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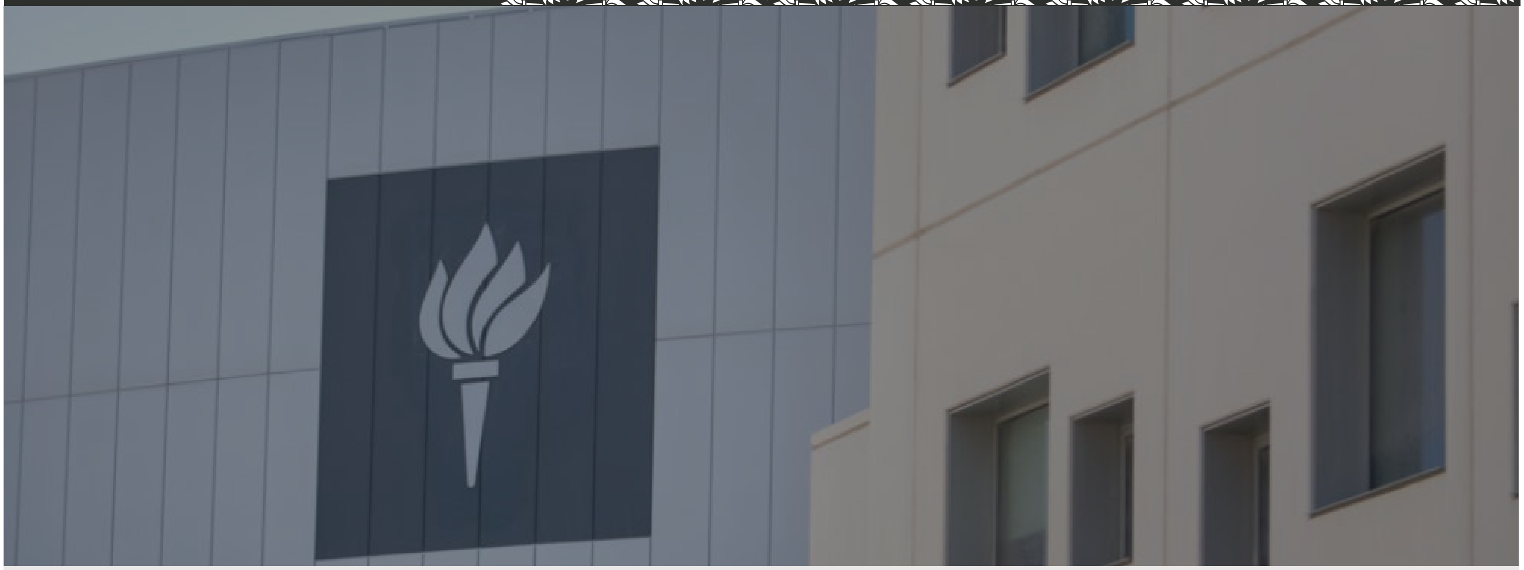

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Communication in Multilateral Bargaining with Joint Production

Andrzej Baranski[*] Caleb A. Cox[†]

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Abstract

We experimentally investigate the effect on efficiency of pre-bargaining communication in a multilateral majoritarian bargaining game with joint production under two conditions: observable and unobservable productive investments. In both conditions, communication mainly fosters fair sharing and is rarely used by proposers to pit voters against each other. A virtuous cycle of proportional surplus sharing arises in treatments with observable investments regardless of whether communication is possible leading to high efficiency gains over time. In the absence of investment observability, communication is widely used by subjects to truthfully report their investments, which coupled with calls for equitable sharing, allows for substantial efficiency gains. These results contrast sharply with previous findings on bargaining over an exogenous fund where communication leads to highly unequal outcomes, competitive messages, and virtually no calls for fair sharing.

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1 Introduction

In many economic situations involving joint production, the distribution of benefits among partners takes place once parties have exerted effort or invested resources into their common task. Communication is an essential component in bargaining settings and it can significantly affect agreements (Andreoni and Rao, 2011), which may in turn affect incentives to exert effort into the production process. Evidence from previous studies shows that pre-play communication leads to highly unequal outcomes (absent joint production see Agranov and Tergiman (2014)) while joint production without communication leads to equitable sharing in bargaining (Cappelen et al., 2007; Baranski, 2016). In this paper, we investigate whether communication during profit-sharing will exacerbate competitive behavior, or instead foster fair sharing. Depending on which effect dominates, efficiency will be affected negatively or positively.

One illustrative example may be found in Major League Baseball where the top 10 teams earn a rank-dependent bonus from the *player's pool* which comes from ticket sales. "Once the money has been divvied out to each club, its up to the players to decide who gets a share of their teams winnings (Elkins, 2018)." In a highly-publicized case of the music industry (Azerrad, 1992), Nirvana lead singer Kurt Cobain negotiated with the band's members to receive 75 percent of the songwriting royalties retroactively since the launch of the album *Nevermind*, citing that he had written most of the songs.[1] Legal partnerships are also well-known for holding end-of-year profit-sharing meetings, once it is known how many hours each partner billed or how many trials were won.

While anecdotal accounts of profit-sharing negotiations are common, field data on the process behind the agreements is virtually nonexistent.[2] A burgeoning experimental literature on bargaining over the benefits resulting from joint production has emerged to fill this gap. There is unequivocal evidence that entitlements matter to bargainers when assigning shares of the common surplus (Cappelen et al., 2007; Karagözoğlu and Riedl, 2014). Such entitlements are even evoked in settings where the surplus is framed as if it had been produced despite no investments or effort taking place (Gächter and Riedl, 2006).[3] Importantly, respecting other's inputs in bargaining, ab-

[1] The agreement in place prior to renegotiation was an equal split.

[2] An exception is van Dolder et al. (2015) who report on a TV show where contestants negotiate how to split their joint profits accumulated through answering trivia questions as a team.

[3] Absent a joint production process, outcomes tend to be positively correlated with *bargaining power*: i.e. who holds proposal rights. For example, in dictator, ultimatum, and multilateral bargaining games, the evidence shows

sent a contract, has been shown to give rise to high efficiency gains in problems of collective action as shown in Baranski (2016, 2018) and Dong et al. (2019).

The literature has largely ignored the role that communication may play in the division of surplus despite its relevance to settings with joint production.[4] To our knowledge, there are no studies on how communication during profit sharing affects productive incentives. To address this problem, we conduct an experiment on the majoritarian bargaining game developed by Baron and Ferejohn (1989) (hereafter BF). In our experiment, the surplus is created via individual investments and we vary whether subjects may communicate or not during the bargaining stage and whether or not group members may observe individual contributions.

The BF model of multilateral bargaining is one of the most widely-studied models in Economics and Political Science both theoretically and empirically.[5] Several experiments (Fréchette et al., 2005a,b; Diermeier and Morton, 2005; Miller et al., 2018) have documented that, when bargaining to divide an exogenous surplus, the proposer typically holds a payoff advantage and modal allocations are those in which only the minimum number of voters required for approval receive a positive share.

It has been well established that communication (absent joint production) leads to highly unequal outcomes (Agranov and Tergiman, 2014): proposers can extract larger rents because communication is used to induce competition between voters for a spot in the winning coalition. Confirming the previous study, Baranski and Kagel (2015) report that voters actively ask proposers to exclude redundant members.[6] On the other hand, joint production (absent communication) fosters equitable sharing: shares are typically correlated with contributions to the common fund (Baranski, 2016). As a result, all-way splits are modal and not minimum winning coalitions.

