



Endogenous claims and collective production: an experimental study on the timing of profit-sharing negotiations and production

Andrzej Baranski¹ 

Received: 31 January 2018 / Revised: 31 July 2018 / Accepted: 18 August 2018 /
Published online: 25 August 2018
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Abstract

We explore the efficiency and distributive implications of a multilateral bargaining model with endogenous production of the surplus under two different timings: *ex ante* and *ex post* bargaining. Both timings are commonly observed in business partnerships and alliance formations. The theoretical predictions confirm an intuitive economic tenet: in *ex post* bargaining, effort is considered sunk and opportunistic bargaining behavior will dissuade players from producing. On the other hand, *ex ante* bargaining entails an allocation of ownership shares that induces at least certain members to invest in the common fund because their return is guaranteed. Experiments show opposite results: *ex post* bargaining yields almost fully efficient outcomes while the reverse timing entails near zero efficiency. The psychological theory of inequity is useful in reconciling these divergent results.

Keywords Multilateral bargaining · Profit sharing · Public goods · Inequity · Baron and Ferejohn (1989)

I would like to thank John H. Kagel for supporting a pilot test and useful comments in the development of the project. I benefitted greatly from conversations with Ernesto Reuben, Arno Riedl, Martin Strobel, Alexander Cappelen, Jordi Brandts, Nikos Nikiforakis, María Montero, Joerg Oechssler, Eric Van Damme, and Patrick Schmitz. Comments obtained from participants at seminars in Nottingham University, Maastricht University, Universidad Pontificia Javeriana in Bogotá, 15th TIBER Symposium on Psychology and Economics (Tilburg 2016), and the 13th Workshop on Employee Ownership and Shared Capitalism organized by the Rutgers School of Management and Labor Relations (La Jolla, 2016) are gratefully acknowledged. Two anonymous referees and the editor, Roberto Weber, provided valuable suggestions. All errors are my own.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10683-018-9591-2>) contains supplementary material, which is available to authorized users.

✉ Andrzej Baranski
a.baranski@nyu.edu

¹ Department of Social Science, New York University Abu Dhabi, P.O. Box 129188, Abu Dhabi, UAE

1 Introduction

Whenever two or more persons, countries, or firms engage in a mutually beneficial activity it is quite common that they will negotiate how to divide the benefits resulting from their joint effort. For example, certain medical groups, law firms, and other partnerships have been reported to hold end-of-year meetings to redistribute profits (or at least a portion of them) while others assign profit shares at the beginning of the year.¹ In fact, multiple management consulting firms offer advice to partnerships on how to design an optimal partner compensation plan in order to induce effort and maximize profits. One particular question that partners must ask regarding their profit-sharing scheme is: “Will the distribution be prospective (distribution percentages or units of participation determined in advance of the year) or retrospective (distribution percentages or units of participation determined when year-end results are known)?” (Rose 2011).² In this article we make use of a laboratory experiment to examine how the timing of profit-sharing negotiations with respect to productive decisions affects both the distribution of profits and the efficiency levels that partnerships can achieve.

Several studies have been concerned with whether a firm should be jointly or individually owned (Hart and Moore 1990; for an experiment see Fehr et al. 2008), why partnerships and other joint ownership structures exist (Levin and Tadelis 2005; Alchian and Demsetz 1972), compensation systems in partnerships (Gilson and Mnookin 1985; Lang and Gordon 1995), and even on how to dissolve partnerships (Morgan 2004). Here, partnerships are broadly represented as a group of players who possess voting rights and must agree on how to share profits which are endogenously determined via individual voluntary efforts or investments. We focus on the interaction between profit-sharing agreements and rent-generating incentives in a setting in which (1) partners can propose and vote on profit-sharing agreements, (2) no partner has total control over the agenda of negotiations, and (3) all engage in production voluntarily. Our model attempts to depict a democratic and participatory system as opposed to a centrally directed mechanism.

Generally speaking, our model is a game of alternating offers and voting in which the surplus to divide is endogenously determined; the latter is an important feature that the standard divide-the-dollar models have typically abstracted from.³ We explore the efficiency implications by providing a theoretical benchmark and

¹ In a lock-step system partners are assigned ownership shares based on their status or seniority within the firm. Such profit-sharing scheme is an example of a compensation plan in which partners know their shares of the profits prior to engaging in productive activities. This system is most widely spread in European law firms but not so common in U.S. and Canadian firms according to three surveys by Edge International (Wessman and Kerr 2015).

² Another setting in which the timing of bargaining with respect to production is essential is the choice of technological standards (see Llanes and Poblete 2014). Setting a standard creates rents which are to be divided among the firms of an industry. How these rents are divided and the timing of rent-sharing with respect to the choice of the standard will likely impact the outcome of negotiations to choose a standard.

³ See Rubinstein (1982) for bilateral bargaining and Osborne and Rubinstein (1990) for a comprehensive analysis of such games. See Baron and Ferejohn (1989), Krishna and Serrano (1996) for multilateral bargaining. Battaglini and Coate (2007, 2008) consider a dynamic model of taxing and spending in which a nation's budget is determined endogenously through labor decisions which are a function of the taxing

an experimental test of two different timings: *ex post* bargaining, which we call *redistribution*, and *ex ante* bargaining, which we call *pre-distribution*. Under pre-distributive bargaining, partners negotiate how to divide ownership shares among themselves and once an agreement is reached, they proceed to a simultaneous game of investments. With redistributive bargaining, investments take place prior to profit-sharing negotiations.

Our theoretical framework can be interpreted as the merging of two influential models in economics: the Baron and Ferejohn (1989) model of multilateral bargaining and the linear public goods game. While the canonical linear public goods game exogenously establishes an equal share of the common fund to every player, both redistributive and pre-distributive bargaining allow to exclude some players from consumption of the joint surplus. In spite of the non-excludability violation, the redistribution game can be conceived of as public goods game with a priori undefined claims and the pre-distribution game as one in which claims are endogenously determined via bargaining. A wealth of theoretical and experimental studies exists in the fields of Public Economics, Political Science, and Political Economy that build on the aforementioned games. Thus, our model and experiments provide a bridge between these streams of literature which are discussed in Sect. 2.

The theory predicts that in the redistribution game, investments are considered sunk and opportunistic bargaining behavior will dissuade players from investing in the joint project. In contrast, the equilibrium prediction under pre-distributive bargaining entails a distribution of shares that induces at least certain members to invest in the common fund because their return is guaranteed and the hold-up problem is absent.^{4,5}

Our experimental results contradict unequivocally the theoretical predictions. The treatments of pre-distribution entail very low levels of efficiency while redistribution gives rise to almost full investments. Subjects largely tend to condition the division of the common fund on each member's investment in the redistribution treatment, a strategy that is not possible when determining shares *ex ante* (the correlation is of course not perfect and opportunistic behavior is also observed). Moreover, a player's contribution also serves as a credible *behavioral commitment* to vote against low offers (those below her contribution) and to not allow for the proposer to extract excessively inequitable shares.

The previous results echo what a growing literature on bargaining over an endogenous fund has been documenting: that initial efforts act as an objective claim over the surplus and that bargainers tend to follow redistributive norms that take those claims into account. Nonetheless, it should be stressed that even in simple settings with clearly objective claims as in the linear and symmetric production case studied

Footnote 3 (continued)

schemes agreed in the bargaining game. For cooperative (Nash) bargaining with an endogenous fund and subjective claims see Gächter and Riedl (2006) and Karagözoğlu and Riedl (2014).

⁴ In both models we use the solution concept of stationary subgame perfect equilibrium, a standard refinement in the bargaining literature.

⁵ For an experiment on how renegotiation (after investments) in a bilateral exchange setting can improve efficiency see Hoppe and Schmitz (2011).

here, behavior reflects a plurality of fairness ideals (Cappelen et al. 2007).⁶ What has been understudied is the effect of bargaining behavior on efficiency. Our findings are particularly striking because partners are not fixed throughout the experiment and reputation concerns play a negligible role.

