Group contest in a coopetitive setup: experimental evidence

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Abstract

We study experimentally cooperation in group contests under a new sharing rule that captures elements of coopetitive setups that are often characterized by the tension between cooperation and competition. It introduces an allocation of the obtained prize which is inversely proportional to individual efforts. We use it to study if the pervasive over-expenditure observed in group contests remains even when individual effort is extremely disincentivized and compare its effects with the egalitarian sharing rule. Participants in our experiment make more effort with the egalitarian than with the inverse proportional rule, but we document a sizeable over-expenditure even with the inverse proportional rule. We find that contribution in a public goods game is positively associated with effort in the group contest. Social value orientation, risk attitudes, competitiveness, or other personality traits do not predict behavior consistently.

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1 Introduction

Group contests are ubiquitous, including rent-seeking and lobbying, innovation tournaments and R&D races or sports competitions. One of the main finding of the literature on group contests is that the actual effort of individuals who participate in such contests tends to be significantly higher than the Nash equilibrium prediction. Since the effort generally does not affect the size of the prize to be gained in the contest and, hence, is wasteful, over-expenditure leads to large welfare losses. A large part of the literature aims at explaining this phenomenon by investigating how different elements of group contests and individual characteristics affect observed behavior in laboratory experiments. We rely on this literature to study group contests in coopetitive setups, where the group members pursuing a common goal have at the same time opposing individual objectives. A considerable share of studies in the management literature on coopetition is concerned about the tension between value creation (cooperation) and capture (competition) (see, for instance, Bengtsson and Kock 2014; Bouncken et al. 2015). Such tensions may go against cooperation, and we attempt to come up with a model and experimental design that exhibit this feature.

We introduce and analyze a new sharing rule (that we call *inverse proportional*) that disincentivizes more intensely participants from contributing to the group performance than known sharing rules (e.g., egalitarian or proportional). With the inverse sharing rule, the prize obtained in the case of winning is allocated to each individual of the winner group in an inversely proportional way to the effort exerted by the individual. For instance, if member A made half of the effort of member B in the winning group, member A receives twice as much from the prize than member B. Importantly, the sharing rule that we introduce here induces that zero effort becomes the dominant strategy for each individual (in contrast to the known sharing rules that predict a positive effort). The main aim of this work is to study the behavior under this rule and to investigate if over-expenditure persists even if zero effort is a dominant strategy for the individual. As a secondary objective, in the experiment we explore individual characteristics (risk, social and competitive preferences) of the participants to see how these associate with observed choices in the group contest to shed light on the significance of individual heterogeneity, another common finding in the literature.

The inverse proportional sharing rule may seem at first puzzling as it does not reward cooperation.[1] However, it may emerge in coopetitive setups that suffer from the tension between value creation and capture, supported by many examples in the

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[1] Colasante et al. (2019) and Rapoport and Bornstein (1987) show that competition may foster cooperation through solving the free-rider problem.

management literature.[2] A simple economic explanation of such tensions can be the resource constraint, as firms use the same resources for cooperation and competition. This feature is captured by the inverse proportionality sharing rule in a group contest context: The more an agent spends on cooperation, the less resources she has to obtain a higher share of the prize (if her group wins it). Consider two examples that illustrate the previous ideas. One is the case of cycling races, in which often two or more cyclists break away from the peloton. To maintain their distance, the cyclists have to cooperate, that is, all of them have to be in front and to take the lead that requires a lot of effort as the leader has to struggle more with air resistance than the followers who are sheltered from wind.[3] On the other hand, these cyclists also compete because each of them wants to win the competition and arrive first at the finish line. To win, they need to economize on efforts so they are interested in less cooperation. The more cooperative a cyclist is, the more likely it is that the escape is successful and they arrive first at the finish line, but at the same time more cooperation decreases his chance of winning the race. A similar dilemma is faced by cyclists in the pursuit squad, who would form the other group competing in the contest. Consider also the example of a set of firms that are using one of several available standards in the market, but at the same time they compete for customers. The high-definition optical disk format competition is a suitable illustration. As HDTV televisions became popular in the mid-2000s, a need emerged for an inexpensive storage medium that should succeed the established DVD format. Leading electronic companies (e.g., Sony, Panasonic, Samsung) founded Blu-ray Disc Association to develop and license the homonymous technology and to promote business opportunities for this standard. A similar association arose led by Toshiba (and supported by Microsoft) to advance a competing format called HD DVD. Members of both associations cooperated in the development of the respective format (the prize being a higher market size for the format), but at the same time competed to sell players compatible with the given format to customers. Firms in such consortia dedicate part of their own resources to the development of the standard, while they still have to compete for customers against their allies in the consortium. These firms face, therefore, a trade-off, the more they contribute to the success of the format, the less resources they have to increase the probability of capturing a larger share of the market.[4] When group members cooperate to win the contest, while at the same time they also compete, any contribution to the group objective is decreasing the opportunities to become successful in the within-group competition.[5]

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[2] Kim and Parkhe (2009) show how competing similarity (e.g., geographical market coverage or product market coverage) hinders, while cooperating similarity (e.g., societal culture or management practices) fosters coopetition. Hence, tension may arise when competing similarity is too high relative to cooperating similarity. In a similar vein, Park et al. (2014) show that the right balance between competition and cooperation is beneficial for firm performance, while imbalances may lead to tensions.

[3] Aerodynamic drag can be reduced up to 50% for cyclists that are not in front (Blocken et al. 2018).

[4] These situations are also present in lobbies of industry associations: Members contribute resources for lobbying efforts, but at the same time they compete with each other directly. Further examples are chambers of commerce and federations of entrepreneurs or schemes of protected designation of origin (which promote and protect names of quality agricultural products of a given region).

[5] Clearly, the trade-off between using resources for cooperation or competition may be more acute in some environments, possibly due to factors like competitive intensity, network externalities or market uncertainty (Ritala 2012).

Our inverse proportional sharing rule captures these types of incentives that involve the trade-off between cooperation and competition due to limited resources. The theoretical analysis shows that individuals maximize their payoff making zero effort to the group performance, independently of the actions of the rest of individuals.[6] This is a strong prediction that we test in the laboratory, analyzing both if this new sharing rule has an effect on effort as well as if over-expenditure remains even in the extreme case where zero effort is always optimal from an individual point of view. In two sessions, both with 14 four-member groups, we investigate behavior in group contest with egalitarian and inverse proportional sharing rule. Moreover, after the group contest, our participants played additional games to measure their social attitude, risk preferences, cooperativeness and competitiveness, as well as an extensive questionnaire capturing personality traits with the aim to better understand what drives their choices in the group contest.

We find a sizeable over-expenditure with the inverse sharing rule, although zero contribution is optimal for each individual. Participants' efforts remain relatively high even at the end of the experiment, after 20 rounds. However, we find a sizable and significant difference in effort between the egalitarian and the inverse proportional rule, effort being much lower under the latter rule, as expected. When relating behavior in group contest with decisions in other situations, we find that contributions in a public good game are positively associated with effort in the group contest, independently of the sharing rule. Competitiveness, measured á la Niederle and Vesterlund (2007) explains part of the behavior. Finally, we do not find any consistent effect of social value orientation or risk aversion.

The rest of the paper is organized as follows. In Sect. 2, we present the theoretical model upon which our main hypothesis is based. Then, in Sect. 3 we briefly review the literature and formulate our hypotheses. Section 4 describes the experiment. In Sect. 5, we present our findings and Sect. 6 concludes.

2 Model

There are two groups (A and B) with N_A and N_B members, respectively, that compete to win a contest and receive a prize υ. In our case groups have 4 members ($N_A = N_B = 4$) and the prize is 4000 tokens. Players in both groups choose simultaneously and independently a level of effort x_{iA} and x_{jB} that is irreversible.

