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Public Good Provision in Inter-team Conflicts: Effects of Asymmetry and Profit-sharing Rule

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ABSTRACT

A fundamental problem in organizations is designing mechanisms for eliciting voluntary contributions from individual members of a team who are entrapped in a social dilemma. To solve the problem, we utilize a game-theoretical framework that embeds the traditional within-team social dilemma in a between-team competition for an exogenously determined prize. In equilibrium, such competition enhances the incentive to contribute, thereby *reducing* free-riding. Extending existing literature, we focus on asymmetric competitions between teams of unequal size, and competitions between more than two teams. Comparing two protocols for sharing the prize—egalitarian and proportional profit-sharing rules—we find that (i) free-riding diminishes and (ii) team members contribute more toward their team's effort when they belong to the larger team and when the profit-sharing rule is proportional. (iii) Additionally, under the egalitarian profit-sharing rule team members contribute *more* than predicted by the equilibrium solution. We discuss implications of our findings for eliciting contributions in competitive environments. Copyright © 2009 John Wiley & Sons, Ltd.

KEY WORDS public goods; social dilemmas; inter-team competition; reward systems; game theory

INTRODUCTION

A fundamental problem in organizations is the design of mechanisms to encourage and sustain voluntary effort expenditures from individual team members (e.g., Milkovich & Newman, 1984). Since contribution toward the team's goals is costly in terms of effort expenditure, and the rewards associated with team effort have the characteristics of a public good, selfish, narrowly rational team members are predicted to free ride on the efforts of others (Dawes, 1980). Various methods are employed to alleviate the pernicious problem of free riding. The one explored in the present study sharply departs from the traditional approach that focuses exclusively on behavior *within* a team. Rather, it *embeds* the traditional within-team social dilemma in a between-team competition for an exogenously determined prize. As coping with the internal problems of a

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team is essential for competing successfully with other teams, this competition is expected to provide an incentive to contribute, thereby *reducing* free riding.

Multi-level asymmetric conflicts

With a few exceptions (Kugler & Bornstein, 2009; Rapoport, Bornstein, & Erev, 1989; Rapoport & Bornstein, 1989), previous studies on inter-team competitions have focused on dyadic conflicts with symmetric number of team members (e.g., Bornstein, Kugler, & Zamir, 2005; Gunnthorsdottir & Rapoport, 2006; Rapoport & Bornstein, 1987; Takács, 2003). However, asymmetric conflicts are the rule not the exception in real life. Examples of such conflicts are abundant: Military confrontations, political disputes, strikes of workers against an individual employer or a unitary board of directors, and a competition between a big established company and a small new venture trying to enter the market. Most of these examples entail, in addition to a conflict between the teams, a conflict within each team. For example, in military confrontations the benefits of winning the conflict (e.g., territory, political influence, natural resources) are public goods that are equally available to all members of the winning team, and therefore selfish team members are likely to try and avoid the risk and cost of participating in the military confrontation, allowing other team members to carry the burden.

In asymmetric conflicts, size asymmetry implies advantages (disadvantages) that result from differences in means and resources, along with disadvantages (advantages) that result from the difficulty in internal coordination with increased size. Multiplicity (as opposed to duality) of teams implies the possibility for clique formations along with reduced probability of collusion. In two experiments, we investigate free riding in a competition between teams of different sizes, and in a competition among multiple teams.

It has already been recognized that analyses of individual behavior in social context that does not account for the interaction between the individual and his team members are of limited usefulness. For example, Klein and Kozlowski (2000) present a multi-level approach to researching organizations and discuss the importance of correctly identifying the level of analysis. Similarly, Dyer and Singh (1998) argue that a firm's competitive advantage may only be understood in the context of the whole network of firms. Extending this logic, we contend that any analysis of team behavior that does not account for the interaction of the individual's team with other teams in the larger social system may often miss additional important sources of influence on the individual's behavior. Both the interchanges between teams and their embedded systems (members) and among teams and their embedding systems (e.g., other teams, organizations) should jointly be considered (McGrath, Arrow, & Berdahl, 2000). Our point of departure is the observation that in many environments conflict and cooperation occur *simultaneously* on several levels of interaction, and that it is precisely the competition among teams that may mitigate the problem of free riding. We address this multi-level interaction by embedding a within-team conflict of the Prisoner's Dilemma type in a between-team competition (see also Bornstein, 2003).

We study these multi-level conflicts using a game-theoretic model (game theory provides a formal modeling approach to social situations, and analyzes interactive decision settings—games—where outcomes depend on the decisions of several players). In its simplest form, our model assumes two or more teams (e.g., departments in a firm) that compete with one another over an exogenous prize. For example, a firm may assign different task forces to work on the same project, or announce an award for a competition among branches of a multi-branch company (e.g., a bank). Consistent with the literature on social dilemmas, resources, capital, and effort are represented in our experimental context by points that team members receive, and then choose to contribute or keep for themselves. Contributions represent the costly nature of effort exertion, its voluntary essence, and its potential for gain.

The overall contribution of each team serves two purposes. First, it creates an internal (team-specific) public good. As is customary in social dilemma research, the payoff structure is designed so that a selfish team member (an individual interested only in maximizing her own good with the minimal effort) will free

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ride and contribute nothing. However, all team members are better off if all contribute rather than if all withhold contribution (Dawes, 1980). Second, in addition to the internal public good, the success of the team in securing the prize (e.g., dominance over the market, financial bonus to the team members, and non-pecuniary utility like commendation or completion of the project) depends on the team contribution *relative* to the contributions of the other teams: The larger the overall contribution of the team, the higher the probability that this team wins the prize. While most of the existing research on inter-team conflict (e.g., Palfrey & Rosenthal, 1983; Rapoport & Bornstein, 1987; Bornstein & Rapoport, 1988; Bornstein, 1992; Schram & Sonnemans, 1996a,b) awards the prize to the team with the higher total contribution (regardless of the difference in contributions), we depart from this deterministic rule in favor of a more realistic winning rule that is prevalent in the literature on contests. The external and ecological validity of a probabilistic rule are easily demonstrated in the following example: Suppose that two teams compete over development of a new product, and the winner will be the team to first introduce a satisfactory product to the market. Team A invests 1 000 000 units of effort in R&D, while team B invests 1 000 001 units. The two investments are practically indistinguishable, with both teams having about the same chances of winning this competition. However, a deterministic winning rule would always award team B.[1]

After the winner is determined, the prize is divided among members of the winning team according to a profit-sharing rule that is commonly known to the participants *before* they determine their individual levels of contribution. We compare two profit-sharing rules: An *egalitarian* rule, where the prize is divided equally among the team members regardless of their levels of contribution, and a *proportional* rule, where the prize is divided among the members of the winning team in proportion to their individual contributions.

