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Parochial altruism and the absence of the group size paradox in inter-group conflicts

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Abstract

Experiments on contests between groups typically find that large groups are more likely to win than small groups even if theory predicts otherwise. One explanation in the literature is parochial altruism: altruism towards members of the in-group and hostility towards members of the out-group. We model a mixed contest - a combination of a group contest and an individual contest - in which parochial altruism is predicted to have no impact on the groups` odds. Preliminary experimental evidence suggests that - contrary to theory - the large group is substantially more likely to win the group contest than the small group. Hence, forces beyond parochial altruism counteract the group size paradox. As deviations from theory diminish over time those other forces seem to be transient.

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1. Introduction

In contests between groups, each member of each group invests non-refundable effort, and a larger joint effort of a group's members increases its likelihood of winning the contest but does not guarantee victory. Examples include different divisions struggling over the distribution of the budget within a firm, teams of researchers fighting for a patent, or political parties competing for political power.

Often, the groups are of different size. Olson's (1965) *group size paradox* then suggests that, under certain conditions, the larger group will find it harder to succeed as it faces bigger problems of free-riding (see e.g. Nitzan, 1991; Katz and Tokatlidu, 1996; Nitzan and Ueda, 2011).

However, all experiments investigating the impact of group size find that larger groups are more likely to win than smaller groups, even when theory predicts otherwise (Sheremeta, 2018). It has been argued that this may be explained by parochial altruism according to which individuals behave pro-socially towards members of their own group, and anti-socially towards members of the out-group (see e.g. Abbink et al., 2012; Kolmar and Wagener, 2019). Yet, other channels may drive the phenomenon. For example, a joy of winning enjoyed by group members may favor the larger group simply due to its size.

In this paper, we design a *mixed contest* between a small and a large group in which parochial altruism is predicted to have no impact on the winning probabilities. Our mixed contest combines a contest between the two groups with a "grand contest" in which members of both groups compete for a prize awarded to one individual. Importantly, each individual only makes a single effort choice which determines the outcome of both contests. Whereas altruism towards members of one's own group lowers free-riding and increases a contestant's effort in the group contest, it decreases effort in the individual contest. We show that there exists a variant of the mixed contest in which the winning probabilities of both groups should be equal regardless of the degree of parochial altruism.

A preliminary experimental test of this mixed contest reveals that the large group spends a larger joint effort than the smaller group, and therefore has a larger probability of winning. Indeed, the large group is almost 50 percent more likely to win the group contest than the small group. The main reason is a larger degree of overbidding in the large group. However, group efforts approach each other over time which suggests that deviations from theoretical predictions that cannot be explained by parochial altruism may be transient.

Overall, our evidence suggests that parochial altruism *per se* is not sufficient to explain why the group size paradox does not manifest in experiments on group contests. We discuss several alternative explanations, among which bounded rationality or ambiguity aversion are maybe most plausible because their impact may fade as a result of learning.

2. Theory

We consider a mixed contest between n players divided into 2 groups. Group $g \in \{1, 2\}$ comprises m_g players, where $m_2 = n - m_1$ and $m_2 > m_1 \geq 2$. The two groups compete for a group prize $R_G \geq 0$. In addition, all n players compete for an individual prize $R_I \geq 0$. The outcome of both contests is determined simultaneously by a single effort choice of each player. Each player has a sufficiently large initial wealth endowment $e \in \mathbb{R}_+$. Let $x_{gi} \geq 0$ denote the effort chosen by player i in group g and $\boldsymbol{x}$ the vector of all n efforts. To keep the analysis tractable, we assume that chances of winning are given by the contest-success function (CSF) proposed by Tullock (1980),[1] effort costs are linear, and players are risk-neutral. Accordingly, the expected payoff of player i in group g is given by

$$E\pi_{gi}(\boldsymbol{x}) := e \,-\, x_{gi} \,+\, \frac{X_g}{X}\, f(m_g)\; R_G \,+\, \frac{x_{gi}}{X}\, R_I, \tag{1}$$