The performance of group A/B, denoted as X_A/X_B, is a function of all individual efforts within the given group. We use perfect substitution of effort, so

$$f_A(x_{1A}, \ldots x_{N_A A}) = \sum_{i=1}^{N_A} x_{iA}. \tag{1}$$

This function describes situations in which the performance of the group hinges on the joint effort of all individuals of the group. As of costs of effort, for simplicity we

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[6] Moreover, zero effort is also the social optimum.

assume homogeneous linear costs, that is $c_{iA}(x) = c_{jB}(x) = x$ for all $i = 1, ..., N_A$ and $j = 1, ..., N_B$.

The probability of winning the contest depends on the relative performance of the groups. A contest success function (CSF) determines the probability that group A wins the prize:

$$p_A(X_A, X_B) = \frac{(X_A)^r}{(X_A)^r + (X_B)^r} \tag{2}$$

We use the lottery CSF, so $r = 1$. In this case higher performance implies higher winning probabilities.

Our main modification is in the way the prize is split. A general way to capture the division of the prize is the following. In the case group A wins the prize, player i receives a share of the prize which is defined by the following sharing rule Nitzan (1991)

$$s_{iA}(x_{1A}, \ldots x_{N_A A}) = \frac{\alpha_A}{N_A} + (1 - \alpha_A)\frac{x_{iA}}{\sum_{i=1}^{N_A} x_{iA}}. \tag{3}$$

In words, share α_A of the prize is split equally among all members of the winning group, and the rest $(1 - \alpha_A)$ is divided according to relative effort. Egalitarian division occurs if $\alpha_A = 1$, while if $\alpha_A = 0$, then the prize is split in proportion to relative effort. In egalitarian treatment we use $\alpha_A = 1$. For the other treatment, we propose a new sharing rule that states that the share of the prize that a member receives is *inversely* proportional to relative effort. More concretely, the less effort a member makes, the more she receives proportionally from the prize.[7] We define the inverse proportional share in the following way:

$$s_{iA}(x_{1A}, \ldots x_{N_A A}) = \begin{cases} \frac{\frac{1}{x_{iA}}}{\sum_{j=1}^{N_A} \frac{1}{x_{jA}}} & \text{if } x_{jA} > 0, \quad \forall j \in [1, \ldots, N_A], \\ \frac{1}{card(x_{jA}=0)} & \text{if } x_{iA} = 0, \\ 0 & \text{if } x_{iA} > 0 \text{ and } card(x_{jA} = 0) > 0, \end{cases} \tag{4}$$

where $card(x_{jA} = 0)$ denotes the cardinality of players in group A who made zero effort. In words, if each player in group A makes a positive effort then player i receives the inverse proportional share. If some member in group A makes zero effort, the inverse proportional share would not be well-defined. But by the logic of the sharing rule, in that case players who make zero effort share the prize equally among them.[8]

To illustrate the effect of sharing rules consider the following example. Suppose a group with subjects Ann, Bob, Chloe and Dan who made the following efforts: 1,2,4 and 4, respectively. In the egalitarian treatment, upon winning the contest all of the members would receive $\frac{1}{4}$ of the prize. However, the inverse proportional rule gives four/two times as much share from the prize to Ann/Bob, than to Chloe and Dan who

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[7] Choi et al. (2016) propose a different possibility that yields an unequal split of the prize in a group contest that also exhibits internal conflict. In their theoretical model, power asymmetry determines who wins the internal conflict. Hausken (2005) also has a theoretical model that features within- and between-group conflict.

[8] Note that neither the general formulation of the sharing rule by Nitzan (1991) nor other approaches to the sharing rule like Balart et al. (2017) are able to capture the inverse proportional rule.

receive the same share. The formula above yields the following shares: $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$ and $\frac{1}{8}$, respectively, to Ann, Bob, Chloe and Dan.

Given perfect substitution in the performance function, homogeneous linear costs, a lottery contest success function ($r = 1$), equal group sizes ($N_A = N_B = N$) and the egalitarian sharing rule, the expected payoff of a risk-neutral player i in group A can be written as:

$$\pi_{iA}(x_{1A}, \ldots x_{NA}, X_B) = \frac{\sum_{i=1}^{N} x_{iA}}{(\sum_{i=1}^{N} x_{iA} + \sum_{j=1}^{N} x_{jB})} \frac{1}{N} \upsilon - x_{iA} \tag{5}$$

The first term of the expected payoff represents the expected benefit of contributing effort x_{iA}. Higher effort of player i in group A increases the probability of group A winning the contest, but yields the same share of the prize ($\frac{1}{N}$) for all members of group A (if this group wins the contest). Cost is captured by the second term. Hence, there is an inherent tension, because player i has an incentive to cooperate with other members of her group, but given the cost of cooperation, there is also an incentive to free ride.

In this setup, with the egalitarian sharing rule there is a unique equilibrium group effort, and if we assume the 'fair share' of each individual effort to be the same, then we obtain[9]

$$x_{1A}^{*} = .. = x_{iA}^{*} = .. = x_{NA}^{*} = \frac{\upsilon}{4N^2}.^9 \tag{6}$$

If we use the inverse proportional sharing rule, then the expected payoff of a risk-neutral player i in group A if all efforts are positive can be written as:

$$\pi_{iA}(x_{1A}, \ldots x_{NA}, X_B) = \frac{\sum_{i=1}^{N} x_{iA}}{(\sum_{i=1}^{N} x_{iA} + \sum_{j=1}^{N} x_{jB})} \frac{\frac{1}{x_{1A}}}{\sum_{i=1}^{N_A} \frac{1}{x_{1A}}} \upsilon - x_{iA} \tag{7}$$

Under the inverse proportional sharing rule, there is a unique equilibrium group effort that coincides with the individual effort:

$$x_{1A}^{*} = .. = x_{iA}^{*} = .. = x_{NA}^{*} = 0. \tag{8}$$

In Appendix A.2 we show that given this rule, zero effort is the dominant strategy for each individual. It means that the optimal decision is always to make a zero contribution, independently of the decision of the rest of individuals. Note that under this rule, the Nash equilibrium in dominant strategies coincides with the socially efficient outcome: Since there is a fixed prize in the contest, it is socially efficient not to make any effort. While this efficient outcome is common in group contests, as far as we know the inverse proportional sharing rule is the first rule in this context in which individual optimal action and social optima coincide.

The previous predictions are based on the following assumptions: (i) players have identical valuations about the payoffs and winning the contest; (ii) players maximize their individual expected payoff without regard to the team's interest; and (iii) players

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[9] Appendix A.1 contains the details of the proof following the line of reasoning by Katz et al. (1990).

are risk-neutral. Hence, deviations from the predictions may be due (at least partly) to the fact that these assumptions do not hold.

3 Literature review and hypotheses

In this section, first we review the main findings of the group contest literature that are related to our theoretical predictions, then we briefly speak about the role of members' heterogeneity in effort in the framework of group contests. After that, we formulate our hypotheses.

3.1 Over-expenditure of effort

A general finding in the group contest literature both in the field (e.g., Erev et al. 1993) and in the laboratory (e.g., Nalbantian and Schotter 1997; Van Dijk et al. 2001) is that with proportional or egalitarian sharing rule contests between groups lead to high individual effort and little free riding. More recent experimental studies (Abbink et al. 2010; Ahn et al. 2011; Bhattacharya 2016; Brookins et al. 2015; Cason et al. 2012, 2017; Chowdhury et al. 2016; Eisenkopf 2014; Ke et al. 2013, 2015; Leibbrandt and Sääksvuori 2012; Sheremeta 2011) also consistently find that average effort level (though often showing a declining pattern) is significantly higher than the equilibrium prediction.[10]

Several explanations for the over-expenditure of effort have been proposed. Pure joy of winning explains part of the over-expenditure in individual contests (Cason et al. 2018; Price and Sheremeta 2011, 2015; Sheremeta 2010). Bounded rationality, both in individual (Fallucchi et al. 2013) and group contests (Chowdhury et al. 2014; Lim et al. 2014), as well as relative payoff maximization (Mago et al. 2016), also have some explanatory power when we try to understand over-expenditure.

