Coordination through Bargaining in Weakest-link Games

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Abstract

Coordination problems are often modeled as weakest-link games, where the minimum-contributing agent determines their group's surplus to be shared in equal parts. Yet in many settings, the sharing of a jointly-produced surplus occurs through bargaining, which acts as a double-edged sword: It can promote effort by disciplining low contributors or deter it through the added uncertainty of returns. We present experimental evidence that bargaining improves coordination by promoting equitable divisions that reward higher contributions, even in one-shot interactions. High contributors are more likely than low contributors to propose allocations that reward effort, creating a virtuous cycle that increases efficiency. Allowing groups to endogenously select who can act as proposers can backfire: Efficiency increases when high contributors are endorsed but falls otherwise. These results highlight the scope and limits of participatory surplus division mechanisms in providing incentives for efficient coordination.

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1 Introduction

Coordination problems are ubiquitous in daily life. From governments investing in fiscal coordination to business partners deciding how much time, effort, and resources to contribute towards a joint venture, the welfare consequences of coordination failure can be substantial. Many of these problems can be modeled as weakest-link games in which the payoff of each agent depends on the smallest contribution made by an agent in a group. In these games, agents have an incentive to coordinate on making the maximum contribution possible, but this exposes them to the risk of losses if one or more group members deviate to lower effort levels. The multiplicity of Pareto-ranked, strict Nash equilibria in weakest-link games has served as a cornerstone for a research program in experimental economics exploring factors that influence coordination failure (Harrison and Hirshleifer, 1989; Van Huyck et al., 1990; Weber, 2006; Brandts and Cooper, 2006; Riedl et al., 2016; Avoyan and Ramos, 2023).

A common assumption, embedded in the weakest-link game as studied throughout the literature in the social sciences, is that agents decide their contributions knowing ex ante that the surplus generated by their contributions will be equally divided among them. However, in many real-life situations, people negotiate the division of a surplus after it has been realized. For example, business partners can negotiate profit sharing once a joint venture is successful and individual contributions have been made (Schuhmacher and Wiernsperger, 2025), or governments can negotiate financial aid packages and debt relief if fiscal coordination fails due to underperformance of one country resulting in a financial crisis. Legal firms often hold end-of-year meetings to distribute earnings among partners, and in legal settlements involving many law firms[1], contingency fee distributions are often renegotiated once the settlement amount is known. A famous case concerns the litigation against the oil company BP for the 2010 Gulf of Mexico oil spill. Given the complexity of the case, several law firms collaborated by providing different types of highly specialized expertise. The contingency fee was negotiated after the settlement for the spill was reached (*Order and Reasons Establishing Fee Committee Protocol*, 2016).[2]

[1] In a survey of legal firms (Wesseman and Kerr, 2015), close to 50% implement *subjective* compensation schemes among equity partners, once profits are known and based on perceived contributions.

[2] There are many concrete examples of ex post profit sharing agreement and renegotiation following joint production decisions beyond legal cases. In the entertainment industry, actor Jack Nicholson renegotiated his profit sharing agreement after the success of Batman in 1989 and similarly did Robert Downey Jr. after the first Iron Man movie, with their respective producers. In 1992, the lead singer of the music band *Nirvana*, renegotiated his royalties with the band members after the successful results from the album *Nevermind*.

In this paper, we present results from a series of laboratory experiments exploring how ex post bargaining affects the prospects of efficient coordination in weakest-link games. Specifically, we consider majoritarian bargaining where the division of the surplus among agents depends on the preferences of the majority, i.e., the division does not require unanimous consent. Majoritarian negotiations are common in many cases (Baron and Ferejohn, 1989; Eraslan and Evdokimov, 2019; Bolton et al., 2003; Kamm and Siegenthaler, 2022; Schuhmacher and Wiernsperger, 2025), but their influence on coordination is *a priori* unclear. On the one hand, bargaining under majority rule provides agents with a mechanism to *punish* underperforming peers by excluding them from profit sharing or awarding them a lower share of the surplus. On the other hand, majoritarian bargaining introduces an extra layer of uncertainty, as even high-performing agents can be excluded from coalitions (or be insufficiently rewarded for their contributions). Thus, beyond the uncertainty induced by the vulnerability of agents to the weakest link in their group, the increased uncertainty of the surplus division can further discourage them from contributing. This issue becomes more pertinent when group members do not interact repeatedly with one another as (*i*) agents have reduced incentives to establish good surplus-sharing norms, i.e., sharing rules that provide incentives for all to maximally contribute, and (*ii*) agents are unaware of what rules will prevail ex post in the different groups they interact.

To explore how ex post bargaining affects coordination prospects, we begin by comparing behavior across conditions that differ in whether bargaining is possible or not, as in the classical weakest-link game. We find that contributions unravel toward the least efficient Nash equilibrium in a control condition where it is common knowledge that the surplus from the weakest-link game will be split equally among the agents. In sharp contrast, we observe high levels of contributions when agents bargain ex post. This happens despite the fact that participants are randomly placed in new groups after every interaction and are unable to establish a reputation. Equitable sharing emerges as the dominant rule driving surplus division, with individuals who contribute more receiving a greater share of the surplus. To further substantiate the role of equitable sharing as the driving force behind sustained contributions, we find that when subjects are unable to observe the individual contributions of each other before they bargain, efforts unravel towards the least efficient equilibrium following a very similar pattern to that of the control treatment without bargaining.

The prevalent norm of distributions based on contributions is by no means universal. Instead, we find that high contributors provide the strongest incentives by conditioning the shares offered to others on contributions made. Low contributors attempt to keep larger shares for themselves, and the shares offered to others induce only weak incentives, if any. In general, proposals put forward by individuals who contribute more face higher odds of being voted in favor by a majority.

These observations raise important institutional design questions about who gets to serve as the proposer within a group, and by what process are these individuals selected. Firms, organizations, and societies alike often grapple with these decisions. In our game, all participants have the same rights to allocate the joint resources (as in most bargaining games). We therefore ask: If individuals are granted influence over the proposer selection process, will they tend to choose those inclined toward equitable distribution? Furthermore, can an endogenous proposer selection mechanism generate additional efficiency gains relative to a system in which everyone has an exogenous and equal chance of being a proposer?

To answer these questions, we designed a separate treatment in which subjects were given the opportunity to endorse others in their group to act as proposers. Endorsements make agents more likely to be selected as proposers to distribute the joint surplus. Our results show a nuanced pattern: In sessions where high contributors are endorsed more often, a higher efficiency is obtained relative to sessions where low contributors receive more endorsements. Thus, endogenous selection of proposers can backfire relative to an equal selection mechanism if groups choose the *wrong* members for this role, as they dilute contribution incentives. In a separate treatment where proposer selection is endogenous but mechanically proportional by design (i.e., higher contributors are more likely to be proposers), we observe that contributions rise, reaching higher levels than those observed in the game with equal proposer selection.

Our study contributes to two strands of literature. First and foremost, it contributes to a body of research that explores factors conducive to efficient coordination. Previous studies have explored the role of communication (Blume and Ortmann, 2007; Knez and Camerer, 1994; Van Huyck et al., 1993), group size (Weber, 2006), action observability (Duffy and Feltovich, 2002), the cost of miscoordination (Goeree and Holt, 2005), commitment (Avoyan and Ramos, 2023), fixed group matching (Van Huyck et al., 1990), endogenous group formation (Riedl et al., 2016), incentives (Brandts and Cooper, 2006; Hamman et al., 2007), intergroup competition (Bornstein et al., 2002), punishment (Lec et al., 2023), and gender composition of groups (Chang et al., 2024). There is also a literature investigating the role of leaders in solving coordination problems (Weber et al., 2001; Brandts and Cooper, 2006, 2007). Close in spirit to our setting, Karakostas et al. (2023) studies a random allocator of the surplus and finds no significant effect on contributions of ex post redistribution. For an early review of the literature on weakest-link games, see Devetag and Ortmann (2007).

We also contribute to the literature on multilateral bargaining. Previous studies on the topic have investigated the influence on bargaining behavior of power asymmetries (Fréchette et al., 2005; Miller et al., 2018; Maaser et al., 2019), the details of the protocol and timing of moves (Fréchette et al., 2003; Kamm and Siegenthaler, 2022), endogenous agenda-setting power (Lee and Sethi, 2022; Kim and Kim, 2022), framing effects and dividing costs (Christiansen et al., 2025; Kim and Lim, 2024), an added policy dimension to the negotiation space (Christiansen et al., 2014), pre-play communication (Agranov and Tergiman, 2014), repeated interactions (Baron et al., 2017), voting rules (Miller and Vanberg, 2015), and voting behavior (Fréchette and Vespa, 2017). For a meta-analysis, see Baranski and Morton (2022) and for a review, see Montero (2025). To our knowledge, this is the first evidence on how multilateral bargaining affects coordination outcomes, and the first experiments where the proposer role in bargaining is assigned through the endorsement of other members.

This article proceeds as follows. In Section 2 we present the weakest-link game that subjects will play in our experiment. In Section 3 we explain the experimental design and state our hypotheses. Section 4 presents the main results. In Section 5 we present the second set of experiments with endogenous proposer selection and proportional proposer selection. Section 6 concludes.

2 The Weakest-Link Game with Ex-post Bargaining

Consider a group of 5 players (indexed by i) each of whom is endowed with 60 units of wealth, hereafter referred to as *tokens*. Players interact in a two-stage game. In the first stage, players make contributions that determine the creation of a surplus to be divided among them in the next stage. Specifically, each player i must choose a number of tokens to contribute $c_i \in \{0, 1, 2, ..., 60\}$ simultaneously and without communication. The total fund (or surplus) is determined as follows:

$$F(c_1, ..., c_5) = 10 \times c_{\min} + x$$

where $c_{\min} = \min\{c_1, ..., c_5\}$, and $x \geq 0$ is an exogenous "team guarantee", a constant that does not depend on individual contributions.[3]

In the second stage, after F has been realized, players bargain over its division through a sequential, majority rule, bargaining game. The bargaining stage may have many rounds, which we denote by t, until an agreement is reached. At the beginning of each round, one of the players is randomly chosen with a 1/5 chance to propose a division of F. We denote a division of the surplus by $(s_1^t, ..., s_5^t)$ where $s_j^t \in [0, 1]$ is the proportion of F offered to player j. We require that $\sum_{j=0}^{5} s_j^t = 1$, that is, that the allocations fully exhaust F. Once a proposal is made, players vote in favor or against the proposal. Proposals are approved by majority vote: if 3 or more players vote in favor, the proposed division of the surplus is approved and the result is binding. If the proposal is rejected, a new bargaining round takes place where each player has 1/5 of being the proposer. The process continues until approval.