where $X_g = \sum_j x_{gj}$ denotes the aggregate effort of group $g \in \{1,2\}$ and $X = X_1 + X_2$ denotes total effort. The first (second) fraction is assumed to equal $1/2$ ($1/n$) if $X = 0$. The function $f : \mathbb{N} \to [0,1]$ captures how the group prize R_G is split within the winning group. For example, $f(m_g) = 1/m_g$ if R_G is evenly divided among the group members.[2] As rivalry and competition are usually fiercer in larger groups, we assume f to be non-increasing.

Rather than assuming that each player selfishly maximizes her expected payoff, we allow players to be altruistic or spiteful towards other players. Moreover, we allow the degree of altruism to depend on the group membership of other players. Accordingly, player i in group g is assumed to maximize her expected utility given by

$$Eu_{gi}(\boldsymbol{x}) \;=\; E\pi_{gi}(\boldsymbol{x}) \,+\, \delta_{in} \sum_{j\in g, j\neq i} E\pi_{gj}(\boldsymbol{x}) \,+\, \delta_{out} \sum_{k\in h} E\pi_{hk}(\boldsymbol{x}), \tag{2}$$

where $h \neq g$. $\delta_{in} \in [-1,1]$ denotes the altruism (or spite) players have towards members of their own group, whereas $\delta_{out} \in [-1,1]$ denotes the altruism (or spite) players have towards members of the other group. Parochial altruism entails that $\delta_{out} < 0 < \delta_{in}$.

Assuming symmetry of efforts within each group, the equilibrium is given as follows:[3]

Proposition 1. *For δ_{out} sufficiently small,[4] the mixed contest has a unique equilibrium with $x^*_{gi} = X^*_g/m_g$ for each $g \in \{1,2\}$ which is characterized by $X^*_h\, v_g\, R_G - \left(X^*_g\, w_g \,+\, X^*_h\, \delta_{out}\right) R_I \;=\; X^*\,(X^* \,-\, R_I)$, where for $g, h \in \{1,2\}$ and $h \neq g$*

$$\begin{aligned} v_g \;&=\; f(m_g) \,+\, \delta_{in}\, (m_g - 1)\; f(m_g) \,-\, \delta_{out}\, m_h\, f(m_h)\,, \\ w_g \;&=\; \frac{1 \,+\, \delta_{in}\, (m_g - 1)}{m_g}. \end{aligned}$$

The equilibrium winning odds of the large group thus equal

$$\frac{X^*_2}{X^*_1} \;=\; \frac{v_2\, R_G \,+\, (w_1 - \delta_{out})\; R_I}{v_1\, R_G \,+\, (w_2 - \delta_{out})\; R_I}. \tag{3}$$

To illustrate the conflicting effects of parochial altruism, consider two benchmarks. First, if $R_I = 0$ and $f(m) = 1/m$, equation (3) yields

$$\frac{X^*_2}{X^*_1} \;=\; \frac{m_1}{m_2}\, \frac{1 \,+\, \delta_{in}\, (m_2 - 1) \,-\, \delta_{out}\, m_2}{1 \,+\, \delta_{in}\, (m_1 - 1) \,-\, \delta_{out}\, m_1}.$$

[1] Tullock's contest success function is a special case of the CSF axiomatized by Skaperdas (1996).

[2] Other cases are $f(m_g) \equiv 1$, which captures a public good R_G, and $f(m_g) = 1/m_g^2$ which applies if R_G is contested within the winning group.

[3] All proofs can be found in Appendix A.

[4] Concretely, $\delta_{out} \,<\, \min_{g\in\{1,2\}} \left[\frac{1-\delta_{in}}{m_g} \frac{R_I \,+\, m_g\, f_h\, R_G}{R_I \,+\, m_g\, f_g\, R_G} \,+\, \delta_{in}\, \frac{A \,+\, m_h\, f_h\, R_G}{R_I \,+\, m_g\, f_g\, R_G} \right]$ with $h \neq g$ and $f_g = f(m_g)$, which is always satisfied under parochial altruism.