A different set of explanations involves social preferences. In social dilemma and collective action games, participants often contribute more to the public account than predicted by standard game theory, (see, for instance, Chaudhuri 2011). Theories based on social preferences like altruism (e.g. Andreoni 1990), fairness (e.g. Rabin 1993) or inequality aversion (e.g. Bolton and Ockenfels 2000; Fehr and Schmidt 1999) offer potential explanation for such behavior and it is natural to think that such social preferences may be at work toward other members of the group.[11] There is also evidence that different individuals have different tendencies to cooperate, some individuals acting as conditional cooperators, and others as free-riders. Conditional cooperation has been found to be a key factor in sustaining high contributions in public good games (Ostrom 2000; Keser and Van Winden 2000; Thöni and Volk 2018), and there is evidence that it plays also a role in group contests (Kiss et al. 2020). Relatedly, social identity the-

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[10] Sheremeta (2013) reports based on 30 studies that the median over-expenditure is 72%.

[11] A related explanation (called parochial altruism) goes further and besides altruism toward in-group members claims the existence of hostility toward members of the rival group. However, such hostility toward out-group subjects is not very common (Abbink et al. 2012; Halevy et al. 2008; Yamagishi and Mifune 2016). Chowdhury et al. (2021) find that in-group preferences boost concern about individual payoff, while the presence of an out-group enhances the interest in the group payoff.

ory (Tajfel and Turner 1979) that proposes that a strong group identity may blur the differences between individual and group interests is another potential explanation. Chowdhury et al. (2016) provides experimental evidence that social identity is in fact important to understand the effort level that players choose in group contest.

Over-expenditure in group contest and the possible causes of it have been studied in environments where equilibrium decisions imply a positive effort, but we are not aware of any study that investigates the case when no effort is a dominant strategy for the subjects.

3.1.1 Heterogeneity in behavior

While the theoretical predictions are mostly based on symmetry, in real life individuals differ in a myriad of ways that may affect their behavior. In most experimental studies on group contest some degree of heterogeneous behavior can be observed. For instance, in Abbink et al. (2010), on average, the most contributing group member expends three times more effort than the least contributing member.[12] We do not only observe heterogeneity on the individual level, but also on the group level. In Abbink et al. (2010), for instance, the most competitive group made six times more effort than the least competitive group.

Besides the principal aim to see if behavior is different under the egalitarian and the inverse proportional rule, another objective of this study is to investigate which individual characteristics and to which extent associate with differences in individual behavior. Sheremeta (2018) pursues the same goal studying individual contests. He elicits loss and risk aversion, cognitive abilities and impulsiveness. He shows that cognitive abilities affect overbidding, but impulsiveness has an even larger predictive power.

3.2 Hypotheses

Prior to running the experiment, we registered it at the Open Science Foundation (https://osf.io/93aus/).[13]

Hypothesis 1 (egalitarian vs. inverse proportional prize sharing): Effort will be significantly lower in the treatment with the inverse proportional prize sharing than in the treatment with the egalitarian rule.

Note that even the egalitarian rule (used, for instance, in Nalbantian and Schotter 1997; Abbink et al. 2010, 2012; Ahn et al. 2011; Sheremeta 2011; Cason et al. 2012, 2017) provides incentives for free riding, because a participant would receive the same

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[12] Theoretically, the existence of asymmetric equilibria may explain why we observe different levels of effort (see, for instance, Baik 1993, 1994).

[13] In the pre-registration we formulated two sets of hypotheses. Hypothesis 1 refers to the treatment effect and conjectures lower effort in the inverse proportional treatment than in the egalitarian treatment. We complement them by testing also if efforts remain positive under the inverse proportional rule. In the second set of hypotheses (Hypotheses 2–5), in an exploratory analysis we study how different individual characteristics may affect individual effort in the group contest, and they are conjectured based on the insights provided by the literature. Here we lump together the second set of hypotheses into one conjecture. In the registration we used a slightly different wording, i.e., instead of effort we used the term contribution.

share of the prize even upon making zero effort as other members of the group who exert a positive level of effort. Evidence of such possible free riding is provided by the comparison of the egalitarian and the proportional sharing rule. Amaldoss et al. (2000), Gunnthorsdottir and Rapoport (2006) and Kugler et al. (2010) find that the proportional sharing rule leads to higher individual efforts than the egalitarian rule. Since the inverse proportional sharing rule disincentivizes effort even more than the egalitarian rule, we expect that under the former rule individual efforts will be significantly lower than under the latter one.

Hypothesis 2 (positive effort in inverse proportional prize sharing): Effort will be significantly different from zero in the treatment with the inverse proportional prize sharing rule.

Given the persistent presence of over-expenditure, we expect to see it also in our experiment, even though positive individual contributions are extremely disincentivized. With this hypothesis, we want to test if the group contest structure promotes effort *per se*, even when there are no incentives to make any effort from an individual point of view.

We also want to explore how over-expenditure is associated with individual characteristics.

Conjectures (level of effort and individual characteristics):

– The higher the individual social value orientation, the higher the effort in the group contest.
– The more risk averse an individual is, the less effort she makes in the group contest, *ceteris paribus*.
– The higher the contribution in the public goods game, the higher the effort in the group contest.
– Competitiveness is associated to effort in the group contest.

Based on the literature about social value orientation, altruist and prosocial participants should tend to contribute more to the performance of the group than individualistic or competitive subjects. Balliet et al. (2009) and Bogaert et al. (2008) show that social value orientation correlates with cooperation in social dilemmas, altruist and prosocial individuals behaving in a more cooperative manner than individuals classified as individualists or competitors. Field studies also reveal that proself individuals behave differently from prosocial individuals.[14]

Contributing to the group performance is risky because winning the prize depends on how much effort the other members make and on the total effort of the other group. These are factors beyond the control of the subjects and represent a source of uncertainty. Not contributing to the group performance lowers the probability of winning the prize but increases the amount of earnings because the money not contributed is a certain earning for the participants. Since due to the contest nature effort is even more risky than in a simple public goods game, we hypothesize that anything else being equal more risk aversion associates with less effort. There are several studies that show that risk attitudes correlate with contribution in public goods game (Sabater-Grande

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[14] For instance McClintock and Allison (1989) show that prosocial individuals exhibit more helping behavior than proself ones. The same is found in case of pro-environmental initiatives (Joireman et al. 2001) or choice between public transportation vs. commuting by car (Van Vugt et al. 1995, 1996).

and Georgantzis 2002; Lange et al. 2007; Charness and Villeval 2009; Gangadharan and Nemes 2009), more risk averse individuals contributing less.

It is natural to think that those participants who are more cooperative in the public goods game will be more cooperative in the group contests as well, independently of the sharing rule. In the group contests that we study there is a tension between individual and group interests. Contributing more to the group performance increases the probability of winning, but lowers the individual earning, *ceteris paribus*. This conflict is more pronounced in the case of the inverse proportional treatment than in the egalitarian case. Contribution to the public account in the public goods game is regarded as a proxy for cooperativeness (e.g., Chaudhuri 2011). Peysakhovich et al. (2014) show convincingly that on the individual level decisions in different cooperation games are strongly correlated.

Regarding competitiveness, note that competition is present on two levels. Groups compete against each other, but on the individual level there is a competition between the members of the same group. If the group competition motive dominates, then the individuals who are more competitive are expected to make more effort. If the competition on the individual level is stronger than the group competition, then we expect the opposite to happen. Thus, competitiveness seems relevant to explain behavior in our design, although it is not clear which direction should dominate.

4 Experiment

The experiment consisted of 2 sessions, each corresponding to an experimental treatment characterized by a different sharing rule. Each session had 5 phases and a debriefing questionnaire. In both treatments, phase 1 corresponded to the group contest, while later phases represented experimental games to gather information about the participants' characteristics.