In the pre-distribution treatments, subjects implement ownership agreements in which no one finds it profitable to invest and free-riding predominates. A generalized downward trend in investments is observed throughout the experimental sessions which is reminiscent of the stylized behavior reported in standard public goods games (Ledyard 1995). One of our initial conjectures was that subjects could feel compelled to invest whenever they voted in favor of a proposal and could perceive others' favorable voting decisions as signals of good will. In turn, these signals would elicit a collective reciprocal behavior in the investment stage. A similar argument has been set forth to explain the findings in experiments with *endogenous institutional choice* in which subjects tend to act more cooperatively and attain efficient outcomes more often when they have a say, by choice or vote, in creating or modifying the environment (see Kosfeld et al. 2009; Dal Bó et al. 2010). However, we did not find strong support for the effectiveness of endogenous ownership agreements in fostering economic efficiency.

Theories of inequality aversion (Bolton and Ockenfels 2000; Fehr and Schmidt 1999) are not useful in explaining our experimental results. Inequality of outcomes is quite prevalent in the game of redistribution since a member who invests a small amount would generally be offered a low share thus receiving smaller payoffs compared to a high investor. Instead, we find that the theory of inequity aversion (Adams 1963; Selten 1987) is more useful in describing our bargaining outcomes in both redistributive and pre-distributive bargaining. Inequity is broadly construed as a feeling perceived from a discrepancy between one's proportion of rewards to costs relative to others in the comparison group. We extend this theory to apply to cases where rewards are assigned ex ante and costs borne ex post as in pre-distribution. If all partners are expected to invest the same amount, inequity theory helps account for the even distribution of shares among partners in ex ante bargaining. We elucidate upon this issue in Sect. 6.

The article proceeds as follows. In Sect. 2, we provide a brief literature review, mainly focused on bargaining games and efficiency-enhancing mechanisms in public goods games. In Sect. 3, we present the model and theoretical results. In Sect. 4 we describe the experimental design and in Sect. 5 we present the results from the main experiments. Section 6 discusses the results and Sect. 7 concludes the article.

⁶ See Konow (2000), Frohlich et al. (2004), and Cappelen et al. (2007) for dictator games with joint production and Gantner et al. (2001) for ultimatum and demand bargaining protocols. All these studies report a significant tendency of subjects to derive entitlements from their own investments.

2 Related literature

The leading models of structured bargaining, Rubinstein (1982), Baron and Ferejohn (1989), and Krishna and Serrano (1996) all assume the existence of an *exogenous fund* which is to be divided between the parties.⁷ Our model builds on the Baron and Ferejohn game of multilateral bargaining as the negotiations protocol through which the *endogenous fund* is split once it has been created (redistribution) or through which equity shares are determined prior to making investments (pre-distribution).⁸

In the canonical Baron and Ferejohn bargaining game under the closed amendment rule, players are randomly chosen to propose a distribution of the total fund followed by a majority voting stage (the process repeats itself until approval and discounting may take place). The stationary subgame perfect equilibrium predictions of the game are intuitive: proposers should form minimum winning coalitions (MWCs) by assigning a positive share of the fund only to the number of voters required for approval. The shares offered to coalition partners are such that each member is indifferent between accepting or rejecting because they match the continuation value of the game. Moreover, there is a favorable payoff differential for the proposer who is able to extract the rents that non-coalition partners would earn if their votes were required for approval. Finally, there is no delay in reaching an agreement which implies that equilibrium outcomes are efficient. The vast experimental evidence⁹ provides strong qualitative evidence to support these predictions: MWCs are the modal allocations, most committees reach an agreement in the first round, and proposers earn a larger share than coalition partners (with the caveat that the proposer's share is not as high as predicted).

Baranski (2016) introduced an investment game to determine the common fund that subjects divide a posteriori via bargaining, which corresponds to the redistributive partnership developed here. Based on the previous bargaining experiments with an exogenous fund, one could have conjectured that players would not invest in the common account because of the likelihood of being excluded from the winning coalition. However, with endogenous production of the fund, this prediction was wrong and most subjects actually conditioned the shares offered on the investments made by partners giving rise to a virtuous cycle that fostered almost full efficiency. Our present experimental treatment on redistribution replicates this finding with a different subject pool and the minor design difference that in the current experiment if no one invests, there is no surplus to divide while in the former experiment groups had 30 tokens (equivalent to 3 US dollars) exogenously given.

The game of equity bargaining with endogenous production is based on Baranski (2017) in which a general framework is developed. In this article we present

⁷ Exceptions for the exogenous fund assumption in the Rubinstein model are Frankel (1998) and Cripps (1997).

⁸ A series of articles have generalized the Baron and Ferejohn model to asymmetric settings. See Eraslan (2002) and Eraslan and McLennan (2013).

⁹ See Fréchette et al. (2003), Fréchette et al. (2005a), Fréchette et al. (2005b), Agranov and Tergiman (2014), Bradfield and Kagel (2015), and Baranski and Kagel (2015).

a simplified version because we are focused on providing a tractable theory for a restricted set of parameters pertinent to the experimental design.

Our experiments are also related to the literature on public good provision and the free-rider problem because the productive technology we implement is exactly the one used in linear public goods game for which dozens of experimental studies exist. Comprehensive reviews may be found in Ledyard (1995) and Chaudhuri (2011). It should be noted that endogenously determined equity agreements may induce differences among partners in valuations for the public good which implies that the marginal return of investing differs for each member. See Fisher et al. (1995) and Reuben and Riedl (2009) for experiments with exogenous heterogeneous valuations for the public good.¹⁰

Redistributive bargaining allows for players to condition shares based on investments, which largely explains the efficiency levels observed in the experiments. Our findings resonate with those of the decentralized sanctioning experiments of Fehr and Gächter (2000), sanctioning and reward mechanisms (Sefton et al. 2007), and institutional sanctioning via voting (Ertan et al. 2009) which show that the possibility to diminish others' payoffs after the investment stage helps overcome the free-rider problem. A recent experiment by Dong et al. (2016) allows for each member to assign payoffs to other members after investments have been made, but each player does not have a say over how much to keep for herself. This mechanism provides a substantial increase in efficiency with almost 80% of subjects fully investing because peers abide mainly by a proportionality standard in assigning payoffs.

3 Theoretical models

Let there be $n \geq 5$ players (odd) labeled by the superscript i , each endowed with E amount of wealth. Players are assumed to be risk neutral and concerned only about their own payoff. Thus, we have that the stage profit is given by $u^i(\mathbf{x}) = x^i$ for any vector of payoffs $\mathbf{x}$. The production technology is linear and additively separable. Specifically, for a given vector of investments $\mathbf{c} \in [0, E]^n$ where c^i represents player i 's investment, total production is given by

$$F := \alpha \sum_{i=1}^n c^i \quad (1)$$

where $\alpha \in (1, 2]$.¹¹

¹⁰ See Buckley and Croson (2006) for exogenous endowment heterogeneity and Cherry et al. (2005) for earned endowments (endogenous heterogeneity).

¹¹ In principle α can be larger and this poses potential changes in the equilibrium predictions, but for our experiments this is the range that matters.

3.1 Redistributive partnership

The timing of the game is as follows. In stage 1, players simultaneously and independently choose $c^i \in [0, E]$. In stage 2, bargaining takes place according to the Baron and Ferejohn (1989) bargaining procedure. At the beginning of a bargaining round, a randomly chosen player proposes an allocation of the available fund to distribute. The allocation is publicly known and all players proceed to cast a vote. If a majority approves, the allocation is binding, if not, another round of bargaining takes place and the fund is discounted by δ .¹²

In each round of bargaining, a proposal $\mathbf{s}_t = (s_t^1, \dots, s_t^n)$ satisfies $\sum_{i=1}^n s_t^i = F$. The payoffs resulting from a vector of investments $\mathbf{c}$ and a distribution of the fund $\mathbf{s}$ approved in round τ are given by

$$u^i(\mathbf{c}, \mathbf{s}) = \delta^{\tau-1} (s^i - c^i + E) \quad (2)$$

Proposal and voting strategies¹³ are formally defined to be functions of the history of play up to the moment of a proposal or voting decision being made. However, since we will focus on stationary equilibria, we omit the extra notation for the sake of a clear exposition.

