Communication in Multilateral Bargaining with Joint Production

Andrzej Baranski* Caleb A. Cox†

April 28, 2022

Abstract

We experimentally investigate the effect of pre-bargaining communication on productive incentives in a multilateral bargaining game with joint production under two conditions: observable and unobservable investments. In both conditions, communication fosters fair sharing and is rarely used to pit individuals against each other. Proportional sharing arises with observable investments with or without communication, leading to high efficiency gains. Without investment observability, communication is widely used to truthfully report investments and call for equitable sharing, allowing substantial efficiency gains. Since communication occurs after production, our results highlight a novel indirect channel through which communication can enhance efficiency in social dilemmas. Our results contrast with previous findings on bargaining over an exogenous fund, where communication leads to highly unequal outcomes, competitive messages, and virtually no appeals to fairness.

*Division of Social Science, New York University Abu Dhabi, Bldg A5 Office 1131, Saadiyat NYUAD Campus, Abu Dhabi, United Arab Emirates, email: *a.baranski@nyu.edu*

†Department of Economics, Virginia Commonwealth University, Snead Hall, 301 W. Main Street, Box 844000, Richmond, VA, USA 23284, email: *cacox@vcu.edu*

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; Charness, 2012), which may in turn affect incentives to exert effort into the production process. Evidence from previous studies in majoritarian bargaining shows that pre-proposal written 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 affect productive incentives. The answer will depend on whether communication exacerbates competitive behavior or fosters *fair sharing*.

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 (Konow, 2000; 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

[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

bargaining, absent a contract, has been shown to give rise to high efficiency gains in problems of collective action as shown in Baranski (2016, 2019) and Dong et al. (2019).[4]

The role that verbal communication may play in the division of a common surplus remains understudied experimentally, despite its relevance to settings with joint production. Notable exceptions are Bolton et al. (2003), Bolton and Brosig-Koch (2012), Abbink et al. (2018), and Gantner et al. (2019), which we discuss in detail in our conclusion once we have described our game and established our results to facilitate comparisons. Instead, the literature has largely focused on communication in joint production absent an endogenous redistribution stage, such as linear public goods games in which the shares of the common fund are pre-specified. It is well established in the experimental literature that the possibilities to communicate prior to investments in public goods games leads to enhanced efficiency (Ostrom et al., 1992; Cason and Khan, 1999; Bochet et al., 2006; Gangadharan et al., 2017). Pre-game communication is also shown to increase efficiency in employee-employer games with moral hazard (Charness and Dufwenberg, 2006) and adverse selection (Charness and Dufwenberg, 2011), double-auction settings (Valley et al., 2002), prisoners' dilemmas (Sally, 1995), and demand bargaining games with outside options (Feltovich and Swierzbinski, 2011). All these studies have one aspect in common: that communication precedes production decisions, and thus may be used to signal directly an intention to achieve efficient outcomes. Our setting precludes this possibility since communication occurs after productive decisions have been made.

To our knowledge, there are no studies on how communication during majoritarian bargaining affects the division of a jointly produced surplus and its effect on productive incentives. To address this question, we conduct an experiment on the majoritarian bargaining game developed by Baron and Ferejohn (1989) (hereafter BF). In our experiment, subjects bargain in groups of three with proposals requiring two votes to pass. The surplus is created via individual investments: subjects may invest any amount up to their endowment, and investments are multiplied times 1.8. Our treatment variables are whether subjects may communicate or not during the bargaining stage and whether or not group members may observe 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]Several experiments have examined the unilateral allocation of a jointly-produced surplus, either by a team leader (Van der Heijden et al., 2009; Drouvelis et al., 2017) or a third party (Stoddard et al., 2014, 2020). These studies generally find that allocators reward high contributors, increasing efficiency relative to equal sharing.

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., 2003, 2005a,b; Diermeier and Morton, 2005; Bradfield and Kagel, 2015; 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 shown in legislative bargaining 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. Importantly, shares of the fund are positively correlated with investments when these are observable by all members, which creates the right incentives for efficiency gains, but absent observability, investments rapidly unravel.

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, 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. Given that any division of the surplus is a Nash equilibrium in the bargaining subgame, and that one can also construct subgame perfect Nash equilibria to sustain any allocation (when players are patient enough), our question is empirical: how will subjects communicate and what impact will this have on equilibrium selection with and without joint production?

Our results show that verbal communication at the bargaining stage is mainly used to promote

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

[6]For two experiments on dynamic bargaining with communication see Baron et al. (2017) and Agranov et al. (2020)

fairness either as equality or equity (i.e. proportionality).[7] In all treatments, the proposer's share is quite low relative to the benchmark 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 describes the games that will be implemented in the laboratory and contains the equilibrium characterizations that will serve as experimental hypotheses. Section 3 presents details of the experimental implementation. The results are reported in Section 4 with a subsection devoted to the analysis of communication content. Section 5 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. First, we focus on the game without communication and will later comment on the role that cheap talk may have at the bargaining stage once we have characterized equilibria absent communication.

The game has two stages: Investments and bargaining. At the beginning of the game, each player holds a 50 unit endowment. In stage 1, players simultaneously and independently choose $c_i \in [0, 50] \subset \mathbb{N}$. The sum of investments multiplied times $\alpha > 1$ determines the total fund which

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

is to be split via bargaining in stage two ($\alpha = 1.8$ in the experiment). Thus, we have that

$$F = \alpha \sum_i c_i \ .$$

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 and a new bargaining round takes place. In the canonical BF game, the pie is discounted by $\delta \in (0, 1]$. In the implementation of our experiment, we induce discounting in terms of a random termination rule where the fund vanishes with probability $1 - \delta$. For the first five rounds, there is no discounting (i.e. $\delta = 1$) and there after the fund vanishes with probability 0.5 (i.e. $\delta = 0.5$).[8]

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 of a proposal, 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.[9] Letting V_i denote player i's expected payoff of the

[8]This feature of our experiment is not common as all BF experiments we are aware of maintain the discount factor constant within a game. A recent meta-analysis Baranski and Morton (in press) showed that regardless of the discount factor in BF experiments with 3 players, the mean proposer share was equal across treatments. Thus, we do not believe this modelling and design choice has an impact on subject behavior in the laboratory. Our goal was to make sure that bargaining games did not go too far in order for sessions to end within reasonable time.

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

game at any stage (due to stationarity this value does not change) we have that

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

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 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 $1 - \delta/3$ of the fund and offers $\delta/3$ to a randomly selected partner;*
3. *Any player receiving at least $\delta/3$ of the fund votes in favor;*
4. *Bargaining ends in round 1.*

We highlight three 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 stationary ex ante value and there is no uncertainty of preferences in the model. Thus, credible messages can only express *equilibrium* behavior. Any player expressing out of equilibrium messages cannot credibly commit to them. 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. Finally, the fact that *delta* changes from 1 to 0.5 after 5 rejections affects the distribution of shares only in the event bargaining reaches round 5.

2.2 Subgame Perfect Equilibrium

When $\delta = 1$, 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. Our game differs from the one analyzed by Herings et al. (2018) in that the discount factor changes from round 5 onward to $\delta = 0.5$. Hence, our first task is to construct the bounds on the SPE set of payoffs.[10]

Corollary 1. *Let $F > 0$ be any pie. Let $\delta = 1$ for the first 5 rounds and $\delta = 0.5$ following a rejection in round 5 onward. Then, the set of shares offered by a proposer in round 1 that can be sustained by an SPE is given by $H = [0.08F, 0.806F]$*

Note, however, that this does not imply that any contribution choice is part of an SPE.[11] 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 allocation is selected in equilibrium is exogenous to the model. We argue below, based on previous experimental evidence, that productive investments and communication can be used as equilibrium selection mechanisms. Furthermore, depending on which equilibrium in the bargaining subgame 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

[10] We are grateful to Arkadi Predtetchinski for valuable insights in proving our result.
[11] The proof is presented in Section 1 of the Online Appendix.

shares.[12] Thus, if communication with joint production serves the same purpose as with an exogenous fund, it is likely that low contributing members will be included more often 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 (see the Online Appendix for a proof).

Lemma 2. 1. *In the game with observable investments, there exists an equilibrium outcome in which $c_i = 50$ and the proposer assigns $s_i = F/3 = 90$ for all i.*

2. *In the game with observable investments, there exists an equilibrium outcome in which $c_i = 0$ for all i.*

Three issues are worth discussing about Lemma 2. First, for part (1) we construct an equilibrium bargaining strategy that specifies the proportional allocation ($s_i = \alpha c_i \, \forall i$) as a bargaining outcome that can sustain efficiency, as long as such divisions are consistent with an SPE (i.e. the shares offered by the proposer are in the set H). Importantly, there exist other strategies, such as the proposer forming an MWC with the highest contributing voter, that would also sustain full efficiency.