We made clear to participants that

– during the phases they would earn tokens that at the end would be converted into Euros;
– the exchange rate may change between phases, but in any case more tokens implied more Euros[15];
– their final payoff would be the sum of two payoffs (performance in phase 1 and in one of the other 4 phases, randomly chosen by the computer) plus the show-up fee;
– after the 5 phases there would be a questionnaire and after finishing the questionnaire they would be paid in private.

In the group contest phase, first groups of four subjects were formed randomly and anonymously. There were 14 groups of 4 individuals in each session. This phase consisted of 20 rounds during which groups were fixed. Each group played against another group, called rival group, such that the pair of rival groups was also fixed across all experimental rounds (as, for instance in Abbink et al. 2010).

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[15] We changed the exchange rates between tasks in a way that in expected terms the payoffs in the different phases be equal.

At the beginning of each round, each subject received 1000 tokens that she could use to buy competition tokens for her group, one competition token costing one token. The tokens not used for buying competition tokens remained on the account of the subject. Subjects knew that the same conditions applied to the other members of the group.

After each round, the amount of the competition tokens a group had accumulated determined the chance of winning the contest. More concretely, imagine groups A and B. Suppose that members of group A/B have bought 1000/2000 competition tokens. Then, group B had twice as high probability of winning the contest (2/3) than group A (1/3).[16]

The group that won the contest received a prize of 4000 tokens. In the *egalitarian* treatment, each member of the winning group received the same amount of the prize, that is 1000 tokens. The payoff of any member of the group is the sum of the tokens that the participant did not use to buy competition tokens plus an equal share of the prize (if her group wins).[17] In the *inverse proportional* treatment, the less competition tokens a member of the winning group bought, the higher is her share from the prize.[18]

In both treatments at the end of each round, each participant obtained the following information:

– the number of competition tokens that she bought;
– the total number of competition tokens that the group accumulated;
– the total number of competition tokens that the rival group accumulated;
– whether the group the participant belongs to is the winner group;
– individual's payoff in the round, expressed in tokens.

In both treatments, earnings in this phase consisted of the sum of the payoffs of 5 randomly chosen rounds (as, for instance, in Chowdhury et al. 2014, 2016). Subjects knew that their earnings would be converted into Euros at the end of the experiment at the following exchange rate: 1000 tokens = 1.2 euros. At the end of the phase, each participant was provided the information on the five rounds randomly chosen to be paid to the participant and on individual's payoff per phase in tokens and in euros.

The rest of the phases was the same in both treatments. In phase 2 we measured social preferences using the social value orientation Murphy et al. (2011). Phase 3 consisted of a one-shot play of the public goods game. Phase 4 served to elicit risk attitudes using

[16] A wheel of fortune determined which group won the contest in the following way. Following the previous example, two-third of the wheel would belong to group B and the rest to group A, and after spinning the wheel the winner is the group over whose territory the pointer of the wheel stopped. We made clear that the probability of winning increased in the number of competition tokens.

[17] For instance, if a participant uses 350 tokens from her initial endowment of 1000 tokens to buy competition tokens and her group wins the contest, then her final payoff is $(1000 - 350) + 1000 = 1650$ tokens. If the other group wins, then her payoff is just $1000 - 350 = 650$.

[18] In the instructions we explained the division of the prize in this treatment using the following example. Assume a group that consists of subjects A,B,C and D who have bought 100, 200, 400 and 400 competition tokens, respectively. Suppose that this group wins the contest. Subjects A/B/C/D would receive 2000/1000/500/500 tokens from the prize. In turn, it implies that in this round the payoff of A is $(1000 - 100) + 2000 = 2900$, the payoff of B is $(1000 - 200) + 1000 = 1800$, while C and D would receive $(1000 - 400) + 500 = 1100$ tokens, both. As in the other treatment, if the other group wins, then the group receives no prize and the final payoff equals the initial endowment minus the tokens used to buy competition tokens, that is A/B/C/D receives 900/800/600/600 tokens.

the bomb risk elicitation task (Crosetto and Filippin 2013). In phase 5, we measured participants' competitiveness using the Niederle–Vesterlund experimental procedure (Niederle and Vesterlund 2007). Finally, at the end of the experiment, subjects had to fill in a debriefing questionnaire. We gathered socio-demographic information and biological features. We explain each phase in more detail in Appendix B.

4.1 Procedures

We ran the experiment in July, 2018 in the laboratory of LINEEX (Valencia, Spain). Fifty-six individuals (corresponding to 14 four-member groups) participated in each session.[19] In the egalitarian and inversely proportional treatment 39.3% and 66.1% of the subjects were females, respectively.

Sessions lasted about two hours and participants earned on average 18 Euros. There were subjects studying Economics or Business, but 36% of the participants studied social sciences, 22% engineering and architecture, 16% health sciences and 5% arts and humanities.

5 Results

5.1 Egalitarian and inverse proportional sharing rule

Figure 1 shows the histograms of individual efforts in the two experimental treatments. In the inverse proportional treatment, effort is clearly more skewed to the left than in the egalitarian treatment, resulting in overall less effort. Two-sample Wilcoxon rank-sum test rejects ($p < 0.001$) the equality of the efforts in the two treatments.[20]

Figure 2 shows the average effort per period in the two treatments. Visual inspection strongly suggests a treatment effect, as in the egalitarian treatment the average effort is considerably higher in each period (except in period 1) than in the inverse proportional treatment.

The average effort in the egalitarian treatment is 332.3, while in the inverse proportional treatment it is 124.8, the former being more than 2.5 times larger than the latter. The difference persists over time, efforts being consistently lower in the inverse proportional treatment. In the first five rounds, the average effort is equal to 353.3/183.8 in the egalitarian/inverse proportional treatment, the former being 92% more; for rounds 6 to 10 the same numbers are 371 and 129.5 (186% more); for rounds 11 to 15 the average efforts are 319.1 and 100.2 (218% more); and for rounds 16 to 20 they equal to 303.8 and 92.3 (229% more). The two-sample Wilcoxon rank-sum test confirms that there is a significant difference in individual efforts between treatments ($p < 0.001$), and the difference is also significant for all periods (except period 1) between the two treatments ($p < 0.001$ in all cases).

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[19] In the absence of previous findings on the effect of the inverse proportional sharing rule, we could not determine the appropriate sample size using power calculations. We followed closely the design implemented in Abbink et al. (2010), including the number of groups.

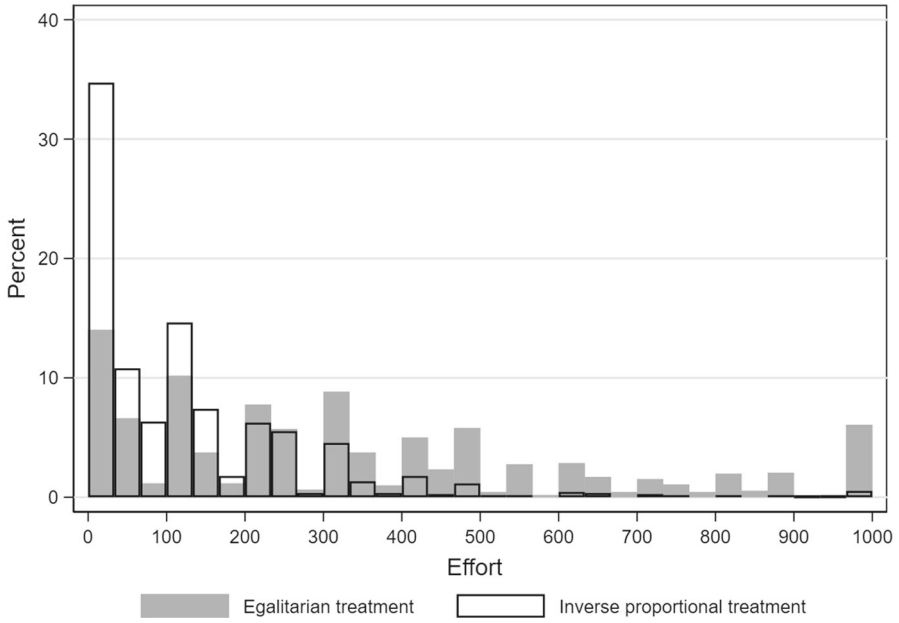[20] Matching group per experimental treatment is the unit of observation for the nonparametric test.