Proposition 1 (Baron and Ferejohn 1989; Baranski 2016) *The stationary subgame perfect equilibrium outcome of the redistributive partnership game is as follows: (1) No one invests ($c^i = 0$); (2) If there are any investments, the proposer assigns $\delta F/n$ to $\frac{n-1}{2}$ members and keeps the rest, the remaining partners receive nothing; (3) All those receiving $\delta F/n$ vote in favor and the proposal is approved without delay.*

The proof can be found in Baranski (2016) and here we provide the economic intuition which relies simply on the same free-riding notion as in the linear public goods games. Note that the ex ante value of the bargaining game (in equilibrium) prior to any player being designated as the proposer, is equal to the average fund (F/n). This implies that for each unit contributed, a player appropriates in expectation only α/n which is smaller than the cost of investing. As such, no one should invest in equilibrium.

If we dispose of the stationarity refinement for equilibrium characterization and focus on subgame perfection, there exists an equilibrium in which full efficiency is achieved when shares are proportional to contributions.¹⁴

¹² If there is no agreement, each player receives a share equal to zero.

¹³ It is commonly assumed that players only vote in favor if the offered share is greater than or equal to the continuation value of the game.

¹⁴ Under our parameter configuration for redistribution, any allocation may be supported as a subgame perfect Nash Equilibrium according to an off equilibrium punishment strategy described in Baron and Ferejohn (1989). Thus, one may construct an equilibrium in which shares are perfectly proportional to investments.

3.2 Pre-distributive partnership

The timing of the game is as follows. In stage 1, players bargain over the distribution of equity shares. A randomly selected member proposes an equity scheme, and if it is not approved by a simple majority, a new round of bargaining and voting starts.¹⁵ Once an allocation is approved, investments take place and the total fund is then split according to the agreed-upon equity scheme.

A bargaining proposal in round t is given by $\mathbf{s}_t = (s_t^1, \dots, s_t^n)$ and satisfies $\sum_{i=1}^n s_t^i = 1$ such that each $s_t^i \in [0, 1]$. The payoffs resulting from an equity agreement $\mathbf{s}$ in round τ and a vector of investments $\mathbf{c}$ is given by

$$u^i(\mathbf{s}, \mathbf{c}) = \delta^{\tau-1} (s^i F - c^i + E). \quad (3)$$

For this section we will assume that $\delta = 1$ for simplicity.

Proposition 2 *The stationary subgame perfect equilibrium outcome of the pre-distributive partnership game is as follows: (1) The proposer assigns $s = \frac{\alpha-1}{an}$ to $\frac{n-1}{2}$ coalition partners and keeps the rest; (2) Coalition partners including the proposer vote in favor and there is no delay in approval; (3) The proposer invests all the endowment and no one else invests.*

We provide a sketch of the proof to give an economic intuition and relegate the formal arguments to “Appendix 1”. Notice that a player finds it optimal to invest only if the share received is greater than $1/\alpha$. Since α is less than or equal to 2, it follows that at most two players will receive a share large enough to invest. A distribution of shares in which two players invest is not an equilibrium because of two constraints: one given by the production technology and the other by the voting requirement. For the highest productivity level ($\alpha = 2$), at most two players could be incentivized by receiving a share of 50% each and all equity is exhausted. Hence, in a committee of 5 members with a majority rule (3 votes) there would be no equity left to offer to a third partner which implies that the proposal would not be approved. One can easily rule out the case that a distribution of shares in which no one invests is an equilibrium. Thus, we are left with the case in which only one person invests (in equilibrium it is the proposer) who offers each coalition partner a share equal to $\frac{\alpha-1}{an}$ since it induces a final payoff equivalent to the ex ante value of the game.

4 Experimental design

In the experiments we implemented a productivity parameter $\alpha = 2$. Committees were composed of five members and three votes were required for approval. The discount factor was set at $\delta = 1$. Subjects were endowed with 50 tokens (equivalent

¹⁵ If no agreement is ever reached, players earn zero.

to 5 euros) in each period of play. The theoretical predictions for this parameter configuration can be found in Table 1.

Subjects participated in ten games (or periods) and were randomly reassigned into new groups in each game (strangers matching protocol). Within each game we observed an investment for each subject and a bargaining stage which could entail as many bargaining rounds as necessary to reach an agreement.¹⁶ In each bargaining round, all subjects were asked to submit a proposal (partial strategy method), but only the chosen one was observed publicly by group members and voted on. The experiment was programmed in zTree (Fischbacher 2007).

Subjects were compensated for only one of the playing periods which was randomly selected and revealed at the end. A small show-up fee of 4 euros was offered in order to keep the investment decision as meaningful as possible. Six sessions were conducted for each treatment with fifteen subjects with the exception of two sessions that had only 10 participants due a low show-up rate. In total, 170 subjects participated in the experiment (85 per treatment). Participants were bachelor students recruited from the Maastricht University subject pool via ORSEE (Greiner 2015) and only took part in one session.¹⁷

One anonymous referee noted that in pre-distribution subjects bargained over 100 equity shares while in redistribution they bargained over the total fund thus introducing a second difference between treatments. We conducted two additional sessions of redistributive bargaining in which subjects distributed 100 ownership shares and find similar patterns of behavior as those reported here (results are reported in the Online Appendix).

The instructions were written without mentioning business partnerships, firms, or teams to avoid priming subjects in any direction. A dry run was conducted to ensure a complete understanding of the screen layouts and software capabilities. Instructions and screenshots may be found in the Supplementary Materials. Given that the investment task entailed assessing the profitability of different scenarios, we provided a payoff calculator in the main screen. Subjects could enter any combination of shares and investments to compute the resulting payoffs. It was important to us that subjects were able to evaluate alternatives in an easy and transparent way.

¹⁶ In all the surveyed literature, we could not find a single observation where players had bargained for more than 10 rounds. Our software automatically stopped in round 15. A group bargaining for 15 rounds would take approximately 30 min, which would not allow us to conclude the experiment within our time frame. Subjects were told that, if they failed to approve an allocation and too much time had passed, the experimenter would move them to the next game in order to continue with the experiment. Payoffs for that round would not count if it was selected for payment. No one reached the limit.

¹⁷ I also conducted a treatment in which half of the fund was negotiated ex ante, investments took place, and the remaining half was negotiated ex post. It yielded similar efficiency levels as those observed in the pre-distribution treatment and the results were omitted from the article for the sake of a concise exposition.

5 Experimental results

We first present a comparison of investment dynamics and efficiency levels between treatments and then proceed to analyze how bargaining behavior explains the observed investment decisions in both treatments.

5.1 Investments and efficiency

Figure 1 shows the evolution of average investments throughout the ten games. In the first game of play, investments for the pre-distributive bargaining treatment start at 15 tokens (out of 50) and quickly unravel to almost zero on average. For redistributive bargaining, average investments start at 29 tokens and quickly rise to almost 80% of endowment, averaging 41 tokens in the last five games of play. We can clearly reject the hypothesis that investments are equal between treatments (p value = 0.004).¹⁸

Conclusion 1 *Contrary to the theoretical predictions, redistributive bargaining induces higher investments than pre-distributive bargaining. When subjects have gained experience in the game (last five games) average investments reached 80% of endowment under redistribution but unravelled in the pre-distribution treatments.*

We now proceed to take a close look at bargaining dynamics to shed light on why investments are reinforced in the redistributive bargaining game and not in the pre-distributive game.

5.2 Bargaining outcomes: an overview

We start our analysis by providing an overview of bargaining outcomes in both treatments in order to assess the predictive power of the SSPE characterization. In Sect. 5.3 our analysis digs deeper into the nature of allocations in relationship to investment decisions which is ultimately our goal: to understand how allocations and investments relate to each other.

In both treatments, the SSPE prediction is that equity or funds should be disbursed only to three out of five members (MWC), but these allocations account for 30% of approved proposals in each treatment. Instead, we find that allocations in which shares are disbursed to all members are modal and represent about half of the approved proposals in each treatment.¹⁹

¹⁸ Mann–Whitney test using session averages as the unit of observation.