Second, the general idea behind the unravelling of investments in part (2) is to consider a strategy where high contributors are likely to be excluded from the coalition. In particular, if the proposer splits the fund in half with the lowest contributing voter, reducing one's investment will enhance the odds of sharing in the surplus and this effect will outweigh the fall in the size of the total fund.

Third, for the strategies described above and used in the proof of Lemma 2, the proposer must be able to identify each member's contribution. Absent observability, the proposer would rely on self-reports. Let $m_j \in \{0, 1, ..., 50\}$ be a message sent by player j to the proposer. 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 $m_j = c_j$ and proposers redistribute according to the strategy for (1).

[12] Importantly, Agranov and Tergiman (2019) show that when approval required unanimous voting, communication does not lead to unequal outcomes.

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 round 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) in order to mitigate reputation concerns or learning to trust partners. 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. 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.[13]

At the beginning of each period, subjects are endowed with 50 tokens (5 tokens equal 1 USD)

[13] All agreements took place in round 4 or earlier, with only 2 agreements in round 4.

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 free-form written messages with each non-proposer individually for up to three minutes. Importantly, each of the two non-proposers can send direct messages only to the proposer, and have no way of communicating directly with each other. Based on the findings by Agranov and Tergiman (2014) that public communication channels are mainly used for prosocial messages (calls for all way splits), 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 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-level averages as the independent unit of observation to account for within-session correlation of individual decisions.[14]

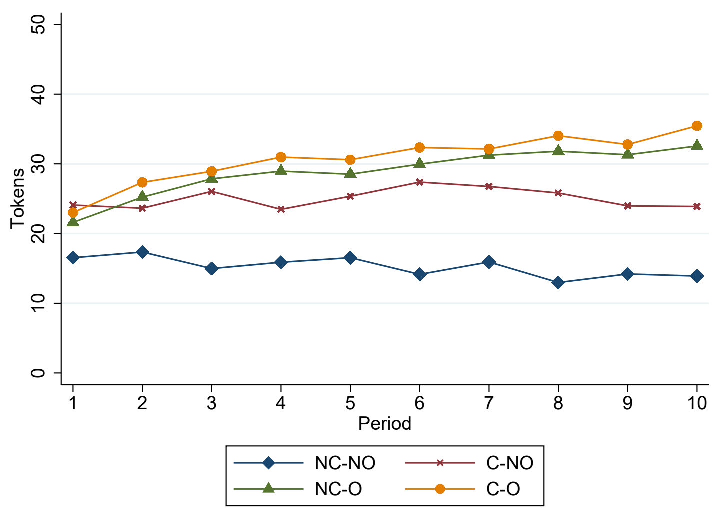
[14] All the MW tests reported are robust to tests at the individual-decision level using cluster bootstrapping as an alternative way to account for within-session correlation.

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.[15]

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. We find that experience in the game leads to a significant increase in investments in NC-O and C-O, there is no effect in C-NO, and a significant decline in NC-NO.[16]

Figure 1: Average Investments by Treatment



Communication has a positive impact on efficiency when investments are observable, based on a comparison of the C-NO and NC-NO treatments there is a significant difference (p-value=0.033, MW test). We find that communication does not affect efficiency when investments are observable (p-value=0.67).[17]

Conclusion 1. *Communication has a positive effect on efficiency when investments are unobservable and has no effect when investments are observable. Efficiency is higher with investment observability.*

[15]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 (0.058). C-O vs. NC-NO (0.033). No other treatment difference is significant.

[16]See Online Appendix Table 2 for regression results.

[17]See Table 1 in the Online Appendix for session level mean investments by treatment and Figure 1 for session level mean investments by period of play.

What explains the differences in efficiency between treatments? Our theoretical characterizations provide guidance since higher contributions are to be expected when the sharing of the total fund follows a norm of proportionality. In what follows, we investigate bargaining outcomes in order to assess the extent to which shares correlate with investments in each treatment and if differences in how the surplus is shared are consistent with the varying levels of efficiency.

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, which we discuss soon. 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.[18]

On average, the percentage of the fund that proposers keep is quite similar across all treatments, ranging from 37.45 in C-O and 41.78 in C-NO. To test if communication enhances the proposers' mean kept shares, we pool observable and unobservable contribution treatments. Absent communication the mean proposer share is 39.73 which is slightly above 39.69, but we find no statistically significant difference (p-value=0.355 two-sided MW test).

We now turn our attention to the overall distribution of the fund, specifically into the prevalence of MWCs. Communication does not uniformly affect the proportion of minimum winning coalitions. Note that in NC-NO only 7.78% of the allocations are MWCs significantly lower than 25.97% (p-value=0.068 two-sided MW test). The pattern reverses with observability, in which MWCs are only 9.17% in C-O and 19.38% NC-O albeit the difference is not significant (p-value=0.24 two-sided MW test).[19] In all treatments, the modal approved allocations include payments to all

[18]While one may construct alternative measures of distance between the fair proposal and actual proposal, we believe this one embodies the notion of equity as described by Adams (1965). The same measure has been employed in Baranski (2016).

[19]Pooling over observable and unobservable treatments we find no statistically significant difference between treatments with and without communication (p-value=0.614 two-sided MW test).

Table 2: Summary of Bargaining Outcomes

	SSPE	Unobservable		Observable	
	Prediction	No Chat	Chat	No Chat	Chat
2-way Splits (MWC)	100%	7.78	25.97	19.38	9.17
3-way Splits	0%	90	73.03	80.63	90.83
Proposer's Share	66.6%	38.10 (0.855)	41.78 (0.845)	41.57 (0.927)	37.45 (0.710)
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)	0.68 (0.016)	0.80 (0.017)	0.86 (0.011)
Proportional Splits (%)[2]	NA	1.51	14.08	17.61	28.41
3-way Equal Splits (%)[2]	0	51.67	27.52	10.63	30.41
Round 1 Approval	100%	86.11	96.12	85.63	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).
[2] A proportional split is an allocation of the fund in which the all the assigned shares are within 10 percent of the perfectly proportional split.

members.[20] Note that three-way equal splits are quite prevalent in NC-NO, representing just over half of all agreements.

Beyond a simple characterization of the splits, it is important to look into the relationship between shares and contributions. The fairness index (see Table 2) provides evidence that treatments in which shares are more fairly distributed have higher levels of efficiency. Note that the lowest fairness index is for NC-NO (despite this treatment having close to 90 percent of all-way splits) and so are contributions. Comparing the treatment averages, it appears that as fairness increases, so do investments. Thus, the high levels of investment in NC-O, and C-O can be interpreted as evidence of subjects playing the efficient subgame perfect equilibrium that we described in point 1 of lemma 2 where shares are proportional to contributions. The correlation coefficient between shares and investments is positive and significant (p-value < 0.001) for all treatments except for NC-NO in which the investments are lowest.[21].

[20] In The Online Appendix, Table 3, we examine the prevalence of MWCs and 3-way splits with stronger inclusion criteria, requiring each coalition member to receive a share strictly greater than 1 or 5 tokens. Even with these stronger criteria, 3-way splits remain far more prevalent than MWCs.

[21] The correlation coefficient between $\hat{c}$ and $\hat{s}$ is 0.02 for NC-NO, 0.13 for C-NO, 0.37 for NC-O, and 0.5 for C-O

We now take a closer look into proportional splits.[22] Proportional splits are virtually non-existent in NC-NO as one may expect, but adding communication leads to them representing 14 percent of approved allocations in C-NO. The largest levels of proportional splits arise when investments are observable 17.6 and 28.4, for NC-O and C-O respectively. Why are these not the overwhelming majority of allocations? The reason is that proposers tend to demand shares beyond those proportional to their contributions more than half of the time.[23]

Note that the equal split is another focal fair allocation.[24] In our experiment, these splits are more common than proportional splits when investments are not observable in contrast to the larger prevalence of proportional splits when investments are observable. This result suggests that subjects largely attempt to be *fair*, but the focal notion of fairness varies according the information available.[25]

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 less than 4 percent delay agreement when communication is possible (p-value<0.001 MW test).

Conclusion 2. *Communication and observability lead to outcomes that resemble an SPE where offered shares are greater than players' investments, consistent with the high contributions in treatments C-O, NC-O, and C-NO. Communication does not increase the proposer's mean share, regardless of investment observability. A large majority of allocations involve 3-way splits rather than MWCs.*

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.[26]

[22]A split is defined as proportional if the share received by each member is within 10 percent of the perfectly proportional share.

[23]This happens 64% of the time in NC-NO, 59% in C-NO, 65% NC-O, and 51% C-O.

[24]As shown in the Online Appendix, Table 4, allocations and shares often fall in between the equality and proportionality benchmarks in C-O (45.8% of allocations), but this occurs less frequently in other treatments.

[25]In the Online Appendix 5 we examine whether subjects are consistent in the types of proposals that they make throughout the experiment. A small percentage of subjects propose consistently proportional allocations (7.2) and equal splits (11.3).