These winning odds equal m_1/m_2 for $\delta_{in} = \delta_{out} = 0$, are increasing (decreasing) in δ_{in} (δ_{out}), and approach parity as $\delta_{in} \to 1$. Furthermore, a higher degree of altruism towards members of the in-group (larger δ_{in}), and a higher degree of spite towards members of the out-group (smaller δ_{out}) both increase efforts of the players in the pure group contest.

Second, if $R_G = 0$, equation (3) implies that the winning odds of the large group equal $X_2^*/X_1^* = m_2/m_1$ for $\delta_{in} = \delta_{out} = 0$, are decreasing in both δ_{in} and δ_{out}, and they approach one as $\delta_{in} \to 1$. Furthermore, altruism decreases equilibrium efforts in this case.

Turning to the mixed contest, we may ask whether the above effects exactly cancel each other out for certain constellations. We obtain the following result:

Proposition 2. *Social preferences have no impact on the equilibrium winning odds (i.e.,* $\frac{d(X_2^*/X_1^*)}{d\delta_{in}} = \frac{d(X_2^*/X_1^*)}{d\delta_{out}} = 0$ *for all feasible combinations of* δ_{in} *and* δ_{out}*), if and only if* $m_1 f(m_1) = m_2 f(m_2)$ *and* $R_I = m_1 f(m_1) R_G$.

Incidentally, $X_2^*/X_1^* \equiv 1$ in this case. Particularly, the conditions hold if $f(m) = 1/m$ and $R_I = R_G$, which is equivalent to $a = 1/2$ in the framework of Nitzan (1991).

3. A Preliminary Experimental Test

Below we present the results of a preliminary experimental test of Proposition 2. Hence, we investigate whether turning off parochial altruism as a driving force moves behavior closer to theoretical predictions. We are particularly interested in the winning odds of the large group vis-a-vis the small group in the group contest.

3.1. Experimental Design and Procedures

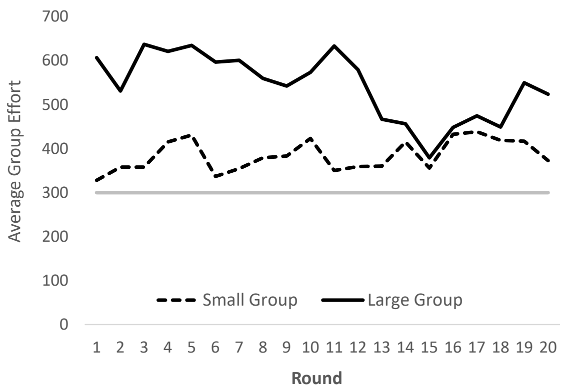
We conduct three experimental sessions in which subjects play 20 repetitions (henceforth *rounds*) of the mixed contest described above with $m_1 = 2$, $m_2 = 4$, $f(m_g) = 1/m_g$, and $R_G = R_I = 600$ points. Each subject is randomly matched with five other subjects in each round, but always belongs to either the small or the large group. Furthermore, each subject receives an endowment of $e = 400$ points in each round which she can spend to increase her winning probability in the individual contest and the winning probability of her group in the group contest. Notably, the subject chooses a single effort that determines both probabilities. At the end of each round, subjects are informed about the effort choices of all five players they have been matched with as well as the winners of the individual and the group prize.

Each session proceeded as follows: Upon arrival at the lab, subjects were randomly assigned to cubicles that did not allow for any visual communication between them, and they were immediately asked to read the basic instructions provided in their cubicle.[5] Subjects then received paper instructions for the first part in which we elicited risk preferences using a multiple price list with ten decisions (see e.g. Holt and Laury, 2002).[6] Subjects were first given time to read the instructions at their own pace, before they were

[5] The instructions are available from the authors upon request.