¹⁹ If a member receives 5% or less (equity or percentage of the fund) she is considered to be excluded. For example, the proposal (50%, 20%, 20%, 5%, 5%) is counted as a minimum winning coalition. Only 7 (of 850) investments represent 5% or less of the total group investments of which 4 receive a larger share of the fund. In 97% of the instances in which a member receives a share 5% or less of the total fund her contribution has been appropriated by others.

The theoretical prediction according to the stationary equilibrium in the pre-distributive bargaining game is that proposers keep a share of 80%. Notice that the apparently large inequality in terms of ownership shares does not translate into a large inequality of final payoffs. However, the average proposer share is only 27.5% which is significantly larger than the voter's average share of 22.3% (p value < 0.01). The difference between proposers' and non-proposers' shares is smaller in the redistributive bargaining game, 26.2% compared to 22.5% for non-proposers, but it is still significant (p value < 0.01).²⁰ Focusing on MWCs, we find that there is virtually an equal split between coalition partners in both treatments.

Conclusion 2 *Bargaining behavior does not conform to the equilibrium predictions. In both treatments, allocations in which shares are distributed to all members are modal and not minimum winning coalitions. The proposer's average share is very small compared to the theoretical benchmark, even when focusing on minimum winning coalitions.*

Our findings for the redistribution treatment are similar to those reported in Baranski (2016) and contrast starkly with the findings from multiple Baron and Ferejohn (1989) experimental studies in which the fund to distribute is exogenously given, mainly because in those studies MWCs are modal and the proposer has a substantial advantage compared to other members.

From Table 1 we can see that the difference between the average proposers' shares in the pre-distribution and redistribution treatments is small, and the same for the average shares for included non-proposers. A member is denoted as *included* when she receives more than 5% of shares. According to Mann–Whitney tests with session averages as the units of observation we cannot reject the null hypothesis that the mean proposer's share is the same in both treatments (p value = 0.423) and neither can we reject that the mean included voters' shares are equal (p value = 1).²¹

Conclusion 3 *The average proposer share (in percentage) does not differ significantly between pre-distribution and redistribution treatments and neither does the average share offered to a voter included in the coalition.*

5.3 Productive incentives and bargaining behavior

In what follows we analyze redistributive and pre-distributive bargaining strategies separately to understand how profit-sharing negotiations translate into productive incentives in the redistribution treatment but not in the pre-distribution treatment.

²⁰ The p values were obtained from an OLS regression controlling for session and period effects, where none of the controls reached significance at conventional levels. Two-sided Wilcoxon signed rank tests using session averages as the pairs of observations further confirm that these differences are significant (p values < 0.05).

²¹ These results remain when performing regression analysis and controlling for whether the allocation was a 3, 4 or 5-way split. The regression table may be found in the Online Appendix.

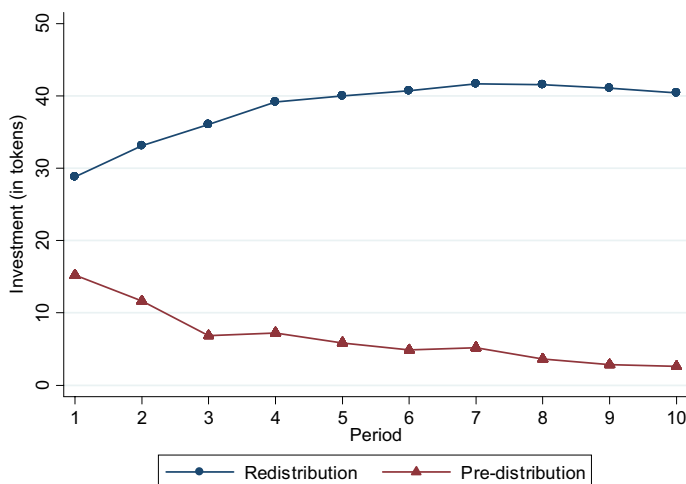


Fig. 1 Average investments

5.3.1 Pre-distributive bargaining behavior

According to our theoretical prediction, a player should only invest in the common fund if she receives an equity share greater than or equal to 50%, however there is only one approved allocation in which a member obtains this amount or more. Hence, the observed investment outcomes can be considered to be a best response given the subgames reached after bargaining.

A clear pattern emerges for non-proposers as we can find that members contributing above 20 tokens earn significantly lower payoffs.²² In the second half of the experiment, almost all investments are concentrated between 0 and 10 tokens and deviations from those levels yield lower payoffs on average. This pattern resembles closely the findings of the standard public goods experiments which lead to unraveling of contributions (Ledyard 1995; Chaudhuri 2011).²³

Prior to reaching the investment stage, players have voted and also received feedback on how others in their group voted. Based on the literature on endogenous institution formation we ask the two following questions. Do members' favorable voting decisions signal a higher willingness to contribute? If so, can it be that groups with higher number of agreeing members reach higher contributions?

To answer these questions we estimated a random effects tobit model (accounting for subject-specific effects) in which the invested amount was the dependent variable. As explanatory variables we included the share received, the player's voting decision (accept or reject), an interaction between the previous two variables, the

²² We can reject the null hypothesis that average payoffs for cases when subjects contribute less than 20 tokens are equal to payoffs when members contribute more (p value < 0.001, two-sided t test). Two-sided Wilcoxon signed rank tests using session averages as the pairs of observations further confirm that this difference is significant (p value = 0.028).

²³ A table with payoffs by contribution level is presented in the Online Appendix.

Table 1 Bargaining outcomes

	Pre-distribution		Redistribution	
	Predicted ^a (%)	Observed	Predicted ^a (%)	Observed
<i>Proposals^b</i>				
3-way split (MWC)	100	29.4	100	30
4-way split	0	20	0	14.1
5-way split	0	50.6	0	55.9
<i>Shares</i>				
Proposer's share ^c	80	27.5 (0.564)	60	26.2 (0.589)
Proposer's share in MWC	80	33.4 (0.751)	60	34.9 (0.700)
Voter's share ^c	10	22.3 (0.265)	20	22.5 (0.281)
Voter's share in MWC	10	31.9 (0.338)	20	31.7 (0.386)
<i>Timing of approval</i>				
Round 1	100	77.0	100	74.7
Round 2	0	16.5	0	15.3

^aPredictions corresponding to the stationary subgame perfect equilibrium.

^bMembers receiving 5% of less are counted as excluded from the allocation.

^cConditional on receiving a share above 5% of the to total fund

player's role (proposer or voter), dummies for the number of votes in favor excluding one's vote conditional on voting in favor, and a period trend variable.²⁴

The estimation results are presented in Table 2. We find that voting in favor of a proposal is positively correlated with the amount a player will invest. At mean levels in game one, voting in favor increases investments by 9.7 tokens, but the marginal effect decreases gradually to only 5.5 tokens in game 10. The coefficient for own share is positive as expected.²⁵ In short, these results show that voting in favor is an indicator of a member's investment intention. This finding echoes what Dal Bó et al. (2010) report in a prisoner's dilemma game in which subjects can vote to implement a tax on non-cooperative behavior, because the voting decision is strongly correlated with willingness to cooperate.²⁶ However, the strength of the effect is rather low in our setting and rapidly fades with experience.

We also find that the proposer role dummy and its interaction with own equity share are insignificant individually and jointly (Wald test p value = 0.871) which means that the agenda setter does not feel compelled to contribute more than non-proposing members.

²⁴ Session dummies were also included only session 5 yielded a significant. However, according to a joint test of significance we cannot reject the hypothesis that all session dummies are equal to zero (Wald test p value of 0.33). The interaction dummy for role and vote was omitted due to collinearity (all proposers vote in favor).

²⁵ A Wald test for $\text{Own Share} \times \text{Vote} + \text{Own Share} = 0$ yields a p value = 0.014.

²⁶ This holds for the case when the implementation of the tax took place endogenously.