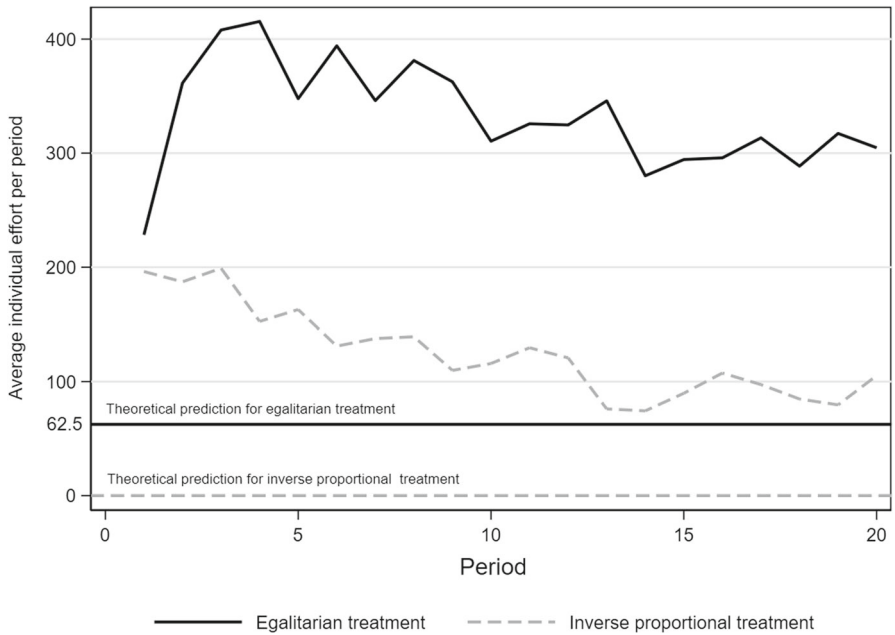**Fig. 1** Histogram of individual efforts in the treatments

Fig. 2 Average individual effort per period in the treatments (horizontal lines indicate theoretical predictions)
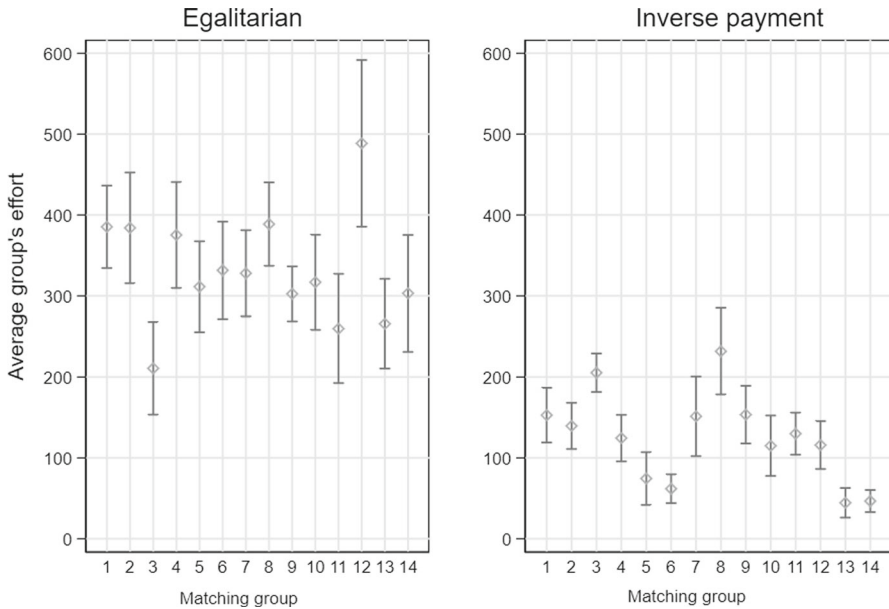
Fig. 3 Heterogeneity in efforts within and between groups (95% confidence interval)

In both treatments we observe a marked downward trend. We check for the presence of a downward trend in both treatments through a within-subject analysis by comparing decisions in the first and last five rounds. A statistically significant lower effort in the last 5 rounds is found relative to the first 5 rounds in both treatments (Wilcoxon signed-rank test, p value = 0.085/<0.001 in the egalitarian/inverse proportional treatment).

The theoretical symmetric prediction for the egalitarian treatment is 62.5. Given average effort of 332.2, we have an 431.5% over-expenditure in the egalitarian treatment, on average. Similarly, the average effort of 124.8 tokens in the inverse proportional treatment is much higher than the predicted zero effort. Hence, although effort in the inverse proportional treatment is significantly lower, than in the egalitarian treatment, we observe over-expenditure even in the inverse proportional treatment. Moreover, we find that this high level of effort remains even at the end of the experiment. Observing a decrease in the effort across rounds in each experimental treatment, we test differences between predicted and actual effort exerted by participants in the last 5 rounds, which is 303.9 and 94.9 in egalitarian and inverse proportional treatment, respectively. t-test shows statistically significant differences in average effort with respect to the predicted effort of 62.5 in egalitarian and 0 in the inverse proportional treatment ($p < 0.001$ in both treatments), which implies the presence of the over-expenditure in both treatments even at the end of the group contest phase.

The above descriptive statistics and tests strongly suggest that there is a difference in the behavior of participants between treatments. Subjects in the egalitarian treatment on average made considerably more effort than participants in the inverse proportional treatment. Furthermore, in both treatments we document a sizable over-expenditure.

The previous findings are silent about the heterogeneity within and between groups. It is natural to ask to which extent the treatment effect is general or due to some groups with extreme efforts, and if the sharing rule influences variance of behavior within groups. Figure 3 indicates that the treatment effect is general as most of the group efforts in the egalitarian treatment are clearly above the group efforts in the inverse proportional treatment.[21] In both treatments, there is considerable heterogeneity between groups. Within groups the heterogeneity seems to be higher in the egalitarian treatment, but it can be due to a higher level of efforts overall. If we adjust for the level of effort and calculate the coefficient of variation, then the average coefficient of variation in the egalitarian treatment (0.843) is lower than in the inverse proportional treatment (1.210).[22] Overall, the inverse proportional sharing rule leads to less effort in general and is associated with more varied behavior.

Besides the treatment, we are also interested in the association between individual effort and economic preferences. Table 1 shows average individual effort in both treatments measured in phase 1 according to the terciles of cooperation measured in phase 3, and risk tolerance measured in phase 4. For instance, 216/87 in the top left cell indicates that participants who were the least risk tolerant and least cooperative contributed on average 216/87 tokens in the egalitarian/inverse proportional treatment. In line with the previous descriptive statistics, in all instances efforts in the egalitarian treatment are larger than efforts in the inverse proportional treatment. Moreover, holding constant risk tolerance, we see that more cooperative participants tend to make more efforts in both treatments, in line with our corresponding hypothesis. However, the association between risk tolerance and individual effort is not clear, in contrast to our conjecture.[23]

5.2 Regression analysis

To investigate the effect of the sharing rule and the different individual characteristics, we proceed with a regression analysis. The variable *Treatment* is a dummy variable which equals 1 if the observation comes from the inverse proportional treatment. *Prosocial* is a binary variable which is equal to 1 if the individual is classified as a prosocial one in the social value orientation task. Risk attitude is represented by the variable *Risk preferences* that measures the number of boxes the participant decided to take out of the store in the bomb risk elicitation task. The higher this number, the more risk-tolerant a subject is. From the public goods game, the variable *Contribution* indicates the amount of tokens contributed to the common project and is a natural measure of cooperativeness: the higher the amount, the more cooperative is the participant. *Competitiveness* is a dummy variable with value 1 if the subject chose the tourna-

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[21] If we compute average group efforts, the two-sample Wilcoxon rank-sum test confirms that there is a significant difference in group efforts between treatments ($p < 0.001$).