The payoff for player i who contributes c_i tokens and receives a share s_i at the end of the second stage is:

$$\pi_i = 60 - c_i + s_i F(c_1, ..., c_5). \quad (1)$$

It is a well-established result that the bargaining stage admits any distribution of the fund as a subgame perfect Nash equilibrium (SPE) (Baron and Ferejohn, 1989; Eraslan, 2002). Therefore, the problem of equilibrium multiplicity at the contribution stage remains in the presence of ex post bargaining. In Appendix A we provide a more general presentation of the game and characterize several subgame perfect Nash equilibria, some based on canonical assumptions (stationary SPE) and other based on norms of fairness and equity (Konow, 2000). After describing the experiment design in Section 3, we present our behavioral expectations, which are both theoretically and empirically grounded.

3 Experimental Design and Hypotheses

We study behavior under 4 main experimental conditions.[4] As a control condition, we use the standard weakest-link game without bargaining. The total surplus is given by $F(c_1, ..., c_5) = 10 \times c_{\min}$ with $x = 0$ (no team guarantee). Since players share the sur-

[3]One may think of this guarantee as a fixed payment guaranteed from senior management to a working team, irrespective of the team's output.

[4]Two additional experimental conditions are introduced in Section 5.

plus equally, the share of each player from the fund is $F(c_1, ..., c_5)/5$. Therefore, the payoff of player i is given by $\pi_i = 60 - c_i + 2 \times c_{\min}$.

To study the impact of ex post bargaining, we conduct two treatments in which individual contributions to the surplus are publicly observable at the moment of bargaining. In treatment *BO* (Bargaining Observable) there is no team guarantee (i.e., $x = 0$). Hence, the total surplus is determined by $F(c_1, ..., c_5) = 10c_{\min}$. In treatment BO^+ there is a positive team guarantee of 150 tokens (i.e., $x = 150$). Hence, the total surplus is determined by $F(c_1, ..., c_5) = 10c_{\min} + 150$. Finally, we conduct a third treatment with ex post bargaining in which contributions to the surplus are unobservable and $x = 0$, denoted *BU*.

3.1 Implementation Details

At the beginning of each experimental session, the instructions were read out loud, followed by a comprehension check to ensure that the participants understood the task.[5] All interactions were computer-mediated, anonymous, and without communication. The experimental software was programmed in zTree (Fischbacher, 2007).

Subjects played a total of 10 games. They were randomly rematched and had no identifiers in order to minimize reputation concerns and other repeated-game effects. To keep bargaining treatments equivalent in terms of the feedback and information received by subjects between one game and the next, subjects were informed of their group member's contributions, shares received, and resulting payoffs once a game ended.

At the end of the experiment, one game was randomly selected to count for payment. Subjects were paid their resulting payoffs (10 tokens = 1 euro) plus a show-up fee of 5 euros in private. Participants were recruited from the subject pool at the Behavioral and Experimental Economics Laboratory at Maastricht University. Details on the number of sessions and participants can be found in Table 1.

3.2 Behavioral Expectations

In what follows, we present the hypotheses for our experimental treatments. These are supported by theoretical considerations emanating from the possible equilibria of the games we study. We also draw on existing results from related experiments that provide evidence

[5]The comprehension check entailed calculating payoffs, demonstrating an understanding of the majority rule and the random rematching protocol.

Table 1: Treatments, Parameters, and Sample Size

Treatment	**Bargaining**	**Contributions**	**Surplus Guarantee**	**# of Sessions**	**# of Participants**
Control	No	Observable	$x = 0$	3	45
BO	Yes	Observable	$x = 0$	4	60
BO^{+}	Yes	Observable	$x = 150$	4	55
BU	Yes	Unobservable	$x = 0$	4	60

of bargaining behavior in settings with joint production. Our main variable of interest is the average contribution to the total surplus in the weakest-link production stage, which we denote by $\bar{c}$ and use a superscript to indicate the name of the treatment.

In the control treatment, any symmetric vector of contributions constitutes a Nash equilibrium. It is by now an established empirical regularity that contributions unravel towards the minimum level in weakest-link games without bargaining similar to our control. This occurs after a few repetitions of the game and we expect a similar pattern to arise in our setting.

As mentioned earlier, in the game with ex post bargaining under our parameter configurations, any distribution of the surplus can be sustained as a subgame perfect Nash equilibrium of the game, which is a well-known result in the bargaining literature (Baron and Ferejohn, 1989; Eraslan, 2002). Thus, depending on how the surplus is expected to be divided through bargaining, different levels of contributions can be sustained in equilibrium. One natural conjecture is that contributions matter for redistribution and that subjects will abide by *equitable* sharing.[6] A robust body of experimental evidence demonstrates that perceptions of entitlement systematically influence how individuals divide a common surplus in bargaining contexts with joint production (Konow, 2000; Gantner et al., 2001; Cappelen et al., 2007; Karagözoğlu and Riedl, 2015; Gantner et al., 2016). Importantly, such entitlement effects persist even when the surplus is framed as having been generated without any underlying investment or effort (Gächter and Riedl, 2006).

We operationalize equitable sharing as *proportionality*, which is perhaps the most popular notion (Adams, 1965). That is, an equitable allocation is one in which every player receives

[6] The standard solution concept used to solve these type of games is the stationary SPE, or SSPE (Eraslan and Evdokimov, 2019). This notion requires players to not condition proposal behavior on the history of play. We do not believe this equilibrium notion is suitable to study a setting with a preceding contribution stage, as contributions are likely to influence proposal behavior. Thus, we only discuss the SSPE in the Appendix for completeness.

a share of the surplus in proportion to her contribution choice. As we show in the Appendix, proportionality in the distribution of the surplus leaves only two symmetric contribution equilibria in BO: no contribution and full contributions. All other interior contribution choices are not equilibria. To see why, suppose that players have coordinated at some contribution level $c \in (0, 60)$. We can show that there is a profitable deviation by marginally increasing one's contribution to obtain a larger share of the surplus. At $c = 60$ one can no longer contribute more, and contributing less reduces the surplus and one's own payoff, hence there is a profitable deviation. At the other extreme ($c = 0$) there is no fund to divide, so it is not profitable to increase one's contribution.[7]

Of course, the standard of proportionality is an ideal, and allocations are not expected to follow this ideal perfectly. Our point is that, if higher contributors obtain higher rewards on average, then the expected bargaining outcome creates the right incentives to contribute. The preceding arguments lead to our first hypothesis.

Hypothesis 1. *Contributions in the weakest-link game are higher in the bargaining treatment with observable contributions compared to the control without bargaining. That is,* $\bar{c}^{Control} < \bar{c}^{BO}$.

Importantly, when there is a positive team guarantee as in BO^+ the fully efficient outcome ($c_i = 60 \forall i$) is the unique equilibrium contribution under proportionality. The reason why $c_i = 0 \, \forall i$ is no longer an equilibrium is because increasing one's contribution leads to capturing the team guarantee of 150 tokens. The observation that the most efficient outcome arises as the unique equilibrium under equitable sharing of the surplus leads to our second hypothesis.

Hypothesis 2. *Contributions in the bargaining game with a team guarantee are higher than in the game without it. That is,* $\bar{c}^{BO^+} > \bar{c}^{BO}$.

Finally, we note that, in order to enact equitable sharing with certainty, subjects must know the contributions of others. Otherwise, they will be unable to assign proportional shares. In this case, we conjecture that contributions will unravel in treatment BU as in the control.

[7] We also consider an alternative and coarser notion of equitable sharing, namely, the formation of coalitions whereby inclusion in the distribution of the surplus is based on contributions. See Appendix for a discussion.

Hypothesis 3. *Contributions are higher in bargaining treatments with observable contributions compared to unobservable contributions. Unobservability of contributions with bargaining leads to similar contribution levels as those in the control treatment. That is,* $\bar{c}^{BO} > \bar{c}^{BU} = \bar{c}^{Control}$.

4 Results

We start by analyzing the contributions in each treatment to test our hypotheses and then investigate the bargaining outcomes.

4.1 Contributions

Figure 1 shows the evolution of the average contributions throughout the 10 games. In the first game, subjects contribute 34.8 tokens in the control treatment, 33 in BO, 38 in BO^+, and 31.1 in BU. There are no significant differences between the control and bargaining treatments (column 1, Table 2).

However, as play evolves, we observe that contributions unravel towards 0 in the control treatment, in line with the existing studies as referenced in the Introduction. In the bargaining treatments with observability, average contributions do not decline, instead, they remain steady in BO and mildly increase in BO^+. This contrasts sharply with the decline of contributions BU.[8]

[8] Supporting regression analysis is provided in Table B1

Table 2: Linear Regression of Amount Contributed in the Weakest-link Game: Period 1 and All Periods

	Period 1	**All Periods**
BO	-1.806	21.118***
	(4.071)	(1.06)
BO^+	3.226	24.628***
	(4.417)	(62.10)
BU	-3.689	0.886
	(4.862)	(4.100)
Constant	34.756***	16.776***
	(3.836)	(46.80)
Observations	220	2200
Test of Treatment Differences:		
BO^+- *BO*	3.38	3.510
	$p = 0.067$	$p = 0.3207$
BO- *BU*	0.50	20.232***
	$p = 0.482$	$p < 0.001$
BO^+- *BU*	6.39**	23.742***
	$p = 0.012$	$p < 0.001$

The dependent variable is the amount invested by a group member in a given game, with the reference group being the control weakest-link. Standard errors in parentheses below coefficient values are clustered at the matching-group level. Post-estimation F tests report effect sizes and corresponding p-values. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In Table 2 we directly test our hypotheses using linear regressions of contributions to the treatment indicator variables as regressors. In line with Hypothesis 1, we find that contributions are significantly higher in *BO* relative to the control (38 vs 16, $p < 0.001$) and in BO^+ relative to the control (41 vs 16, $p < 0.001$). Hypothesis 2 posits that we should expect higher contributions in BO^+ relative to *BO*. We find the tendency of the data to be in the direction of our hypothesis. However, the mean difference between *BO* and BO^+ of 3.5 tokens does not achieve statistical significance (Wald test, $p = 0.321$). Finally, we test hypothesis 3 and find support that contributions in bargaining treatments with observability are higher compared to *BU* ($p < 0.001$ for both *BO* vs. *BU* and BO^+ vs. *BU*). There is no statistical difference between the control treatment and *BU* ($p = 0.832$).

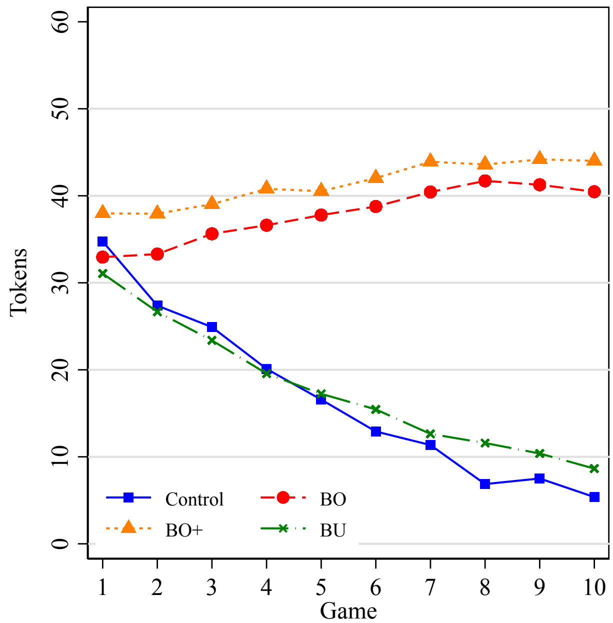


Figure 1: Evolution of Contributions

Note: The graph illustrates the evolution of average contributions over 10 games across the four treatments in Study 1: Control, *BO* (Bargaining Observable), BO^+ (Bargaining Observable with a positive team guarantee), and *BU* (Bargaining Unobservable).