Given the opposing effects on bargaining outcomes that joint production and communication have (considered in isolation), our experiment will shed light on whether the competitive effect of communication crowds out the tendency to share the surplus based on individual contributions,

that proposers typically enjoy a larger share of the endowment. In Settings with symmetric bargaining power equal splits prevail. For details, see Roth (1987).

[4]See Abbink et al. (2018) for a recent experiment in which peers decide on surplus divisions but only a subset of peers may communicate. In their experiment, subjects excluded from communication channels reduce their investments because communicating peers collude against isolated members. Absent communication, full efficiency obtains as in Dong et al. (2019).

[5]See Eraslan and Evdokimov (2019) for a comprehensive review of the theoretical literature.

[6]For an experiment on dynamic bargaining with communication see Baron et al. (2017).

or whether equitable sharing prevails. Absent communication, investments create a focal point on how to redistribute equitably. However, some players would benefit from alternative redistribution schemes such as minimum winning coalitions and thus may use communication to pursue them.

Our results show that communication at the bargaining stage is mainly used to promote fairness either as equality or equity.[7] In all treatments, proposer power is quite low and all-way splits are modal, not minimal winning coalitions. Communication content reveals that exchanged messages differ widely from those reported in experiments with an exogenous fund. Proposers are not actively seeking for the *cheapest* coalition partners, nor are voters actively requesting the exclusion of redundant members as one would conjecture if the competitive effect of communication prevailed. Instead, calls for equitable sharing are commonplace.

Communication has a significant positive impact on efficiency when investments are unobservable because truthful reporting of one's investment is quite common. Proposers tend to use this information to redistribute proportionally as they would under observability. Thus, a weaker version of the virtuous cycle that arises when investments are observable fosters efficiency gains. We find no treatment differences of communication on average efficiency when investments are observable, meaning that subjects do not use communication to coordinate on *competitive* outcomes as they typically do with an exogenous fund.

The article is structured as follows. Section 2 presents the experimental design. Section 3 contains the equilibrium characterizations and experimental hypotheses. The results are reported in Section 4 with a subsection devoted to the analysis of communication content. Section 5 presents a discussion and concludes the article.

2 The Model and Equilibrium Predictions

Below we describe the game with the same parameters that were implemented in the experiment for conciseness, although it can be easily extended to a more general framework. Our focus will be on the game without communication but will comment on the role that cheap talk may have at the bargaining stage.

The game has two stages: Investments and bargaining. In stage 1, players simultaneously and

[7] In our experiment communication only takes place during the proposal stage, not at the investment stage. We discuss this issue in light of existing literature in our final discussion.

independently choose $c_i \in [0, 50] \subset \mathbb{N}$. The sum of investments multiplied times 1.8 determines the total fund. Thus, we have that

$$F = 1.8 \sum_i c_i \ .$$

In stage two, players bargain according the following rule: a randomly selected player makes a proposal after which the remaining players simultaneously vote. If a majority, including the proposer, votes in favor, bargaining ends and payoffs are realized, otherwise the process repeats itself until approval.

The payoffs of player i when she contributes c_i and receives a share s_i are given by

$$u_i(c_i, s_i) = 50 - c_i + s_i \ .$$

2.1 Stationary Subgame Perfect Equilibrium

The literature has almost exclusively focused on stationary subgame perfect equilibrium (SSPE), meaning that there are no profitable deviations at any point and that strategies are history independent in the bargaining game. Thus, at every identical subgame following a rejection, equilibrium prescribes the same strategies. SSPE have been particularly attractive because they establish a unique outcome (see Eraslan (2002)).

At the bargaining stage, each player faces three disjoint possibilities: (1) being the proposer, (2) being included into the coalition or (3) being excluded. The smallest amount a player is willing to accept is given by the average payoff resulting from the three scenarios above because it makes her indifferent between accepting or rejecting.[8]. Letting V_i denote player i's expected payoff of the game at any stage (due to stationarity this value does not change) we have that

$$V_i = (1/3)(F - \sum_{j \neq i} \delta \phi_{ij} V_j) + (1/3) \sum_{j \neq i} \delta \phi_{ji} V_i \qquad (1)$$

where ϕ_{ij} is the probability that player i includes j into the winning coalition and where δ is the discount factor in case the proposal is rejected. We normalize equation 1 dividing by F on both

[8] We follow the standard assumption in the literature that players vote in favor whenever indifferent.

sides to obtain

$$v_i = (1/3)(1 - \sum_{j \neq i} \delta \phi_{ij} v_j) + (1/3) \sum_{j \neq i} \delta \phi_{ji} v_i$$

where $v_i = V_i/F$. This is equivalent to bargaining over a unit of wealth, with the interpretation that v_i's denote a proportion of the total fund.

Imposing symmetry, meaning that each player has the same expected payoff ($v_i = v_j = v$) and that players perfectly randomize over whom to include in the winning coalition ($\phi_{ij} = 1/2$ for all i, j), we obtain that $v = 1/3$. Thus, prior to the investment stage, players expect to receive 1/3 of the total fund. As such, backward inducting to stage one, a player's maximization problem is given by

$$max_{c_i} \, 50 - c_i + F/3 \ .$$

It is straightforward to verify that profits are decreasing in c_i for any vector of investments, thus it is optimal to not contribute at all.

Lemma 1. *The stationary subgame perfect equilibrium of the game is given by:*

1. *No one contributes;*
2. *If there are contributions the fund is split as follows: The proposer keeps* 2/3 *of the fund and offers* 1/3 *to a randomly selected partner;*
3. *Any player receiving at least* 1/3 *of the fund votes in favor;*
4. *Bargaining ends in round 1.*

We highlight two aspects. First, allowing for communication during the proposal stage of the bargaining subgame game will not play any role on equilibrium. Rational players compute the ex ante value and there is no uncertainty of preferences in the model. Thus, credible messages can only express *equilibrium* behavior. Second, observability of investments is irrelevant, because these are considered sunk at the bargaining stage. This irrelevance is due to the stationarity assumption which we dispose of in the next subsection.

2.2 Subgame Perfect Equilibrium

Any allocation can be admitted as subgame perfect equilibrium (SPE) at the bargaining stage when strategies are allowed to depend on history. This is because punishment for off-equilibrium behavior can be exercised. The proof may be found in Theorem 3.1 of Herings et al. (2018) and is omitted here. Note, however, that this does not imply that any contribution choice is part of an SPE. Investments will certainly depend on the bargaining equilibrium played at the subgame.

The main contribution of Herings et al. (2018) is to identify a punishment strategy for deviators such that it does not pay to vote against the equilibrium proposal or propose differently. Which proposal is selected in equilibrium is exogenous to the model. We argue that productive investments and communication can be used as equilibrium selection mechanisms. Furthermore, depending on which equilibrium is selected, different levels of efficiency may be sustained.

In Baranski (2016) the data show that investments are used by subjects to redistribute proportionally, which eventually leads to efficient outcomes. However, communication without investments (Agranov and Tergiman, 2014; Baranski and Kagel, 2015) is shown to lead to highly unequal outcomes in which proposers form coalitions with *cheap* voters, i.e. those stating low reservation shares. Thus, if communication with joint production serves the same purpose as with an exogenous fund, it is likely that low contributing members will be more often included in a coalition since they are expected to have a lower asking share. As we show, this would lead to an unravelling of investments.

The following lemma summarizes our analysis.

Lemma 2.