To the best of our knowledge, except for a previous study by Gunnthorsdottir and Rapoport (2006) who examined symmetric conflicts only, there are no experimental studies that explore the effects of different incentive schemes (profit-sharing rules) in the context of an inter-team competition. Nevertheless, the form of payoff allocation within the team is expected to have a considerable effect on the patterns of contribution, echoing the critical role of reward systems in shaping team members' attitudes and performance in real organizations (Thompson, 2004). The two profit-sharing rules represent two prevalent forms of team-based reward strategies (e.g., Beersma, Hollenbeck, Humphrey, Moon, Conlon, & Ilgen, 2003; Wageman, 1995). The proportional rule is analogous to competitive reward systems, which embody *equity* norms and emphasize performance differences among team members and a negative link between their outcomes, thus encouraging individual initiative, independent effort, and achievement. The egalitarian rule is analogous to cooperative reward systems, which apply *equality* norms, diffuse distinctions among team members, and emphasize teamwork and interdependence. Cooperative reward systems promote trust, cohesiveness, helping behavior, and team commitment, more so than competitive ones (Ferrin & Dirks, 2003; Hackman, 1987; Tjosvold, 1984). The current paper, therefore, provides a first attempt to test the effect of the two profit-sharing rules in asymmetric conflicts or in conflicts with more than two teams. These extensions are not trivial mathematically as shown in Appendix I, or experimentally as we show below.

Generating game-theoretic predictions

Following Rapoport and Amaldoss (1999), we propose a minimalist setting that allows formal description while still capturing fundamental features of behavior that we wish to investigate. For a full description of the game theoretic model and its equilibrium predictions see Appendix I. Our setting consists of individual participants who receive initial endowments and are assigned to teams of various sizes that compete for an exogenous prize. Each team member decides how much of her initial endowment to contribute toward the

[1]This situation was already recognized by Tullock (1967) in contests among individuals (rather than teams), who proposed to assign a "rent" according to some increasing function of effort. Much of the literature on contests between individuals uses some variant of Tullock's rule.

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team. Contributions are forfeited. The structure of the competition gives rise to two kinds of conflict—within teams and between teams. The total contributions in each of the teams go toward generating a within-team public good from which team members benefit equally by receiving a payoff that is equal to the public good generated. A within-team conflict is generated by setting the parameters so that the marginal increase in the public good for contributing an additional unit of endowment is smaller than the payoff the contributor has to forgo from contributing one unit to the public good. The between-team conflict consists of the competition among teams for a prize. The probability of winning the prize is positively affected by an increase in the team's total contribution and negatively affected by an increase in the other team(s)' contribution.

The prize is then divided among members of the winning team according to a profit-sharing rule which is commonly known. The final individual payoff consists of three components—the portion of endowment that she keeps for herself, the payoff from the team-specific public good, and the share of the external prize, conditional on winning the competition.

Designing the inter-team competition as a game for experimental purposes allows us to use game theory to derive benchmark predictions regarding behavior. The Nash equilibrium,[2] a standard solution concept in game theory, is invoked for deriving closed-form predictions regarding individual contributions in this multi-level conflict. Rapoport and Amaldoss (1999) and Kugler and Szidarovsky (2009) outline more general solutions for this model. Following them, and omitting details of the derivations, we present the equilibrium predictions for two specific sets of parameters, which are the ones implemented in Experiments 1 and 2.

Experiment 1: Asymmetric team size

Experiment 1 investigates a competition between two teams of different sizes: There are three members in the smaller team and five members in the larger team. The initial endowment for each team member is 40, so that the maximal total contribution in the small team is 120 and in the large team 200. The actual public good generated is proportional to the percent of endowment contributed by the team members. The size of the maximal public good is 60 for the small team and 100 for the large team. The external prize is 150. Note that if an external prize is excluded from the incentive scheme, the best choice for each player is to withhold contribution (thus maximizing her gain with minimal investment). In both teams, each unit contributed increases the size of the public good by half a unit only (if all members of the small team contribute their entire endowment they all receive 150 percent of their original endowment, while if all members of the large team contribute their entire endowment they all receive 250 percent of their endowment).

With the inclusion of the prize (150 payoff units), the equilibrium solution predicts positive contributions. In particular, under the egalitarian profit-sharing rule members of the three-person team are predicted to contribute 7.8 units and earn an expected payoff of 137.8, while members of the five-person team are predicted to contribute 2.8 units and earn 100.3. Under the proportional profit-sharing rule, members of both teams are predicted to contribute 32.8 units each. The expected payoffs are 112.7 and 183.0 for members of a three-person team and a five-person team, respectively. The intuition behind the higher expected contribution under the proportional profit-sharing rule is as follows. While a higher contribution from a team member increases the probability of winning by the same amount under both sharing rules, under the proportional profit-sharing rule a higher contribution also increases the player's share of the prize (conditional on her team winning the competition), thereby creating a further incentive to increase contribution (while under the egalitarian profit-sharing rule the prize is always divided equally and independently of the individual contributions).