[22] Considering the coefficient of variation on the group level, the two-sample Wilcoxon rank-sum test confirms that the coefficient of variation is lower in the egalitarian treatment ($p < 0.06$).

[23] Note that while in the case of risk tolerance the intervals of the terciles are very similar in both treatments, we see sizable differences in cooperativeness. It may be due to the fact that these preferences were measured after the group contest, so experiences in the group contest may have affected cooperativeness. Nevertheless, it is still true that cooperativeness and effort in the group contest are positively associated.

Table 1 Individual effort in treatments according to cooperation and risk tolerance

Risk tolerance	Cooperation		
	Tercile 1 Egalitarian/inverse (≤ 200)/(≤ 100)	Tercile 2 Egalitarian/inverse (200 < ≤ 450)/(100 < ≤ 250)	Tercile 3 Egalitarian/inverse (450 <)/(250 <)
Tercile 1			
Egalitarian/Inverse	216/87	297/141	463/182
(≤ 40)/(≤ 35)	(256)/(124)	(177)/(119)	(325)/(138)
Tercile 2			
Egalitarian/Inverse	276/134	300/129	319/146
(40 < ≤ 50)/(35 < ≤ 50)	(312)/(194)	(212)/(134)	(250)/(164)
Tercile 3			
Egalitarian/Inverse	287/67	451/92	462/194
(50 <)/(50 <)	(220)/(151)	(332)/(82)	(332)/(244)

The numbers in parentheses below the treatments' names indicate the values of the corresponding terciles. For example, for cooperation ≤ 200 indicates that in the lowest tercile participants contributed less or equal to 200 units in the public goods game
Each cell provides the mean and the standard deviation (in parentheses) of individuals' effort per experimental treatment

ment payment instead of the piece-rate payment in the competition task (Niederle and Vesterlund 2007).

In Fig. 2 we see a clear declining pattern of the effort, so we control for that by introducing the variable *Period* indicating the period that the decision was made in. We also consider the possibility that effort made in the previous period may be correlated with effort in the current period, so we include the variable *Effort* $(t-1)$ in the specifications (3)–(5). To account for past decisions, we include the variables *Group (-i's) total effort* $(t-1)$ and *Rival group's total effort* $(t-1)$ that indicate the total effort of the participant's group (excluding own effort that is captured already by *Effort* $(t-1)$) and the total effort of the rival group in the previous period, respectively. These variables control partially for the probability of having won the contest in the last period.

We also consider a wide range of controls grouped into socio-demographics, linguistic and cognitive ability and personality characteristics.[24] In all the regressions standard errors are clustered on the group level.

In Table 2, in specifications 1–3 we see a clear treatment effect (significant at 1%), indicating that in the inverse proportional treatment participants make less effort. In specifications 4 and 5, when we introduce interaction terms between treatment and our variables of interest, the coefficient of *Treatment* decreases moderately, and it ceases to be significant, indicating that the interaction terms absorb the effect of treatment.

As expected, the variable *Period* is negative and significant, reflecting the downward trend in effort. The lack of significance in the interaction term reveals that this effect is not substantially different between treatments. Own previous effort (*Effort* $(t-1)$) is consistently significant and positive, indicating that participants who make a great effort in a period tend to do so in the next one as well. When interacted with treatment, the coefficient is negative and significant, showing that overall the positive correlation in own effort between subsequent periods is weaker in the inverse proportional treatment. The variable capturing the effort of the other group members (*Group (-i's) effort* $(t-1)$) is consistently significant and negative, showing that a major total effort by the other group members tends to make the participant exert less effort. The interaction with treatment is consistently significant, positive and of comparable magnitude, indicating that *Group (-i's) effort* $(t-1)$ does not affect effort in the inverse proportional treatment. The total effort of the rival group in the previous period (*Rival group tot. effor* $(t-1)$) has a similar effect as the total effort of the other group members: the higher the total effort of the rival group in $t-1$, the lower the participant's effort in period t. The corresponding interaction term indicates that in the inverse proportional treatment this negative association is more than compensated by an opposite effect.

Turning to the measured preferences, prosociality as captured by the social value orientation is not associated with the participants' efforts, even the sign of the coef-

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[24] Socio-demographics comprises variables like female, age, body mass index, academic degree, digit ratio, breadwinner, breadwinner's employment, number of siblings, and hours worked per week. Linguistic and cognitive ability refers to participant's command of more than two languages and cognitive abilities were measured through cognitive reflection test. Related to personality, we consider personality traits as agreeableness, conscientiousness, extraversion, neuroticism and openness from the BIG5 and subject's self-reported self-esteem and happiness. See Appendix G for a more detailed discussion on these variables.

Table 2 Determinants of individual effort (Random effect panel linear model)

	(1)	(2)	(3)	(4)	(5)
Treatment (=1 if Inverse)	− 200.365***	− 175.695***	− 161.729***	− 133.597	− 140.575
	(20.437)	(23.247)	(18.497)	(88.205)	(88.308)
Prosocial (SVO)		− 6.215	− 12.094	2.358	2.757
		(22.800)	(16.984)	(26.475)	(25.243)
Risk pref.s (Bomb task)		0.756	0.379	1.562	1.024
		(0.969)	(0.610)	(0.961)	(1.121)
Contribution (PGG)		0.180**	0.109**	0.119**	0.126**
		(0.074)	(0.049)	(0.056)	(0.063)
Competitiveness (Niederle and Vesterlund 2007)		− 10.647	− 5.214	− 41.937**	− 40.366**
		(23.954)	(14.428)	(20.234)	(19.032)
Period			− 4.388***	− 3.099*	− 3.145*
			(1.018)	(1.862)	(1.867)
Effort ($t − 1$)			0.376***	0.395***	0.373***
			(0.068)	(0.072)	(0.075)
Group(-i's) effort ($t − 1$)			− 0.051***	− 0.065***	− 0.062***
			(0.018)	(0.021)	(0.022)
Rival group tot. effor ($t − 1$)			− 0.022*	− 0.051***	− 0.044***
			(0.012)	(0.013)	(0.012)
Treatment*Prosocial				− 3.522	− 13.401
				(38.787)	(33.823)
Treatment*Risk pref.s				− 2.062*	− 1.383
				(1.231)	(1.457)

Table 2 continued

	(1)	(2)	(3)	(4)	(5)
Treatment*Contribution				-0.004	-0.021
				(0.081)	(0.080)
Treatment*Competitiveness				63.077***	58.618**
				(23.844)	(23.599)
Treatment*Period				-2.686	-2.601
				(2.629)	(2.633)
Treatment*Effort ($t-1$)				-0.180**	-0.161**
				(0.073)	(0.069)
Treatment*Group(-i's) effort ($t-1$)				0.053**	0.047*
				(0.027)	(0.027)
Treatment*Rival group effort				0.079***	0.072***
				(0.019)	(0.018)
Socio-demographics (9 variables)	YES	YES	YES	YES	YES
Linguistic and cogn. ability (3 variables)	NO	NO	NO	NO	YES
Personality traits (7 variables)	NO	NO	NO	NO	YES
Constant	-17.267	6.476	176.713	167.431	409.226
	(279.534)	(306.172)	(187.549)	(188.513)	(256.069)
Observations	2240	2240	2128	2128	2128

Standard errors clustered on the group level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Socio-demographics: Female, Age, Body Mass Index, Academic degree, 2-4DR(left hand),Number of siblings
Breadwinner, Breadwin.'s employm., Work (hrs/week). Linguistic and cogn. ability: Reflective, (Ir)reflecitve
Number of languages. Personality traits: Agreeableness, Conscientiousness, Extraversion, Neuroticism
Openness, Happiness (degree), Self-esteem

ficient is changing. If we interact this variable with treatment, we do not see any significant effect either. Risk tolerance exhibits a consistent positive association with effort, more risk-tolerant subjects making more effort, but the coefficient fails to be significant. The interaction between risk attitudes and treatment does not reveal any consistently significant association. Cooperativeness proxied by contribution in the public goods game has a consistent and significant positive coefficient in all specifications, indicating that more cooperative individuals tend to make more effort in group contest, *ceteris paribus*. The effect of cooperativeness is not contingent on treatment, as indicated by the interaction term. Turning to competitiveness, in specifications (4) and (5), competitiveness and the interaction term involving competitiveness are significant and of comparable magnitude, but with opposite sign, suggesting that in the egalitarian treatment competitive participants tend to make less effort, but in the inverse proportional treatment there is no difference in effort as a function of competitiveness.[25] Appendix D.4 shows that including a dummy variable of whether the group won the contest in period $t - 1$ does not change the findings, as neither the dummy, nor the corresponding interaction term is significant in any specification.