The reason we included dummies for the number of votes in favor was because we conjectured that higher agreement rates could be a signal of good faith and foster trust among the committee members. Our estimation shows that, conditional on voting in favor, subjects' contributions are highest when all other members approved the equity agreement and lowest when only two others voted in favor, but again the effect is rather weak.

Lastly, we find that the period trend variable is negative and significant as one would expect based the evolution of investments presented in Fig. 1.

Conclusion 4 *In the pre-distributive bargaining game the approved equity agreements induce free-riding behavior and the resulting average payoffs are reminiscent of those reported in standard public goods games with predefined equal shares. Subjects are more likely to invest when they have voted in favor and also when all other partners have voted in favor too. But as they gain experience in the game, investments unravel toward zero.*

I conducted three sessions for an identical treatment but with smaller groups which is reported in the Online Appendix. The theory predicts an equal split of the equity shares between the proposer and another member which entails that both players should invest. We conjectured that the reduced group size could aid in two ways to foster efficiency: by enhancing the available per capita shares and by reducing inequality of payoffs in equilibrium among productive partners. Nevertheless, we find the same pattern of unravelling (see Fig. 6 in the “Appendix 2”), and even when subjects agree on an equal split, investments are rather low.

5.3.2 Redistributive bargaining behavior

Investments are likely to yield a high return in redistributive bargaining: 82% of shares to non-proposers in approved allocations are greater than or equal to members' investments and in 71% of the cases the share received is at least twice as large. Proposers always retrieve their investments.²⁷ In stark comparison with the payoffs arising in pre-distributive bargaining, the highest payoffs are obtained by members who contribute above 40 tokens (out of 50).

What is clear from analyzing the data and the scatter plot displayed in Fig. 2, is that in a large portion of accepted proposals, shares and investments are positively correlated, but this correlation is not perfect and other bargaining strategies are observed which need not follow a norm of investment based redistribution. In panel A of Fig. 2 each plotted observation corresponds to share as a percentage of the fund and the respective contribution as a proportion of the group's total contributions for allocations with 4 or 5 included members while panel B is for MWCs. All points lying on the 45 degree line (dash and dot line) are perfectly proportional shares. Notice that for observations in panel A the fitted line is closer to the proportionality

²⁷ We find one proposer in the first game that assigned herself 0. The subject then voted against perhaps because this was a mistake.

Table 2 Random effects tobits for investments in pre-distribution

	All shares	Shares > 5%
Vote (= 1 if Yes)	26.15*** (5.38)	23.82** (3.27)
Proposer (= 1 if Yes)	− 2.597 (− 0.39)	− 2.126 (− 0.32)
Own share	0.980*** (4.74)	0.960** (2.65)
Vote × own share	− 0.586* (− 2.24)	− 0.533 (− 1.37)
Role × own share	0.114 (0.47)	0.111 (0.46)
Additional votes in favor ^a		
2 Votes	− 7.164** (− 3.22)	− 6.610** (− 3.14)
3 Votes	− 4.878* (− 2.33)	− 4.615* (− 2.34)
Period	− 3.380*** (− 13.33)	− 3.297*** (− 13.65)
Constant	− 19.99*** (− 3.89)	− 18.19* (− 2.37)
Num. Obs.	850	716
Correlation (predicted and observed)	0.446	0.416
χ^2	245.7	211.8
ρ (subject-level var/total var)	0.474	0.528
χ^2 (LR test for $\rho = 0$)	90.44	94.59

***, **, *Significance at 0.1%, 1%, and 5% respectively. *t*-statistics reported in parentheses below coefficient values. Investments are censored from below at 0 and from above at 50. Interaction between Vote and Role is excluded because of collinearity. Session dummies included but not shown

^aDummy variables for the number of votes in favor excluding oneself and conditional on having voted in favor. 4 votes in favor (unanimous agreement) is the omitted category

standard while for MWCs the fitted line is slightly negative, revealing that some allocations may be following an opportunist scheme in which lower contributors exclude higher contributors from the total profits.²⁸ Conditional on being part of the coalition, however, the relation between investments and shares is positive (the correlation coefficient is 0.457, p value < 0.001). The Online Appendix reports a similar figure for the first and last five periods.

In order to better describe how shares relate to investments, we regressed the share received (in tokens) on a member's contribution, the period of play (trend), her role (proposer or voter), and pairwise interactions of all the previous variables.

The results are presented in Table 3 and our discussion will focus on the estimations obtained from the first column. The coefficient for investment is positive and significant. Thus, increasing investments by one token yields an increase of 1.7 tokens in the share received (at mean levels).

The coefficient for the period variable is positive which indicates that shares in tokens are getting larger in each successive game. However, the interaction between

²⁸ See Hamman et al. (2011) for a similar result on the tyranny of the majority, where some elected leaders force contributions from a minority and implicitly distribute the benefits to a majoritarian minimal coalition. However, just like in our setting, they find that a majority of outcomes are not MWCs contrary to theoretical predictions.

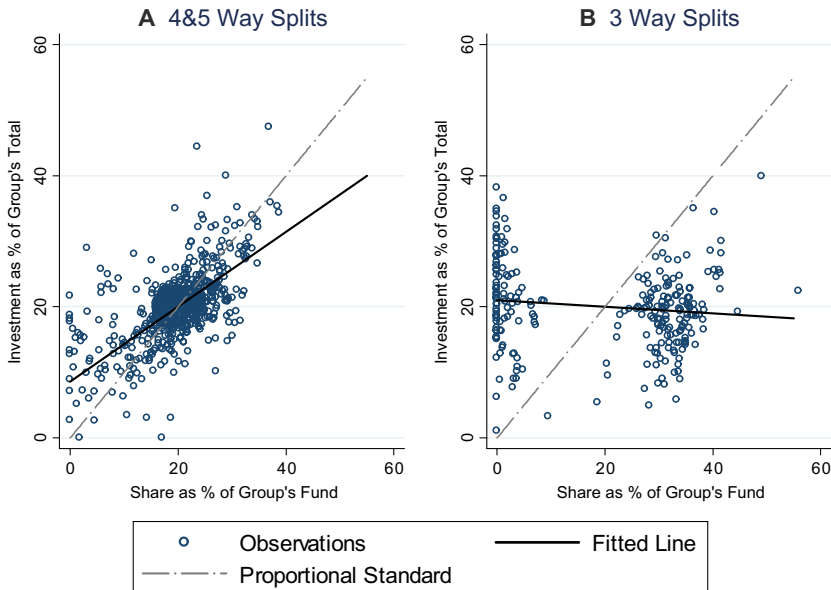


Fig. 2 Shares and investments in redistribution

period and investment is negative, which evidences that shares are less correlated with investments as subjects gain experience. In the last three games the overall effect of contributions is below 1, meaning that the investment-based bargaining behavior weakens with experience, but this negative effect is apparently not strong enough as to cause a reduction in average investments.²⁹

Controlling for the amount invested, proposers have a significant advantage over other members and this advantage increases in time. Although the coefficient on the interaction between the proposer role and contribution is not significant³⁰ its sign indicates that proposers' shares are less sensitive to investments.

In order to analyze how *fair* an allocation is,³¹ we introduce the fairness index (FI) given by

$$FI = \sqrt[2]{\sum_{i=1}^5 \left(\frac{Share_i}{Fund} - \frac{Investment_i}{\sum_{j=1}^5 Investment_j} \right)^2} \quad (4)$$

²⁹ MWC allocations increase from 22% in the first five games to 37% in the last five and five way split decrease from 63 to 48%. In a post experimental survey, some subjects explained that they shifted from more to less inclusive allocations as they encountered these at some point.

³⁰ We reject the hypothesis that the proposer dummy and its interaction with investment are jointly equal to zero (Wald test p value = 0.037).

³¹ See Cappelen et al. (2007) for a study on the pluralism of fairness ideals. One could argue that minimizing final payoff inequality or an equal split of the fund regardless of investments represent alternative fairness notions.