[2]A Nash equilibrium is a profile of strategies, one for each participant, such that no participant has an incentive to deviate unilaterally from her equilibrium strategy. To derive the equilibrium, we need to assume that all the participants are profit maximizers and risk-neutral, and that this is common knowledge.

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Two further issues are worth noting. First, in this operationalization the asymmetry in group size also results in asymmetry in power/wealth.[3] Therefore, in interpreting the results we cannot differentiate between the effects of the two, as is often the case in real life where wealth and group size are confounded. Future work will have to address this issue by manipulating each of the factors independently. Second, we empirically test only one set of parameters, where the small team has three members and the large team has five members. We draw tentative conclusions regarding the effect of team size, but further work is required to test other differences in size in order to generalize our conclusions.

Experiment 2: Three symmetric teams

Experiment 2 extends the dyadic interaction to a competition among three teams of three members each. We set the initial endowment at 50 and the size of the public good at 60 for all three teams. The external prize is set at 180. In equilibrium, team members are predicted to contribute 7.4 units under the egalitarian sharing rule and 29.6 units under the proportional sharing rule, a ratio of 1:4. The expected payoffs are 71.5 and 75.9 for the egalitarian and proportional profit sharing rules, respectively.

Although we consider the equilibrium predictions a benchmark for evaluating individual contributions, we already have good reasons to expect systematic deviations from equilibrium play. Gunnthorsdottir and Rapoport (2006) tested the equilibrium solution in a simplified case of two symmetric teams with four members each. Their major finding is that the equilibrium solution accounted exceedingly well for the aggregate contribution of the players who participated in the proportional profit-sharing rule condition. In contrast, the equilibrium solution for the egalitarian profit-sharing rule failed to account for the mean contributions. Rather, when the egalitarian sharing rule was implemented their participants contributed significantly *above* the equilibrium values (but still contributed significantly less than under the proportional profit-sharing rule). The present experiments are also designed to explore whether the over-contribution is a systematic finding or it is specific to some features of the games in the Gunnthorsdottir and Rapoport experiment.

EXPERIMENT 1: ASYMMETRIC TEAM SIZE

In Experiment 1, we chose to confront a small team of three members with a large team of five members. In addition to the equilibrium predictions discussed in the previous section, earlier research in social psychology gives rise to two opposing predictions regarding the effects of unequal team size. When the individual endowments are equal, as they are in Experiment 1, larger teams have more resources and are therefore expected to perform better against smaller teams. Previous research on social dilemmas reveals mixed findings. Some studies suggest that team members contribute less the larger their team is (Olson, 1965), while others indicate otherwise (Bonacich, 1976; Issac & Walker, 1988). Experiment 1 is designed to test this question directly by confronting two teams of different sizes under the egalitarian and proportional profit-sharing rules.

The parameters of this experiment yield the following testable equilibrium prediction that reverses the expected payoffs of the small and large teams under the two profit-sharing rules. As stated earlier, under the egalitarian sharing rule individual members of the three-person team are expected to contribute about three times as much as individual members of the five-person team (7.8 and 2.8, respectively) and receive a higher expected payoff (137.8 vs. 100.3). Under the proportional sharing rule, players in both teams are expected to contribute identical amounts (32.8), resulting in a higher total contribution in the five-person team, and a higher expected payoff (183 per member in the five-person team vs. 112.7 per member in the three-person team).

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[3]We are grateful to an anonymous referee for pointing this out.

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Hypotheses

These point predictions may easily be refuted because of multiple reasons (e.g., heterogeneity of participants due to different attitudes toward risk or non-pecuniary utilities associated with winning). Nevertheless, focusing on the *qualitative* implications of our model, namely on the directions of the effects, we predict that individual contributions will be significantly higher under the proportional than egalitarian profit-sharing rule (H1), that under the egalitarian profit-sharing rule, members of the three-person team will contribute more toward their team's success than members of the five-person team (H2), and that under the proportional profit-sharing rule, members of both teams will contribute equal amounts (H3).

Method

Sample and design

The participants were 96 undergraduate students at the University of Arizona with no previous experience with the task. Participants were recruited by campus advertisements offering monetary rewards for participation in an interactive decision making task. Players participated in the experiment in cohorts of 16; 3 such cohorts took part in the egalitarian condition and 3 more in the proportional condition. We therefore had 48 participants in each of the two conditions.

Procedure

Upon arrival at the laboratory, each participant received a payment of $5 for showing up and was seated in a separate cubicle facing a personal computer. The participants were given written instructions concerning the rules (including the particular profit-sharing rule) and payoffs of the game and were encouraged to read them carefully. Examples were provided to assist the participants in understanding the structure of the game, and questions were answered individually by the experimenter.

The participants played 80 identical rounds of the game. In order to avoid end-of-game effects, the participants were not informed of the number of rounds, although they knew that there would be multiple rounds. At the beginning of *each* round, the 16 participants were randomly divided into two cohorts of eight players each. Each cohort was divided again into two teams: A large team of five members, and a small team of three members. This information was explained carefully to the participants. As a result, participants did not know which of the players were in their team on any given round, and could not establish reputation.

After they had been assigned to teams, each player received an initial endowment of 40 points (payoff units) and had to decide how many points to contribute toward his team's success. The computer summed up contributions in each team, and calculated the size of the resulting public good (the maximum being 100 points for the large team and 60 points for the small team) as well as the probabilities of winning the external prize (150 points), and the actual winning team. Following the completion of the round, each participant received outcome information concerning the total number of points contributed by members of her team and members of the competing team on that round, the number of points she earned from the public good on that round, the probability that her team would win the external prize, the number of points she earned from the external prize, and her cumulative earnings (in points).

Following the last round, the participants were paid in cash according to an exchange rate of $\$1 = 380$ payoff units. The average length of a round lasted about 1 minute, although rounds took considerably longer in the beginning of the experiment, and were significantly shorter toward the end, as players gained experience with the task. The entire session (including instructions, debriefing, and payment) lasted about 2 hour. The mean and maximal individual payoffs (disregarding the $5 show up fee) were $17 and $22, respectively.