[26]Two independent native English-speaking students were hired as coders for an hourly rate. Both received the same set of written instructions available in the Online Appendix.

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.

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

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. Example conversations may be found in Section 3 in the Online Appendix as well as a summary of coders' agreement rates and Cohen's kappa (Cohen, 1960).[27] Importantly, all agreement rates are above 90 percent and Cohen's kappa is above 0.52 for all categories except *competition*.[28]

Table 3 presents the percentage of bargaining rounds coded for each communication category. 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

[27]On the suggestion of an anonymous referee, we also hired an additional research assistant to code further chat categories, including discussions of past or future periods of play and a friendly tone of conversation. While these categories were coded relatively infrequently, we do find a positive correlation between friendly conversation and the share allocated to a voter. The analysis for these categories is presented in the Online Appendix.

[28]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.

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 0.393 for proposers and 0.132 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). While we have coded for equality and proportionality as separate categories, the distributive implications coincide when all members have contributed equally. In the 26 bargaining rounds where this happened (out of 519 in the treatments with communication), we find that proposers call for equality in 6 of these committees and voters in 13 of them.

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 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. *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 in a given bargaining round, we regressed the different chat categories on two distinct outcomes of interest: the fairness index and the probability of all members retrieving their investments (i.e. share is greater than contribution). 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

Table 4: Estimation results for the Impact of Communication on Proposals.

	Dependent Variables	
	(1)	(2)
	Fairness	All Members Retrieve Investment
(β_0) Constant	0.69***	0.29
	(0.056)	(0.216)
(β_1) Observable	0.22***	1.60***
	(0.059)	(0.327)
Proposer Messages:		
(β_2) Proportional	0.11**	0.52***
	(0.049)	(0.192)
(β_3) Observable $\times$ Proportional	-0.09	-0.45
	(0.057)	(0.343)
(β_4) MWC	-0.19***	-1.20***
	(0.047)	(0.216)
(β_5) Observable $\times$ MWC	-0.06	-1.11***
	(0.067)	(0.290)
Voter Messages:		
(β_6) Proportional	0.13**	0.56***
	(0.052)	(0.160)
(β_7) Observable $\times$ Proportional	-0.15**	-0.69***
	(0.056)	(0.242)
(β_8) MWC	-0.13***	-0.82***
	(0.030)	(0.194)
(β_9) Observable $\times$ MWC	0.05	-0.46
	(0.040)	(0.329)
Estimation	Linear	Probit
Num. Obs.	517	517
F-statistic	84.20	
χ^2		1646.45

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Robust standard errors reported in parentheses below coefficient values clustered at the session level.

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.[29]

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 appears to fade when investments are observable.

Communicating intentions to form a MWC negatively affects the fairness index and the odds of all members retrieving their investments (proposers' messages have a larger impact). For example, when no one argues for an MWC, the predicted probability of all members retrieving their contribution is 82 percent. If only a voter argues for an MWC, the probability drops to 56 percent, but if only a proposer argues for it, it drops to 31 percent. When both the proposer and a voter discuss and MWC, chances of an all members retrieving their investments drop to 7 percent.

MWCs are more prevalent without observability when communication is possible (25.7 versus 9.2 percent) despite them being almost equally discussed by bargainers in both treatments.[30] The opposite happens when investments are observable. Thus, it appears that voters may have been quite successful at convincing proposers to be more inclusive in C-O than in C-NO. Note that the percentage of messages from voters asking for proportionality is almost double in C-O compared to C-NO (47.1 vs 24.6, see Table 3).

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. Reports are largely truthful, as there is a 0.82 correlation between stated and actual contribution, and only 24 percent of stated contributions are inflated. Figure 2 shows a scatter plot of reported and actual investments (the size of the circle is proportional to the number of observations).

We estimated the relationship between a subject's actual investment and each of the three

[29]Due to an error, our research assistants were unable to code beyond round 2, which left out two cases in which subjects reached an agreement in round 3. We asked another assistant to code these conversations and re-estimated the model (Table 8 in Online Appendix). There are no meaningful changes in the estimation results.

[30]The data show that in bargaining rounds that were not coded for proportionality, equality, or MWCs, 30 percent of allocations are MWCs without observability compared to only 4 percent with observability.

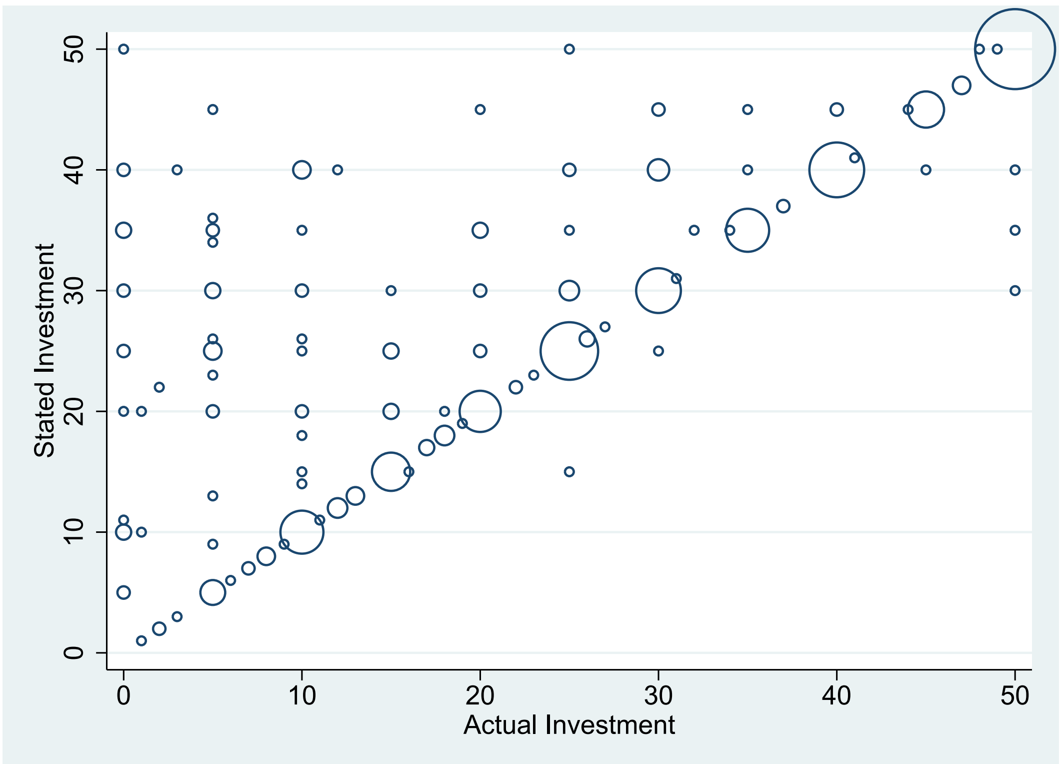


Figure 2: Actual versus Stated Investments in Communication Treatment with Unobservable Investments.

following outcomes: the probability of over-reporting, not reporting at all, and truthfully reporting.[31] 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.

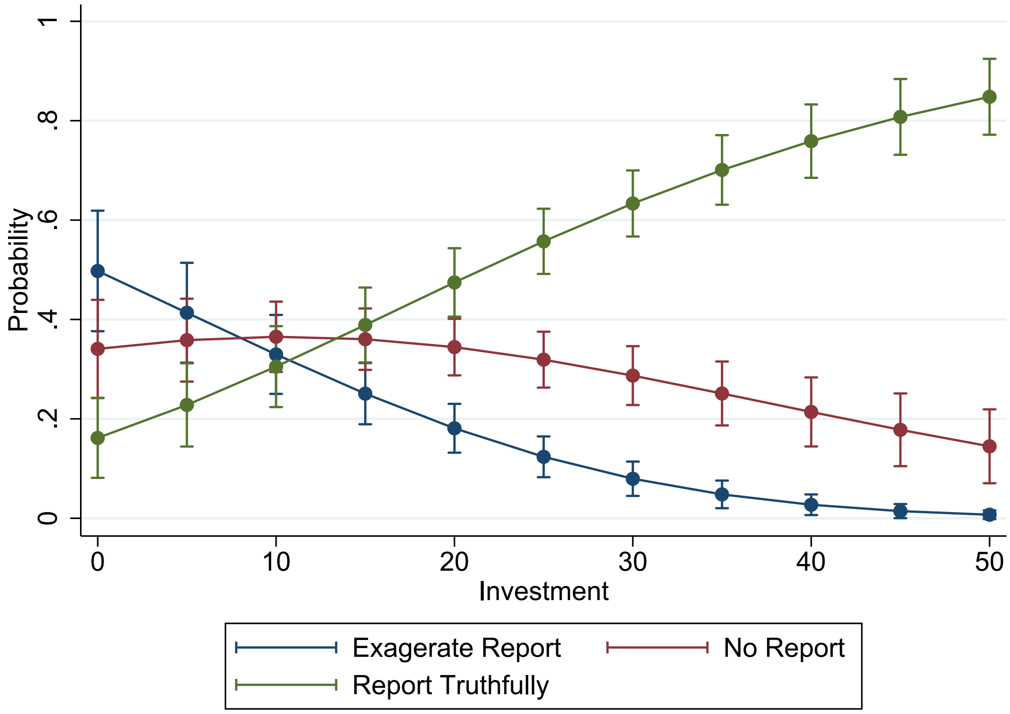


Figure 3: Predicted Probability of Lying, Not Reporting, and Truthfully Reporting One's Investment

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

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.[32]

[31] Estimation results are reported in the Online Appendix, Table 11.
[32] See Karagözoğlu (2012) for a review, as well as the previously cited work.