1. *When there is no discounting, any allocation of the fund is an SPE of the bargaining game (Herings et al., 2018).*
2. *In the game with observable investments, maximum efficiency will arise in equilibrium if the proposer assigns $s_i \geq c_i$ for all i. (Baranski, 2016)*
3. *In the game with observable investments, zero efficiency will arise if the proposer splits the fund in half with the lowest contributing non-proposing partner.*

Several issues are worth discussing. For (2) to hold, the proposer must be able to identify each member's contribution. Absent observability, the proposer would rely on self-reports. Let

$m_i \in \{0, 1, ..., 50\}$ be a message sent by player i to the proposer prior. If players know that the share offered by the proposer is positively correlated with their report, then they have an incentive to overstate their contribution. While talk is monetarily cheap (free), being dishonest may well carry non-pecuniary costs. For example, assuming a large enough moral cost of lying (Kartik, 2009), there would exist an equilibrium in which players choose $m_i = c_i$ and proposers redistribute proportionally.

A proof for (3) in lemma 2 may be found in Appendix B. The general idea behind the unravelling of investments is that if proposers form a coalition with the lowest contributing partner, being a high contributor is too costly. By reducing one's investments, the enhanced odds of sharing in the surplus outweigh the fall in the size of the total fund.

3 Experimental Design

We conducted four treatments in which we varied the presence of pre-bargaining communication and the observability of investments. Table 1 presents the number of sessions, subjects per session and average payoffs. Subjects were recruited via ORSEE (Greiner 2015) from the Virginia Commonwealth University laboratory pool during the Fall semester of 2018. Each subject participated in only one session. On average, each subject earned \$14.29, excluding a \$5 show-up fee. Typical sessions lasted approximately 45 minutes (No Chat) to 60 minutes (Chat).

Table 1: Summary of Experimental Treatments

Treatment	Abbreviation	# Sessions	# Subjects	Earnings
No Chat & Unobservable Investments	NC-NO	4	54	12.7
Chat & Unobservable Investments	C-NO	6	78	14.2
No Chat & Observable Investments	NC-O	4	48	14.7
Chat & Observable Investments	C-O	6	72	15.3

In each session, subjects were handed written instructions, which were also read aloud by the experimenter. A practice run was conducted to ensure a proper understanding of the experimental interface, which was programmed in z-Tree (Fischbacher 2007). The complete instructions and experimental screen shots are presented in the Online Appendix.

Each session consists of ten bargaining games or periods, with one randomly selected for payment and revealed at the end of the session. Across periods, matching into groups is random and anonymous (strangers matching). Within a period, an indefinite number rounds of bargaining could take place until agreement, and subjects had constant ID numbers within their three-person groups.[9]

At the beginning of each period, subjects are endowed with 50 tokens (5 tokens equal 1 USD) and can invest any non-negative integer amount up to their endowment. Investments are chosen simultaneously and independently. The sum of investments within the group is multiplied times 1.8 to determine the total fund which is displayed to all group members. Each member's individual investment is displayed only in the treatments with observable investments.

Next, one group member is randomly selected to propose a distribution of benefits which must exhaust the total fund. In the chat treatments, the proposer may exchange written messages with each non-proposer individually. But, importantly, non-proposers have no way of communicating with each other. We believe that this structure favors the emergence of competitive communication over messages of equitable sharing since voters have no way of knowing if they are both jointly calling for fair sharing. The chat interface closes after three minutes have passed or when the proposer submits a distribution of the fund, whichever comes first.

Once a proposal is submitted, non-proposing members are shown the distribution of the fund (each member's share) and must vote to accept or reject. The proposer is automatically counted in favor. The voting result is reported back and the decision is binding if a majority approves. Otherwise, the process repeats itself until approval. The history of previously rejected proposals is displayed including the ID numbers of the proposers. At the end of a period, all payoff information is publicly revealed.

4 Results

We present our results in a series of conclusions at the end of each subsection that summarize the main findings. Our data are typically pooled for all periods of play, and we focus on approved

[9] If 5 rounds of proposing go by without approval, thereafter members face a 50 percent probability of breakdown case in which the fund vanishes and all shares are 0. However, this scenario never occurred.

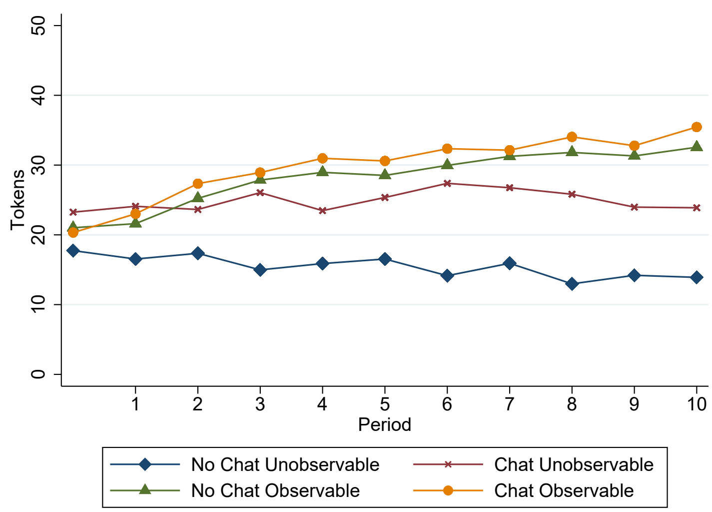
proposals unless stated otherwise. When Mann-Whitney (MW hereafter) tests are conducted, we report the p-value for a two-sided test and use session averages as the independent unit of observation.[10]

4.1 Investments

In the first period of play, subjects initially invest approximately 22 tokens (of 50) on average in all treatments except in NC-NO, where the average investment is approximately 16.5 tokens.[11]

This result suggests that there is some anticipation of the effect that unobservability of investments absent communication may have on bargaining outcomes and subsequently on incentives to contribute. The evolution of average investments by treatment is displayed in Figure 1.

Figure 1: Average Investments by Treatment



Communication has a positive impact on efficiency when investments are unobservable, averaging approximately 25 tokens in the C-NO treatment, which is significantly greater than 15 in NC-NO (p-value=0.033 for MW test). We find that communication does not affect efficiency when investments are observable (p-value=0.67).

Conclusion 1. *On average, communication has a positive effect on efficiency when investments are unobservable and has no effect when investments are observable. Efficiency is higher with*

[10] All the MW tests reported are robust to tests at the individual-decision level using cluster bootstrapping instead as a way to account for within-session correlation.

[11] These differences are significant. The p-values for MW tests are in parentheses: C-NO vs. NC-NO (0.004). NC-O vs. NC-NO (0.057). C-O vs. NC-NO (0.033). No other treatment difference is significant.

investment observability.

4.2 Bargaining Outcomes

In previous experiments with an exogenous fund, the focus has been on the average proposer share, the proportion of minimum winning coalitions, and the timing of approval. For comparison, we report these outcomes in Table 2 for all approved proposals. We also report the Fairness index defined by

$$Fairness = 1 - \sqrt{(\hat{c}_1 - \hat{s}_1)^2 + (\hat{c}_2 - \hat{s}_2)^2 + (\hat{c}_3 - \hat{s}_3)^2} \tag{2}$$

where $\hat{s}_i$ denotes the share offered to i as proportion of the total fund and $\hat{c}_i$ is player i's contribution as a proportion of the sum of contributions.