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Table 1. Mean contribution per condition across 80 rounds in Experiment 1

Sharing rule	Egalitarian	Proportional
Team size		
Small team ($n = 3$)	16.76 (8.89)	25.02 (11.32)
Equilibrium prediction	**7.8**	**32.8**
Large team ($n = 5$)	17.39 (9.53)	31.16 (8.91)
Equilibrium prediction	**2.8**	**32.8**

Note: Standard deviations in parentheses.

Results and discussion

Overall contribution rates

Table 1 presents the mean individual contributions (and standard deviations) across 80 rounds, separately for each condition and each team size. It also presents (in bold) the equilibrium contribution levels.

The individual contributions were subjected to a 2×2 mixed ANOVA, with one between factor (profit-sharing rule) and one within factor (team size).[4] The analysis reveals a significant effect of profit-sharing rule—contribution rates under the proportional rule are significantly higher than under the egalitarian rule ($F(1,94) = 39.89$, $p < 0.05$), a significant effect of team size—contribution rates are higher in the large teams ($F(1,94) = 12.89$, $p < 0.05$), and a significant interaction—the difference between small teams and large teams is mainly attributed to the proportional sharing rule ($F(1,94) = 8.5$, $p < 0.05$).

In line with hypothesis H1, players contributed more in the proportional condition than in the egalitarian condition. However, while contributions in the proportional condition are close to the equilibrium prediction (especially for members of the large team), contributions in the egalitarian condition are much higher than predicted. Therefore, the difference in contribution between the egalitarian and proportional sharing rules is smaller than expected in equilibrium. This finding is consistent with Bornstein, Kugler, and Budescu (2008) and Gunnthorsdottir and Rapoport (2006).

Contrary to hypothesis H2, under the egalitarian sharing rule members of the five-person team contributed slightly more than members of the three-person team. This difference is accentuated in the proportional condition, thereby rejecting hypothesis H3.

Behavior over time

We turn next to the dynamics of contribution over time. To facilitate presentation and minimize the effects of trial-to-trial fluctuations, the 80 rounds were divided into 8 blocks of 10 rounds each. Figure 1 shows the mean contribution by condition for each block. The data were analyzed in a $2 \times 2 \times 8$ mixed ANOVA, with one between-subject factor (profit-sharing rule) and two within-subject factors (block and team size). The analysis reveals a significant effect of sharing rule ($F(1,85) = 33.63$, $p < 0.05$)—contribution rates are higher in the proportional profit-sharing rule than in the egalitarian rule; a significant team size effect ($F(1,85) = 12.85$, $p < 0.05$)—members of the five-person team contribute more than members of the three-person team; and no significant block effect ($F(7,595) = 1.14$, ns)—there is not much change over time. The

[4]In this design, the appropriate statistical unit is the cohort (group of 16 players). With only three data points for each condition, statistical comparisons within condition are not possible. Notwithstanding this problem, which is common to large group experiments, in the rest of the analysis players (but not repeated decisions of the same player) are assumed to be independent. We list two reasons in justification of this assumption. First, as n becomes larger the effect of any particular player on the population becomes negligible. With groups of $n = 16$ player each, treating the group as a population is not unreasonable. Second, our experimental design does not allow for establishing reputation as the identity of individual participants is not revealed, and the composition of groups is randomly determined at the beginning of each round.

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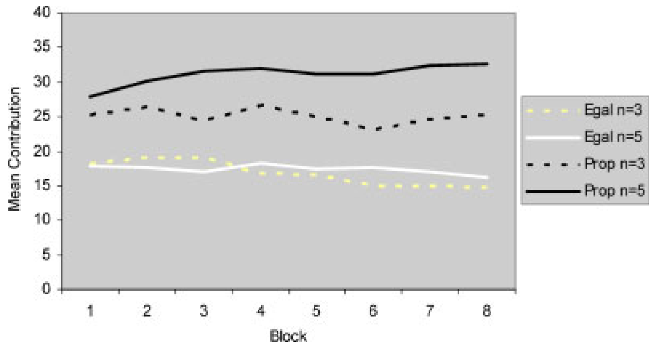

Figure 1. Mean contribution over time in Experiment 1

interaction between team size and sharing rule is significant ($F(1,85) = 8.37$, $p < 0.05$)—the differences between the five-person team and three-person team are bigger in the proportional profit-sharing rule, as well as the interaction between team size and block ($F(7,595) = 2.17$, $p < 0.05$). There is no significant interaction between profit-sharing rule and block ($F(7,595) = 1.2$, ns). The three-way interaction is also not significant ($F(7,595) = 0.76$, ns).

The ANOVA results reinforce the findings reported earlier. Except for the interaction between team size and block (that is mainly attributed to the increase in contribution of members of the large team in the proportional sharing rule), we do not find consistent patterns of change over time. The main conclusion drawn from this analysis is that behavior changes very little over time. Specifically, behavior in the egalitarian profit-sharing rule remains higher than predicted, and does not converge to equilibrium in this condition. The lack of convergence and change may be due to the complexity of the game, the probabilistic winning rule, the fact that each participant had to play two different roles in the same session, or some combination of the above.

Learning

Even though we do not observe general trends over time, participants may still be learning from one round to another and adapting their behavior in response to the outcome feedback they receive. To test for sequential effects, we computed the change in the number of points contributed by each player following either a win or a loss. Table 2 presents the results. In both conditions players increased their contributions following a loss, and decreased their contributions following a win, although this difference was more pronounced for the proportional profit-sharing rule. A two-way mixed ANOVA with one within factor (outcome in previous round) and one between factor (experimental condition) reveals a significant effect of condition ($F(1,94) = 9.5$, $p < 0.01$), a significant effect of outcome in previous round ($F(1,94) = 22.76$, $p < 0.05$), and a significant interaction ($F(1,94) = 9.86$ $p < 0.01$). This result shows that the players were ‘‘working the task’’ and reacting to their own and others’ behavior, and not just responding randomly or according to a routine

Table 2. Mean change in contribution as a function of previous outcome in Experiment 1

Sharing rule	Egalitarian	Proportional
Previous outcome		
Win	−0.5 (1.58)	−2.01 (3.26)
Loss	0.46 (1.8)	2.67 (4.2)

Note: Standard deviations in parentheses.