Absent a joint production process, shares distributed 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 in majoritarian bargaining, we believe that our experiment is a stress test of the proportionality standard typically observed with joint production.

We are not the first to study the role of communication on bargaining outcomes with joint production. Bolton et al. (2003) study an unstructured bargaining game in which the total surplus to divide depends on the identity of players forming a coalition, with grand coalitions being the most efficient but not necessarily yielding the highest per capita return. An important difference is that productive and distributive decisions are simultaneous in their setting while sequential in ours. The authors vary who can communicate with whom during negotiations in triads to study efficiency and payoff distribution. They find that players that are central in the communication network (similar to our communication protocol) enjoy higher mean payoffs compared to other players. In a related game, Bolton and Brosig-Koch (2012) report an increase in efficiency and equality when players may freely communicate with each other before making proposals compared to their no communication benchmark. Based on these findings and those by Agranov and Tergiman (2014, 2019) that public messages are mainly used to promote fair outcomes, we conjecture that the closed-door communication protocol that we implement plays in the proposer's advantage. Thus, more open communication networks would likely increase equitable sharing and incentives to invest.

Gantner et al. (2019) study how communication affects the distribution of a jointly produced surplus under several mechanisms, including a unanimity bargaining game by Sutton (1986). The authors find less self-serving demands, lower payoff dispersion, and less costly negotiations regardless of the communication structure. Importantly, subjects mainly discuss equitable sharing. Our experiments differ in several regards. First, we consider a majoritarian voting game which leads to very different strategic incentives compared to the unanimity rule, namely that excluding members is not possible without their consent. The evidence from bargaining with an exogenous fund suggests that communication under unanimity does not have the same effect as under majority Agranov and Tergiman (2019). Second, we have focused on a linear production function where it is clear who produced what while Gantner et al. purposefully create a setting with complementarities in production for subjective claims to arise. When it is hard to assign credit objectively, norms of equality tend to be more focal. Finally, our main objective has been to understand how communication affects incentives to produce while subjects in their experiment produce only once and then negotiate under different mechanisms how to split the total surplus. Despite the differences in our research questions and designs, we share two common findings. First, joint production affects what people communicate. Second, communication possibilities shape bargaining outcomes away from self-serving and strategic towards fair and equitable ones.

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. The effect of communication is mildly lower when subjects are assigned heterogeneous rates of return Gangadharan et al. (2017). 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. We argue that the anticipation of a truthful and fair communication process is what drives efficiency gains in our setting. Based on this literature, we conjecture that allowing for communication prior to investments would increase contributions relative to the no communication treatments.

In a closely related experiment, Abbink et al. (2018) explore how excluding productive team members from communication channels can be detrimental to efficiency. In their experiment, team members participate in a production stage similar to a public goods game. Upon observing total production and individual contributions, each member simultaneously proposes a distribution of one third of the fund among the two other members. Absent communication, full efficiency obtains as in Dong et al. (2019) because team members properly reward each other following the norm of proportionality that also arises in our treatments NC-O, C-O, and C-NO. When communication channels are available between a subset of players only, efficiency falls since those excluded from communication channels reduce their investments in response to peers' colluding schemes against them. There are several key differences between our work and that of Abbink et al. (2018). First, we do not allow for communication at the investment stage. Second, groups are randomly rematched in our game while Abbink et al. (2018) keep the colluding players together and rematch them randomly with a third member, which helps build incentives to collude with their partners. Third, in our bargaining game subjects also have a say on how much they get to keep when they are in the proposer role which heightens the tensions between strategic bargaining behavior and fairness. While our experiments differ in significant ways that make comparisons difficult, one general finding is that the timing and structure of communication are key in determining how efficiency is affected.

There are several parameters and design features that may affect the results obtained here. We do not believe that increasing group size to five members will affect our insights especially because we examine the robustness of the Baranski (2016), which had five members. Our choice of smaller groups was also with the intention to simplify the chat content analysis, which becomes more onerous as group size increases.

Asymmetries in proposer recognition probabilities or voting shares, or even knowing ahead of time who will be the first proposer, can certainly affect efficiency. It is unclear if players with a bargaining advantage will invest more and if these asymmetries will obscure what constitutes a *fair share*. Thus, we believe that the ex ante symmetry of players is important for achieving efficiency.

While we have focused on the effect of communication in a game of multilateral bargaining, our experiment also contributes to the large and growing literature on the effect of communication in strategic behavior across different domains. Besides increasing contributions in public goods games, allowing for cheap talk has been shown to increase the likelihood of efficient coordination in games with multiple Pareto-ranked equilibria (Cooper et al., 1992; Duffy and Feltovich, 2002). In our setting, communication allows subjects to coordinate on a distribution of the common fund and we find that the origin of the common fund drastically affects the role of communication in the equilibrium selection: highly unequal divisions when the fund is exogenous and highly inclusive distributions when it is endogenous.

Acknowledgements

The authors thank Gianluca Campanile, Thomas Yates, and Laila Al-Eisawi for excellent research assistance. We are grateful for helpful comments and conversations with Andrew Caplin, Alexander Cappelen, Guillaume Frechette, Andreas Leibbrandt, Rebecca Morton, Arkadi Predtetchinski, Ariel Rubinstein, Andy Schotter, Simon Siegenthaler, Erik Sorensen, and Bertil Tungodden. We benefited greatly from participants' comments at the 2019 Maastricht Behavioral and Experimental

Economics Symposium, 2019 New England Experimental Economics Workshop, the 2019 and 2021 ESA North American Meetings, and seminars at VCU School of Business, Norwegian School of Economics, and NYU CESS. Funding for this research was generously provided by NYU Abu Dhabi. Additional funding for research assistants was provided by VCU School of Business. Baranski gratefully recognizes financial support by Tamkeen under the NYU Abu Dhabi Research Institute Award CG005. This study is registered in the AEA RCT Registry and the unique identifying number is: AEARCTR-0003254.

REFERENCES

Abbink, K., Dong, L., and Huang, L. (2018). Talking behind your back: Asymmetric communication in a three-person dilemma. *CeDEx Discussion Paper Series ISSN 1749-3293*.

Adams, J. S. (1965). Inequity in social exchange. In *Advances in Experimental Social Psychology*, volume 2, pages 267–299. Elsevier.

Agranov, M., Cotton, C., and Tergiman, C. (2020). Persistence of power: Repeated multilateral bargaining with endogenous agenda setting authority. *Journal of Public Economics*, 184:104126.

Agranov, M. and Tergiman, C. (2014). Communication in multilateral bargaining. *Journal of Public Economics*, 118:75–85.

Agranov, M. and Tergiman, C. (2019). Communication in bargaining games with unanimity. *Experimental Economics*, 22(2):350–368.

Andreoni, J. and Rao, J. M. (2011). The power of asking: How communication affects selfishness, empathy, and altruism. *Journal of Public Economics*, 95(7-8):513–520.

Azerrad, M. (1992). Inside the heart and mind of Nirvana. Rolling Stone. Retrieved from `https://web.archive.org/web/20080109140249/http://www.rollingstone.com/artists/nirvana/articles/story/5937982/inside_the_heart_and_mind_of_nirvana`. Last accessed October 10, 2019.

Baranski, A. (2016). Voluntary contributions and collective redistribution. *American Economic Journal: Microeconomics*, 8(4):149–73.

Baranski, A. (2019). Endogenous claims and collective production: An experimental study on the timing of profit-sharing negotiations and production. *Experimental Economics*, 22(4):857–884.

Baranski, A. and Kagel, J. H. (2015). Communication in legislative bargaining. *Journal of the Economic Science Association*, 1(1):59–71.

Baranski, A. and Morton, R. (in press). The determinants of multilateral bargaining: A comprehensive analysis of Baron and Ferejohn majoritarian bargaining experiments. *Experimental Economics*.

Baron, D. P., Bowen, T. R., and Nunnari, S. (2017). Durable coalitions and communication: Public versus private negotiations. *Journal of Public Economics*, 156:1–13.