The weakest-link production technology has the feature that higher average contributions do not necessarily reflect higher *efficiency*. This is because investing above the minimum carries a loss of resources. To compare the treatments in this dimension, we calculate efficiency as the sum of payoffs divided by the maximum possible payoffs in a group.[9] In the control treatment, efficiency is 43%, in *BO* 60%, in BO^+ 65%, and in *BU* 48%. As such, there is higher aggregate welfare in bargaining with observability.

Result 1. *Three empirical regularities emerge: (i) Initial contributions average 57% of subjects' endowments and exhibit no statistically significant differences between the baseline weakest-link game and the bargaining treatments. (ii) In repeated interactions without bargaining, contributions decay, whereas enabling ex post bargaining over surplus division induces rising contributions and improves efficiency. (iii) Contribution observability is a necessary condition for sustaining higher contribution levels: when individual contributions are concealed, contributions decline to levels comparable to those in the baseline game.*

[9]The formula for calculating efficiency in all treatments is $Efficiency := \frac{10 * c_{min} + 300 - \sum_{i=1}^{5} c_i}{600}$.

The fact that initial contributions are statistically indistinguishable between the control and treatments with bargaining is of particular importance. This reveals that subjects do not appear to anticipate the effect of ex post bargaining. Instead, contributions rise or fall with experience. As we argue next, subjects learn about the relationship between contributions and shares as they play the game.

4.2 Relationship between Shares of the Fund and Contributions

We now seek to understand whether the incentives that redistribution through bargaining create can explain the divergent patterns of contributions. Our goal is to understand why contributions increase with experience and meaningful efficiency gains are obtained in BO and BO^+ treatments but not in BU or the control treatments.

To answer this question, we estimate a linear regression model of the share received (in tokens) as a function of one's contribution decision. If the marginal effect of one's contribution on the share received is greater than 1, this means that subjects receive a share that covers the cost of their contribution and make a profit (on average).

The regression results (Table 3) show that the marginal effect of contributing one token is greater than 1 in the share received in both bargaining treatments with observable investments. Thus, in expectation, subjects are recovering the cost of their contributions, meaning that it is profitable for them to contribute. The same is not true for the control and bargaining treatment with unobservable contributions: In expectation, subjects do not recover their contributed tokens.

We perform the same analysis and control for the proposer role in order to investigate whether proposers have an advantage. In both bargaining treatments with observable contributions, the *Proposer* dummy variable is positive and significant, meaning that proposers receive a larger share on average. Importantly, the relationship between shares and investments remains qualitatively similar after controlling for the proposer role.

Table 3: Linear Regression of Share of the Surplus Received on Amount Contributed in the Weakest-Link Production Stage

	Control	*BO*		*BO*$^+$		*BU*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Contribution	0.438	1.750**	1.697**	1.860**	1.841**	0.625***	0.622***
	(0.196)	(0.511)	(0.496)	(0.366)	(0.380)	(0.060)	(0.064)
Proposer			24.733**		30.421***		5.763**
			(5.033)		(2.643)		(1.431)
Constant	0.695	-15.480	-18.449	12.217	6.929	4.162**	3.057**
	(0.688)	(16.923)	(16.815)	(14.422)	(14.550)	(1.081)	(0.900)
Observations	450	600	600	550	550	595	595

The dependent variable is the share of the surplus (in tokens) received by a group member in a given game. In bargaining treatments, this is the share received in the approved proposal. Standard errors in parentheses below coefficient values are clustered at the matching group level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Result 2. *Subjects agree to distributions of the fund that create the correct economic incentives to contribute when contributions are observable. Absent observability, subjects on average do not recover their contribution cost, which explains their decline similar to that observed in the control treatment without bargaining.*

4.3 Relationship between proposals and contributions

It is easy to see that distributions of the joint surplus in which high contributors are prioritized over low contributors are more favorable for those who contributed large amounts than for those who contributed small amounts in terms of the shares received. We now take a closer look at subjects' proposals depending on the ranking of their contributions within their groups. Uncovering differences in proposal-making strategies by contribution levels can shed light into the origins of the efficiency gains that arise in the bargaining treatments with observability. Specifically, we ask: Do incentives to contribute emerge from high contributors enforcing *norms* of sharing that foster efficiency or is this behavior more widespread? To answer our question, we will exploit the nature of our experimental data. Because the strategy method was implemented at the proposal stage, we observe a proposal from every member of the group in each round. We estimate a linear regression model of the share offered (in tokens) as a function of the recipient's contribution decision (we observe five shares per subject per round of bargaining). We also include *Own Share*, which is an indicator variable that takes the value of 1 for the share assigned to oneself. This would be what we have referred to as the *proposer's share* if the proposal was selected to be voted on. We estimate our regressions by contribution level, separating at- or above-median contributors (henceforth high contributors) from below-median contributors (henceforth low contributors).

Table 4: Linear Regression of Share of the Surplus Offered on Amount Contributed by the Recipient in the Weakest-Link Production Stage

	Treatment *BO*			Treatment BO^{+}		
	Contribution			Contribution		
	Low	High	All	Low	High	All
	(1)	(2)	(3)	(4)	(5)	(6)
Contribution of recipient	1.262**	1.802***	1.572**	1.111*	2.242***	1.823***
	(0.318)	(0.282)	(0.286)	(0.374)	(0.258)	(0.290)
Recipient is self (=1 if yes)	33.605***	21.717**	27.406***	37.299***	23.135***	31.721***
	(5.697)	(4.172)	(4.467)	(4.702)	(3.516)	(2.129)
Constant	-4.720	-20.711	-13.757	33.060*	-7.166	7.494
	(10.124)	(9.345)	(9.242)	(13.138)	(10.198)	(10.151)
Obs	1270	2930	4200	1205	2670	3875

High contributors are those contributing at or above the group median; low contributors contribute below it. The dependent variable is the share of the surplus (in tokens) offered to a group member in a proposal. All proposals in all rounds, in all games are included. Standard errors in parentheses below coefficient values are clustered at the matching group level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Our estimation results presented in Table 4 indicate that proposals vary by contribution level, in accordance with our previous conjecture. The coefficient of contribution of the recipient is significantly different between high contributors ($\beta = 1.802$ for *BO*; $\beta = 2.242$ for *BO+*) and low contributors ($\beta = 1.262$ for *BO*; $\beta = 1.111$ for *BO+*). Wald tests confirm that these differences are significant ($p < 0.001$).

The share that players assign to themselves is significantly greater than the one they assign to others, as the coefficient on the dummy variable *"Recipient is self"* is positive and significant in all our estimations. However, it is particularly revealing that low contributors aim to extract a substantially larger share than high contributors. In treatment *BO*, low-contributing subjects assign themselves approximately 33.6 more tokens while high contributors assign themselves approximately 21.7 more tokens, a 54.7% significant difference ($p < 0.001$). Wald tests confirm that these differences are significant ($p = 0.041$) and similar effect holds in BO^{+}.

Given the differences in proposing behavior between low and high contributors, it is plausible that their proposals also face different likelihoods of being approved. In fact, we find that proposals made by high contributors are 13.1% more likely to be approved than those emanating from low contributors. As a consequence, 75% of approved proposals are made by high contributors.

We further investigate individual voting behavior as it might be that high contributors receive more support simply because they are more *fair* and generous. Alternatively, all else equal, proposals by high contributors may be perceived as being more *legitimate*. To this end, we estimate a linear regression in which the dependent variable is equal to 1 if a subject votes in favor of a proposal and 0 otherwise. As independent variables, we have the offered share, the proposer's share, and a categorical value equal to 1 if the proposer is a high contributor and 0 otherwise.

The estimation results are presented in columns 1 and 2 of Table B2 in the Appendix. For *BO* we have that the coefficient of one's own share is positive and significant (0.009, $p < 0.001$), meaning that the likelihood of voting in favor increases in one's share. The proposer's share coefficient is negative and significant (0.003, $p < 0.001$), albeit smaller in magnitude than one's own share.[10] High contributing proposers are more likely to receive a favorable vote, as the coefficient is positive and significant. Similar results hold for BO^{+}. This is consistent with subjects perceiving proposals made by high contributors as being more legitimate or worthy of approval *per se*.

Result 3. *High contributors distribute more equitably than low contributors, thereby promoting stronger contribution incentives. Controlling for the share offered and the share the proposer assigns himself, subjects are more likely to vote in favor of proposals made by high contributing proposers, and therefore these proposals are more likely to be accepted.*

Having established that the strongest contribution incentives are fostered by high contributors, and these contributors command higher approval rates when proposing, we now examine whether groups prefer to select these members as proposers when the likelihood of taking on this role is endogenized.

[10]These results are consistent with a wide body of literature studying voting in multilateral bargaining games. See the meta-analysis by Baranski and Morton (2022).

5 Treatments with Endogenous Proposer Selection

In many organizations, decision makers and resource allocators (i.e., managers, team leaders, committee chairs in legislative bodies, deans, provosts) are chosen from within the group of those invoked in the process of joint production. Understanding whether and how the possibility of choosing and being chosen as a proposer affects coordination on efficient outcomes is therefore of relevance beyond the laboratory.

In the games analyzed so far, all players have had an equal (and exogenously determined) probability of being selected as the proposer. We now examine behavior in a modified version of the bargaining game in which group members can actively influence the likelihood of being chosen as proposers. Once contributions to the joint surplus have been made, we conjecture that these may convey information about how subjects intend to distribute the surplus, based on the evidence reported earlier (Result 3). Therefore, if high contributors are more likely to be proposers, it may be that stronger incentives to contribute emerge.

5.1 The game subjects play

In the new game that we consider, subjects proceed to an *endorsement stage* once contribution decisions have been made. Members indicate independently who they would like select as proposers, a decision that carries no cost. Players are free to endorse as many members of their group as they wish in the group. During this stage, members contributions are common knowledge. Endorsements are then tallied, and the probability of being the proposer in a given round is proportional to the support a player received relative to other group members. Players are counted as endorsing themselves automatically, and therefore, if no group member receives the support from any other group member, all of them are equally likely to be selected as proposers, just as in treatment BO. Once all players have made their endorsement decisions, they are informed of the likelihood of being the proposer of each member but do not know who has supported them.[11] In all other respects, the bargaining game follows the same protocol as in BO.

We conducted 6 experimental sessions with 70 new subjects from the same pool, following the bargaining protocol with the endorsement stage just described. We refer to this treatment as *ENDO*.

[11]Note that revealing who endorsed who can lead to proposers reciprocating by assigning larger shares to their endorsers. Therefore, we wanted to preclude this possibility by design.