[6] Each subject is presented with a table of ten ordered decisions between a safe amount of 180 points and a risky lottery which offers either 400 points or 0 points, where the likelihood of receiving the 400 points increases from 0.1 in the first row to 1.0 in the last row in steps of 0.1. Subjects are required to select one of the options in each row. We use the number of times a subject chooses the safe lottery as a measure of her risk aversion.

FIGURE 1
Average group efforts across rounds.



read aloud and subjects were permitted to ask questions. Once all subjects had submitted their ten decisions in the first part, we distributed paper instructions for the second part in which we ran the contests. Subjects were again given time to read them at their own pace before the instructions were read aloud. The instructions for part 2 were followed by a short quiz to check subjects' understanding. The experimenters controlled subjects' answers and explained mistakes in private if necessary. Afterwards, the 20 rounds of part 2 were run. Subjects submitted their efforts using the computer, and we included a simulation tool to assist subjects in their decision-making.

At the end of the session, we randomly selected one out of the 10 decisions from part 1, and one each out of the first and the last ten rounds from part 2 for payment using a ten-sided dice. Points were converted into cash at the rate 1 point = €0.01 and added to a show-up fee of €4.00. Before collecting their earnings, we asked subjects to fill out a questionnaire involving several demographics as well as assessments of certain personal characteristics and various aspects of the experiment. Afterwards, subjects retrieved their earnings in private and left.

The sessions took place at the experimental laboratory of the University of Bamberg in July and November 2018. Students from the University of Bamberg were invited using the ORSEE recruitment system (Greiner, 2015). 18 subjects participated in each session. The experiment was programmed in zTree (Fischbacher, 2007). Sessions lasted 90 minutes on average. Overall, we collected 1,080 effort choices. The average payment was €15.02.

We test the following hypothesis:

Hypothesis 1. *Both groups invest the same group effort and achieve the same winning probability.*

3.2. Experimental Results

Figure 1 plots average group efforts across rounds for the large (solid line) and the small group (dotted line) as well as the Nash equilibrium prediction (gray line, 300 points).

Across all (the last ten) rounds, the large group spends 543.2 (496.1) points on average whereas the small group spends 384.4 (391.9) on average. To provide statistical evidence for the effects, we run an OLS regression of group efforts on a dummy for the large team which allows for standard error clustering at the session level. In a further specification,

TABLE I
Determinants of Group Efforts

	(1)		(2)	
	Estim.	Clust. SE	Estim.	Clust. SE
Constant	384.35***	(13.878)	376.76**	(51.154)
Large Team	158.87*	(51.870)	213.60*	(72.946)
Last Ten			15.19	(33.389)
Last Ten × Large Team			-109.47	(46.807)
Observations	360		360	
R^2	0.124		0.150	

Notes: Standard errors in parentheses. Significance levels: *** (1%), ** (5%), * (10%).

we also include a dummy for the final ten rounds, and its interaction with the large-team-dummy. The results are presented in Table I.

The regression results confirm that the difference in group efforts is significant. Indeed, the group contest is won by the large group in 108 out of 180 contests. However, the group effort of the large group decreases over time, whereas the group effort of the small group hardly changes. As a consequence, we cannot reject our hypothesis for the second part of the experiment. Indeed, across the last ten rounds, the large group only wins 43 out of 90 contests, well in line with the theoretical prediction. This confirms findings by Abbink et al. (2010, 2012) that group efforts decrease over time and approach the group equilibrium predictions.

As a robustness check and to control for subject-specific co-variates, we additionally estimate Tobit models of individual efforts which allow for subject-specific random-effects. The results are presented in Appendix B. They confirm that group efforts are larger in the large than in the small group across the first but not across the second half of the experiment.[7] In addition, we find that individual efforts are smaller for more risk averse subjects and subjects who care more about their final payment, and larger for more generous subjects, subjects who more frequently play board games or games of chance, and subjects who focus more on winning the individual prize.