Baron, D. P. and Ferejohn, J. A. (1989). Bargaining in legislatures. *American political science review*, 83(4):1181–1206.

Bochet, O., Page, T., and Putterman, L. (2006). Communication and punishment in voluntary contribution experiments. *Journal of Economic Behavior & Organization*, 60(1):11–26.

Bolton, G. E. and Brosig-Koch, J. E. (2012). How do coalitions get built? Evidence from an extensive form coalition game with and without communication. *International Journal of Game Theory*, 41(3):623–649.

Bolton, G. E., Chatterjee, K., and McGinn, K. L. (2003). How communication links influence coalition bargaining: A laboratory investigation. *Management Science*, 49(5):583–598.

Bradfield, A. J. and Kagel, J. H. (2015). Legislative bargaining with teams. *Games and Economic Behavior*, 93:117–127.

Cappelen, A. W., Hole, A. D., Sørensen, E. Ø., and Tungodden, B. (2007). The pluralism of fairness ideals: An experimental approach. *American Economic Review*, 97(3):818–827.

Cason, T. N. and Khan, F. U. (1999). A laboratory study of voluntary public goods provision with imperfect monitoring and communication. *Journal of Development Economics*, 58(2):533–552.

Charness, G. (2012). Communication in bargaining experiments. In *The oxford handbook of economic conflict resolution*.

Charness, G. and Dufwenberg, M. (2006). Promises and partnership. *Econometrica*, 74(6):1579–1601.

Charness, G. and Dufwenberg, M. (2011). Participation. *American Economic Review*, 101(4):1211–37.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1):37–46.

Cooper, R., DeJong, D. V., Forsythe, R., and Ross, T. W. (1992). Communication in coordination games. *The Quarterly Journal of Economics*, 107(2):739–771.

Diermeier, D. and Morton, R. (2005). Experiments in majoritarian bargaining. In *Social Choice and Strategic Decisions*, pages 201–226. Springer.

Dong, L., Falvey, R., and Luckraz, S. (2019). Fair share and social efficiency: A mechanism in which peers decide on the payoff division. *Games and Economic Behavior*, 115:209–224.

Drouvelis, M., Nosenzo, D., and Sefton, M. (2017). Team incentives and leadership. *Journal of Economic Psychology*, 62:173–185.

Duffy, J. and Feltovich, N. (2002). Do actions speak louder than words? An experimental comparison of observation and cheap talk. *Games and Economic Behavior*, 39(1):1–27.

Elkins, K. (2018). The Red Sox just won the World Series—heres how much money they'll earn.

Eraslan, H. (2002). Uniqueness of stationary equilibrium payoffs in the Baron–Ferejohn model. *Journal of Economic Theory*, 103(1):11–30.

Eraslan, H. and Evdokimov, K. S. (2019). Legislative and multilateral bargaining. *Annual Review of Economics*, 11(1):443–472.

Feltovich, N. and Swierzbinski, J. (2011). The role of strategic uncertainty in games: An experimental study of cheap talk and contracts in the Nash demand game. *European Economic Review*, 55(4):554–574.

Fréchette, G., Kagel, J. H., and Lehrer, S. F. (2003). Bargaining in legislatures: An experimental investigation of open versus closed amendment rules. *American Political Science Review*, 97(2):221–232.

Fréchette, G., Kagel, J. H., and Morelli, M. (2005a). Behavioral identification in coalitional bargaining: An experimental analysis of demand bargaining and alternating offers. *Econometrica*, 73(6):1893–1937.

Fréchette, G., Kagel, J. H., and Morelli, M. (2005b). Nominal bargaining power, selection protocol, and discounting in legislative bargaining. *Journal of Public Economics*, 89(8):1497–1517.

Gächter, S. and Riedl, A. (2006). Dividing justly in bargaining problems with claims. *Social Choice and Welfare*, 27(3):571–594.

Gangadharan, L., Nikiforakis, N., and Villeval, M. C. (2017). Normative conflict and the limits of self-governance in heterogeneous populations. *European Economic Review*, 100:143–156.

Gantner, A., Horn, K., and Kerschbamer, R. (2019). The role of communication in fair division with subjective claims. *Journal of Economic Behavior & Organization*, 167:72–89.

Greiner, B. (2015). Subject pool recruitment procedures: Organizing experiments with ORSEE. *Journal of the Economic Science Association*, 1:114–125.

Herings, P. J. J., Meshalkin, A., and Predtetchinski, A. (2018). Subgame perfect equilibria in majoritarian bargaining. *Journal of Mathematical Economics*, 76:101–112.

Isaac, R. M. and Walker, J. M. (1988). Communication and freeriding behavior: The voluntary contribution mechanism. *Economic Inquiry*, 26(4):585–608.

Karagözoğlu, E. (2012). Bargaining games with joint production. In *The Oxford handbook of economic conflict resolution*, pages 359–372. Oxford University Press.

Karagözoğlu, E. and Riedl, A. (2014). Performance information, production uncertainty, and subjective entitlements in bargaining. *Management Science*, 61(11):2611–2626.

Kartik, N. (2009). Strategic communication with lying costs. *Review of Economic Studies*, 74(4):1359–1395.

Konow, J. (2000). Fair shares: Accountability and cognitive dissonance in allocation decisions. *American Economic Review*, 90(4):1072–1091.

Landis, J. R. and Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1):159–174.

Miller, L., Montero, M., and Vanberg, C. (2018). Legislative bargaining with heterogeneous disagreement values: Theory and experiments. *Games and Economic Behavior*, 107:60–92.

Ostrom, E., Walker, J., and Gardner, R. (1992). Covenants with and without a sword: Self-governance is possible. *American Political Science Review*, 86(2):404–417.

Roth, A. (1987). Bargaining phenomena and bargaining theory. In *Laboratory Experimentation in Economics: Six Points of View*, pages 14–41. Cambridge University Press Cambridge, UK.

Sally, D. (1995). Conversation and cooperation in social dilemmas: A meta-analysis of experiments from 1958 to 1992. *Rationality and society*, 7(1):58–92.

Stoddard, B., Cox, C. A., and Walker, J. M. (2020). Incentivizing provision of collective goods: Allocation rules. *Southern Economic Journal*. Forthcoming.

Stoddard, B., Walker, J. M., and Williams, A. (2014). Allocating a voluntarily provided common-property resource: An experimental examination. *Journal of Economic Behavior and Organization*, 101:141–155.

Sutton, J. (1986). Non-cooperative bargaining theory: An introduction. *The Review of Economic Studies*, 53(5):709–724.

Valley, K., Thompson, L., Gibbons, R., and Bazerman, M. H. (2002). How communication improves efficiency in bargaining games. *Games and Economic Behavior*, 38(1):127–155.

Van der Heijden, E., Potters, J., and Sefton, M. (2009). Hierarchy and opportunism in teams. *Journal of Economic Behavior and Organization*, 69(1):39–50.

Van Dolder, D., Van den Assem, M. J., Camerer, C. F., and Thaler, R. H. (2015). Standing united or falling divided? High stakes bargaining in a TV game show. *American Economic Review*, 105(5):402–07.

Online Appendix for Communication in Multilateral Bargaining with Joint Production

Andrzej Baranski and Caleb A. Cox

April 28, 2022

1 Proofs

1.1 Proof of Corollary 1

Proof. From Herings et al. (2018) we know that the continuation values of the game are bounded from below by $\underline{v} = \frac{3-3\delta}{9-6\delta-\delta^2}$ and bounded from above by $\overline{v} = \frac{3-\delta}{9-6\delta-\delta^2}$. Thus, out of equilibrium if play were to reach round 5, shares offered to voters by the proposer must be in $H^5 = (0.261, 0.435)$. Using these bounds, we can backward induct, to estimate the continuation payoffs from above and from below to construct H^4.

The backward step is based on the following reasoning. Consider round 4. To construct the lower bound on continuation values, note that in this round, a proposer can guarantee to get at least $1 - 0.435 = 0.565$, and a responder can only guarantee 0. This gives the lower bound of $(1/3) * 0.565 + (2/3) * (0) = 0.188$. A proposer cannot get more than $1 - 0.261$, and a responder will never be offered more than 0.435. Thus, $(1/3) * (1 - 0.261) + (2/3) * (4.35) = 0.536$ which gives the upper bound for continuation values in round 4. Hence we have the set of continuation values that can be sustained as an SPE in round 4 to be $H^4 = (0.188, 0.536)$. One can continue working backwards and the bounds expand with each step. Thus, prior to any proposer being selected in round 1, the set of admissible shares as part of an SPE becomes $H = (0.08, 0.806)$.