5.2 Hypotheses

From a strategic point of view, based on the standard equilibrium notion (SSPE), the addition of the *endorsement stage* is inconsequential for bargaining behavior, and therefore for contribution behavior. Supporting any other group member is a weakly dominated strategy. Players should never endorse anyone other than themselves because the expected bargaining payoffs (in equilibrium) are weakly increasing in the probability of proposing (Eraslan, 2002). Therefore, because supporting other members to be the proposer (weakly) reduces one's chance of proposing, standard equilibrium arguments provide no rationale for the *endorsement stage* to have any effect on contribution choices under the SSPE.

Despite theoretical considerations offering no reason for an effect of the endorsement stage on contribution choices, we offer the *behavioral* conjecture that adding an endorsement stage can aid in fostering efficient coordination. As demonstrated in the analyses of the preceding treatments *BO* and BO^+, high-contributing members are more prone to propose distributions that give rise to *better* incentives. Thus, the endorsement stage may serve as a selection filter by precluding low contributors from having their proposals being selected for voting. By increasing the odds that high contributors' proposals are up for a vote, and subsequently implemented, strong contribution incentives may arise.

Hypothesis 4. *Contributions in ENDO will be higher than contributions in BO.*

5.3 Results

Figure 2 shows the evolution of contributions in the ten games. The data tell an interesting story, more nuanced than we initially conjectured. First, the mean contributions in the first game of the *ENDO* treatment start at 35.3 tokens, which is not significantly different from the mean contributions in *BO* (35.3 vs 33, p-value = 0.886).[12] Pooling all periods of play, contributions average 34.6 tokens. Regression analysis yields a negative period trend coefficient for treatment *ENDO* which is significantly different from the trend coefficient in *BO* (-0.402 vs 1.008, p-value$<$ 0.001.)[13]

[12]Regression results are provided in Table B5, Column 1.

[13]Regression results are provided in Table B4.

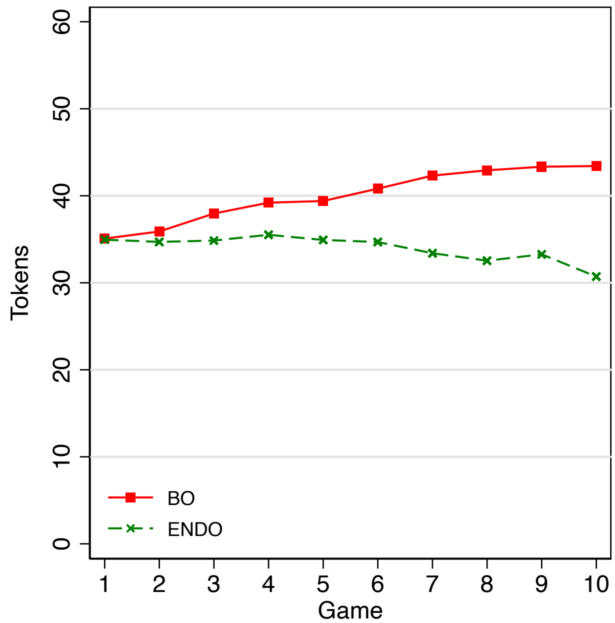


Figure 2: Evolution of Contributions in Treatment ENDO

Note: The graph illustrates the evolution of average contributions over 10 games in bargaining with observable investments (*BO*) and bargaining with proposer endorsements (*ENDO*).

However, the preceding analysis of mean contributions pools all sessions together, masking an important underlying heterogeneity in behavior. As shown in Table B3, contributions grow in half of the sessions while they decline in the other half, leading to an average stability of contributions throughout the experiment. To understand the divergent patterns in different sessions, we turn to investigating endorsement choices, which, as one may reasonably expect, will also vary substantially from session to session.

Table 5 shows that high contributors are more likely to receive support than low contributors, and therefore high contributors have increased odds of proposing. The proportion of endorsements that high contributors receive (50%) and that low contributors receive (25%). It also appears that high contributors may anticipate that they will benefit from having proposers of their same contribution ranking, as we see that they endorse low contributors only 17% of the time, and are more likely to endorse other high contributors, 55% of the time. Low contributors endorse other low contributors 43% of the time, which is slightly higher than the rate at which they endorse high contributors, 39% of the time.

Table 5: Proportion of Endorsements, by Contribution Ranking

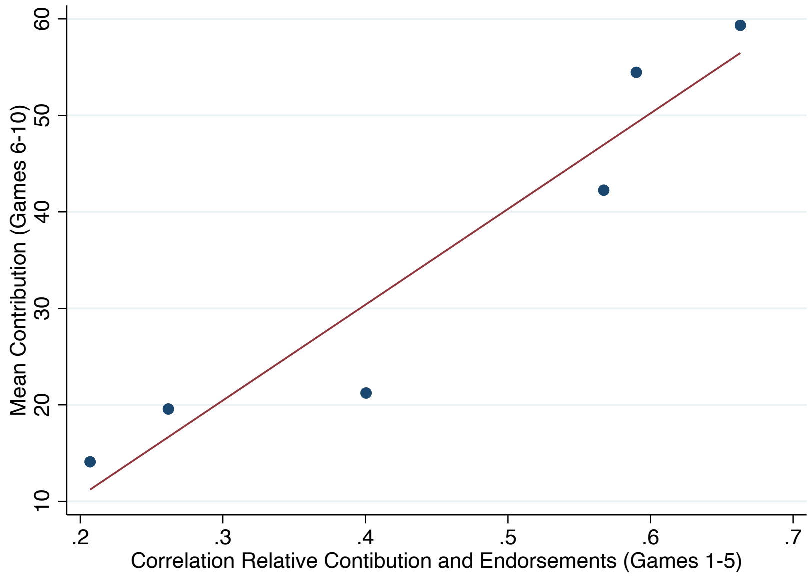
		Who received an endorsement?	
		High Contributor	Low Contributor
Who is the endorser?	High Contributor	0.55	0.17
	Low Contributor	0.39	0.43
	Pooled	0.50	0.25

High contributors are those contributing at or above the group median; low contributors contribute below it. Self-endorsements are excluded as these are by default. The minimum and maximum values for each entry in this table are 0 and 1, respectively. For example, if everyone is endorsed by everyone, all entries would be 1. And if no one endorses low contributors, all values in the last column would be 0.

To assess the impact that endorsement choices may have on contribution levels, we now look at the correlation between a member's relative contribution and the probability of being endorsed, restricting attention to the first five games of play.[14] We argue that during the first half of the experiment, subjects experience how contributions empirically influence the likelihood of being the proposer through endorsements, and about the incentives to contribute that arise through the approved proposals. Therefore, we ask: Is there a relationship between endorsement behavior in early games and mean contributions in late games? A positive answer to this question could be useful in explaining the heterogeneous effect that the *endorsement stage* has on contributions.

[14]The relative contribution is $\frac{c_i}{\sum_{j=1}^{5} c_j}$.

Figure 3: Endorsement Behavior in Early Games and Contributions in Late Games



Notes: The x-axis measures the Pearson correlation coefficient between the probability of being endorsed by others in the group and one's contribution relative to the group's total contributions, in games 1-5. The y-axis measures the average contributions in games 6-10. Each circle represents a session. The solid line is the linear regression prediction (line of best fit).

Figure 3 plots the Pearson correlation coefficient between the probability of being endorsed by others in the group and the contribution relative to the total contributions of the group in the first five games in the abscissa. In the ordinate axis we measure the average contribution in the last five games. The pattern in the data shows a clear positive relationship, indicative of the role that endorsing *the right* members can have on efficiency.[15]

Result 4. *Letting members decide who can propose, based on endorsements, has a mixed effect on contributions. When high contributors are more likely to be endorsed and become proposers, overall contributions are higher than when they are less likely to be endorsed.*

5.4 An Institutionalized Proposer Selection Rule

In the *ENDO* treatment, we have provided evidence that when groups endorse the *wrong* proposers, efficiency suffers. Thus, our findings allow us to conclude that the endorsement stage is not a strong enough institution to consistently preclude low contributors from having

[15]We do not offer statistical tests as this analysis is based on 6 independent units of observation (session averages).

a high likelihood of proposing, thereby diluting incentives. On average, it performs worse relative to the equiprobable proposer selection rule in *BO* in eliciting contributions. Is this fall in contributions driven by the competition for the right to propose induced by the endorsement stage, or is it due to the endorsement of the *wrong* kind of proposing members?

To answer our questions, we design a treatment in which we institutionalize a proposer-selection rule that *mechanically* penalizes low contributors, whereby members' chances of selection are proportional to their contributions. Specifically, the chance of proposing is given by $\pi_i = c_i / \sum_{j=1}^{5} c_j$ if at least one $c_i > 0$, otherwise $\pi_i = 1/5$. All else remains identical to treatments *BO* and *ENDO*. We conducted four experimental sessions (treatment *PROP*), with 15 subjects each who had not participated in any other treatment.

Average contributions in the first period start at 38.6 tokens, which is higher than in *ENDO* starting at 35 tokens, although the difference is not statistically significant. Regression analysis reported in Table B4 yields a positive period trend coefficient (1.019) for treatment *PROP* which is not significantly different from the trend coefficient in *BO* (1.008), but significantly higher than the trend coefficient for treatment *ENDO* (-0.402).[16] Pooling all periods of play, treatment *PROP* yields contribution levels greater than *BO* ($p < 0.001$), and greater than *ENDO* ($p < 0.001$).

Result 5. *Institutionalizing a rule that allocates proposal rights proportionally to contributions leads to higher contributions compared to the case where subjects can influence their and others' odds of becoming proposers.*

6 Conclusion

In this article, we have studied behavior in a foundational coordination game – the weakest-link – gradually incrementing the role and ability of players to shape the distribution of the resources produced jointly. We have departed from the common assumption of equal sharing. Our findings highlight the significant influence of bargaining on coordination outcomes. The increased uncertainty due to the unknown returns to contributing does not deter subjects from doing so. Instead, the distribution of the surplus tends to reward high contributors, which promotes further contributions. The reinforcement of contributions driven by learning is remarkable given the matching protocol that we implement, which precludes reputation building. We are unaware of any other institutional variant of the weakest-link

[16] Figure B1 in the Appendix displays the evolutions of contributions by game.

game leading to substantial efficiency gains under a strangers rematching protocol. Thus, we conjecture that a stronger effect would arise under stable partner matching.

Our treatment in which subjects can influence their and others' chances of being proposers through endorsements offers both cautionary advice and encouraging results from an institutional design perspective. The cautionary tale is that in groups with a higher propensity to endorse low contributors, we find that efficiency suffers. The reassuring lesson is that the opposite happens when high contributors are endorsed. Therefore, a way to diminish the likelihood that low contributors act as proposers is by institutionalizing a proportional selection rule. In a separate treatment, we find that this mechanism provides higher average contributions and stronger incentives to contribute.