Table 3. Mean payoff per condition across 80 rounds in Experiment 1

Sharing rule	Egalitarian	Proportional
Team size		
Small team ($n = 3$)	69.86 (9.49)	80.67 (19.42)
Equilibrium prediction	**137.8**	**112.66**
Large team ($n = 5$)	77.39 (7.76)	98.92 (18.9)
Equilibrium prediction	**100.3**	**182.97**

Note: Standard deviations in parentheses.

formula. Specifically, if players are trying to guess the minimal level of contribution that leads to winning, they should increase their contribution following a loss and reduce it following a win. As for the interaction, it is plausible that the proportional profit-sharing rule enhances learning since increasing contribution results not only in an increased likelihood to win the prize but also in a larger share of the prize.

Payoffs

Table 3 displays the mean individual payoff for each team size and each profit-sharing rule separately. Equilibrium predictions appear in bold numerals. The results were analyzed in a 2×2 mixed ANOVA, with one between factor (sharing rule) and one within factor (team size). The analysis reveals a significant effect of profit-sharing rule—payoffs under the proportional rule are significantly higher than under the egalitarian rule ($F(1{,}94) = 187.82$, $p < 0.05$); a significant effect of team size—payoffs are higher in the 5-person teams ($F(1{,}94) = 31.4$, $p < 0.05$), and no team size by sharing rule interaction ($F(1{,}94) = 3.45$, $p = 0.07$). Notably, in all conditions the average payoff is considerably lower than expected in equilibrium.

From the perspective of social welfare, the proportional profit sharing rule results in higher (average) payoffs for all players. Because contributions in the egalitarian condition are higher than in equilibrium, the difference in payoff is not as large as predicted, but it still exceeds 20%. On the other hand, the larger variance of payoff in the proportional condition might have adverse implications with regard to social welfare. These findings suggest that if a competition over an external prize is used as a mechanism to increase contribution, the proportional profit-sharing rule is both theoretically and empirically more effective. It also yields higher payoffs, albeit more dispersed, and hence it is socially problematic. We return to this issue in the discussion.

Individual differences

Aggregate results may mask systematic individual differences and, consequently, not represent individual behavior. Figure 2 displays the frequency distribution of the mean individual contributions by team size and profit-sharing rule. It shows that in all conditions there are participants who contributed little and others who contributed their entire endowment. This finding is further supported when we examine the correlation between the mean individual contribution of a participant assigned to a small team and assigned to the large team. The overall correlation is 0.64, 0.76 for the egalitarian profit-sharing rule and 0.39 for the proportional profit-sharing rule (all correlations are significantly larger than zero ($p < .05$), and the difference between the two correlations is significant). These high and positive correlations yield two tentative conclusions. First, while participants contributed different amounts in the two different conditions, they seemed to have an overall propensity for contribution that affected their behavior in both cases. Second, it is possible that because participants had to learn playing both roles (five-person team and three-person team), there was considerable carryover between the two conditions that resulted in similar contribution rates. The significant

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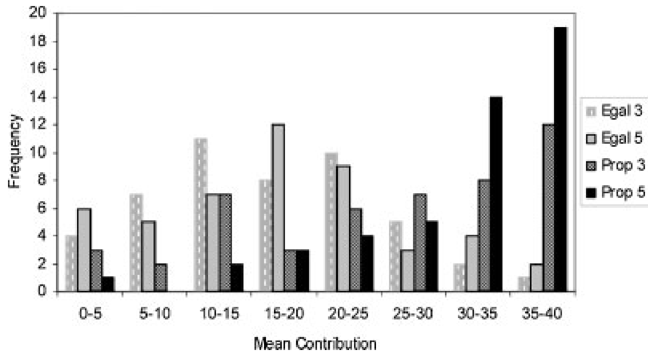

Figure 2. Frequency distribution of mean contribution of individual players in Experiment 1. *Note*: The total endowment is 40

difference between the two correlations indicates that behavior under the egalitarian condition is more stable and less size-sensitive.

EXPERIMENT 2: THREE TEAMS

As argued in the introduction, one goal of this study is to test whether the results reported in the literature on inter-group conflict are generalizable beyond symmetric dyadic interactions. Toward this goal, Experiment 1 examined interaction between teams of different sizes. It is equally important to look at conflicts that are not dyadic. Just like findings from two-person games that typically do not generalize to *n*-person games, there is no reason to assume that competitions between two teams will be similar to competitions among several teams. Therefore, Experiment 2 was designed to generalize the literature on dyadic competitions by extending it to a triadic competition among teams of equal size.

To the best of our knowledge, there is hardly any work on competition between more than two teams (the theoretical and experimental literature on markets assumes each organization is a single player). This is unfortunate since it is clear that competitions in real organizations are seldom dyadic. Furthermore, there are theoretical reasons to assume a ''discontinuity effect'' between dyadic competitions and interaction between three or more competitors (e.g., coalitions of subsets of teams may form). Finally, establishing cooperation or reciprocal behavior is significantly easier when only two competitors are involved (e.g., Bornstein, Budescu, & Zamir, 1997).

In Experiment 2, we keep the maximal public good for each of the three teams to be 60 but increase the prize value from 150 to 180 and the size of the initial endowment from 40 to 50. In equilibrium, players are expected to contribute 7.4 points in the egalitarian condition and 29.6 points in the proportional condition. The resulting expected payoff is 71.48 per team member under the egalitarian sharing rule and 75.93 under the proportional sharing rule. The difference in expected payoffs is quite small, especially compared to the large difference in equilibrium contribution. The higher contribution in the proportional rule increases the expected payoff from the internal public good, but this increase is offset by a lower amount kept, resulting in similar expected payoffs for the two conditions.