4. Discussion and Conclusion

In this paper, we show how a mixed contest – a combination of a group contest and an individual contest – can be used to "turn off" the impact of parochial altruism on contest behavior. Our preliminary experimental evidence suggests that the recurrent finding that large groups are more likely to win in group contests than small groups even if theory predicts otherwise is only partially explained by parochial altruism.

Various behavioral forces besides parochial altruism may explain the empirical advantage of large vis-á-vis small groups in group contests. First, risk aversion tends to lower contest expenditures (see Dechenaux et al., 2015). If group expenditures are mainly driven by the least risk averse group member (see Brookins and Jindapon, 2021), larger groups are at an advantage as the minimal risk aversion among group members is likely

[7]Concretely, we test whether subjects in the small group invest exactly twice as much as subjects in the large group.

to be lower in the larger group. Second, if subjects derive a non-monetary utility from winning (see Sheremeta, 2013, for an overview), this benefits members of the large group more than members of the small group. Third, subjects' expectations about others' effort choices may be affected by, e.g., bounded rationality or ambiguity aversion (see Sheremeta, 2013; Kelsey and Melkonyan, 2018). For example, if subjects expect members of the large group to exert very little effort (expecting free riding), members of the large group may compensate this expectation by overexerting effort and driving up the group effort.[8] Fourth, large groups may be better able to develop a group identity than small groups (see Kolmar and Wagener, 2019, and the references therein). Finally, if subjects are disappointment averse (see March and Sahm, 2017), members of the large group may feel entitled to win the group contest, and overexert effort to "make it happen". While we are not able to discriminate between the alternative explanations, our evidence suggests that those other behavioral forces disappear across repetitions. This may favor an explanation in terms of bounded rationality or ambiguity aversion, which is driven out by learning. Future work should dig deeper into the behavioral channels driving behavior in group contests.

This paper also indicates that mixed contests provide a fruitful topic for future research. Besides their value as an experimental mechanism to isolate different behavioral forces, their analysis may inform the design of workplace incentives which are frequently mixed (see e.g. Libby and Thorne, 2009). Some recent papers take first steps in this direction (e.g. Balart et al., 2018; Majerczyk et al., 2019). In a companion paper, we investigate mixed contests more thoroughly, both theoretically and experimentally (see March and Sahm, 2019).

A basic premise of the model presented here and in our companion paper is the single choice variable available to each player to affect the outcome in both contests. This enables the different impacts of parochial altruism to be balanced out in an appropriate mixed contest. Future work may offer players more freedom in affecting the two contests. For example, players may be allowed to decide whether to employ their resources in the individual or the group contest. See e.g. Münster (2007), Münster and Staal (2012), or Hausken (2012) for models along those lines, all of which assume, however, that the players compete in the individual contest for the winnings in the group contest. A second possibility would be the introduction of sabotage into a mixed contest. While sabotage is always directed towards members of the other group in a group contest (see e.g. Gürtler, 2008; Doğan et al., 2019), the combination with an individual contest may make a player's own group members susceptible to sabotage as well.[9] For instance, one may assume that players have a single sabotage variable which affects all other players (as in Harbring and Irlenbusch, 2005, 2011), but to a different degree depending on their group membership. Alternatively, one could allow each player to distinguish how much sabotage to direct at members of the own or the other group, and assume group-specific sabotage costs. Such approaches constitute promising avenues for future research.

[8] See Appendix Appendix C for a formal statement.

[9] See Chowdhury and Gürtler (2015) for a recent survey of sabotage in (individual) contests.