In the Introduction, we noted that the potential effect of bargaining on contributions in the weakest-link game is ex ante ambiguous. In the expanded game we consider here, participants face two dimensions of strategic uncertainty: uncertainty about others' contributions and about their redistribution strategies. In the standard weakest-link game with an exogenously imposed equal split, uncertainty of the first type (i.e., others' contributions) has been identified as a key factor behind coordination failures and the resulting inefficiency. In our bargaining treatment, where redistribution outcomes are endogenously determined and uncertainty is unarguably greater, we observe higher contributions and meaningful efficiency gains. This finding suggests that the decline in contributions under the equal-split rule is less likely to be driven by strategic uncertainty and more likely by the inequity embedded in the fixed redistribution when players contribute different amounts.

The findings we report open up new avenues for exploration of practical importance. For example, firms, teams, and alliances facing coordination dilemmas are often made up of a diverse set of individuals, who may have different abilities to contribute to their common goal (). Conflicting views of fairness regarding how to share the proceeds of joint production may be exacerbated under heterogeneity, which can impact bargaining behavior and contributions as a result. Future research can focus on understanding how the plurality of distributive norms or fairness ideals (Cappelen et al., 2007) in groups affects efficiency. Another source of heterogeneity concerns players' productivity and bargaining power (Fréchette et al., 2005; Maaser et al., 2019), which can create differences in expectations about fair sharing. We leave the investigation of these and other questions for future research.

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Online Appendix for *"Coordination and Bargaining in Weakest-link Games"*

by Andrzej Baranski, Lina Lozano, and Nikos Nikiforakis

Table of Contents

A General Formulation of the Game and Theoretical Considerations

In this section we first present the weakest-link game with ex-post bargaining in a general framework (any number of players, any productivity parameter, etc.). Next, we solve for several equilibria assuming risk neutral, selfish preferences. These equilibria are useful in informing our behavioral hypotheses.

A.1 Description of the Game

Let there be n (odd) number of players indexed by i which are endowed with a wealth amount W. They are risk neutral and derive utility only from their own payoffs. Players interact in a two-stage game, where production occurs first in order to determine the total surplus to be distributed via a bargaining game.

In the first stage, players choose simultaneously and independently a contribution level $c_i \in [0, W]$. The total surplus is determined as follows:

$$F(\mathbf{e}) = \alpha n e_{\min} + x$$

where $\alpha > 1$, $c_{\min} = \min\{c_1, ..., c_n\}$, and $x \geq 0$ is an exogenous group endowment that does not depend on contributions.[17] The parameter α can be interpreted as a productivity measure. We will only consider linear costs, thus, we normalize the marginal cost of contributions to 1.

Once F is produced, players proceed to bargain over its division. In this game of complete information, the vector of contributions $\mathbf{c}$ is common knowledge. The bargaining stage may have potentially many rounds (denoted by t) until an agreement is reached. At the beginning of each round, one of the players is randomly chosen with $1/n$ chance to propose a division of $F(\mathbf{c})$ given by $(s_1^t, ...s_n^t)$ where $s_j^t \in [0, 1]$ denotes a proportion of $F(\mathbf{c})$. We require $\sum_{j=0}^{n} s_j^t = 1$, that is, the allocations fully exhaust the surplus.

Once a proposal is made, players proceed to vote in favor or against the proposal on the floor. Let $q < n$ be the voting rule. If the total number of votes in favor is greater than or equal to q, the proposal is approved and the result is binding. If the proposal is rejected (i.e., less q votes in favor), a new bargaining round takes place, with a player again randomly selected. The process continues until approval. Let $\delta \in [0, 1]$ be the discount factor in case of rejection.

The payoff for a player that invests c and receives a share s is $W - c + sF(\mathbf{c})$.

A.2 Equilibria

We start by explaining our approach to solving the game. As a benchmark case that will help understand the effect of bargaining, we first solve the game without bargaining, where

[17] The bold letters denote vectors, as usual.

each player receives an equal share of the total surplus (as in our control treatment).

Next we focus on the generalized weakest-link game with ex post bargaining. We will restrict attention to subgame perfect Nash equilibria (SPE). To do so, we proceed by backward induction. We begin our analysis by focusing on the equilibria of the bargaining subgame, once contributions have taken place. It is well-known that the bargaining game we study has multiple equilibria. Thus, each player's expected payoff from bargaining depends on the equilibrium played. This, in turn, determines the incentives to contribute at the weakest-link production stage.

Within the multiplicity of bargaining equilibria, we focus on three natural candidates. The first equilibrium we study is the *stationary* SPE (SSPE). Most – if not all – the literature on sequential bargaining games *á la* Baron and Ferejohn, typically restricts attention to history-independent strategies because these generally result in a unique equilibrium payoff vector.[18]

Next, we focus on two possible divisions of the surplus based on documented notions of fairness: equality and equity (Adams, 1965; Cook and Hegtvedt, 1983). It is important to stress that we do not assume any changes in players' utility functions. The bargaining strategies and resulting payoffs are sustained as part of an SPE with selfish players ($u(x) = x$). Thus, we do not need to resort to assuming different functional forms to account for social preferences (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000).

For each of the three equilibria in the bargaining subgame (SSPE, equality, and equity), we derive the expected payoffs from bargaining. To fix notation, we denote by V_i the proportion of the total surplus $F(\mathbf{c})$ by player i at the bargaining stage, before any player has been selected to propose. Depending on the equilibrium, V_i may or may not be a function of the vector of preceding contributions. For SSPE and equality, V_i is not a function of the contribution profile; for proportionality, it is. Having solved the bargaining subgame, we backward induct to determine the equilibrium contributions in the weakest-link game by imputing the payoff function derived in the equilibrium of the bargaining subgame.

A.2.1 Equilibrium of the Weakest-Link game without Bargaining

In this game, a player's payoff is from contributing c_i given that others are contributing $\mathbf{c}_{-i}$ is given by $W - c_i + F(\mathbf{c})/n$ which is equal to $W - c_i + \alpha c_{\min} + x/n$.

[18] The comprehensive review of the theory by Eraslan and Evdokimov (2019).

Lemma 1. *Any symmetric vector of contributions is a Nash equilibrium of the weakest-link game with an equal split of the surplus.*

The proof follows from noting that any player deviating downward from an interior equilibrium will cause a fall in her share of the surplus that is greater than the cost savings from undercutting. Similarly, any upward deviation only creates a cost, but no additional benefit, as the surplus remains the same.

A.2.2 Stationary Subgame Perfect Equilibrium

We say that a strategy is stationary if we require players to follow it in every identical bargaining subgame. In our game, this means that the proposal strategies in round t are neither a function of the history of bargaining play, nor a function of the weakest-link effort vector $\mathbf{e}$. Voting strategies in round t depend only on the proposal to be voted on. The following lemma describes the equilibrium of the game.

Lemma 2. *In a Stationary Subgame Perfect Equilibrium we have that:*

1. *The proposer offers $q-1$ voters a share $s_j = \delta F(\mathbf{c})/n$, and keeps the rest. Each player receiving a share of $\delta F(\mathbf{c})/n$ or more votes in favor. The remaining $n-q$ voters receive nothing and vote against.*

2. *The expected payoff of the game bargaining is $V_i(\mathbf{c}) = 1/n$.*

3. *Any symmetric vector of contributions $\mathbf{c}$ can be sustained as an equilibrium.*

Parts 1 and 2 of Lemma 2 follow from Proposition 3 in Baron and Ferejohn (1989), which we only explain intuitively here. In an SSPE, the proposer maximizes her earnings by forming the smallest coalition that can pass a proposal. These distributions are referred to as minimum winning coalitions (MWCs). To this end, the proposer randomizes over which members to invite to her MWC by offering each of them the discounted expected share of the surplus. In equilibrium, the discounted share of the surplus a player expects to receive is $\delta F/n$.[19] To see why any symmetric contribution vector $\mathbf{c}$ is an equilibrium at the weakest-link stage, note that the payoffs at the contribution stage for player i are given by $W - c_i + V_i F(\mathbf{c})$ which are equal to $W - c_i + F(\mathbf{c})/n$. These are identical to the payoffs of the canonical weakest-link game without bargaining, and the result follows from Lemma 1.

[19]The fact that $V_i = 1/n$ follows from the fact that each player is either the proposer with $1/n$ chance, an included voter $(q-1)/n$ chance, or an excluded voter with $(n-q)/n$ chance.

A.2.3 Subgame Perfect Equilibria: Equality and Equity

It is well known that sequential bargaining games often have multiple equilibria. When the number of players is $n \geq 5$ and players are sufficiently patient, any vector of shares can be sustained as a subgame perfect Nash equilibrium in the game we study.[20]

In the experiments we focus in the parameter region where the entire set of distributions can be sustained as SPE. We investigate two popular fairness principles as possible equilibrium divisions of the surplus: equality and equity. There are several ways in which one can operationalize the notion of *equity*, hence we begin with invetigating *equality*. Under the principle of equality, every player receives a proportion of the total surplus given by $V_i = 1/n$, regardless of their contribution. It is straightforward to see that this expected bargaining payoff induces the same payoff structure as the canonical weakest-link game without bargaining.

Lemma 3. *Consider the bargaining equilibrium with an equal division of the surplus. Then, any symmetric vector of contributions is an SPE.*

We first operationalize the principle of equity as *proportionality* in the distribution of the total surplus.[21] Specifically, we have that $V_i(c_i, \mathbf{c}_{-i}) = \frac{c_i}{\sum_{j=1}^{n} c_j}$. In this equilibrium, the share of the surplus that a player expects is an increasing function of her contribution.

We show that, when the productivity parameter is high enough, one can sustain only full contributions ($c_i = W, \quad \forall i$) and no contributions ($c_i = 0, \quad \forall i$) as the only equilibria. Importantly, when there is a team guarantee ($x > 0$) full contributions arise as the unique equilibrium.

To see why, we start with the extreme case that no one contributes, the total surplus is only the exogenous component x. Any player increasing her contribution by $\epsilon > 0$ captures the entire surplus x. Note that when $x = 0$, it is not profitable to increase one's contribution when no one contributes. At the other extreme, the maximum contribution level, undercutting does not pay as it reduces the total surplus and one's share. This is true regardless of x.

At any other symmetric contribution vector, it pays to increase one's contribution marginally as it increases one's share of the surplus. But this is true as long as the surplus is relatively

[20] For details, see Proposition 2 in Baron and Ferejohn (1989). The proof relies on the construction of a credible off-equilibrium punishment for deviators.

[21] There are several ways in which one can operationalize the principle of equity. For a discussion see Cook and Hegtvedt (1983).

large, which depends on the productivity parameter ($\alpha \leq n/(n-1)$).

In the following lemma, we summarize arguments above.

