4	1.60	26.40	**54**	291.60	86.40
5	2.50	32.50	**55**	302.50	82.50
6	3.60	38.40	**56**	313.60	78.40
7	4.90	44.10	**57**	624.90	74.10
8	6.40	49.60	**58**	336.40	69.60
9	8.10	54.90	**59**	348.10	64.90
10	10.00	60.00	**60**	360.00	60.00
11	12.10	64.90	**61**	372.10	54.90
12	14.40	69.60	**62**	384.40	49.60
13	16.90	74.10	**63**	396.90	44.10
14	19.60	78.40	**64**	409.60	38.40
15	22.50	82.50	**65**	422.50	32.50
16	25.60	86.40	**66**	435.60	26.40
17	28.90	90.10	**67**	448.90	20.10
18	32.40	93.60	**68**	462.40	13.60
19	36.10	96.90	**69**	476.10	6.90
20	40.00	100.00	**70**	490.00	0.00
21	44.10	102.90	**71**	504.10	-7.10
22	48.40	105.60	**72**	518.40	-14.40
23	52.90	108.10	**73**	532.90	-21.90
24	57.60	110.40	**74**	547.60	-29.60
25	62.50	112.50	**75**	562.50	-37.50
26	67.60	114.40	**76**	577.60	-45.60
27	72.90	116.10	**77**	592.90	-53.90
28	78.40	117.60	**78**	608.40	-62.40
29	84.10	118.90	**79**	624.10	-71.10
30	90.00	120.00	**80**	640.00	-80.00
31	96.10	120.90	**81**	656.10	-89.10
32	102.40	121.60	**82**	672.40	-98.40
33	108.90	122.10	**83**	688.90	-107.60
34	115.60	122.40	**84**	705.60	-117.60
35	122.50	122.50	**85**	722.50	-127.50
36	129.60	122.40	**86**	739.60	-137.60
37	136.90	122.10	**87**	756.90	-147.90
38	144.40	121.60	**88**	774.40	-158.40
39	152.10	120.90	**89**	792.10	-169.10
40	160.00	120.00	**90**	810.00	-180.00
41	168.10	118.90	**91**	828.10	-191.10
42	176.40	117.60	**92**	846.40	-202.40
43	184.90	116.10	**93**	864.90	-213.90
44	193.60	114.40	**94**	883.60	-225.60
45	202.50	112.50	**95**	802.50	-237.50
46	211.60	110.40	**96**	921.60	-249.60
47	220.90	108.10	**97**	940.90	-261.90
48	230.40	105.60	**98**	960.40	-274.40
49	240.10	102.90	**99**	980.10	-287.10
50	250.00	100.00	**100**	1000.00	-300.00

Table A-2A
Profit in the private mode (Cost equals squared effort level divided by 8)

Effort level	Effort cost	Profit	**Effort level**	Effort cost	Profit
1	0.13	6.88	**51**	325.13	31.88
2	0.50	13.50	**52**	338.00	26.00
3	1.13	19.88	**53**	351.13	19.88
4	2.00	26.00	**54**	364.50	13.50
5	3.13	31.88	**55**	378.13	6.88
6	4.50	37.50	**56**	392.00	0.00
7	6.13	42.88	**57**	406.13	-7.13
8	8.00	48.00	**58**	420.50	-14.50
9	10.13	52.88	**59**	435.13	-22.13
10	12.50	57.50	**60**	450.00	-30.00
11	15.13	61.88	**61**	465.13	-38.13
12	18.00	66.00	**62**	480.50	-46.50
13	21.13	69.88	**63**	496.13	-55.13
14	24.50	73.50	**64**	512.00	-64.00
15	28.13	76.88	**65**	528.13	-73.13
16	32.00	80.00	**66**	544.50	-82.50
17	36.13	82.88	**67**	561.13	-92.13
18	40.50	85.50	**68**	578.00	-102.00
19	45.13	87.88	**69**	595.13	-112.13
20	50.00	90.00	**70**	612.50	-122.50
21	55.13	91.88	**71**	630.13	-133.13
22	60.50	93.50	**72**	648.00	-144.00
23	66.13	94.88	**73**	666.13	-155.13
24	72.00	96.00	**74**	684.50	-166.50
25	78.13	96.88	**75**	703.13	-178.13
26	84.50	97.50	**76**	722.00	-190.00
27	91.13	97.88	**77**	741.13	-202.13
28	98.00	98.00	**78**	760.50	-214.50
29	105.13	97.88	**79**	780.13	-227.13
30	112.50	97.50	**80**	800.00	-240.00
31	120.13	96.88	**81**	820.13	-253.13
32	128.00	96.00	**82**	840.50	-266.50
33	136.13	94.88	**83**	861.13	-280.13
34	144.50	93.50	**84**	882.00	-294.00
35	153.13	91.88	**85**	903.13	-308.13
36	162.00	90.00	**86**	924.50	-322.50
37	171.13	87.88	**87**	946.13	-337.13
38	180.50	85.50	**88**	968.00	-352.00
39	190.13	82.88	**89**	990.13	-367.13
40	200.00	80.00	**90**	1012.50	-382.50
41	210.13	76.88	**91**	1035.13	-398.13
42	220.50	73.50	**92**	1058.00	-414.00
43	231.13	69.88	**93**	1081.13	-430.13
44	242.00	66.00	**94**	1104.50	-446.50
45	253.13	61.88	**95**	1128.13	-463.13
46	264.50	57.50	**96**	1152.00	-480.00
47	276.13	52.88	**97**	1176.13	-497.13
48	288.00	48.00	**98**	1200.50	-514.50
49	300.13	42.88	**99**	1225.13	-532.13
50	312.50	37.50	**100**	1250.00	-550.00