1.2 Proof of Part 1 of Lemma 2

Proof. We show first that there exists an SPE strategy that sustains full efficiency and equal sharing as the outcome of the game. First, we consider the set $C^{Proportional} := \{(c_1, c_2, c_3)\, s.t.\, s_i = 1.8c_i \in H\, \forall i\}$ and C^{MWC} as its complement. Consider the following equilibrium proposals: (1) $s_i = 1.8c_i$ if and only if $(c_1, c_2, c_3) \in C^{Proportional}$ and (2) $\mathbf{s} = (F/2, F/2, 0)$ where the proposer offers $= F/2$ to the highest contributing voter (breaks ties randomly). Note that in both cases the shares offered are within the bounds of the SPE set. We must now show that deviating from full contributions is unprofitable. There are two cases. If the deviation is small enough, then players are in the proportional equilibrium sharing where they receive a proportionally smaller share. It is clear that it does not pay to deviate since decreasing contributions by 1 unit results in a fall of 1.8 units from the share received. If the deviation is large enough such that proportional sharing is not supported by an SPE (i.e. $(c_1, c_2, c_3) \in C^{MWC}$), then, a deviating player is never invited to the coalition when others propose and only secures F/2 when she proposes (which happens with 1/3 chance). For the case of the most extreme deviation (contributing 0), this results in expected earnings of 80, which are lower than the payoffs from full contribution (90).

1.3 Proof of Part 2 of Lemma 2

Proof. Consider the division $\mathbf{s} = (F/2, F/2, 0)$ where the proposer offers $= F/2$ to the lowest contributing voter (breaks ties randomly). We show that $c_i = 0$ is the only equilibrium.

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 $50 - c_i + \frac{1}{3} \cdot \frac{1}{2} \cdot (1.8c_i) + \frac{2}{3}0$. This equals $50 - 0.7c_i < 50$ for all c_i. Thus, it does not pay to deviate.

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.

2 Supporting Tables and Figures

Table 1: Average Investments by Treatment

Treatment	Mean	Session Means
NC-NO	15.2	17.4 - 10.9 - 21.3 - 12
C-NO	25	33.5 -30.7 -15.2 - 26.1 - 21.9- 25.9
NC-O	28.9	28.4 - 29.8 - 27.6 -29.8
C-O	30.8	12.1 -29.2 -42.1 - 43.6 - 17.1 - 35.8

Figure 1: Evolution of Investments, by Treatments at the Session Level

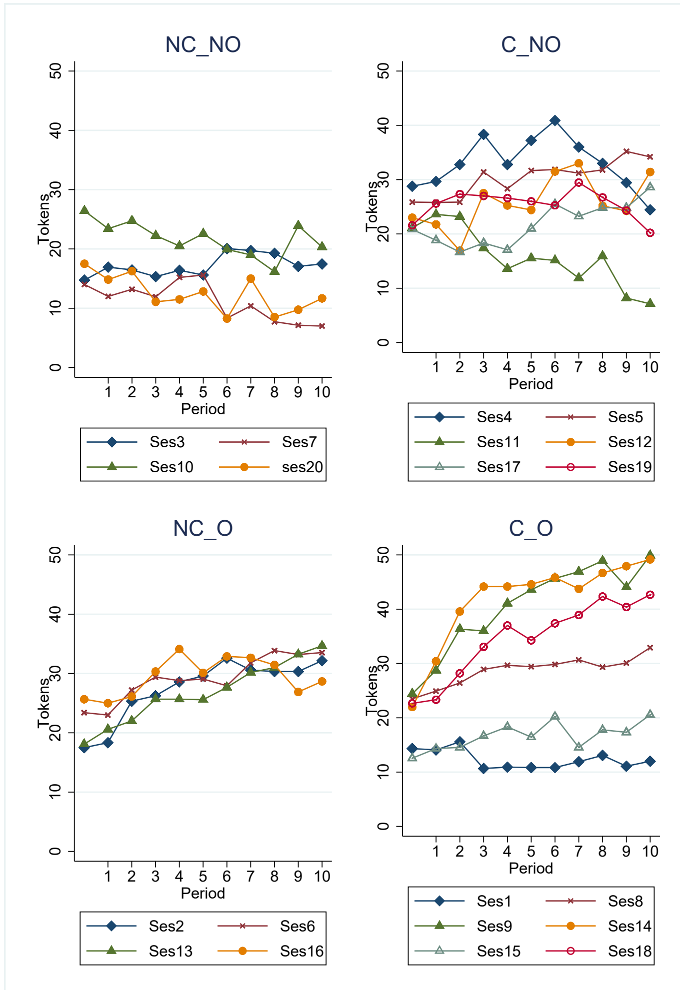


Table 2: OLS Regressions for Investments

	(1) NC-NO	(2) C-NO	(3) NC-O	(4) C-O
Period	-0.35*	0.07	1.03***	1.10***
	(0.194)	(0.248)	(0.230)	(0.190)
Constant	19.37***	33.08***	22.76***	6.07***
	(3.564)	(2.437)	(1.940)	(2.025)
N	540	780	480	720
R^2	0.10	0.13	0.06	0.54
F-statistic	4.45	5.15	5.67	64.23

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

Table 3: Bargaining Outcomes with Stronger Inclusion Criteria

	SSPE	Unobservable		Observable	
	Prediction	No Chat	Chat	No Chat	Chat
Minimum Share > 1					
2-way Splits (MWC)	100%	11.11	26.74	20.63	9.58
3-way Splits	0%	86.67	72.87	79.38	90.42
Minimum Share > 5					
2-way Splits (MWC)	100%	17.22	29.84	26.88	12.92
3-way Splits	0%	78.33	68.60	73.13	86.25

Here we require each a group member to receive a share strictly greater than 1 or 5 tokens to be considered included in the coalition.

Table 4: Percentage of allocations and shares falling between the proportionality and equality benchmarks.

	NC-NO	C-NO	NC-O	C-O
Allocations	8.0	19.0	18.5	45.8
Shares				
Proposer	33.8	43.3	32.8	59.8
Voters	40.6	46.8	37.0	64.7

3 Chat Content and Impact on Bargaining

3.1 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 Proposer. [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

In table 5, we present a summary of the coding categories, agreement rates, and Cohen's Kappa.

Table 5: 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	98.3%	0.76	37	41	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.

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. Table 6 reproduces Table 4 in the body of the paper accounting for the more demanding case where both coders must agree.

Table 6: 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	0.70***	0.29
	(0.049)	(0.208)
(β_1) Observable	0.18***	1.12***
	(0.052)	(0.258)
Proposer Messages		
(β_2) Proportional	0.24***	0.43**
	(0.054)	(0.205)
(β_3) Observable × Proportional	-0.18***	
	(0.055)	
(β_4) MWC	-0.20***	-1.79***
	(0.059)	(0.532)
(β_5) Observable × MWC	-0.08	-0.47
	(0.080)	(0.632)
Voter Messages		
(β_6) Proportional	0.15***	1.05***
	(0.041)	(0.314)
(β_7) Observable × Proportional	-0.15***	-0.91**
	(0.042)	(0.376)
(β_8) MWC	-0.17***	-1.03***
	(0.040)	(0.223)
(β_9) Observable × MWC	0.11**	0.16
	(0.044)	(0.296)
Num. Obs.	519	498 [1]
F-statistic	13.65	
χ^2		295.90

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at session level reported in parentheses below coefficient values.

[1] 21 observations where dropped because of collinearity since the proposer calling for a proportional allocation leads to all members retrieving their investment in every case in Treatment C-O.

Table 7: Estimation results for the impact of communication including calls for equality on bargaining outcomes.

	Dependent Variables	
	(1)	(2)
	Fairness	All Members Retrieve Investment
Constant	0.703***	0.235
	(0.0591)	(0.259)
Observable	0.200**	1.637***
	(0.0601)	(0.317)
Proposer Messages		
Proportional	0.107	0.527**
	(0.0500)	(0.195)
Observable × Proportional	-0.0824	-0.370
	(0.0572)	(0.353)
MWC	-0.197**	-1.200***
	(0.0479)	(0.223)
Observable × MWC	-0.0543	-0.919**
	(0.0714)	(0.295)
Equality	-0.0191	0.00707
	(0.0237)	(0.137)
Observable × Equality	-0.0213	-0.0474
	(0.0617)	(0.519)
Voter Messages		
Proportional	0.125*	0.586***
	(0.0502)	(0.153)
Observable × Proportional	-0.151*	-0.678***
	(0.0539)	(0.203)
MWC	-0.130**	-0.819***
	(0.0306)	(0.203)
Observable × MWC	0.0558	-0.354
	(0.0361)	(0.253)
Equality	-0.0177	0.136
	(0.0208)	(0.145)
Observable × Equality	0.0574	-0.374
	(0.0399)	(0.402)
Num Obs.	519	519

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at session level reported in parentheses below coefficient values. A given round of communication is coded as proportional, MWC, or equality only if at least one coder marks it as such.

Table 7, investigates how calls for equality in the communication stage can affect proposals. In Table 4 of the body, we omitted this category.