Lemma 4. *Consider the bargaining equilibrium with a proportional division of the surplus.*

1. *If $\alpha \leq n/(n-1)$ then any symmetric contribution vector is part of a SPE.*

2. *If $\alpha > n/(n-1)$ and $x = 0$, then no contributions and full contributions are the only SPE contribution vectors.*

3. *If $\alpha > n/(n-1)$ and $x > 0$, then full contributions is the unique SPE contribution vector.*

Proof. Consider any symmetric contribution vector $\mathbf{c} = (c, ..., c)$ where $0 < c \leq 1$ from which we obtain that $F(\mathbf{c}) = \alpha nc$ and $\bar{s}_i(\mathbf{c}) = 1/n$. The resulting payoff is given by $\Pi(\mathbf{e}) = \alpha c - c + 1$. We will now prove that there exists $\epsilon > 0$ such that the resulting payoff for player i from choosing $c + \epsilon$ is greater than $\Pi(\mathbf{c})$. Denote by $\bar{s}_i(c+\epsilon, \mathbf{c})$ the percentage share received from deviating, which is given by

$$\bar{s}_i(c+\epsilon, \mathbf{c}) = \frac{c+\epsilon}{\sum_{j=1}^{n} c_j + \epsilon} \quad .$$

Notice that the total surplus does not change because the minimum is still c. As such, the payoff from deviating is given by

$$\Pi(c+\epsilon, \mathbf{c}) = \left(\frac{c+\epsilon}{\sum_{j=1}^{n} c_j + \epsilon}\right) \alpha nc - (c+\epsilon) + 1 \quad .$$

We compute the difference in payoffs and show that

$$\begin{aligned}
\Pi(c+\epsilon, \mathbf{c}) - \Pi(\mathbf{c}) &> 0 \iff \\
\alpha c \left[\frac{n(c+\epsilon)}{nc+\epsilon} - 1\right] - \epsilon &> 0 \iff \\
\alpha c \left[\frac{(n-1)\epsilon}{nc+\epsilon}\right] &> \epsilon \iff \\
c\left[\alpha(n-1) - n\right] &> \epsilon \ .
\end{aligned}$$

From the last inequality we conclude that there exists a profitable positive deviation of size ϵ if and only if $\alpha(n-1) - n > 0 \iff \alpha > \frac{n}{n-1}$. Note that at $\mathbf{c} = \mathbf{1}$ there is no possibility of increasing the contribution, and hence there is no positive profitable deviation in that case.

We now proceed to show that there is no negative profitable deviation from any symmetric vector of contributions. Consider the payoffs of decreasing by ϵ one's contribution. These are given by

$$\Pi(c-\epsilon,\mathbf{c}) = \bar{s}(c-\epsilon,\mathbf{c})F(c-\epsilon,\mathbf{c}) - (c-\epsilon) + 1$$

and note that $\Pi(c-\epsilon,\mathbf{c}) < \bar{s}(\mathbf{c})F(c-\epsilon,\mathbf{c}) - (c-\epsilon) + 1$ because $\bar{s}(\mathbf{c}) = \frac{1}{n} > \bar{s}(c-\epsilon,\mathbf{c})$. Hence, we have that

$$\Pi(\mathbf{c}) - \Pi(c-\epsilon,\mathbf{c}) > \Pi(\mathbf{c}) - \left[\bar{s}(\mathbf{c})F(c-\epsilon,\mathbf{c}) - (c-\epsilon) + 1\right] .$$

We now show that

$$\begin{aligned}
\Pi(\mathbf{c}) - \left[\bar{s}(\mathbf{c})F(c-\epsilon,\mathbf{c}) - (c-\epsilon) + 1\right] &> 0 \iff \\
\bar{s}(\mathbf{c})\left[F(\mathbf{c}) - F(c-\epsilon,\mathbf{c})\right] - \epsilon &> 0 \iff \\
\frac{1}{n}\left[\alpha n \epsilon\right] - \epsilon &> 0 \iff \\
\epsilon(\alpha - 1) &> 0
\end{aligned}$$

and it follows that $\Pi(\mathbf{c}) - \Pi(c-\epsilon,\mathbf{c}) > 0$ for all ϵ.

Next, we consider a second operationalization of equity that is *coarser* than proportionality as it requires the formation of MWCs including only the highest contributing members and excluding the lowest contributing members. For simplicity we assume an equal split of the surplus among the coalition partners. We refer to this strategy as equity MWC or EMWC for short.

Formally, let r_q be the q^{th} order statistic of the list $\{c_1, ..., c_n\}$. We must specify a tie-breaking rule for entering the winning coalition whenever more than q members are at or above r_q. For this purpose, let $E = \{i | c_i > r_q\}$ and $\underline{E} = \{i | c_i \geq r_q\}$ where $|E|$ and $|\underline{E}|$ represent the number of players in each set. We denote by s_i^{EMWC} the share received from the surplus with probability θ_i. An allocation under EMWC is defined by

$$s_i^{\text{EMWC}} := \begin{cases} 1/q & \text{with probability} \quad \theta_i \\ 0 & \text{with probability} \quad 1-\theta_i \end{cases}$$

where

$$\theta_i := \begin{cases} 0 & \text{if} \quad c_i < r_q \\ \frac{q-|E|}{|\underline{E}|-|E|} & \text{if} \quad c_i = r_q \\ 1 & \text{if} \quad c_i > r_q \end{cases} .$$

Lemma 5. *Consider the bargaining equilibrium with equity MWCs.*

1. *If $x = 0$, then no contributions and full contributions are the only SPE contribution vectors.*

2. *If $x > 0$, then the full contribution is the unique SPE contribution vector.*

Proof. Consider any symmetric vector $\mathbf{c}$ where $c \in (0, 1)$ so that profits are given by

$$\Pi(\mathbf{c}) = \theta_i s_i^{\text{EMWC}} \alpha nc - c + 1 = \alpha c - c + 1 \,.$$

We now show that there exists $\epsilon > 0$ such that exerting $c+\epsilon$ yields a higher payoff. Notice that such player is invited with certainty to a coalition of q players. Thus, she receives $1/q$ of the surplus. This yields

$$\Pi(c + \epsilon, \mathbf{c}) = \frac{\alpha nc}{q} - c - \epsilon + 1$$

and clearly

$$\Pi(c + \epsilon, \mathbf{c}) - \Pi(\mathbf{c}) = \alpha c \left(\frac{n}{q} - 1 \right) - \epsilon > 0$$

for some ϵ.

A player who deviates downward from a symmetric contribution choice is excluded with certainty thus receiving

$$\Pi(c + \epsilon, \mathbf{c}) = -c + \epsilon + 1$$

which is strictly smaller than $\Pi(\mathbf{c})$. At $\mathbf{c} = \mathbf{0}$ it is straightforward to verify there is no profitable deviation when $x = 0$. However, when $x > 0$, a small upward deviation leads to capturing $1/q$ of the surplus with certainty.

Now consider any asymmetric vector $\mathbf{c}$ such that $c_{\min} > 0$. If there exists i such that $c_i < r_q$, it is easy to show that member i has an incentive to choose 0, since being below r_q only generates an individual cost and no benefits. If there exists i such that $c_i > r_q$ then player i would benefit from choosing $c_i - \epsilon > r_q$ because she still receives $1/q$ of the surplus with certainty and reduces her individual cost without affecting the total surplus. If there does not exist i such $c_i < r_q$ or $c_i > r_q$ then it means $c_i = c_j$ $\forall i, j$ which is the symmetric case discussed previously. Finally, if $c_{\min} = 0$, then all other players are better off by choosing 0. Thus, there are no asymmetric equilibria.

Finally, we consider a notion of *equity* in which the lowest contributor is excluded altogether by being offered a share of 0. We assume for simplicity that the remaining members share the fund equally and that if there are ties, these are broken by assigning the lowest share among the lowest contributors (with equal chance).

Formally, let $c_{\min} = \min\{c_1, ..., c_n\}$. let $\underline{E} = \{i | c_n = c_{\min}\}$ where $|\underline{E}|$ represent the number of players who contributed the lowest amount. We denote by $s_i^{\text{E4-Way}}$ the share received from the surplus by player i with probability θ_i. An allocation under *E4-Way* is defined by

$$s_i^{\text{E4-Way}} := \begin{cases} 1/(n-1) & \text{with probability} \quad \theta_i \\ 0 & \text{with probability} \quad 1-\theta_i \end{cases}$$

where

$$\theta_i := \begin{cases} \frac{1}{|\underline{E}|} & \text{if} \quad c_i = c_{\min} \\ 1 & \text{if} \quad c_i > c_{\min} \end{cases} .$$

Lemma 6. *Consider the bargaining equilibrium with equity 4-ways splits (E4-Way).*

1. *If $x = 0$, then no contributions and full contributions are the only SPE contribution vectors.*

2. *If $x > 0$, then the full contribution is the unique SPE contribution vector.*

Proof. Consider any symmetric vector $\mathbf{c}$ where $c \in (0, 1)$. In this case $\theta_i = (n-1)/n$, so that profits are given by

$$\Pi(\mathbf{c}) = \theta_i s_i^{\text{E4-Way}} \alpha n c - c + 1 = \alpha c - c + 1 .$$

We now show that there exists $\epsilon > 0$ such that exerting $c + \epsilon$ yields a higher payoff. Notice that such player is offered $s_i = 1/(n-1)$ with certainty (i.e., $\theta_i = 1$). This yields

$$\Pi(c+\epsilon, \mathbf{c}) = \frac{\alpha n c}{n-1} - c - \epsilon + 1$$

and clearly

$$\Pi(c+\epsilon, \mathbf{c}) - \Pi(\mathbf{c}) = \alpha c \left(\frac{n}{n-1} - 1 \right) - \epsilon > 0$$

for some ϵ.

A player who deviates downward from a symmetric contribution choice is excluded with certainty ($\theta_i = 0$) thus earning

$$\Pi(c + \epsilon, \mathbf{c}) = -c + \epsilon + 1\,,$$

which is strictly smaller than $\Pi(\mathbf{c})$.

At $\mathbf{c} = \mathbf{0}$, it is straightforward to verify that there is no profitable deviation when $x = 0$. However, when $x > 0$, a small upward deviation leads to capturing $1/(n-1)$ of the surplus with certainty.

Now consider any asymmetric vector $\mathbf{c}$ such that $c_{\min} > 0$. For player i such that $c_i = c_{\min}$, it is easy to show that member i has an incentive to deviate to $0 < c_{\min}$. This is because contributing $c_{\min}$ only generates an individual cost and no benefits.

If there exists i such that $c_i > c_{\min}$, then player i would benefit from choosing $c_i - \epsilon > c_{\min}$ because she still receives $1/(n-1)$ of the surplus with certainty and, at the same time, reduces her individual cost without affecting the total surplus.

Finally, if $c_{\min} = 0$, then all other players are better off by choosing 0. Thus, there are no asymmetric equilibria.

B Main Treatments: Additional Regressions, Tables and Figures

Table B1: Linear Regression of Amount Invested in the Weakest-link Game on the Period of Play

	Control	*BO*	*BO*$^+$	*BU*
	(1)	(2)	(3)	(4)
Game	-3.173***	1.008	0.798*	-2.408***
	(0.359)	(0.464)	(0.282)	(0.207)
Constant	34.230**	32.351***	37.016***	30.906***
	(6.287)	(1.389)	(1.782)	(3.169)
Observations	450	600	550	600

The dependent variable is the amount invested by a group member in a given game. Standard errors in parentheses below coefficient values are clustered at the matching group level. * $p < 0.1$, ** $p < 0.05$, *** p< 0.01.