Appendix A. Proofs

Proof of Proposition 1. The first-order condition for the expected utility maximizing effort of player i in group g is given by

$$
\begin{aligned}
0 = \frac{\partial E u_{gi}}{\partial x_{gi}} = & \frac{X - X_g}{X^2}\, f(m_g)\; R_G + \frac{X \;-\; x_{gi}}{X^2}\, R_I - 1 \\
& + \delta_{in}\; (m_g - 1)\; \frac{X - X_g}{X^2}\, f(m_g)\; R_G - \delta_{in} \sum_{j \in g, j \neq i} \frac{x_{jg}}{X^2}\, R_I \\
& - \delta_{out}\, \frac{X_h}{X^2}\, m_h\, f(m_h)\; R_G - \delta_{out} \sum_{k \in h} \frac{x_{kh}}{X^2}\, R_I
\end{aligned}
$$

where $g, h \in \{1, 2\}$ and $h \neq g$. Using $x_{gi} = X_g / m_g$ for each $g \in \{1, 2\}$ and each i in group g and rearranging terms implies that in an interior equilibrium

$$
\begin{aligned}
X\; (X - R_I) = & \left[(1 - \delta_{in} + \delta_{in}\, m_g)\; f(m_g) - \delta_{out}\, m_h\, f(m_h)\right]\; X_h\, R_G \\
& - \frac{1 + \delta_{in}\; (m_g - 1)}{m_g}\, X_g\, R_I - \delta_{out}\, X_h\, R_I
\end{aligned}
\tag{A.1}
$$

for each $g, h \in \{1, 2\}$ with $h \neq g$. With v_g and w_g as defined in Proposition 1, this yields the stated equilibrium condition. Furthermore, noting that the left hand side of equation (A.1) above is independent of g implies that

$$
v_1\, X_2\, R_G - w_1\, X_1\, R_I - \delta_{out}\, X_2\, R_I = v_2\, X_1\, R_G - w_2\, X_2\, R_I - \delta_{out}\, X_1\, R_I
$$

which is equivalent to equation (3).

To finish the proof, we must show that the above equilibrium is unique. The only alternative candidate equilibrium entails $X_g^{**} = 0$ for some $g \in \{1, 2\}$ and $X_h^{**} = (1 - \delta_{in})\, \frac{m_h - 1}{m_h}\, R_I$ for $h \in \{1, 2\}$ and $h \neq g$. In addition, a necessary condition is that $\partial EU_{ig} / \partial x_{gi} \leq 0$ at $x_{gi}^{**} = X_g^{**} = 0$. This is equivalent to $X_h^{**} \geq v_g\, R_G + (1 - \delta_{out})\; R_I$. Hence, $X_g^{**} = 0$ in equilibrium only if[10]

$$
\begin{aligned}
& (1 - \delta_{in})\; \frac{m_h - 1}{m_h}\, R_I \geq v_g\, R_G + (1 - \delta_{out})\; R_I \\
\Leftrightarrow \qquad & \delta_{out} \geq \frac{1 - \delta_{in}}{m_h}\, \frac{R_I + m_h\, f(m_g)\; R_G}{R_I + m_h\, f(m_h)\; R_G} + \delta_{in}\, \frac{R_I + m_g\, f(m_g)\; R_G}{R_I + m_h\, f(m_h)\; R_G}.
\end{aligned}
$$

The condition stated in the footnote to Proposition 1 ensures that the above inequality is never satisfied for either group $g \in \{1, 2\}$. □

Proof of Proposition 2. The derivatives of the large group's winning odds $q^* = X_2^* / X_1^*$

[10] In many specifications, the condition is also sufficient: depending on the functional form of f, either group might drop from the contest if δ_{out} is sufficiently large.