Table 3 Tobit for approved shares in redistribution

	Model 1	Model 2
Investment	1.807*** (0.209)	1.965*** (0.210)
Proposer (= 1 if proposer)	29.39* (11.47)	25.82* (11.62)
Proposer $\times$ investment	– 0.526 (0.269)	– 0.449 (0.272)
Period	4.453** (1.434)	1.973 (1.376)
Period $\times$ investment	– 0.114** (0.0355)	– 0.0611 (0.0345)
Proposer $\times$ period	3.039** (1.152)	3.040** (1.170)
Constant	9.432 (8.327)	– 2.862 (7.736)
Session dummies	Yes	No
Num. obs.	850	850
χ^2	301.0	274.0
Correlation (predicted vs observed)	0.575	0.555

***, **, *Significance at 0.1%, 1%, and 5% respectively. Standard errors reported in parentheses below coefficient values

which measures the distance of a proposal to the perfectly proportional allocation. Notice that a perfectly fair allocation yields an *FI* of 0. We also consider a coarse measure which counts how many members of the group are retrieving their own investment.

In Table 4 one can see that sessions with outcomes that are more fair according to our notions display higher average investments. Given that within each session a unique *culture* of bargaining and investments coevolves, we do not have enough independent observations to establish the statistical significance of this relationship at the session level. Nevertheless, our evidence is supportive of the economic intuition that if shares and investments are strongly positively correlated, high efficiency gains obtain.

We now proceed to investigate voting behavior by estimating a probit model in which the probability of voting in favor is a function of a measure of own surplus (OS defined by $\frac{\text{Share} - \text{Contribution}}{\text{Fund}}$) and the proposer's surplus (PS).³² We also incorporate as dependent variables the notions of fairness we have previously discussed and their interaction with OS.

Our econometric estimations reported in Table 5 reveal why proposers cannot extract a large share as predicted in the stationary equilibrium: the probability of voting against a proposal is positively correlated with the proposer's share in excess of her contribution. As expected, subjects are more likely to vote in favor as their own return to investment increases.

While the coefficient for the *FI* and its interaction with own surplus are not significant individually, a Wald test rejects the hypothesis that they are jointly equal

³² Another measure one may use is $\frac{\text{Share}}{\text{Fund}} - \frac{\text{Investment}}{\sum_{j \in \text{Group}} \text{Investment}_j}$ and this has no major consequence on the results of our estimations.

Table 4 Fairness in redistribution outcomes by session

Session	Fairness index	No. of members that retrieve investment	Average investments
7	0.095	4.47	45.03
8	0.088	4.53	46.41
9	0.063	4.67	44.51
10	0.196	4.07	33.7
11	0.291	3.73	28.26
12	0.277	3.85	28.51

to zero (p value < 0.05). If voters were to be affected negatively by unfair allocations, one should expect a negative coefficient for *FI* (recall that an *FI* closer to zero means an allocation is more fair), yet our estimations show it is positive. Since this result was rather puzzling we reestimated the model with an indicator variable for the number of members retrieving their investment, in which three members was the base level (see columns 3 and 4).³³ Again, our estimations show a negative coefficient for 4 and 5 members, meaning that the probability of voting in favor is lower in those cases compared to the base level. While the marginal effect for the cases of 4 and 5 included members at mean levels is a small drop by about 1% point in the probability of voting in favor, one would have expected a significant increase. Moreover, the positive coefficients for the interaction with *OS* reveal that own profitability becomes all more important when more members are retrieving their investments.

In order to assess the implications of our model (column 1) we examine the predictions for two types of allocations: a five-way equal split (5W-ES) and a minimum winning coalition equal split (MWC-ES), both in which all members invested fully. For the 5W-ES, the probability of an individual casting a vote in favor is 66.7 which is below 93.4% for the MWC-ES. While this difference is relatively large, it is actually quite small in terms of approval odds. Notice that in the MWC-ES if one of the two included non-proposers votes against, the allocation does not receive a majority vote and is then rejected. Hence, the chances of MWC-ES passing are 87%.³⁴ For the 5W-ES there are three events in which the allocation is approved: all four voters besides the proposer vote in favor, only three of them do, or only two. Calculating the appropriate combinations for each event and weighing them by the associated probabilities, we obtain a 88% chance of approval.³⁵ Under similar computations,

³³ Our data shows that subjects always vote against a proposal in their share is lower than their investment ($OS < 0$). Thus we estimate our models in columns 2 and 4 conditioning on profitable shares.

³⁴ We assume that the proposer votes in favor, thus chances of both voters voting in favor are $0.934^2 \approx 0.87$.

³⁵ The calculation is as follows:
 $\left(\frac{4}{2}\right)(0.667)^2(1 - 0.667)^2 + \left(\frac{4}{3}\right)(0.667)^3(1 - 0.667)^1 + \left(\frac{4}{4}\right)(0.667)^4$. Here, $(0.667)^k(1 - 0.667)^m$ is the probability that k members vote in favor and m against.

Table 5 Voting probits for redistribution

	Model 1		Model 2	
	All shares	Profitable shares ^a	All shares	Profitable shares ^a
Own surplus (OS) ^b	21.30*** (2.165)	21.05 *** (2.213)	13.98*** (1.806)	8.930** (3.336)
Proposer surplus (PS)	− 6.565*** (1.556)	− 6.668 *** (1.595)	− 5.906*** (1.493)	− 6.326*** (1.574)
Fairness index (FI)	0.257 (1.595)	0.396 (1.644)		
FI × OS	− 13.05 (8.242)	− 13.09 (8.310)		
4 Retrieve (4R)			− 1.279 (0.804)	− 2.368 * (1.043)
5 Retrieve (5R)			− 0.904 (0.471)	− 2.062 * (0.801)
4R × OS			9.933 (5.591)	14.61 * (6.430)
5R × OS			10.35** (3.187)	15.34*** (4.230)
Cons.	− 0.821** (0.300)	− 0.787* (0.307)	− 0.278 (0.490)	0.933 (0.836)
Num. obs.	952	760	952	760
χ^2	586.9	260.6	595.6	272.5

***, **, *Significance at 0.1%, 1%, and 5% respectively. Standard errors reported in parentheses below coefficient values. Session dummies are not displayed and omitting from the regressions does not change the results.

^aProfitable shares are those such that a member at least retrieves his investment (Share $\geq$ Investment)

^bThe OS is defined as the difference between one's share and investment as a proportion of the total fund

the stationary equilibrium proposal (proposer keeps 60% and two voters keep 20% each) has virtually zero chance of passing (less than 0.01%).

Analyzing the bargaining behavior in round two following a rejection in round one sheds some light as to why abiding by more inclusive allocations might be attractive despite the fact that proposers would keep a larger share in a MWC and these are almost equally likely to be accepted compared to a five way split. Players who proposed a MWC in the first round of a bargaining game and faced a rejection obtained on average 40 tokens in the following round, much lower than the 64 tokens that proposers of more inclusive allocations received. This punishment stems mainly from those who voted against the proposal since they offer on average 25 tokens less to the previous proposer compared to the share offered to other partners, thus evening up expected payoffs.³⁶ Non-proposing members in a first round were always better off in a second round of bargaining compared to proposers.

Conclusion 5 *Redistributive bargaining is used as a mechanism to assign shares which cover the cost of investment and yield a profit in 82% of the cases, and as a consequence, high efficiency gains obtain. When voting on a proposal, subjects tend to be mainly guided by their own gain and dissuaded by the proposer's gain; notions of fairness are not a strong force behind the voting decision. Minimum winning*

³⁶ The final payoffs for a player that proposed an MWC in round 1 are on average 111 tokens and 105 tokens if a more inclusive allocation would have been proposed initially.

coalitions entail similar odds of acceptance compared to more inclusive proposals, but conditional on a rejection, previous proposers are punished with lower shares in the following round thus moderating the attractiveness of such schemes.

Our results about proposing and voting are somewhat puzzling. Bargaining outcomes tend to follow a norm of investment-based fairness in which higher contributors obtain higher payoffs (especially strong relationship in sessions 7–9). Nevertheless, subjects' concerns for others' payoffs relative to their investments do not seem to play a substantial role at the voting stage, and instead our econometric estimations reveal that the main determinants are one's own surplus and the proposer's surplus. These happen to be the determinants of voting in experiments with an exogenous fund as well. In order to fully and clearly understand the role of others' payoffs in redistributive bargaining one would need to conduct a treatment with private shares and directly observe the effect of such information structure on efficiency. However, this design change could potentially alter what players initially propose and how much they invest.