Table 2: Summary of Bargaining Outcomes

	SSPE	Unobservable		Observable	
	Prediction	No Chat	Chat	No Chat	Chat
Investments	0	15.25 (0.573)	25.04 (0.586)	28.91 (0.591)	30.76 (0.616)
2-way Splits (MWC)	100%	7.75	25.67	19.54	9.17
3-way Splits	0%	90.04	73.56	80.46	90.83
Proposer's Share	60% (0.855)	38.10 (0.844)	41.78 (0.927)	41.57 (0.709)	37.44
Lowest Share	0%	24.45 (0.904)	17.86 (0.842)	16.21 (0.944)	21.80 (0.699)
Fairness[1]	NA	0.61 (0.016)	0.70 (0.016)	0.80 (0.017)	0.86 (0.011)
Round 1 Approval	100%	86.13	96.17	85.65	96.25

Standard errors of the mean reported in parentheses below mean values.
[1] Fairness is calculated as 1 minus the euclidean distance between the perfectly proportional allocation. Exact definition in equation (2).

On average, proposers keep between 37 and 40 percent of the total fund. There is no difference in the proposer's mean share with and without communication (p-value=0.355 two-sided MW test). Moreover, communication does not uniformly affect the proportion of minimum winning coalitions (p-value=0.588 two-sided MW test).

Absent investment observability, communication leads to more MWCs (p-value=0.064 two-sided

MW test) but it makes no significant difference when investments are observable (p-value=0.239 two-sided MW test). In all treatments, the modal approved allocations include payments to all members.

Communication has a significant impact on the timing of agreement as it leads to less delay. 14 percent of bargaining groups settle after round 1 when there is no possibility to chat while only 4 percent delay agreement when communication is possible (p-value<0.001 MW test).

Conclusion 2. *When the fund to distribute is endogenous, communication leads to outcomes that resemble an SPE where offered shares are greater than players' investments. The possibility to communicate does not significantly increase the proposer's mean share regardless of investment observability and allocations with payments to all members are modal, not minimum winning coalitions.*

4.3 Communication Content

We now turn to analyze the relationship between the messages exchanged by players and the bargaining outcomes. For this purpose, we inspected each chat to see which of the elements defined below were present in the discussions.[12]

1. **Proportionality:** whenever a member argues that the fund should be split proportionally in relation to each members contribution.

2. **Equality:** whenever a member states that the total fund should be split in equal parts between all three members.

3. **Minimum winning coalition:** Whenever the proposer mentions that she will only give money to one of the voters. When a voting member explicitly tells the proposer that the other member should get zero.

4. **Competition:** Whenever the proposer pits voters against each other by revealing their desired shares (truthfully or not) or ranking them. For voters, whenever they inquire how much the other one is willing to accept and offer to undercut.

[12] Two independent native English-speaking students were hired as coders. Both received the same set of written instructions available in the online appendix.

5. **Punishment:** when members discuss retaliating against the proposer of the previous round. (Only coded from round 2 onwards).

6. **Lying Detection:** whenever a group member expresses that the reported contributions are not compatible with the total fund. (Only coded in treatment with unobservable investments.)

Furthermore, we recorded subjects' stated minimum acceptable shares. For the unobservable investments treatment, we also recorded stated contributions and lying detection whenever a member argued that the sum of reported contributions exceeded those implied by the total available fund (or suspected someone was lying). Example conversations may be found in Appendix C and a summary of coders' agreement rates and Cohen's kappa (Cohen, 1960) are shown in the Online Appenix. Importantly, all agreement rates are above 90 percent and Cohen's kappa is above 0.52 for all categories except *competition*.[13]

For our analysis we count messages as belonging to each category if at least one coder recorded it as such. The Online Appendix reproduces our analysis taking the more conservative stance where both coders need to be in agreement, revealing no meaningful difference in our results.

In the treatment with observable investments, subjects are more likely to talk about proportional redistribution than any other of our categories. Proposers discuss proportionality in 31.6 percent of the bargaining rounds and at least one voter does in 47.1 of the cases. When investments are unobservable, the prevalence of proportionality is approximately halved, but the difference is not significant (p-value of 0.337 for proposers and 0.109 for voters. In both treatments, arguments for equality are made frequently, and are quite prevalent among voters when investments are unobservable (36.2 percent). These results contrast starkly from the Agranov and Tergiman (2014) and Baranski and Kagel (2015) as both studies report that arguing for fairness or all-inclusive allocations virtually disappears with experience (below 5 percent).

One particular mode of communication that both Agranov and Tergiman (2014) and Baranski and Kagel (2015) find is that voters solicit a spot in the coalition by stating their reservation shares to the proposer (74 percent in Agranov and Tergiman) and even actively request for other members to be excluded (close to 80 percent in Baranski and Kagel). Proposers also search for the voters with the lowest acceptance threshold and induce a competition between them for a spot in

[13]Cohen's kappa above 0.4 indicates moderate or better agreement based on the benchmark scale of Landis and Koch (1977).

Table 3: Percentage of Bargaining Rounds Coded for each Communication Category.[1]

	Unobservable	**Observable**
Proportional		
Proposer	17.9	31.6
Voter	24.6	47.1
MWC		
Proposer	15.7	13.8
Voter	23.5	20.4
Equality		
Proposer	15.7	19.6
Voter	36.2	26.7
Competition		
Proposer	2.2	3.1
Voter	0.4	0.9
Punishment[2]		
Proposer	0	26.7
Voter	10.5	26.7
Lying Detection		
Proposer	7.8	N/A
Voter	4.9	N/A

[1] We exclude all empty chat screens. Approximately 2% of all non-empty chat screens were marked as irrelevant by coders.
[2] This only includes conversations for bargaining round 2.

the MWC they were attempting to form (about 25 percent in each study). Our data show that proposers suggest forming MWCs less than 15 percent of the time and voters less than 24 percent of the time. Furthermore, proposers rarely pit voters against each other as we find almost no evidence for messages falling under the category *competition*.

Conclusion 3. *In our setting with joint production, communication is mainly used to argue for proportional sharing and equality. Messages suggesting the formation of minimal winning coalitions represent less than 24 percent of messages. Furthermore, proposers rarely pit voters against each other in order to lower their asking shares.*

In order to investigate how communication content relates to the proposals being made, we regressed the different chat categories on two distinct outcomes of interest: the fairness index and the probability of all members retrieving their investments. In our regressions we account for whether it is the proposer or a voter who is asking for proportional sharing or an MWC. We interact all regressors with a dummy variable that takes the value 1 when investments are observable in order to account for possible treatment effects. The results are reported in Table 4.

We find that arguing for proportionality has a positive effect on the fairness index of the proposal regardless of whether it is voters or proposers talking about proportionality. Our results are further confirmed by the estimated coefficients of the probability of proposing an allocation in which all members receive a share greater than or equal to their investments (column 2). However, the effect is smaller for the treatment with observability.

Communicating intentions to form an MWC negatively affects the fairness index and the odds of all members retrieving their investments with proposers' messages having a larger impact. For example, when no one argues for an MWC, the predicted probability of all members retrieving their contribution is 81 percent. If only a voter argues for an MWC, the probability drops to 68 percent, but if only a proposer argues for it, it drops to 50 percent.

We now turn to examine more closely the treatment without observability in order to understand the enhanced efficiency levels attained in the presence of communication. In 80 percent of all bargaining rounds, at least one member reports a contribution and in 26.7 percent of all bargaining rounds all members do it. Truth telling largely prevails as there is a 0.84 correlation between stated and actual contribution, and only 24 percent of stated contributions are inflated. Figure 2 shows

Table 4: Estimation results for the impact of communication on bargaining outcomes when both coders agree.