with respect to δ_{in} and δ_{out} are given by

$$\begin{aligned}
\frac{\partial q^*}{\partial \delta_{in}} &= \frac{1}{Y^2}\left[(m_2 - m_1) f_1 f_2 R_G^2 - \frac{m_2 - m_1}{m1 m_2} R_I^2 - \delta_{out} z\right], \\
\frac{\partial q^*}{\partial \delta_{out}} &= \frac{1}{Y^2}\left[\left(m_2 f_2^2 - m_1 f_1^2\right) R_G^2 + \frac{m_1 + m_2}{m_1 m_2}\left(m_2 f_2 - m_1 f_1\right) R_G R_I + \frac{m_2 - m_1}{m_1 m_2} R_I^2 + \delta_{in} z\right],
\end{aligned}$$

where $Y = v_1 R_G + (w_2 - \delta_{out}) R_I$, $f_g = f(m_g)$, and

$$\begin{aligned}
z = & \left(m_2 (m_2 - 1) f_2^2 - m_1 (m_1 - 1) f_1^2\right) R_G^2 + (m_2 f_2 - m_1 f_1)\left(\frac{m_1 - 1}{m_1} + \frac{m_2 - 1}{m_2}\right) R_G R_I \\
& - \frac{m_2 - m_1}{m_1 m_2} R_I^2.
\end{aligned}$$

Thus $\partial q^* / \partial \delta_{in} = 0$ and $\partial q^* / \partial \delta_{out} = 0$ for all feasible combinations of δ_{in} and δ_{out} if and only if the following three equations hold:

$$\begin{aligned}
(i)\ 0 &= (m_2 - m_1)\ f_1\ f_2\ R_G^2 - \frac{m_2 - m_1}{m1\ m_2}\ R_I^2, \\
(ii)\ 0 &= \left(m_2\ f_2^2\ -\ m_1\ f_1^2\right)\ R_G^2 + \frac{m_1 + m_2}{m_1\ m_2}\ (m_2\ f_2\ -\ m_1\ f_1)\ R_G\ R_I + \frac{m_2 - m_1}{m_1\ m_2}\ R_I^2, \\
(iii)\ 0 &= z.
\end{aligned}$$

Condition (i) is equivalent to $R_I^2 = m_1\ m_2\ f_1\ f_2\ R_G^2$. Plugging this into condition (ii) and rearranging terms yields

$$0 = (m_2\ f_2\ -\ m_1\ f_1) \cdot \left\{(f_1 + f_2)\ R_G^2 + \frac{m_1 + m_2}{m_1\ m_2}\ R_G\ R_I\right\}.$$

As the term in curly brackets is strictly positive for any $R_G > 0$, it must hold that $m_2\ f_2 = m_1\ f_1$. This again implies $R_I = m_1\ f_1\ R_G$. Finally, using these two identities, one easily computes $z = 0$, i.e., condition (iii) is satisfied as well. $\square$

Appendix B. Econometric Results for Individual Efforts

TABLE II
Random-Effects Tobit Models of Individual Efforts

Model	(1)		(2)		(3)	
Covariate	Coef.	Clust.SE	Coef.	Clust.SE	Coef.	Clust.SE
Constant	185.15***	(25.468)	197.69***	(24.968)	260.04***	(30.481)
Large Group	-39.22	(31.213)	-46.29	(30.012)	-66.87***	(22.662)
Last 10 Rounds	12.40	(12.063)	12.38	(12.065)	12.46	(12.077)
× Large Group	-41.91***	(14.855)	-41.86***	(14.857)	-42.01***	(14.873)
Nb. Safe Choices Part 1			-24.93**	(10.894)	-7.13	(7.390)
Age					1.39	(1.285)
Female					-28.91	(18.172)
Field of Studies = BA					-38.22	(29.073)
Field of Studies = Econ					-40.25	(31.149)
Field of Studies = SSH					-16.18	(28.820)
School Grade in Math					3.12	(9.789)
Nb. of Siblings					-12.29*	(6.441)
Freq. Games of Chance					12.48*	(7.014)
Freq. Board Games					10.03*	(5.948)
Ambition					-8.27	(7.415)
Generosity					18.72***	(6.269)
Importance Payment					-25.37***	(6.403)
Importance Ind. Prize					31.74***	(6.218)
Importance Group Prize					-9.11	(7.643)
Predicted Group Efforts at Median Values						
First 10 Rounds						
Small Team	370.3		395.4		520.1	
Large Team	583.7		605.6		772.7	
p(H0: Small = Large)	0.016		0.013		0.004	
Last 10 Rounds						
Small Team	395.1		420.1		545.0	
Large Team	465.7		487.7		654.5	
p(H0: Small = Large)	0.424		0.424		0.218	
Observations	1,080		1,080		1,080	
Log-Likelihood	-5,552.3		-5,549.8		-5,518.9	