Table B2: Linear Regression for Voting

	BO	BO^+	ENDO	ENDO Low	ENDO High	PROP
	(1)	(2)	(3)	(4)	(5)	(6)
Own Share	0.009***	0.006***	0.006***	0.006***	0.006***	0.007***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Prop. share	-0.003***	-0.002***	-0.006***	-0.006***	-0.005***	-0.003***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Prop. High (1=yes)	0.099**	0.074*	0.135**	0.035	0.246**	0.150***
	(0.044)	(0.041)	(0.057)	(0.057)	(0.092)	(0.034)
Constant	0.158***	0.197***	0.570***	0.691***	0.420***	0.190***
	(0.046)	(0.066)	(0.049)	(0.052)	(0.082)	(0.055)
Observations	672	620	712	332	380	648

The dependent variable is a subject's voting decision which takes the value of 1 if the subject votes in favor and 0 otherwise. *Own Share* is the share in tokens offered to the voter. *Prop. Share* is the share in tokens the proposer assigns to herself. Standard errors in parentheses below coefficient values are clustered at the matching group level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B3: Investment and Correlation Data by Session

	Correlation between Endorsements and Relative Contribution (Rounds 1–5)	Average Contributions (Rounds 6–10)
A. Sessions with Low Contributions		
Session 2	0.21	14.10
Session 3	0.26	19.57
Session 6	0.40	21.23
Sessions 2, 3 and 6	0.31	18.82
B. Sessions with High Contributions		
Session 1	0.56	42.25
Session 4	0.59	54.47
Session 5	0.66	59.33
Sessions 1, 4, and 5 Pooled	0.60	52.02

Table B4: Linear Regression of Amount Invested in the Weakest-link Game on the Period of Play in Treatments *BO*, *ENDO*, and *PROP*

	BO	PROP	ENDO
	(1)	(2)	(3)
Period	1.008	1.019**	-0.402
	(0.464)	(0.299)	(0.432)
Constant	32.351***	36.192***	36.169***
	(1.389)	(3.889)	(2.106)
Observations	600	600	700

The dependent variable is the amount invested by a group member in a given game in Period 1 only. Standard errors in parentheses below coefficient values are clustered at the matching group level. * $p < 0.1$, ** $p < 0.05$, *** p< 0.01.

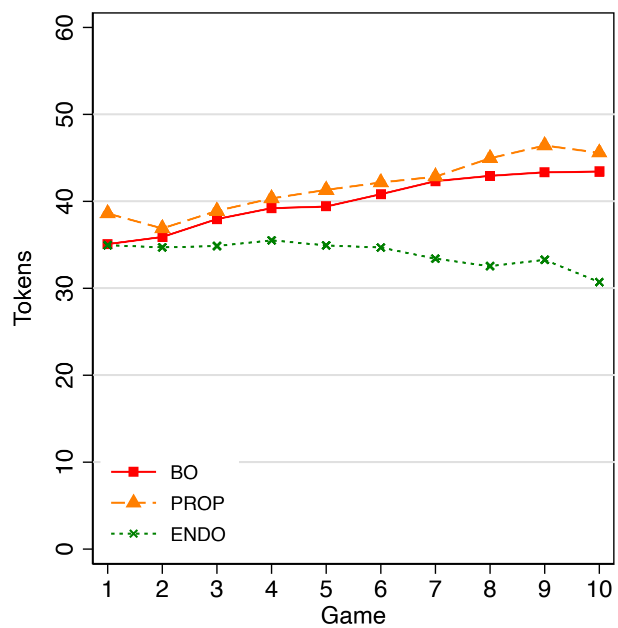

Figure B1: Evolution of Contributions, Treaments *ENDO*, *PROP* and *BO*

Note: The graph illustrates the evolution of average contributions over 10 games across treatments *BO*, *PROP* and *ENDO*.

Table B5: Linear Regression of Amount Contributed in Treatments *BO*, *ENDO*, and *PROP*: Period 1 vs. All Periods

	Period 1	**All Periods**
PROP	5.650**	3.905***
	(2.432)	(0.987)
ENDO	2.007	-3.936***
	(2.276)	(1.393)
Constant	32.950***	37.893***
	(1.699)	(0.598)
Observations	190	1900
Test of Treatment Differences:		
PROP – ENDO	3.643	7.841***
	$p = 0.153$	$p < 0.001$

The dependent variable is the amount invested by a group member in a given game, with the reference group being treatment *BO*. Standard errors in parentheses below coefficient values are clustered at the matching-group level. Post-estimation F tests report effect sizes and corresponding p-values. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C Instructions

Instructions for treatments *BO*, BO^+ and *BU* are very similar (weakest link and ex-post bargaining), with the main difference being that in treatment *BO* (Bargaining Observable), there is no team fee guarantee (i.e., $x = 0$). In treatment BO^+, there is a positive team guarantee of 150 tokens (i.e., $x = 150$). Lastly, in Treatment *BU* with ex post bargaining in which contributions to the surplus are unobservable and $x = 0$.

C.1 Treatments *BO*, BO^+ AND *BU*

Experiment Instructions

This is an experiment in the economics of decision-making. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment.

Please read the following carefully, as you will be asked to answer some comprehension questions later during the experiment. **If you answer a comprehension question incorrectly after 3 attempts, you will not receive any payment.**

We follow a no-deception ethical policy in this laboratory; hence these instructions fully describe the experiment. Your identity is **secret**. You will never be asked to reveal it to anyone during the course of the experiment. Your name will never be recorded by anyone. Neither the experimenters nor the other participants will be able to link you to any of the decisions you make.

A Brief Overview of the Experiment

In this experiment, you will be part of a group of 5 people that must decide on how much to invest into a common fund. You will then proceed to bargain with your group members on how to divide the group's common fund.

The figure below provides a visual diagram of the experimental tasks.

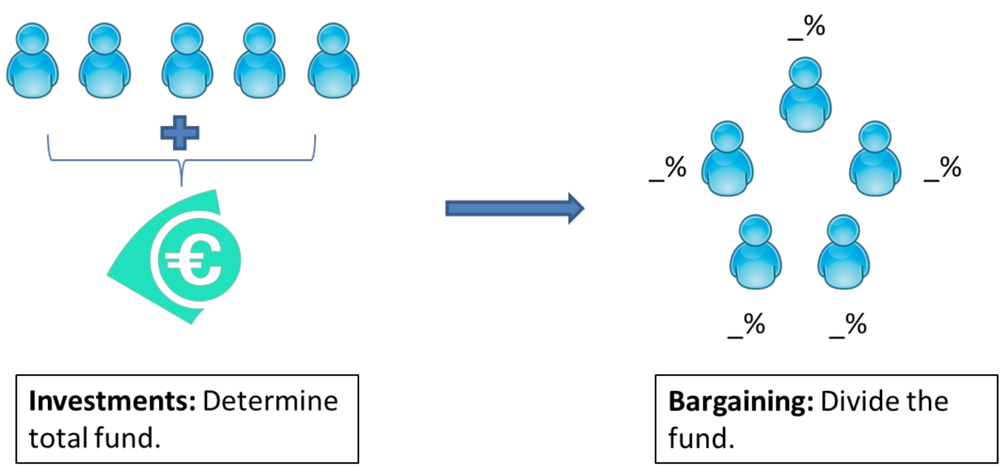

Figure 1: Experimental Tasks Diagram

The Details of the Experiment

This experiment involves two main tasks: (1) **Investment** and (2) **Bargaining to divide the fund**. We proceed to fully explain each stage.

(1) Investment Stage

a. You are endowed with 60 tokens and will be asked to enter an amount that you wish to invest in the group's account. Your investment is multiplied **times two** and this determines your **contribution**. All decisions are simultaneous. Note that whatever amount you decide to invest is deducted from your initial holdings of 60 tokens.

b. Once everyone in your group has chosen an investment level, the computer will pick the **smallest contribution** and this amount will count as everyone's contribution. The smallest contribution is multiplied times the number of members in your group (times 5) in order to determine the **total fund**. Hence, the fund is determined according to the following simple equation:

$$\text{Fund} = 5 \times [\text{Minimum Investment in Group} \times 2]$$

c. **Examples:**
Example 1: Your investment = 57; others invest (30, 43, 60, 35). The smallest investment is 30, hence the total group fund is 300.
Example 2: Your investment = 40; others invest (50, 50, 60, 60). The smallest investment is 40, hence the total group fund is 400.

Bargaining Stage

Bargaining consists of two stages: (2a) Proposal and (2b) Voting.

(2.a) **Proposal:** Each member of the committee will be asked to choose a division of the fund assigned to each member including him/herself. We call this division a **proposal**. Naturally, the sum of the shares must equal to 100% of the total fund. Only **one of the proposals will be randomly chosen** by the computer to be voted on. All proposals have the same chance of being selected.

(2.b) **Voting:** After a proposal has been randomly chosen, everyone will proceed to a voting stage. At this point, you are asked to "Accept" or "Reject" the distribution of shares that is being proposed. If your proposal is the one selected for voting, you also have to cast a vote. A majority (3 or more members) must vote in favor to approve.

(a) **If rejected:** every member in your group will proceed to stage (2.a) in order to enter a new distribution of shares. Feedback on the previous proposals, the voting result, and who was the proposer, will be displayed below on your screens.

(b) **If approved:** the result will be binding and your payoffs are determined for that period.

Other Details

You will participate in **10 periods** consisting of stages (1. Investment) and (2. Bargaining).

A period ends when an agreement is reached. Each new period you will be endowed again with 60 tokens and your group composition will be determined randomly, meaning that it is unlikely to face the same members from one period to the other. Also, your ID will change when you are assigned to a new group. In one period you can be "Subject 1" and in another period you can be "Subject 3", so that no one can identify you in further periods. Have in mind that, within a period, your ID is always the same and known to others in your group.

Your Earnings

One of the 10 periods will be randomly selected for payment, and all have an equal chance of being selected. The period is chosen by the computer and is the same for all subjects in the room. Your earnings (E) are given by:

$$E = (60 - \text{Your Investment}) + \text{Assigned Share} \times \text{Fund}$$

where the group fund is:

$$\text{Fund} = 5 \times [\text{Minimum Investment in Group} \times 2].$$

The conversion rate is **10 tokens = 1 euro**. Your final payment is:

$$\text{Payment} = \text{Show-up Fee} + E/10.$$

Example

The following example is not meant to guide you through the steps.

If Subject 1 invests 30, Subjects 2 and 3 invest 10, and Subjects 4 and 5 invest 20, the smallest investment is 20 which determines a total group fund of 100. Suppose that Subject 1's proposal is chosen to be voted on and specifies 40% for himself, and 15% for Subjects 2, 3, 4, and 5. If there are three or more votes in favor the proposal is approved and the following table contains the earnings information of each person:

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Investment	30	10	10	20	20
Minimum Investment	20	20	20	20	20
Total Fund	100	100	100	100	100
Share of Fund (%)	40%	15%	15%	15%	15%
Share in Tokens	40	15	15	15	15
Earnings	70	65	65	55	55

The earnings for Subject 1 are computed as follows: 60 (endowment) – 30 (investments) +40% x 100 (Share x Fund)= 70. A similar calculation is performed for each other subject in the group.