	Dependent Variables	
	(1)	(2)
	Fairness	All Members Retrieve Investment
(β_0) Constant	0.687***	0.240
	(0.0342)	(0.197)
(β_1) Observable	0.194***	1.305***
	(0.0490)	(0.314)
Proposer Messages:		
(β_2) Proportional	0.0970***	0.740***
	(0.0285)	(0.234)
(β_3) Observable × Proportional	-0.0598	-0.0435
	(0.0387)	(0.383)
(β_4) MWC	-0.148***	-0.899***
	(0.0273)	(0.216)
(β_5) Observable × MWC	-0.0439	-0.596*
	(0.0412)	(0.330)
Voter Messages:		
(β_6) Proportional	0.0856***	0.522**
	(0.0268)	(0.215)
(β_7) Observable × Proportional	-0.0820**	-0.466
	(0.0362)	(0.337)
(β_8) MWC	-0.0630**	-0.501***
	(0.0255)	(0.194)
(β_9) Observable × MWC	0.0303	-0.154
	(0.0375)	(0.305)
Estimation	Linear	Probit
Num. Obs.	571	569
χ^2	123.5	87.92

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors reported in parentheses below coefficient values. Regression account for session-specific random effects.

scatter plot of reported and actual investments (the size of the circle is proportional to the number of observations).

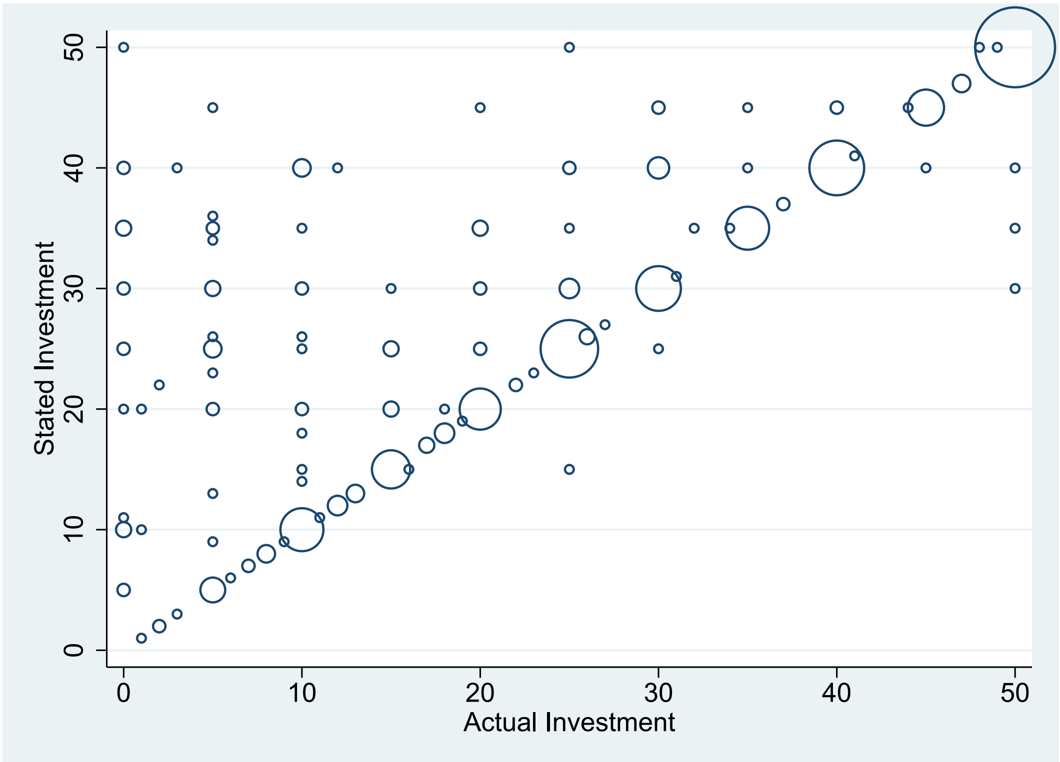


Figure 2: Actual versus Stated Investments in Communication Treatment with Unobservable Investments.

We estimated the relationship between a subject's actual investment and each of the three following outcomes the probability of over-reporting it, not reporting it at all, and truthfully reporting. The results of our multinomial probit estimation are reported in Table A1 (in Appendix). Figure 3 plots the marginal effect of investments on the probability of each outcome. The probability of over-reporting decreases with one's investment, while the probability of not reporting increases with investment. Finally, higher investors are more likely to state their contribution truthfully.

Conclusion 4. *The efficiency enhancing effect of communication in the treatment without observable investments is consistent with the high levels of truthful contribution reporting, which is used by proposers to distribute proportionally.*

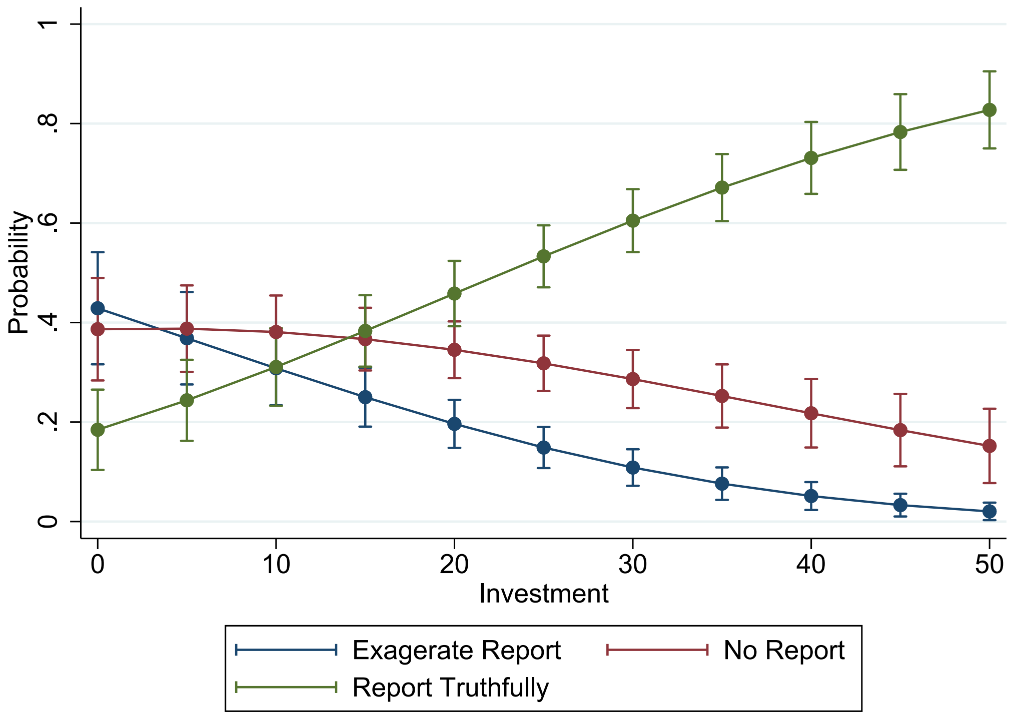


Figure 3: Predicted Probability of Lying, Not Reporting, and Truthfully Reporting One's Investment

5 Discussion and Concluding Remarks

A burgeoning experimental literature on bargaining over joint production provides clear evidence that entitlements matter to bargainers when assigning shares of the common surplus. Absent a joint production process, outcomes tend to be positively correlated with *bargaining power*: i.e. who holds proposal rights. We contribute to this growing body of work by showing that communication may foster equitable sharing and efficiency even when players efforts are unobservable. Given the previous findings revealing that cheap talk fosters competitive behavior from proposers and voters, we believe that our experiment is a stress test of the proportionality standard typically observed with joint production.

Our setting can be interpreted as the combination of a voluntary contribution mechanism with an endogenous surplus-sharing stage. Studies such as Isaac and Walker (1988); Ostrom et al. (1992); Bochet et al. (2006) have found that allowing for communication prior to subjects making investment decisions leads to an increase in efficiency in public goods games. A key difference with our study is that communication occurs after investments have been made, thus it cannot be used to coordinate on efficiency directly. Thus we argue that the expectations of a truthful and fair communication process is what drives efficiency gains in our setting.