Note: There are 137 left-censored, and 84 right-censored observations. Standard errors in parentheses. Significance levels: *** (1%), ** (5%), * (10%). Control variables (except gender and field of studies) are normalized as differences from the median. We distinguish the following fields of studies: business administration (BA), economics (Econ), social sciences and humanities (SSH), and other (baseline).

Appendix C. A Simple Model of Boundedly Rational Expectations

Consider a group contest ($R_I = 0$) between two groups $g \in \{1, 2\}$ with group sizes $m_2 > m_1 \geq 2$. Assume that each player of group g expects each member of group k to exert effort $\hat{x}_g^k$. We here allow expectations $\hat{x}_g^k$ to deviate from rational (equilibrium) expectations due to, e.g., limited reasoning or ambiguity aversion. We do however assume that expectations reflect the insight that the free riding problem is more severe in larger groups which is why $\hat{x}_1^1 \geq \hat{x}_2^2$ (expectations about own group members) and $\hat{x}_2^1 \geq \hat{x}_1^2$ (expectations about other group members).

It is easily shown that under these assumptions, the best response of player i in group g to her expectations is given by

$$x_{gi}^{**} = \sqrt{m_h \; \hat{x}_g^h \; f\left(m_g\right) \; R_G} - \left[m_h \; \hat{x}_g^h \; + \; \left(m_g - 1\right) \; \hat{x}_g^g\right] \tag{C.1}$$

where $h \neq g$.

If $f\left(m_g\right) \equiv 1$ (and therefore $X_1^* = X_2^* = R_G/4$ in equilibrium), we find that $X_2^{**} = m_2 \; x_{2i}^{**} > m_1 \; x_{1i}^{**} = X_1^{**}$, if and only if

$$\begin{aligned} &\sqrt{m_1 \; m_2 \; R_G} \; \left(\sqrt{m_2 \; \hat{x}_2^1} \; - \; \sqrt{m_1 \; \hat{x}_1^2}\right) \; - \; m_1 \; m_2 \; \left(\hat{x}_2^1 \; - \; \hat{x}_1^2\right) \\ &> m_2 \; \left(m_2 - 1\right) \; \hat{x}_2^2 \; - \; m_1 \; \left(m_1 - 1\right) \; \hat{x}_1^1. \end{aligned} \tag{C.2}$$

If $f\left(m_g\right) = 1/m_g$ (and therefore $X_1^* = \left(m_2/m_1\right) \; X_2^*$ in equilibrium), we find that $X_2^{**} > X_1^{**}$, if and only if

$$\begin{aligned} &\sqrt{m_1 \; m_2 \; R_G} \; \left(\sqrt{\hat{x}_2^1} \; - \; \sqrt{\hat{x}_1^2}\right) \; - \; m_1 \; m_2 \; \left(\hat{x}_2^1 \; - \; \hat{x}_1^2\right) \\ &> m_2 \; \left(m_2 - 1\right) \; \hat{x}_2^2 \; - \; m_1 \; \left(m_1 - 1\right) \; \hat{x}_1^1. \end{aligned} \tag{C.3}$$

It is easily checked that the above assumptions admit combinations $(\hat{x}_1^1, \hat{x}_1^2, \hat{x}_2^1, \hat{x}_2^2)$ satisfying either of the two equations (consider for instance the case that $\hat{x}_g^2 = 0$ for each $g = 1, 2$; i.e. the assumptions that members of the large group fully free ride).

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