In Appendix F we carry out the same analysis, but separately for each treatment. This analysis reveals that cooperativeness has a markedly lower effect in the egalitarian treatment than in the inverse proportional treatment. Prosociality, risk attitudes and competitiveness do not show a consistently significant association with effort in these regressions. Own effort in the previous period has the same effect as in Table 2, but the magnitude is considerably lower in the inverse proportional treatment. The group's and the rival group's total effort in the previous period have similar coefficients as before in the egalitarian treatment. However, the coefficients of these variables fail to be significant in the inverse proportional treatment.

From the rest of the variables that we used as controls, among personality traits, we find that conscientiousness tends to have a negative effect on the effort, while agreeableness associates in the same way with effort in the egalitarian treatment (see Table 11 and Table 12 in Appendix G, respectively). As for the set of socio-demographic variables, we do not observe consistent patterns that hold consistently across the treatments.

6 Conclusion

Over-expenditure in group contests is a puzzling phenomenon that attracted the attention of many scholars. In this paper, we investigated if a new sharing rule (called inverse proportional) that theoretically strongly disincentivizes effort eliminates over-expenditure or not. The sharing rule is based on the idea that in coopetitive environments where members of the same group cooperate and compete with each other at the same time face a resource constraint: More resources spent on cooperation lowers the capacity to compete. Therefore, the sharing rule assumes that less cooper-

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[25] Our measure of competitiveness may depend on the beliefs of the individual about her own performance relative to the members of the group. To take it into account, in Appendix E we estimate the same model controlling for the beliefs of the individual about her performance, and the effects of competitiveness remain similar.

ation proportionally increases the capacity to capture a larger share of the prize. In a laboratory experiment, we compare behavior under this new rule to behavior observed when the prize is shared in an egalitarian way. In line with the theoretical prediction, we document that less effort is made under the inverse proportional rule than under the egalitarian one. However, still we observe a substantial over-expenditure that does not vanish even at the end of the experiment.

To understand better the behavior of the participants we also measured economic preferences. We see that more cooperative participants choose a higher level of effort in both treatments. Competitive preferences have some effect in the inverse proportional treatment: more competitive participants contributing larger amounts from their endowment. Social and risk preferences do not seem to have any effect.

A Theoretical predictions

In this section we derive the theoretical predictions of the model.

A.1 Egalitarian case

Given perfect substitution in the performance function, homogeneous linear costs, a lottery contest success function ($r = 1$), equal group sizes ($N_A = N_B = N$) and the egalitarian sharing rule, the expected payoff of a risk-neutral player i in group A can be written as:

$$\pi_{iA}(x_{1A}, \ldots x_{NA}, X_B) = \frac{\sum_{i=1}^{N} x_{iA}}{(\sum_{i=1}^{N} x_{iA} + \sum_{j=1}^{N} x_{jB})} \frac{1}{N} \upsilon - x_{iA} \qquad (9)$$

As in Katz et al. ([1990](#)), we use the Nash equilibrium to find the solution. Assuming a regular interior solution, the first-order condition for members of group A is

$$\frac{\partial \pi_{iA}}{\partial x_{iA}} = \frac{\sum_{j=1}^{N} x_{jB}}{(\sum_{i=1}^{N} x_{iA} + \sum_{j=1}^{N} x_{jB})^2} \frac{1}{N} \upsilon - 1 = 0 \tag{10}$$

Similarly, for group B

$$\frac{\partial \pi_{jB}}{\partial x_{jB}} = \frac{\sum_{j=1}^{N} x_{iA}}{(\sum_{i=1}^{N} x_{iA} + \sum_{j=1}^{N} x_{jB})^2} \frac{1}{N} \upsilon - 1 = 0 \tag{11}$$

In a symmetric equilibrium, $x_{1A} = x_{2A}.. = x_{iA} = .. = x_{NA}$ and $x_{1B} = x_{2B}.. = x_{jB} = .. = x_{NB}$, the previous conditions become

$$\frac{\partial \pi_{iA}}{\partial x_{iA}} = \frac{x_{jB}}{N^2(x_{iA}^2 + 2x_{iA}x_{jB} + x_{jB}^2)} \upsilon - 1 = 0 \tag{12}$$

and

$$\frac{\partial \pi_{jB}}{\partial x_{jB}} = \frac{x_{iA}}{N^2(x_{iA}^2 + 2x_{iA}x_{jB} + x_{jB}^2)} \upsilon - 1 = 0 \tag{13}$$

These first-order conditions imply that in equilibrium $x_{iA}^* = x_{jB}^*$. As a consequence, we obtain that

$$x_{1A}^* = .. = x_{iA}^* = .. = x_{NA}^* = \frac{\upsilon}{4N^2} \tag{14}$$

A.2 Inverse proportional case

In the proof, we will use the following additional notation:

$$X_{A-i} = \sum_{j \in A, j \neq i} x_j$$

By our definition the inverse proportional rule implies the following expected pay-offs:

$$\pi_i \left(x_{i,A}, X_{A-i}, X_B \right) = \frac{X_A}{X_A + X_B} \frac{x_{i,A}^{-1}}{\sum_{j \in A} x_j^{-1}} \upsilon - x_{i,A} \quad \text{if} \quad _{i,A} > 0 \tag{15}$$

$$\pi_i \left(0, X_{A-i}, X_B \right) = \frac{X_{A-i}}{X_{A-i} + X_B} \upsilon \quad \text{if} \quad \$X_{A-i} > 0 \tag{16}$$

The second line specifies that if all other members of group A make a positive effort while member i makes zero effort, then in case group A wins the contest, member i will receive the whole prize.

Next, we prove that the individual payoff upon making a positive effort is less than the payoff related to zero effort, conditional on all the other members of the group making a positive effort:

$$\pi_i\left(x_{i,A}X_{A-i}, X_B\right) - \pi_i\left(0, X_{A-i}, X_B\right) = \frac{X_A}{X_A + X_B} \frac{x_{i,A}^{-1}}{\sum_{j\epsilon A} x_j^{-1}} v - x_{i,A} - \frac{X_{A-i}}{X_{A-i} + X_B} v$$

$$= \left[\frac{X_A}{(X_A + X_B)} \frac{x_{i,A}^{-1}}{\left(\sum_{j\epsilon A} x_j^{-1}\right)} - \frac{X_{A-i}}{(X_{A-i} + X_B)}\right] v - x_{i,A}$$

$$= \left[\frac{X_A \cdot x_{i,A}^{-1} \cdot (X_{A-i} + X_B) - X_{A-i} \cdot (X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)}{(X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)(X_{A-i} + X_B)}\right] v - x_{i,A}$$