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Appendix

A Supporting Tables and Figures

B Proof of Lemma 2

We show that no member contributing is the only equilibrium if at the bargaining subgame proposers form MWCs with the lowest contributing non-proposer member.

We start by showing that no player would like to deviate unilaterally from $\boldsymbol{c} = (0, 0, 0)$. In such scenario, every player earns 50 (endowment). Suppose player i invests $c_i > 0$. Then, the total fund is $F = 1.8 \cdot c_i$. With 1/3 chance she is the proposer and receives $0.5 \cdot F$ and with 2/3 chance she is a non-proposer and is never invited to the coalition. Her expected payoffs are $50 - c_i + \frac{1}{3}(1.8c_i) + \frac{2}{3}0$. This equals $50 - 0.4c_i < 50$ for all c_i. Thus, it does not pay to deviate.

Table A1: Probability of Voters Exaggerating Investment, Not Reporting, or Truthfully Reporting.

Exaggerate Investment in Report	
Investment	-0.0650***
	(0.00813)
Constant	1.949***
	(0.356)
Not Report Investment	
Investment	-0.0395***
	(0.00756)
Constant	1.323***
	(0.371)
Num. Obs.	540
χ^2	213.9

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard deviations reported in parentheses below coefficient values. Session fixed effects included but not shown.

Let $\boldsymbol{c} = (c_1, c_2, c_3) \geq (0, 0, 0)$ be a symmetric contribution vector, $c_1 = c_2 = c_3 = c$. The expected payoff is $1.8c + 50 - c = 50 + 0.8c$ because all players are equally likely to form the MWC and split in half the surplus. A player reducing her investment by 1 unit to $c - 1$ is invited to the coalition with probability 1, thus always sharing in half of the total fund. This leads to earning $50 - (c - 1) + \frac{1.8(3c-1)}{2}$. It straightforward to verify that it pays to undercut.

For an asymmetric vector of contributions, one can easily note that the highest contributing member is always better off by reducing her investment because she is never included in the coalition when the other members are proposing. Thus, she is able to receive half of the fund for 1/3 of the times (when she proposes). In expectation, the costs of contribution outweigh the expected return.

C Examples of Chat Coding Categories.

The following conversations are edited for grammatical mistakes.

Example 1: Proportionality expressed by a voter. [Observable Investments, Session 1, Group 2, Period 2, Round 1]

Voter:	I think since you didn't contribute that much, it would be fair if me and 3 got more

Example 2: Proportionality implied by the Propopser. [Unobservable Investments, Session 4, Group 2, Period 2, Round 1] In this example the proposer and voter are truthfully reporting their investments.

Voter:	I contributed 50 to the fund, for maximum return
Proposer:	good idea thank you
Voter:	it looks like 35 was contributed by yourself or between you and subject 2
Proposer:	ok thanks for the info - will distribute fairly. I did 15
Voter:	I'm not greedy so a 1.8 return is 90, is that acceptable?
Proposer:	yes

Example 3: Equality and Proportionality. [Unobservable Investments, Session 5, Group 3, Period 3, Round 1]. The proposer argues for an equal split, while the voter is coded as arguing for proportionality.

Proposer:	I want to split evenly. How much did you contribute?
Voter:	if we split evenly we gotta contribute evenly right? that makes sense
Proposer:	no
Voter:	last time I threw up the most and got the least profit compared. why should we split evenly if everyone contributes different amounts. that seems very....marxist like

Example 4: Proposer expresses desire to form a Minimum Winning Coalition. [Observable Investments. Session 9, Group 3, Period 4, Round 1]

Proposer:	want to split it evenly and screw the other person over
Voter:	Nah.. not worth my soul
Proposer:	you right lol

Online Appendix for Communication in Multilateral Bargaining with Joint Production

Andrzej Baranski and Caleb Cox

November 12, 2019

1 Chat Content and Impact on Outcomes when Both Coders Agree

In the body of the article we have conducted our analysis on communication content by assigning a chat category to a given bargaining round if at least one coder recorded it as such. In this section we present the results by requiring that both coders agree.

Table 1: Estimation results for the impact of communication on bargaining outcomes when both coders agree.

	Dependent Variables	
	(1) Fairness	(2) All Members Retrieve Investment
(β_0) Constant	0.697***	0.337*
	(0.0333)	(0.195)
(β_1) Observable	0.169***	1.017***
	(0.0474)	(0.295)
Proposer Messages		
(β_2) Proportional	0.196***	2.112***
	(0.0375)	(0.580)
(β_3) Observable $\times$ Proportional	-0.118**	-0.993
	(0.0490)	(0.711)
(β_4) MWC	-0.164***	-1.797***
	(0.0332)	(0.419)
(β_5) Observable $\times$ MWC	-0.0543	0.0800
	(0.0485)	(0.517)
Voter Messages		
(β_6) Proportional	0.0964***	0.753*
	(0.0347)	(0.390)
(β_7) Observable $\times$ Proportional	-0.0734*	-0.490
	(0.0438)	(0.484)
(β_8) MWC	-0.120***	-0.916***
	(0.0277)	(0.238)
(β_9) Observable $\times$ MWC	0.0951**	0.339
	(0.0414)	(0.358)
Estimation	Linear	Probit
Num. Obs.	571	569
χ^2	133.2	89.05

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors reported in parentheses below coefficient values. Coefficients estimated accounting for session-specific random effects. See text for model specification.

Table 2: Estimation results for the impact of communication including calls for equality on bargaining outcomes.

	Dependent Variables	
	(1)	(2)
	Fairness	All Members Retrieve Investment
Constant	0.747***	0.299
	(0.0339)	(0.257)
Observable	0.0640	1.162**
	(0.0507)	(0.446)
Proposer Messages		
Proportional	0.0559	0.367
	(0.0322)	(0.268)
Observable × Proportional	-0.0537	-0.268
	(0.0431)	(0.415)
MWC	-0.177***	-1.204***
	(0.0324)	(0.270)
Observable × MWC	-0.0878	-0.930*
	(0.0493)	(0.428)
Equality	-0.00781	0.0864
	(0.0319)	(0.243)
Observable × Equality	-0.0386	-0.278
	(0.0477)	(0.450)
Voter Messages		
Proportional	0.0488	0.215
	(0.0292)	(0.237)
Observable × Proportional	-0.0535	-0.170
	(0.0391)	(0.372)
MWC	-0.0839**	-0.634**
	(0.0280)	(0.211)
Observable × MWC	0.0135	-0.456
	(0.0420)	(0.348)
Equality	-0.00677	0.0984
	(0.0260)	(0.205)
Observable × Equality	0.0306	-0.330
	(0.0407)	(0.385)
Num Obs.	491	465
R^2	0.455	
pseudo-R^2		0.341
χ^2		203.0

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors reported in parentheses below coefficient values. Session fixed effects included but not displayed. A given round of communication is coded as proportional, MWC, or equality only if at least one coder marks it as such.

Table 3: Coding Categories Summary

Category	Agreement	Cohen's Kappa	#Obs by Coder 1	#Obs by Coder 2	Total Possible [1]
Proportional	90.84%	0.61	245	291	1964
MWC	96.59%	0.78	151	186	1964
Equality	94.81%	0.77	233	277	1964
Compete	99.34%	0.13	9	6	1964
Desired Share	90.94%	0.52	272	150	1964
Stated Contribution	97.20%	0.94	521	509	1072
Lying Detection	100%	1.00	2	2	1072
Punishment	97.06%	0.74	5	3	68

[1] We exclude all empty chat screens (5%). For each bargaining round, coders saw both chat screens: one for each voter with the proposer. Since each category can be coded separately for each sender (proposer or voter) in each chat screen, there are 4 possible times per bargaining round in which a coder could mark the different categories. The punishment category is only analyzed for proposals in round 2.