6 Discussion of the results and inequity aversion

Our results for the game of redistribution are consistent with the theory of inequity developed by Adams (1963) who defines inequity as a perception by the individual that her ratio of rewards to inputs is different to the ratio of others in the group.³⁷ A key prediction of the theory is that inequity creates tensions, and our results show that these tensions are evidenced in that no one ever votes in favor of a share in which she is not retrieving her investment. As in Selten (1987) who further develops the theory of Adams, we also argue in our setting that “it is unreasonable that experimental subjects perform complicated mathematical operations in an attempt to understand the strategic structure of the situation” (p. 43). Instead, we observe that investments are largely used as an objective cue to determine what an equitable share should be. Clearly, not all subjects abide by the equity standard of contribution based redistribution, but there is a critical mass of equitable redistributors such that large efficiency gains are attained.

One potential explanation for why investment incentives are not reached in pre-distributive bargaining is that the equilibrium agreement (80%, 10%, 10%, 0, 0), where the proposer keeps a share eight times larger than that of included coalition partners, appears to be very skewed in favor of the proposer. Nevertheless, final payoffs are 80 tokens for the proposer and 60 for the coalition partners, which is only 1.3 times larger than that of included coalition partners. Hence, ex ante inequality

³⁷ We have not invoked economic theories of inequality aversion such as Bolton and Ockenfels (2000) or Fehr and Schmidt (1999), because as Montero (2007) shows, these preferences predict more unequal payoffs in favor of the proposer in the Baron and Ferejohn bargaining game. Moreover, aversion to inequality would imply that redistribution would tend to more equal payoffs even when players have contributed different amounts, contrary to what we observe in redistribution.

in ownership is reduced in final payoffs, but subjects might not foresee this. In an attempt to mitigate the effect of cognitive constraints, we provided a fully functional payoff calculator which allowed subjects to easily compute alternative scenarios prior to making investment and proposal decisions.

It can also be that the symmetry of the environment might be used as a cue for equal divisions (or equal divisions within the coalition) which is mostly what we observe. In Hoffman et al. (1994), the authors argue that the first mover advantage in bilateral bargaining games may dissipate when the right to move first is randomly allocated, just as in our setting. They find that when the right to move first is earned in a legitimate way which is commonly known and accepted, a significant favorable payoff differential is observed for the proposer.³⁸ This latter finding is in line with inequity theory, because those who earned the right to propose might be perceived as deserving a larger proportion of the common fund. However, the argument that *ex ante* symmetry could be the force behind the prevalence of equal splits in pre-distribution should also apply to redistribution experiments with exogenous funds. But this is not the case: as Fréchette et al. (2005a, b) report and multiple other experiments confirm, the proposer typically holds a payoff advantage receiving close to 38% of the total fund.³⁹ Thus, the *ex ante* symmetry does not appear to be the driving force of the low proposer power observed in the pre-distributive bargaining game.

We propose a slight modification of the theory of inequity for our setting which makes it applicable to the *ex ante* bargaining game. Instead of assigning rewards based on inputs as in the canonical theory of Adams (1963), rewards are assigned based on *expected* inputs. Our data clearly show that there is no significant difference between the investments of proposers and non-proposers. Thus, if both types of players are expected to contribute the same amount, the theory of inequity would imply that shares would tend to be allocated on equal proportions between members. This helps explain the prevalence of five way equal splits (26% of all approved allocations). Note that the fact that minimum winning coalitions are often formed does not contradict the theory, because the modal allocation in such cases is an equal split between members (40% of all MWC allocations) and the two excluded partners are expected to not contribute. Thus, there is no inequity in the sense of Adams.

7 Conclusion

In this article we have examined theoretically how the timing of property rights negotiations affects incentives to invest in a common project and explored actual human behavior with incentivized laboratory experiments. Bargaining over the endogenous fund *a posteriori* yields large efficiency gains, while bargaining *a priori* to define ownership shares yields near zero investments. When shares are negotiated prior to production, subjects fail to agree on ownership schemes that induce investments. Even when

³⁸ The authors introduce a quiz in which the best performers earn the right to propose.

³⁹ Based on the treatment with five members and no discounting in the last five games.

minimum winning coalitions form and incentives to invest are quite high, partners do not trust other committee members and free riding prevails. With redistributive bargaining, subjects do not treat investments as sunk, and instead, investment-based redistribution strategies explain the high levels of efficiency.

The production technology we assumed is similar to the one employed in the linear public goods game, which has been the workhorse of a large body of literature studying the emergence of cooperation in human societies and the tragedy of the commons. Our contribution to this stream of literature is that negotiations to determine property rights in the standard public goods game prior to investment decisions do not give rise to efficiency-inducing ownership shares and free-riding prevails. Such results provide weak evidence for the effectiveness of endogenous institutions in fostering cooperative or efficient outcomes and contrast with the findings by Kosfeld et al. (2009) and Dal Bó et al. (2010) who report that a significant portion of subjects form institutions that can lead to efficient outcomes. Certainly, more work is needed to further understand which institutional conditions are more conducive to the formation of efficiency-enhancing agreements.

We motivated our analysis as profit-sharing model of partnerships, but we have overlooked several aspects of interest in our attempt to establish a tractable model. First, partnership formations are usually voluntary, while in our setting players are forced to interact. Moreover, relations endure in time and reputation concerns (due to possibility of exclusion in the future) are likely to mitigate the efficiency loss observed in pre-distribution experiments. Also, the presence of production synergies, risk and uncertainty, and observability or not of others' actions and compensations can play important roles in profit-sharing and production decisions, especially by altering what might be perceived as a fair share (Karagözoğlu and Riedl 2014; Reuben and Riedl 2013; Capelen et al. 2007; Gantner et al. 2016; Selten 1987). It is well known that asymmetries in bargaining games give rise to more complex strategic dynamics (see Eraslan 2002), thus we leave the development of these dimensions for future analysis.

Appendix A: Proof of Proposition 2

Starting in stage 2 after an equity agreement has been reached in round τ we have that a member finds it optimal to invest if and only if the return of doing so is larger than the cost. Formally, the equilibrium investment strategy in any subgame is

$$c_i^*(s^\tau) = \begin{cases} 0 & \text{if } \alpha s_i^\tau < 1 \\ E & \text{if } \alpha s_i^\tau \geq 1 \end{cases} \quad (5)$$

Now we partition the set of subgames into three possible disjoint sets and show that equilibrium can only occur in one of those subsets. We define

$$S_k := \left\{ (s^1, \dots, s^n) \in [0, 1]^n : \sum_{i=1}^n c_i^* = kE \right\} \quad (6)$$

where the S_k determines all equity agreements in which k members receive a share that induces investments. It is straight forward to show that the sets S_k are pair-wise disjoint and that $S_0 \cup S_1 \cup S_2 = [0, 1]^n$. Moreover, $S_k = \emptyset$ for $k > 2$. If $\alpha < 2$, then $S_2 = \emptyset$ also. This is a consequence of the equity constraint which requires that the sum of shares must add to 1.