In Table 8 we include the two cases in which subjects reached round 3 and re estimate Table 4 in the body of the article. By mistake, our original coders did not code these conversations, thus Table 4 in the article is only for rounds 1 and 2. We hired a third coder to fill in this missing data. As is clear, there are no meaningful changes in the estimation results.

At the suggestion of an anonymous referee, we hired an additional research assistant to code the chat for some additional categories. We report frequencies of these additional categories in Table 9. The first category indicates discussions of previous periods of play (as distinct from previous bargaining rounds within the same period of play). Similarly, the second category indicates discussions of future periods of play. As matching across periods is randomized, there is limited room for relevant discussion of previous and future periods, but nonetheless it does occur sometimes. The third new category indicates a friendly tone of conversation, such as joking.

Table 10 shows regression results on the correlation between friendly conversation and the proportion of the group fund allocated to an individual voter. The independent variables are the voter's own investment as a proportion of the total investment, an indicator for friendly conversation between the voter and the proposer, Observability, and interactions between Observability and the other independent variables. The Friendly indicator equals one if both the proposer and the voter in a particular conversation were coded as friendly.[1] Friendly chat correlates with a higher share to the voter. However, this correlation is somewhat weaker in the Observable treatment. One possible interpretation might be that friendly chat in the Unobservable condition indicates trust between the proposer and voter about reported investment. Alternatively, the friendliness may matter less in the Observable treatment because the individual investments give the proposer a stronger basis for allocating shares.

[1] If instead an indicator for either the proposer or the voter being coded as friendly is used, the results are very similar.

Table 8: Estimation results for the impact of communication on bargaining outcomes (Including Round 3 Proposals)

	Dependent Variables	
	(1) Fairness	(2) All Members Retrieve Investment
(β_0) Constant	0.69***	0.29
	(0.056)	(0.216)
(β_1) Observable	0.21***	1.51***
	(0.058)	(0.283)
Proposer Messages		
(β_2) Proportional	0.11**	0.52***
	(0.049)	(0.192)
(β_3) Observable × Proportional	-0.09	-0.35
	(0.056)	(0.341)
(β_4) MWC	-0.19***	-1.20***
	(0.047)	(0.216)
(β_5) Observable × MWC	-0.05	-0.95***
	(0.069)	(0.266)
Voter Messages		
(β_6) Proportional	0.13**	0.56***
	(0.052)	(0.160)
(β_7) Observable × Proportional	-0.15**	-0.66***
	(0.056)	(0.225)
(β_8) MWC	-0.13***	-0.82***
	(0.030)	(0.194)
(β_9) Observable × MWC	0.05	-0.34
	(0.037)	(0.268)
Num. Obs.	519	519
F-statistic	49.65	
χ^2		1858.49

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at session level reported in parentheses below coefficient values.

Table 9: Percentage of Bargaining Rounds Coded for Additional Communication Categories.[1]

	Unobservable	**Observable**
Past		
Proposer	0.7	0.7
Voter	2.7	3.9
Future		
Proposer	1.3	0.0
Voter	0.9	1.5
Friendly		
Proposer	3.1	4.9
Voter	6.0	5.4

[1] We exclude all empty chat screens. Approximately 2% of all non-empty chat screens were marked as irrelevant by coders.

Table 10: Regression results on friendly conversation and proportion of the group fund allocated to an individual voter.

	Own Proportion Share
(β_0) Constant	0.26***
	(0.021)
(β_1) Observable	-0.10**
	(0.038)
(β_2) Own Proportion of Investment	0.09
	(0.074)
(β_3) Observable $\times$ Own Proportion of Investment	0.38***
	(0.121)
(β_4) Friendly	0.11***
	(0.020)
(β_5) Observable $\times$ Friendly	-0.07*
	(0.035)
Num. Obs.	1038
F-statistic	41.25

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at session level reported in parentheses below coefficient values.

Table 11: Probability of Voters Exaggerating Investment, Not Reporting, or Truthfully Reporting.

Exaggerate Investment in Report	
Investment	-0.08***
	(0.010)
Constant	2.29***
	(0.432)
Not Report Investment	
Investment	-0.04***
	(0.008)
Constant	1.29***
	(0.398)
Num. Obs.	537
χ^2	186.50

*,**, 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 shown.

4 Dynamic Analysis of Investments

In this section we investigate how experience throughout the experimental session affects subjects' affects subjects' decision to invest. To do so, we focus on two key variables that shape subjects' experiences: (1) lagged returns to investment, defined as the difference between the amount invested and the share received in the previous game and (2) the lagged fairness index of the agreed split. Note that in all treatments, once an agreement is reached, feedback is displayed revealing each member's investment and share. Thus, the inter-period information is identical across treatments. This is important to highlight because investments are unobservable in NC-NO and C-NO, but once an agreement is reached, they are made public.

We estimate a simple reinforcement learning model with one a period lag. It is natural to conjecture that experiencing positive returns in a previous agreement as well as high levels of fairness (i.e. proportionality) may encourage higher investments. Specifically, we estimate $\Delta\text{Investment}_{i,t} = \beta_0 + \beta_1(\text{Share}_{i,t-1} - \text{Investment}_{i,t-1} + \beta_2\text{Fairness Index}_{i,t-1} + \beta_3\text{Period} + \epsilon_{i,t}$ where $\Delta\text{Investment}_{i,t} = \text{Investment}_{i,t} - \text{Investment}_{i,t-1}$. The fairness index is defined as the Euclidean distance between the agreement and proportional split (relative to investments, see main text). The estimation results are displayed in Table 12.

The estimation results reveal a positive correlation between the change in investments and Fairness in all treatments with the exception of NC-NO. This means that Fairness is a key driver of investments in treatments in which subject can enact proportional redistribution. Recall that messages about invested amounts are largely truthful in C-NO, and so are calls for proportionality. Interestingly, lagged returns impact investment behavior only in the absence of investment observability (NC-NO and C-NO).

Table 12: OLS Regression for Change in Investments from one Period to the Next

	(1) NC-NO	(2) C-NO	(3) NC-O	(4) C-O
Fairness of Previous Agreement	-0.316	6.507***	6.684*	6.294**
	(2.164)	(1.813)	(2.504)	(2.204)
Lagged Return (Share-Investment)	0.156**	0.0416*	-0.0329	-0.0236
	(0.0491)	(0.0184)	(0.0222)	(0.0286)
Constant	-1.016	-5.877**	-1.366	-0.734
	(1.908)	(2.044)	(2.979)	(2.121)
N	486	696	432	648
R^2	0.0681	0.0424	0.0362	0.0382
F-statistic	1.582	3.442	1.817	1.957

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at subject level reported in parentheses below coefficient values. Period effects included but not shown.

5 Subject-Level Analysis of Consistency in Proposals

In this section we explore whether subjects are consistent in the type of proposals they make throughout an experimental session. To do so, we calculate for each subject the following:

1. Number of times the subject was the proposer;
2. Number of times the subject proposed an equal split;
3. Number of times the subject proposed a proportional split.

Since subjects were called to propose by chance, the number of times they were proposers differs. As such, it is natural to consider the proportion of proposals made by each individual subject that was a proportional split or an equal split. Note that these are not exhaustive categories.

We categorize a subject as being *consistent* if she makes the same type of proposal 70% of the time or more. As Table 13 shows, there is very little evidence for consistency in both categories. The largest levels of consistency are observed in NC-NO for equal splits (21.56%) and proportional splits in C-O (18.75%).

Table 13: Percentage of Subjects that Propose in a Consistent Manner throughout the Session[1], by Treatment

Treatment	**Equal Split**	**Proportional Split**
NC-NO	21.56	0
C-NO	12.31	4.62
NC-O	2.37	2.38
C-O	7.81	18.75

[1] A subject is categorized as being consistent if he or she makes the same type of proposal 70% of the time or more. We only include in the analysis subjects that proposed two or more times.

6 Analysis of Self-serving Bias in Proposals

To investigate if there is evidence of self-serving biases in distributions of the common fund, we classified subjects in two groups: below median contributors (i.e. the lowest contributor of the group) and at or above-median contributors (the two highest contributors). Since higher investors would benefit more from proportional sharing than lower investors, differences in fairness index between these two groups can be interpreted as evidence of a self-serving bias at play.

When investments are observable and no communication is possible, accepted proposals from below-median contributors have an FI=0.67 on average which is lower than 0.84 for higher contributors, consistent with the fact that proportionality favors higher contributors. Interestingly, the difference is smaller when subjects can communicate with each other. To investigate if these differences are significant, we conducted an regression accounting for session level and subject level random effects presented in Table 14. In both treatments, higher contributing members significantly distribute closer to the proportionality standard, albeit the effect is weaker when there is chat.

In Table 15 we investigate the likelihood of calling for a proportional distribution of the surplus as a function of the player's contribution.