Table 4: Average Fairness Index of all Proposals by Communication Content and Observability of Investments.[1]

	Investments are:	
	Unobservable	**Observable**
Proposer messages:		
Proportional	0.95	0.91
	(0.014)	(0.021)
Not Proportional	0.66	0.84
	(0.017)	(0.014)
MWC	0.46	0.60
	(0.051)	(0.054)
Not MWC	0.71	0.88
	(0.016)	(0.011)
Equality	0.71	0.82
	(0.027)	(0.044)
Not Equality	0.68	0.85
	(0.018)	(0.012)
Voter messages:		
Proportional	0.89	0.86
	(0.027)	(0.018)
Not Proportional	0.66	0.84
	(0.017)	(0.016)
MWC	0.51	0.80
	(0.037)	(0.041)
Not MWC	0.72	0.86
	(0.017)	(0.012)
Equality	0.65	0.85
	(0.026)	(0.026)
Not Equality	0.70	0.85
	(0.020)	(0.014)

Standard errors of the mean reported in parentheses below mean value.

[1] A given round of communication is coded as proportional, MWC, or equality only if both coders are in agreement.

Table 5: Proportion of proposals in which all group members retrieve their investment by communication content and observability of investments.[1]

	Investments are: Unobservable	Investments are: Observable
Proposer messages:		
Proportional	1.00	0.89
Not Proportional	0.52	0.81
MWC	0.04	0.20
Not MWC	.61	0.89
Equality	0.69	0.81
Not Equality	0.54	0.82
Voter messages:		
Proportional	0.92	0.87
Not Proportional	0.52	0.81
MWC	0.20	0.66
Not MWC	0.64	0.86
Equality	0.59	0.73
Not Equality	0.54	0.85

[1] A given round of communication is coded as proportional, MWC, or equality only if both coders are in agreement.

2 Instructions for Treatment with Communication and Observable Investments

Text with solid underline appears only in treatments observable investments (C-O & NC-O).

Text with dotted underline appears only in treatments with unobservable investments (C-NO & NC-NO).

Text with dashed underline appears only in treatments with chat (C-O & C-NO).

Experiment Instructions

This is an experiment in the economics of decision making. We follow a no-deception ethical policy at the Economics Lab, hence these instructions fully describe the experiment.

A Brief Overview of the Experiment

In this experiment you will be part of a group of 3 people. Each of you must decide individually how many tokens to contribute into a common account. The tokens that you and the other two group members contribute will be added up and multiplied times 1.8. All of you will learn how much each person in your group contributed. Next, one of you will be asked to propose a distribution of the group's fund among the members and, before a proposal is submitted, group members will be able to communicate with each other through a chat screen. Proposals are voted up or down according to the simple majority rule. In case the current proposal is rejected, the members of the same group proceed to another chat, proposal and voting round until one allocation is approved. The details of the experiment follow.

The Details of the Experiment

As expressed above, this experiment involves four main parts: **(1) contribution, (2) chat, (3) proposal, and (4) vote.** We proceed to fully explain each stage.

(1) Contribution

You are endowed with 50 tokens initially and will be asked to enter a contribution that you wish to make to the group's account no greater than your initial endowment. Whatever amount you decide to give is multiplied by 1.8.

(2) Chat

The computer will randomly choose one of you to be the proposer of a distribution of the total common account (which equals the sum of contributions times 1.8). Before doing so, you will have three minutes in which you can exchange written messages with the other two members of your group. Members who are not proposers will not be able to communicate with each other, only with the proposer. Please be respectful and do not reveal your identity or personal information while chatting.

(3) Proposal

In this stage the proposer submits a division of the total group account.

(4) Voting

You will observe how much the proposer assigned to each member of the group. You can then click "accept" or "reject". For approval, the proposal requires a simple majority (at least 2 votes).

If rejected: every member in your group will proceed to stage (2) with a member randomly selected as proposer. Feedback on the previous proposal, the voting result, and who was the proposer will be given to you.

The process repeats itself until an allocation of the group account is approved. If 5 rounds of proposing go by without approval, thereafter there is a 50% probability that no more proposals take place. In this case, all group members receive 0 tokens from the common account. For example, following a rejection in round 6, the probability that round 7 takes place is 50%.

If approved: the result will be binding and you will learn how much each person contributed and earned. Next, you will then be matched into new groups to repeat the stages (1)-(4). You will participate in a total of 10 periods. In each period, you will be randomly reassigned into a group of 3 people, and your subject number for each period is determined randomly too. This is, in period 1 you can be subject A, and in period 2 you can be subject C.

Your Earnings

Only 1 of the 10 periods will be randomly selected for payment. Your earnings (E) are then given by

$$E = \underbrace{(50 - Contribution)}_{How\ much\ you\ kept} + Assigned\ Share$$

The conversion rate between tokens and dollars is 5 Tokens = 1 dollar. In addition to your earnings from the experiment, you will receive a $5 show up fee. Hence, your final payment is given by:

$$Payment = 5 + E/5$$

Are there any questions so far?

Example.

Below, we provide an example for you to understand how the payoffs of the experiment work.

Consider a 3 person group in which individuals are endowed with 50 tokens and each unit contributed to the group account is multiplied times 1.8. If Person A contributes 1, Person B contributes 10, and Person C contributes 9, then the total fund to distribute will be

$$1.8 \times (1 + 10 + 9) = 36$$

Suppose that player C was randomly chosen as the proposer and distributed the group account as follows: 10 for A, 20 for B, and 6 for C. Then, if votes are respectively “yes”,” no”, “yes”, the proposal is accepted. If this period was randomly chosen for payment, player A would receive

$$E = \underbrace{49}_{50-Contribution} + \underbrace{10}_{Assigned\ Share}$$

Similarly, player B would receive 40+20 and player C will receive 41+6. This is just an example; you do not have to do this. Instead, votes could have been “no”,”no”, and “yes”. Hence a new proposal round would take place.

Are there any questions?

Review of the experiment

1. Everyone is randomly assigned into groups of 3
2. Out of your 50 token endowment, you will decide how much to contribute to the group account
3. The sum of members’ contributions will be multiplied times 1.8. Your contribution will not be displayed for others to see until a proposal has been accepted.
4. One of you will be randomly chosen as the proposer.
5. You will have three minutes to chat with the proposer.
6. Once a proposal is made, voting will take place. If a majority accepts, the allocation is binding, and you will wait in standby until the other groups decide on an allocation.
7. If a majority rejects, the process repeats itself until a given allocation is accepted.
8. Once an allocation is accepted, you will start a new period with randomly selected members. 1 of the 10 periods of play will be chosen randomly for payment.

What should you do? If we knew the answer to this question, we would not need to run an experiment.