Please make sure you understand how the earnings are determined. If you have a question please raise your hand.

Control Questions

Before the experiment starts, we will ask you some questions to check your understanding.

Bargaining stage:

1. If a proposal is rejected by 3 out of 5 players in your group, the game finishes, and a new Proposal and Voting stages start (FALSE/TRUE)
2. You will keep the same ID and subject number within each period (FALSE/TRUE)
3. You will keep the same ID and subject number in all 10 periods (FALSE/TRUE).
4. In every period of the experiment, you are interacting with:
   - 4.1. The same group of five people.
   - 4.2. A randomly selected new group of five people.
   - 4.3. A group from a previous session.
   - 4.4. A computer.

Review of the Experiment

- Everyone is randomly assigned into groups of 5 people.
- Out of your 60 token endowment, you will decide how much to invest.
- Each member will propose a distribution of the common fund.
- One of the proposals will be chosen for voting, and everyone will cast a vote.
- If a majority accepts, the allocation is binding.
- If a majority rejects, everyone in the group will be called to submit a new proposal, and the process repeats itself until a given proposal is accepted.
- In each period you will be randomly paired with new members.
- 1 of the 10 periods of will be randomly chosen for payments.

Now we will proceed to a trial period that does not count for money, it is only meant to familiarize you with the screens and functionalities of the computer program. We ask you to not click or enter anything until we tell you to do so.

Post-Experiment Questionnaire

Thank you for your participation in the experiment! Before you finish the study, we will ask you some more questions

Self-Assessment

1. On a scale from 1–10, how willing are you to take risks?

2. On a scale from 1–10, how willing are you to trust people you have not met?

3. How important is competitiveness for success in life?

4. On a scale from 1–10, indicate agreement with:

   4.1. Effort should determine compensation, even if it leads to inequality.

   4.2. Everyone should be equally compensated, even if it reduces incentives.

   4.3. I stand up for myself even if it seems unpleasant to others.

   4.4. Competition brings out the best in me.

Final Questions

1. In general, how willing are you to take risks? On a scale from 1 to 10 please indicate your willingness to take risks where 1 means "avoid taking risks at all" and 10 means "completely willing to take risks".

2. In general, how willing are you to trust people you have not met before? On a scale from 1 to 10 please indicate your willingness to trust people you have not met before where 1 means "avoid trusting at all" and 10 means "completely willing to trust".

3. In your opinion, in order to succeed in life, how important is it to be competitive? [Not at all important] [Slightly Important] [Important] [Fairly Important] [Very Important]

From 1 to 10, how strongly do you agree with the following statements? 1 means "strongly disagree" and 10 means "strongly agree"

1. In general, I think that individual compensation should reflect one's effort, even if it implies highly unequal earnings.

2. In general, I believe that individuals should be equally compensated, even if it eliminates monetary incentives for exerting effort.

3. In general, I do not mind standing up for myself, even if it implies risking becoming unpleasant in the eyes of others.

4. In general, competition brings the best out of me

Please answer the questions below. There is no "right" or "wrong" answer. Your responses will help us to understand the results of the experiment, thus we appreciate you taking your time to answer these questions sincerely.

1. From 1 to 10, how likely are you o agree with the following statement: "in general, I am willing to engage in negotiations for my benefit" 1 means "strongly disagree" and 10 means "strongly agree"

2. What considerations did you take into account when proposing a distribution of the common fund?

3. What considerations did you take into account when voting on a distribution? What made you vote in favor? What made you vote against it?

4. What considerations did you take into account when deciding how much to invest?

We thank you for the time spent taking this experiment. You will be told your corresponding earnings from this experiment.

C.2 Treatment ENDO

Experiment Instructions

This is an experiment in the economics of decision making. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment. We follow a no-deception ethical policy in this laboratory; hence these instructions fully describe the experiment.

A Brief Overview of the Experiment

In this experiment you will be part of a group of 5 people that must decide on how much to invest into a common fund that can grow in magnitude. You will then proceed to bargain with your group members on how to divide the group's common fund.

The Details of the Experiment

As expressed above, this experiment involves two main tasks:

1. Investment
2. Bargaining to divide the fund

(1) Investment Stage

a. You are endowed with 60 tokens and will be asked to enter an amount that you wish to invest in the group's account. Your investment is multiplied **times two** and this determines your **contribution**. All decisions are simultaneous. Note that whatever amount you decide to invest is deducted from your initial holdings of 60 tokens.

b. Once everyone in your group has chosen an investment level, the computer will pick the **smallest contribution** and this amount will count as everyone's contribution. The smallest contribution is multiplied times the number of members in your group (times 5) in order to determine the **total fund**. Hence, the fund is determined according to the following simple equation:

$$\text{Fund} = 5 \times [\text{Minimum Investment in Group} \times 2]$$

c. **Examples:**
Example 1: Your investment = 57; others invest (30, 43, 60, 35). The smallest invest-

ment is 30, hence the total group fund is 300.

Example 2: Your investment = 40; others invest (50, 50, 60, 60). The smallest investment is 40, hence the total group fund is 400.

(2) Bargaining Stage

Bargaining consists of three stages:

a. **Proposer Selection:** After investments are made and revealed to the group, you will indicate which member(s) of your group you would want to be able to propose a division of the group's common fund. By supporting a member, you are metaphorically introducing a hypothetical raffle ticket with their subject number into a raffle box from which a proposer will be drawn. The more raffle tickets that a given member has (i.e., supporters), the more likely that member will be selected as the proposer. You will always be counted as supporting yourself.

   The probability that a given member is the proposer is equal to the number of raffle tickets (i.e., supporters) he or she has, divided by total number of tickets in the hypothetical raffle box.

   You will know your probability of being the proposer, but you will not reveal who supported you and who did not.

   Example:

   Suppose that, after tallying the support each member has received, we have the following result.

Subject	Support Received	Probability of Proposing
1	1	10%
2	2	20%
3	1	10%
4	2	20%
5	4	40%

   In this example, the probability that player 1 proposes is 1 / 10 = 10%, player 2 is 2 / 10 = 20%, and so on. Note that players 1 and 3 only received their own support, while player 5 received the support of three other subjects.

b. **Proposal:** Each member of the committee will be asked to choose a division of the fund assigning a share to each member including him/herself. We call this division a proposal. Naturally, the sum of the shares must equal to the total available fund. Only one of the proposals will be randomly chosen by the computer to be voted on. The probability that a given proposal is selected by the computer is determined by the support received as explained in 2.a.

c. **Voting:** After a proposal has been randomly chosen, everyone will proceed to a voting stage. At this point you are asked to "Accept" or "Reject" the distribution of shares that is being proposed. If your proposal is the one selected you also have to vote. A majority (3 or more members) must vote in favor to approve.

- **If rejected:** every member in your group will proceed to stage (2.b) in order to enter a new distribution of shares. Feedback on the previous proposals, the voting result, and who was the proposer, will be displayed below on your screens.
- **If approved:** the result will be binding and your payoffs are determined for that period

Other Details

You will participate in 10 periods consisting of stages (1. Investment) and (2. Bargaining). Each period you are again endowed with 60 tokens and your group composition will be determined randomly, meaning that it is unlikely to face the same members from one period to the other. Also, your ID will change when you are assigned into a new group. In one period you can be "Subject 1" and in another period you can be "Subject 3", so that no one can identify you in further periods. Have in mind that, within a period, your ID is always the same and known to others in your group.

Your Earnings

One of the 10 periods will be randomly selected for payment, and all have equal chance of being selected. The period is chosen by the computer and is that same for all subjects in the room. Your earnings (E) are given by

$$E = (60 - \text{Your Investment}) + \text{Assigned Share}$$

The conversion rate is 10 tokens = 1 euro. Thus:

$$\text{Payment} = \text{Show-up Fee} + \frac{E}{10}$$

Are there any questions so far?

Examples

The following examples are meant to guide you through the steps. You are free to make your own choices during the experiment.

Example 1. Consider a 5-person committee in which each individual is endowed with 60 tokens. The total fund is determined as described above. If person A invests 30, persons B and C invest 10, and persons D and E invest 20, the smallest investment is 20, which determines a total group fund of 200. Suppose that person A's proposal is chosen and specifies 40 for himself and 15 for each of B, C, D, and E. If there are three or more votes in favor, the proposal is approve,d and the following table contains the earnings information of each person:

	A	B	C	D	E
Investment choice	30	10	10	20	20
Minimum	10	10	10	10	10
Total Fund	5x10x2=100	100	100	100	100
Share of fund	40	15	15	15	15
Earnings	60–30+40=70	60–10+15=65	60–10+15=65	60–20+15=55	60–20+15=55

Please make sure you understand each how the earnings are determined. If you have a question please raise your hand.

This is just an example; you do not have to do this. Instead, alternative investment could have taken place or the proposal could have been voted down and a new proposal round would have taken place.

Example 2. Consider a 5 person committee in which individuals are endowed with 60 tokens. The total fund is determined as described in the separate Table provided to you. Now suppose that Persons A,B, and C invest 50, Person D invest 40, and Person E invests 60, the smallest investment is 40 which determines the total fund of 400. Suppose that member

B's proposal was chosen and each player is assigned a 80 tokens. If votes were "Yes" for persons A,B,C, and D and person E votes against, the proposal is approved. The following table contains the information of each person but you have to calculate the earnings. In 3 minutes we will check that your answers are correct, and if more than one is incorrect, you may be asked to leave the experiment.

	A	B	C	D	E
Investment choice	50	50	50	40	60
Minimum	40	40	40	40	40
Total Fund	400	400	400	400	400
Share of fund	80	80	80	80	80
Earnings					

If votes would have been "no","no","no","yes","no", then a new round of proposals and voting will take place. Also, different investments could have occurred.

Are there any questions?

What should you do? If we knew the answer to this question we would not be conducting an experiment.

Review of the Experiment

1. Everyone is randomly assigned into groups of 5 people.
2. Out of your 60 token endowment, you will decide how much to invest.
3. Members will decide who they would want to be the proposer and who they would not.
4. Each member will propose a distribution of the common fund.
5. One of the proposals will be chosen for voting according to the probability of proposer selection as determined by support received (see step 3)
6. Everyone will cast a vote on the division of the group fund that was selected.
7. If a majority accepts, the allocation is binding.

8. If a majority rejects, everyone in the group will be called to submit a new proposal, and the process repeats itself until a given proposal is accepted.

9. In each period of play you will be randomly paired with new members.

10. 1 of the 10 periods of play will be randomly chosen for payments.

Now we will proceed to a trial period that does not count for money, it is only meant to familiarize you with the screens and functionalities of the computer program. We ask you to not click or enter anything until we tell you to do so.