Hypotheses

Focusing once again only on the qualitative implications of the equilibrium solution, Experiment 2 tested the hypotheses that contribution is significantly higher under the proportional than the egalitarian profit-sharing

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rule (H1), and that despite differences in contribution rates, participants earn similar amounts under both profit-sharing rules (H2).

Method

Sample and design

The participants were 108 undergraduate students at the University of Arizona. Players participated in cohorts of 18; 3 such cohorts took part in the egalitarian condition and 3 more in the proportional condition. Overall, 54 people participated in each of the two conditions. None had participated in Experiment 1.

Procedure

The procedure was identical to that of Experiment 1 except for the following: At the beginning of the each round, the 18 participants were randomly divided into 2 cohorts of 9 players each. Then, each cohort was further divided into 3 teams of 3 members each. The initial endowment in this experiment was 50 points, the maximal size of the public good was 60 points per team member, and the external prize was 180 points.

Results and discussion

Table 4 presents the mean individual contribution across 80 rounds for each condition. The equilibrium contribution levels are displayed (in boldface) in the right-hand column. In line with hypothesis H1, mean contribution rates are significantly higher in the proportional than egalitarian condition (one-way ANOVA, $F(1{,}107) = 13.95$, $p < 0.05$).

Similarly to Experiment 1, mean contributions under the proportional sharing rule are close to the equilibrium levels, but mean contributions under the egalitarian sharing rule are considerably higher than predicted. Once again, the equilibrium solution fails to predict the high contribution rates in the egalitarian condition. Possible explanations for this finding are presented in the general discussion below.

Behavior over time

Similarly to Experiment 1, we test for temporal changes by examining the mean contribution per block for each condition. Figure 3 presents the results. The data were subjected to a mixed ANOVA with one repeated factor (block) and one between-factor (profit-sharing rule). The analysis reveals a significant effect of sharing rule ($F(1{,}106) = 13.95$, $p < 0.05$)—contributions are higher for the proportional profit-sharing rule; a significant block effect ($F(7{,}742) = 3.56$, $p < 0.05$), contributions decrease over time; and no block by profit-sharing rule interaction effect—the rate of decrease is similar under both profit-sharing rules. This analysis shows that contribution rates slowly decreased over time in both conditions. Note that in both conditions actual contribution rates exceed the level predicted in equilibrium, suggesting that the decrease over time may reflect a move toward equilibrium play. Despite this decrease, in the egalitarian profit-sharing rule contribution rates are still much higher than equilibrium predictions—so even if the decrease continues at this rate convergence would occur only after several hundred rounds.

Table 4. Mean contribution per condition across 80 rounds in Experiment 2

Condition	Mean contribution	Equilibrium prediction
Egalitarian	25.72 (10.99)	**7.4**
Proportional	32.70 (8.24)	**29.6**

Note: Standard deviations in parentheses.

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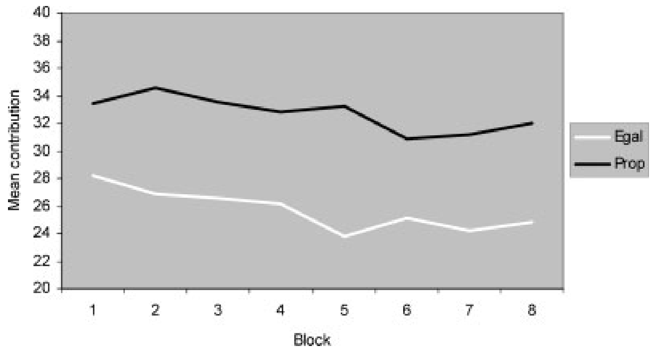

Figure 3. Mean contribution over time in Experiment 2

Table 5. Mean payoff per condition across 80 rounds in Experiment 2

Condition	Mean payoff	Equilibrium prediction
Egalitarian	75.14 (5.42)	**71.48**
Proportional	76.54 (3.21)	**75.93**

Note: Standard deviations in parentheses.

Payoffs

Table 5 presents the mean individual payoff for each condition separately. Equilibrium predictions are shown in the right-hand column. In agreement with hypothesis H2, the difference between the two profit-sharing rules ($F(1{,}107) = 2.65$, ns) is not significant.

Individual differences

Just like in Experiment 1, there are substantial differences between individual contribution levels. Figure 4 shows the frequency distribution of the mean individual contributions. While the variance of the distribution under the proportional profit-sharing rule is smaller than under the egalitarian profit-sharing rule, both conditions exhibit considerable heterogeneity of our participants.

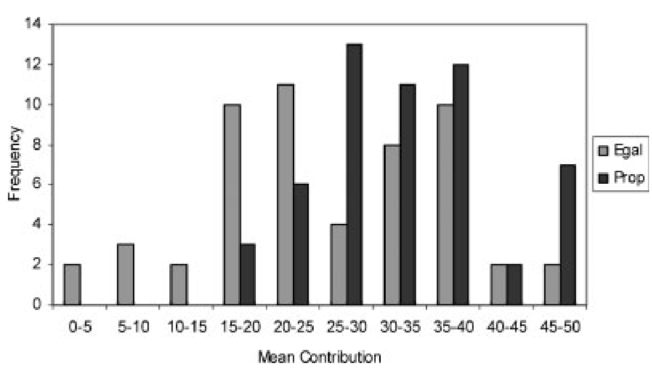

Figure 4. Frequency distribution of individual player's mean contribution in Experiment 2. *Note*: The total endowment is 50

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Table 6. Mean total payoff per game

Condition	With prize (equilibrium prediction)	With prize (observed behavior)	Without prize (equilibrium prediction)	Prize	Surplus created
Egalitarian Experiment 1	**914.9**	596.5	**320**	150	123.5
Proportional Experiment 1	**1252.83**	736.6	**320**	150	266.6
Egalitarian Experiment 2	**646.02**	676.3	**450**	180	46.3
Proportional Experiment 2	**683.93**	688.8	**450**	180	58.8

Finally, we ask whether the benefits from introducing a competition (i.e., increase contribution and reduce free-riding) outweigh its cost (the cost of the prize). To address this question, we compare the total welfare, as measured by the sum of payoffs to all players, in our model to the total welfare expected in equilibrium when there is no external prize (and contribution converges to zero, as indeed happens after many repetitions of a public good game). Table 6 summarizes the results for both experiments. In all conditions, the difference in total payoff between a model with an external prize and a model without an external prize exceeds the size of the prize. This is the case both when we calculate the expected total payoff in equilibrium or the actual total payoff.