$$= \left[\frac{X_A \cdot x_{i,A}^{-1} \cdot X_{A-i} + X_A \cdot x_{i,A}^{-1} \cdot X_B - X_{A-i} \cdot X_A \cdot \left(\sum_{j\epsilon A} x_j^{-1}\right) - X_{A-i} \cdot X_B \cdot \left(\sum_{j\epsilon A} x_j^{-1}\right)}{(X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)(X_{A-i} + X_B)}\right] v - x_{i,A}$$

$$= \left[\frac{X_B - X_{A-i} \cdot X_A \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right) - X_{A-i} \cdot X_B \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right)}{(X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)(X_{A-i} + X_B)}\right] v - x_{i,A}$$

$$= \left[\frac{\left[1 - X_{A-i} \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right)\right] X_B - X_{A-i} \cdot X_A \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right)}{(X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)(X_{A-i} + X_B)}\right] v - x_{i,A}$$

$$= \left[\frac{\left[1 - \left(\sum_{j\epsilon A, j\neq i} x_j\right) \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right)\right] X_B - X_{A-i} \cdot X_A \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right)}{(X_A + X_B)\left(\sum_{j\epsilon A} x_j^{-1}\right)(X_{A-i} + X_B)}\right] v - x_{i,A} < 0 \quad (17)$$

since $\left(\sum_{j\epsilon A, j\neq i} x_j\right) \cdot \left(\sum_{j\epsilon A, j\neq i} x_j^{-1}\right) > 1$ always.

Hence, we proved that

$$\pi_i\left(x_{i,A}X_{A-i}, X_B\right) - \pi_i\left(0, X_{A-i}, X_B\right) < 0,$$

so making zero effort yields always a higher payoff than making a positive effort if the other members of the group make a positive effort.

We turn now to the case when another member of the group makes zero effort. In this case, making a positive effort would yield the loss of the effort, because if the group wins the contest, then the member with zero effort obtains the whole prize, while in case of losing the contest the effort is lost anyway. Therefore, if another member of the group makes zero effort, then making zero effort yields a payoff that is higher than the payoff related to a positive effort.

The same argument applies also if nobody in the group makes a positive effort.

Thus, we have shown that to make zero effort leads always to higher payoffs than to make a positive effort in the case of the inverse proportional sharing rule.

B Experimental phases after contest game

In phase 2 we measured social preferences using the social value orientation. There are various ways to measure social value orientation, we followed Murphy et al. (2011).

Participants were randomly paired and each of them had to make 6 decisions. In each decision, subjects saw 9 pairs of payoff allocations, each allocation containing a payoff for the decision-maker and a payoff for her co-player. The decision-maker had to choose in all 6 decisions her preferred joint payoff distribution. Choices can be scored to come up with a single score. Social value orientation conceptualizes four idealized orientations:

– altruists maximize the allocation for the other party;
– prosocial individuals tend to maximize their own payoffs, but care also about the other player's payoff;
– subjects with individualistic tendencies are not concerned about the other player, they just maximize their own payoffs;
– competitive individuals attempt to maximize their own payoffs, but at the same time also minimize the other player's payoff.

The score achieved after choosing the 6 allocation allows to classify participants in one of the above categories. Participants knew that if at the end of the experiment this phase would be chosen for payment, then the computer would pick one of the six decisions and would randomly choose one of the participants in each pair (called the elector) and the allocation chosen by the elector in the given decision would be paid. The exchange rate used for payment was 1 token = 0.02 Euros.

Phase 3 consisted of a one-shot play of the public goods game. We aimed to measure cooperativeness with this game. We presented the most widely used format of the public goods game, with four players, each of them endowed with 1000 tokens. Participants had to decide how much of the endowment to assign to a public account, knowing that everybody in the group would receive 40% of the total amount assigned to the public account (that is, marginal per capita return = 40%). The earning of a subject in this phase consisted of the amount received from the public account plus the amount not assigned to the public account. The exchange rate used for payment was 1 token = 0.02 Euros.

Phase 4 served to elicit risk attitudes using the bomb risk elicitation task (Crosetto and Filippin 2013).[26] Participants were presented the following situation. There was a store with 100 boxes, one of them containing a bomb. The bomb could be in any of the boxes with the same probability. Subjects had to decide how many boxes they wanted to take out of the store. For each box taken out that did not contain the bomb, they received money (1 token), but if the bomb happened to be in one of the boxes that had been taken out, then their payoff in this task was zero. We explained that if, for example, they decide to take out 7 boxes and the bomb is in box 42, then they would earn 7 tokens. However, if a participant decides to remove 56 boxes from the store and the bomb is in box 51, then her earning is zero. We informed participants that if at the end of the experiment this task is the payoff-relevant task, the exchange rate would be 1 token = 0.1 Euros.

In phase 5, we measured participants' competitiveness using the Niederle–Vesterlund experimental procedure (Niederle and Vesterlund 2007). The only modifi-

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[26] Crosetto and Filippin (2016) compare four risk elicitation methods, among them the bomb risk elicitation task. They show the pros and cons of each method and argue convincingly that the bomb risk elicitation task is appropriate to distinguish between subjects based on their risk attitudes.

cation compared to the original study is that we used the slider task (Gill and Prowse 2011, 2018) instead of adding up numbers as experimental task. Following Niederle and Vesterlund (2007), this phase consisted of 4 subphases. In subphase 1, subjects performed the slider task (positioning as many sliders on the number 50 as they could in one minute) knowing that they would be paid on a piece-rate basis, earning 1 token for each correctly positioned slider. We also explained that if at the end of the experiment this task would be chosen for payment, then the exchange rate would be 1 token = 0.15 Euros. In subphase 2, before playing again the slider task, groups of 4 members were formed randomly and we informed participants that they would be paid as in a tournament. More concretely, we told them that only the member of the group with the highest number of correctly placed sliders receives a payoff, but she receives 4 tokens for each correctly positioned slider.[27] We used the same exchange rate as before. We also informed subjects that they would not know the result of the tournament until the end of the phase. In subphase 3, we explained that they would perform again the slider task and that they could choose the way to be compensated: piece-rate payment as in subphase 1 or tournament payment as in subphase 2. Hence, we have a binary classification: participants are either competitive (if they choose the tournament) or not competitive (if they choose the piece-rate scheme). As before, we explained that we would not tell them the result of the tournament until the end of the phase. We applied the same exchange rate here as in the previous subphases. In subphase 4, participants were not required to perform the task again, but could earn money by choosing an incentive scheme (piece rate vs. tournament) to be applied to their performance in subphase 1. We reminded participants about the number of correctly positioned sliders in subphase 1. We used the same exchange rate as in the previous subphases. At the end of this subphase, participants were asked to evaluate their own performance relative to other members of the group in subphase 1 and in the subphase 2. We incentivized participants for this task. This subphase allows us to see what participants believed about their relative performance.

At the end of the experiment, subjects had to fill in a debriefing questionnaire. We gathered socio-demographic information (age, gender, educational attainment, field of study, knowledge of languages, number of siblings, education and employment of the breadwinner in the family, factors related to family income) and biological features (height, weight, dexterity: left- vs right-handed and the digit ratio).[28] We also measured cognitive abilities with a 5-item version of the cognitive reflection test (Frederick 2005; Toplak et al. 2014). We used a 10-item version of the Big Five test (Rammstedt and John 2007) to elicit personality traits and the Rosenberg test (Rosenberg 1965) to measure self-esteem. We also asked participants if they were happy in general.

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[27] We also explained that in case of a tie, the computer randomly would select one of the members with the highest number of sliders correctly positioned.

[28] We gathered information on participants' digit ratio since we believed that there might be some relationship between digit ratio and decisions in the group contest. There is a growing literature indicating that digit ratio associates with several individual characteristics, such as competitiveness, social preferences and risk aversion among other domains of economic interest (Brañas-Garza et al. 2013, 2018; Garbarino et al. 2011; Millet and Dewitte 2006; Pearson and Schipper 2012). Brañas-Garza et al. (2019) report that digit ratio has explanatory power in contests.

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