Lemma 3 *In equilibrium, $\mathbf{s} \notin S_0$.*

Proof By the contrary, assume that $\tilde{\mathbf{s}} \in S_0$ is an equilibrium. Then, $u(\tilde{\mathbf{s}}) = 1$ for each player which implies that the ex ante value of the game is equal to 1 for every player. As such, a voter will vote yes for any share, because it will yield at least a payoff of 1. A proposing member can deviate to $(1, 0, \dots, 0)$ where the first entry is the proposer's share (without loss of generality). Every player would earn $u(\tilde{\mathbf{s}}) = u(1, 0, \dots, 0) = 1$ which means they would vote in favor. The proposer who would find it profitable to invest and earn $\alpha > 1$. $\square$

Lemma 4 *In equilibrium, $\mathbf{s} \notin S_2$.*

Proof By the contrary, assume that $\tilde{\mathbf{s}} \in S_2$. This means that exactly 2 players are offered a share of $s_{inv} = 0.5$. Without loss of generality, the payoff vector that arises will be $(\alpha, \alpha, 1, \dots, 1)$. This is, two players will earn α and the $n - 2$ will earn only their endowment. Since ex ante any player can attain each payoff with equal chances, the equilibrium expected value of the game is $V = \frac{2}{n}\alpha + \frac{n-2}{n} > 1$. Here, we are imposing symmetry in the sense that what player i offers j is what j offers i . Recall that a member votes in favor if and only if her payoff resulting from the share received is greater than or equal to V . However, this proposal will never be approved, because only two players exhaust all the available equity and the proposal does not receive a majority vote. $\square$

Proof of Proposition 2 We now focus on the case of $\mathbf{s} \in S_1$ and will show that there exists an equilibrium with one productive member. Without loss of generality, we assume that the proposer assigns herself a share s^{prop} greater than or equal to $1/2$ which means that she invests in equilibrium. We denote by s^{vote} the positive share offered to m coalition partners. The equity feasibility constraint is given by

$$s^{\text{prop}} + m \cdot s^{\text{vote}} = 1. \quad (7)$$

With probability $\frac{m}{n}$ a member is an included voter who earns a share of the fund s^{vote} and keeps his endowment. With probability $1 - \left(\frac{1+m}{n}\right)$ a member receives zero equity and only keeps his endowment. Hence, the ex ante value of the game is given by

$$V = \frac{\alpha s^{\text{prop}}}{n} + \frac{m}{n}(\alpha s^{\text{vote}} + 1) + 1 - \left(\frac{1+m}{n}\right) \quad (8)$$

which is simply the payoff associated to each role weighed by its probability. Imposing the equity constraint (7) we obtain that $V = \frac{\alpha-1}{n} + 1$. As such, the proposer faces the following problem:

$$\max_{s^{\text{prop}}, s^{\text{vote}}, m \in \{1, \dots, n-1\}} \alpha \cdot s^{\text{prop}} \text{ subject to} \quad (9)$$

$$s^{\text{prop}} \in [1/2, 1] \quad (10)$$

$$s^{\text{prop}} \alpha \geq V \quad (11)$$

$$s^{\text{vote}} \in [0, 1/2] \quad (12)$$

$$s^{\text{vote}} \alpha + 1 \geq V \quad (13)$$

$$m \geq \frac{n-1}{2}. \quad (14)$$

The objective function states that the proposer is seeking to maximize his own payoff and must choose a share for himself, a share offered to coalition partners s^{vote} , the number of shares s^{vote} that she will offer (m). Constraints (10) and (12) simply guarantee that the chosen equity scheme $\mathbf{s}$ is in S_1 . Conditions (11) and (14) ensure that the proposal receives at least the required number of votes in favor. The equity constraint (7) specifies that the sum of shares have to be feasible, i.e., less than one from which we obtain that $s^{\text{prop}} = 1 - m \cdot s^{\text{vote}}$. This implies that (14) binds at $m = \frac{n-1}{2}$, namely, that minimum winning coalitions are optimal. To obtain s^{vote} we use constraint (13) which clearly binds as well because if the share was higher the proposer could decrease it and still obtain a favorable vote. Thus, we have $s^{\text{vote}} = \frac{V-1}{\alpha} = \frac{\alpha-1}{\alpha n}$ and $s^{\text{prop}} = 1 - \frac{n-1}{2} \frac{\alpha-1}{\alpha n}$. With simple computations one verifies that (11) and (10) hold. $\square$

Appendix B: Supplementary figures

See Figs. 3, 4, 5 and 6.



Fig. 3 Investments and approved shares in pre-distributive bargaining

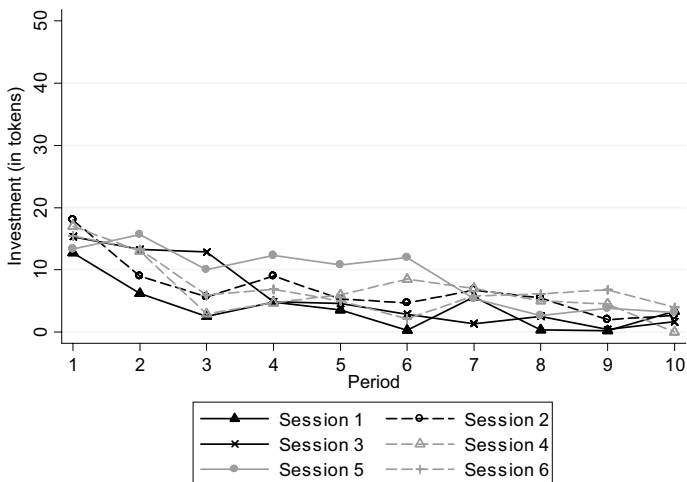


Fig. 4 Average investments in pre-distribution by session

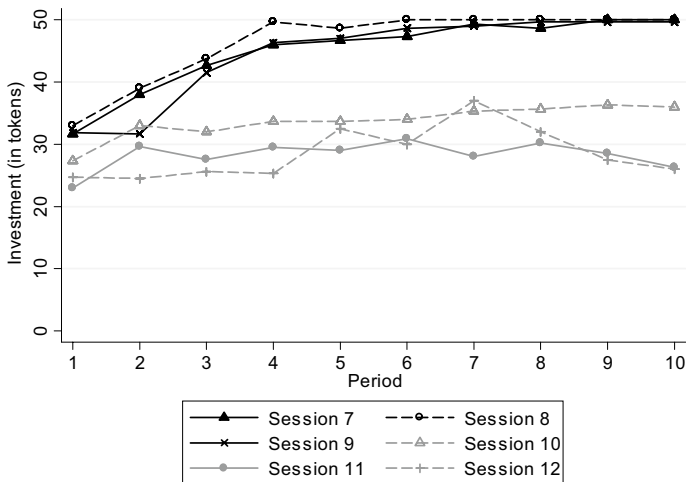


Fig. 5 Average investments in redistribution by session

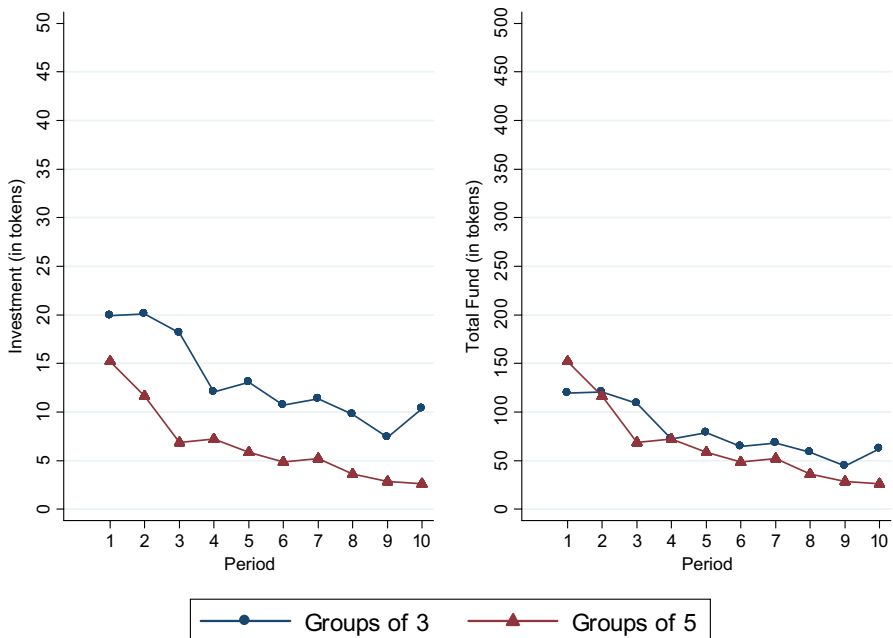


Fig. 6 Average contributions and total fund in pre-distribution by group size

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