GENERAL DISCUSSION

Competition between teams over an exogenously determined prize is analogous to horizontal conflicts between units in organizations that are characterized by goal incompatibility, resource scarcity, and uncertainty regarding goal attainment (Daft, 2001). Our study shows that horizontal conflicts might alleviate internal problems of low unit commitment and internal cross-purposes, thus limiting group process losses. Importantly, we find that this effect is contingent upon the reward structure and team size, so that it is more noticeable in the proportional (or hybrid[5]) structure and in larger teams. Moreover, in terms of net gain, competition is cost effective to the larger organization. These findings are in line with common knowledge that when in competition people try harder to the benefit of the organization as well as with evidence regarding the performance boosting effects of competition and conflict. Our main contribution is twofold: First, the inter-team competition literature is extended to asymmetric and non-dyadic conflicts. Second, we assess the effect of different profit-sharing rules on intra-group dynamics. We discuss these issues below.

Asymmetric competitions

Although asymmetry between competitors is the rule rather than the exception, most of the literature focuses on dyadic and symmetric conflicts, with an identical number of players in each team, equal resources, and identical sharing rules. The findings are then uncritically generalized to the asymmetric case. This paper presents a first attempt to investigate asymmetry theoretically and experimentally. We have chosen to focus on asymmetry in team size and in the number of teams involved. Further research is needed to address issues of asymmetry in profit-sharing rules within the competition and asymmetric players within teams.

[5]In fact, in a public good context, the proportional condition is analogous to a hybrid reward system due to its combination of equal (internal public good) and proportional (external prize) components.

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Team size asymmetry

Unlike the typical focus in size research on issues of overstaffing or understaffing with regard to optimal team functioning, our focus is on size asymmetry, not on size per se. We view both team resources (that increase with size) and coordination problems (that are exacerbated with size) within a comparative framework. Keeping in mind that we tested only a single case of team size differences, we draw tentative conclusions regarding team size asymmetry. The results indicate that when a large (five-person) team competes against a small (three-person) team, members of the larger team contribute more, especially in the proportional condition. Thus, resource accumulation is the dominant factor. The perception of resource advantage among members of the larger team yields higher performance-reward expectancy and, therefore, higher investment (Guzzo & Dickson, 1996). The design of the experiment fits this explanation. It was relatively easy for players to estimate and compare the assets of the two teams. On the other hand, because of the simultaneity of contribution and lack of communication, they were less likely to expect that coordination problems would harm one team rather than the other.

The differential effects of profit-sharing rules

A major finding in both experiments is the effect of the profit-sharing rule. In equilibrium, the proportional rule elicits higher individual contributions than the egalitarian rule, as indeed happens. The results are also consistent with previous findings by Thompson, Peterson, and Brodt (1996) and Morgan and Tindale (2002) who show that individuals believe that larger teams have a size advantage that increases their chances of winning. However, in their experiments there was no actual asymmetry in resources and the differences that resulted from the perception of asymmetry. The results of our study also reveal a systematic over-contribution under the egalitarian sharing rule, resulting in a smaller difference between the two sharing rules than expected in equilibrium. Whereas these results were first anticipated by Gunnthorsdottir and Rapoport (2006), the current experiment shows that they are not an artifact of the specific game used there. Rather, they are robust and extend over several variations of the competition.

There are several possible reasons for this finding. The first may have to do with the demand characteristics of the task. Under the egalitarian sharing rule, the expected contribution is rather small (2.8 and 7.8 in Experiment 1, 7.4 in Experiment 2). Participants may find it surprising that, given the initial endowment (40 and 50, respectively), they should contribute so little. Rather, they may very well presume that they are expected to "play the game" and contribute more. The second possibility also relies on the low equilibrium values. Suppose that players sample their behavior from a distribution with a central value around the equilibrium prediction. Because the game does not allow negative contributions, this distribution will necessarily become positively skewed in the egalitarian condition, and the mean contribution will increase. The third explanation invokes processes of belonging and social categorization. Contribution, which is higher than expected if players were to pursue their self-interest and assume that all others pursue it in the same way, suggests that additional social motives operate in this situation. We suggest that the salient input of an egalitarian norm shifts members' attention from strictly self-centered material gains to collective benefits, such as belonging (Baumeister & Leary, 1995) or group identification (Tajfel, 1978). Over-contribution may be explained by social identity theory in spite of the anonymity, membership fluctuation, team boundary, and lack of interaction in the two experiments (which, incidentally, are not uncommon in contemporary forms of computer-mediated or virtual teams). The theory contends that even the minimal conditions of (random) group assignment are sufficient for group identification to occur (Tajfel, 1978; Tajfel & Turner, 1986). Due to its congruence with socially endorsed values, the egalitarian norm elicits collective identification in this group.Polzer, Stewart, and Simmons (1999) investigate contribution in a nested social dilemma game, where two groups participate simultaneously in a social dilemma. In this game, an endowment can be allocated to one of three accounts: An individual account, an in-group account, and a collective account. They manipulate the initial location of the endowment (individual, subgroup, or collective level) and find that allocations to the

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collective are higher when the location of the endowment is identical in both subgroups. They suggest that similarity in initial locations enhances the salience of collective category (i.e., increases identification with both in-group and out-group members), and results in more money allocated to the collective, while asymmetry in initial location enhances the in-group or individual categories, and therefore results in less contribution to the collective. While the structure of their game is fundamentally different from ours (there is no competition between the two sub-groups), the social categorization explanation may help explaining over-contribution in the egalitarian condition: While the proportional condition shifts the focus of player to the individual level, the egalitarian sharing rule enhances the similarities between the team members, and renders the team the more salient category, resulting in higher contributions than predicted under rationality.