Table 14: Random Effects Linear Regression for Fairness Index of Accepted proposals in Treatments with Observability

	Dep. Var: Fairness Index
At or Above Median Investment	0.13***
	(0.030)
Communication	0.12**
	(0.047)
At or Above × Communication	-0.09*
	(0.038)
Constant	0.71***
	(0.037)
Num. Obs.	400
χ^2	23.19

Standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.01$

Table 15: Random Effects Probit for Mentioning Proportionality in Chat Treatment with Observable Investments.

	Probability of Mentioning Proportionality	
	(1)	(2)
At or Above Median Investment	0.25	0.44***
	(0.152)	(0.080)
Proposer	-0.32	
	(0.446)	
At or Above × Proposer	0.57	
	(0.449)	
Constant	-1.02***	-1.12***
	(0.161)	(0.140)
Num. Obs.	753	753
χ^2	27.03	30.39

*,**, and *** denotes significance at the 0.1, 0.05, and 0.01 levels or better. Standard errors clustered at the session level reported in parentheses.

7 Instructions

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.

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

Figure 2: Investment Screen (all treatments)

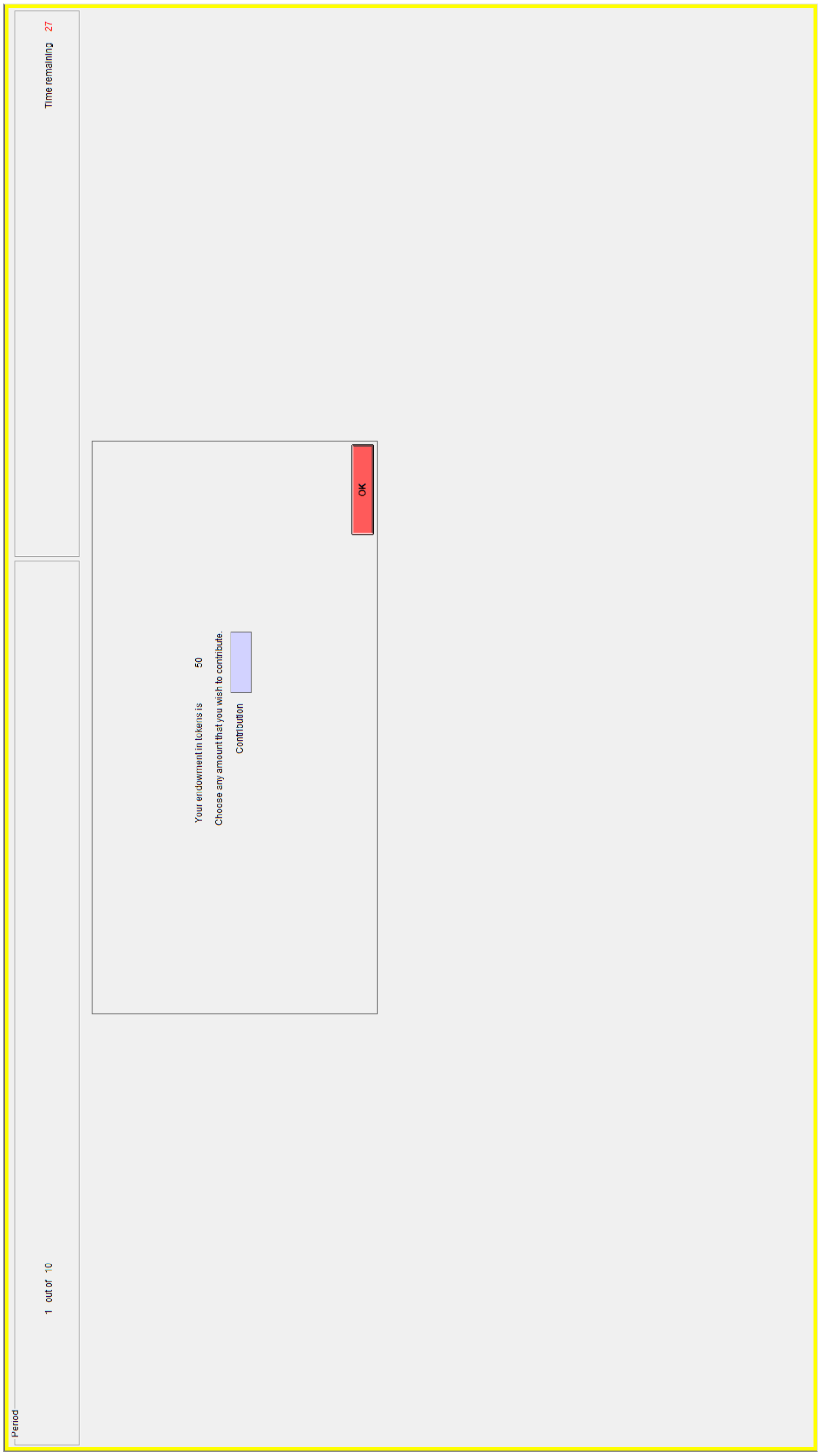


Figure 3: Proposal stage with Chats Screens for Proposers

Figure 4: Proposal stage with Chats Screens for Voters

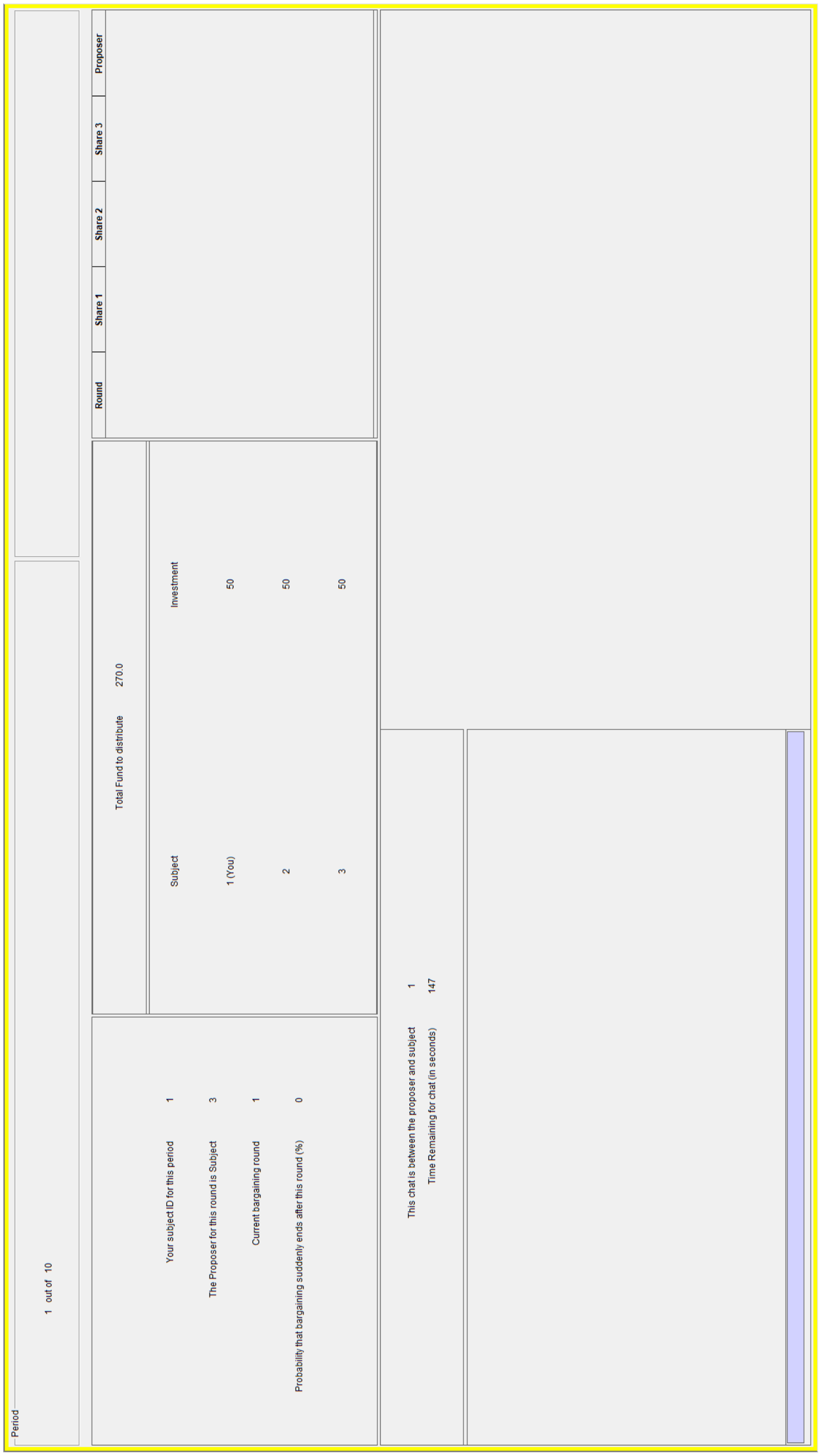


Figure 5: Voting Screen