3 Screenshots of Experimental Software for Treatment of Communication with Observable Investments.

Figure 1: Investment Screen (all treatments)

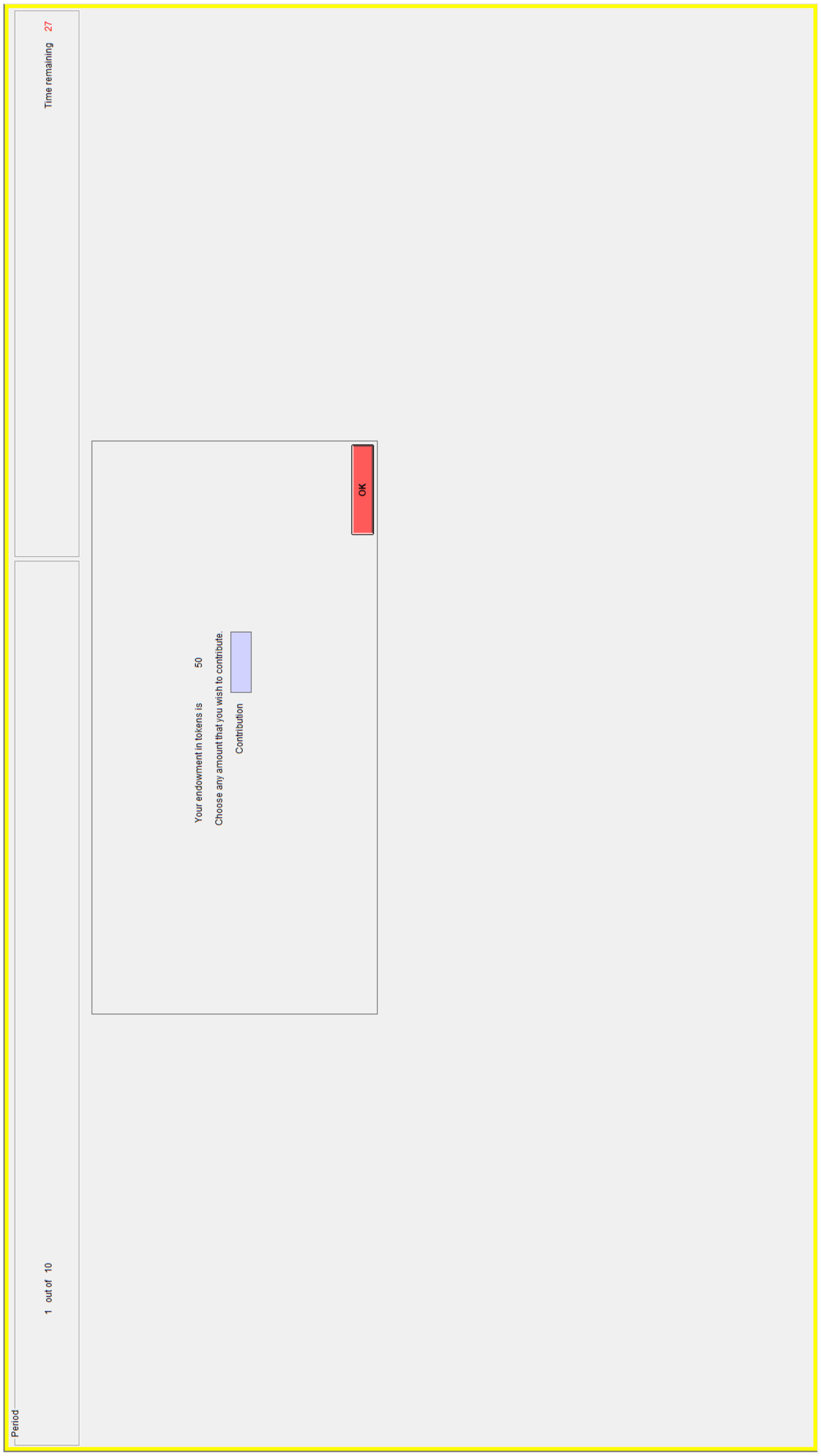

Figure 2: Proposal stage with Chats Screens for Proposers

Figure 3: Proposal stage with Chats Screens for Voters

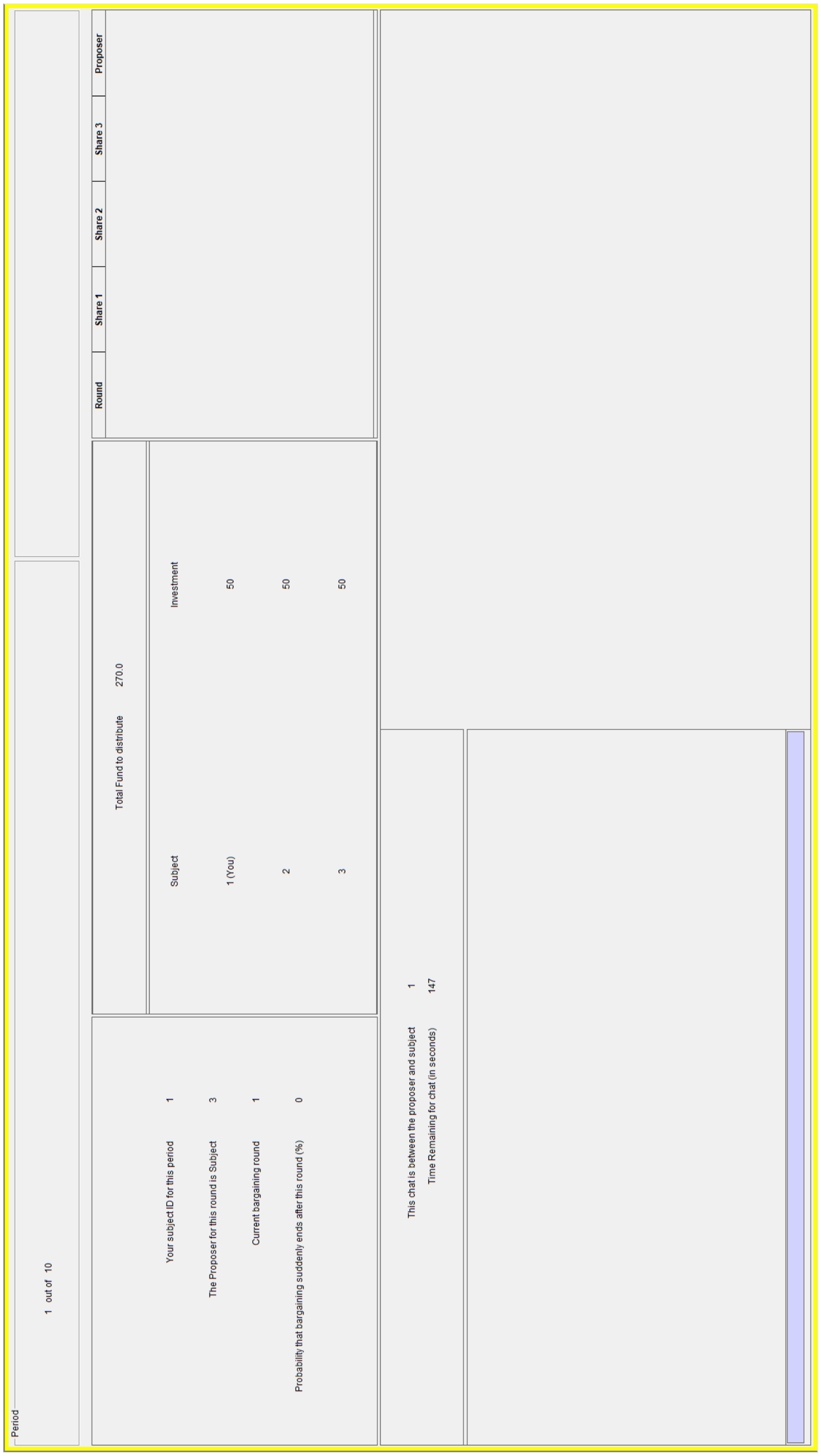

Figure 4: Voting Screen