Another noteworthy finding concerns the significantly lower variance of payoff in the egalitarian condition. Consistent with research showing that pay dispersion and large compensation gaps in organizations impede collaboration and impair commitment to common unit or organizational causes (Bloom, 1999; Shaw, Gupta, & Delery, 2002), this is an additional indication that an egalitarian reward system facilitates the consolidation of group identity and group-oriented behavior. This interpretation is supported by the considerable similarity of mean contributions that was found in the egalitarian condition of Experiment 1. As group identity is a construct abstracted from particular membership or from particular circumstances, it can also account for the behavioral similarity that was found in different-sized teams under that condition.

Limitations

A game is a scientific metaphor for human interaction. As a metaphor, its artificiality, minimalism, and symbolism might be viewed as limitations. Indeed, the lab setting of the present study abstracts away from many important characteristics that are present in real life inter-team competitions. This should be kept in mind when considering the generalizability of the results. On the other hand, it is exactly this minimalism that allows us to systematically and rigorously test the effect of important variables such as the number of teams, size of teams, and profit-sharing rules in a setting that controls for alternative explanations.

For instance, the choice of team sizes in Experiment 1 balances the need to generate sufficiently big differences between the two teams, with the constraints of a laboratory study. First, we wanted to avoid teams of fewer than three members, since two-person teams are qualitatively different from teams of three members or more in terms of reciprocal behavior. Therefore, the minimal feasible team size was set at three members. By confronting a three-person team with a five-person team, we created a 67% difference that should be sufficient to capture important differences in behavior, as well as create a feeling of belonging to a substantially smaller (larger) team. Of course, it is not certain that this comparison will yield similar results to a competition between a small team of, say, 20 members and a larger team of 40 members. While we conjecture that the results will be qualitatively similar, only future research can address this concern. Such research will probably have to be conducted in a different setting (e.g., internet experiments), since traditional laboratory experiments cannot accommodate so many participants.

Another important limitation of both experiments is the exogenous nature of the prize. An organization that wants to implement the team-competition as a mechanism to increase intra-team cohesion is faced with the need to identify a source to finance the necessary resources. However, as Table 6 shows, this cost may be offset by the benefits created by the competition.

Finally, it might be useful in future research to explore the implications of the two profit-sharing rules in significantly longer time ranges and in settings that require enduring collaboration such as can be found in field experiments. The immediate advantage of the proportional rule in terms of contribution boost should be weighed against the advantages of over-contribution and behavioral constancy that characterize the egalitarian rule. Likewise, the usefulness of competition in decreasing free riding should be weighed against the possible drawbacks of competitions in such settings.

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APPENDIX I

Denote the number of competing teams by n, the number of players in team i by $n(i)$, and the overall number of players across the n teams by N. Each player k in team i receives an initial endowment y and can contribute any fraction of her endowment. The contribution of player k in team i is denoted by x_{ik} ($0 \le x_{ik} \le y$), the total contribution in team i by $x_i = \sum_{k=1}^{n(i)} x_{ik}$, and the total contribution across all n teams by $x = \sum_{i=1}^{n} x_i$.

Within-group conflict

Denote by g_i the maximal public good that team i can generate if all its members contribute their entire endowment. The public good that is actually generated by the team is proportional to the total amount contributed by all the team members: $(x_i/n(i)y)g_i$. Note that $x_i = n(i)y$, if each member contributes her entire endowment. As this is a public good, we assume that all members of the team benefit from it equally by receiving a payoff that is equal to the public good generated. A within-group social dilemma of the Prisoner's Dilemma type is generated if the parameters are set so that the marginal increase in the public good for contributing an additional unit of endowment is smaller than the payoff the contributor has to forgo from contributing one unit to the public good.

Between-group conflict

Denote the prize by S. As a probabilistic contest rule is employed, the probability that team i wins the contest is proportional to the team's total contribution: $P_i = x_i/x$. Clearly, the probability of winning is positively affected by an increase in the team's total contribution and negatively affected by an increase in the other team(s)' contribution.

Profit-sharing rule

The last property of the model is the profit-sharing rule that stipulates the way the prize S is divided among members of the (single) winning team. Common knowledge of the profit-sharing rule is critical in determining which portion of the endowment to contribute. Under the egalitarian sharing rule, the prize is divided *equally* among members of the winning team, and therefore the expected payoff for member k in team i is $P_i(S/n(i))$. Under the proportional sharing rule, the prize is divided *proportionally* to the contribution of each member of the winning team. Therefore, the expected payoff for member k in team i is $P_i(x_{ik}/x_i)S$.

Individual payoff

The individual payoff π_{ik} of member k in team i consists of three components: The portion of endowment that she keeps for herself, the payoff from the group-specific public good, and the share of the external prize:

$$\pi_{ik} = (y - x_{ik}) + g_i \frac{x_i}{n(i)y} + S\frac{x_i}{x}\frac{x_{ik}^c}{\sum_k x_{ik}^c}$$

where $c = 0$ for the egalitarian sharing rule, and $c = 1$ for the proportional sharing rule. Note that if $c = 0$, then the last component simplifies into $(x_i/x)(S/n(i))$, and if $c = 1$, then the last component is $S(x_i/x)(x_{ik}/x_i)$. For details of the mathematical derivation of the equilibrium point predictions in Tables 1, 3, and 4, see Rapoport and Amaldoss (1999).

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