Voluntary Contributions and Collective Redistribution

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Abstract

I study a multilateral bargaining game where committee members decide how much to invest in a common project and then proceed to redistribute the total value of production. The game corresponds to a Baron and Ferejohn (1989) legislative bargaining model with an endogenous production stage similar to the voluntary contribution mechanism in which the fund to distribute is determined. In this game, voluntary contributions reach almost full efficiency in a random rematching experimental design. The high contributions are explained by the fact that posterior bargaining outcomes tend to follow an equity standard of proportionality: higher contributors obtain higher shares. Unlike other experiments of the same bargaining game with an exogenously determined amount of money to distribute, allocations involving payments to all members are modal (and not minimal winning coalitions), and proposer power is quite low.

In many productive activities, output is jointly generated by several partners that invest or exert effort in a common project. This paper examines two angles of the same dilemma: How will members redistribute the profits of a joint project and how will redistribution dynamics affect individual investment decisions.

I develop a model in which members of a group must decide how much to contribute into a common project in order to produce a given output, similar to the voluntary contribution mechanism (VCM). Subsequently, committee members proceed to redistribute the output via a multilateral bargaining game of alternating offers modeled after the well-known Baron and Ferejohn (1989; BF henceforth) game. The introduction of a production stage followed by the bargaining game departs from the usual assumption that the funds to be distributed among the members of the committee have appeared *out of nowhere*.[1]

A salient real-world example in which committee members negotiate the distribution of an endogenous common fund can be found in business partnerships such as law firms, medical groups, and architect consortiums among others.[2] In the particular case of law firms, multiple partners bring in clients with new cases while others provide legal analysis for the cases in hand, both equally important tasks from a revenue perspective. How each partner should be compensated has been a question that management consulting firms have been offering to clients with no clear consensus. Interestingly, a survey reports that 65% of American legal firms undergo a profit sharing meeting at the end of the year, which will be the essential characteristic of the setting studied here.[3] In the model studied in this paper, I will abstract from the many factors that may come into play in a partnership, such as repeated interactions, inequality in partners' productivities, complementarities in

[1] This assumption is suitable for legislative bodies or other committees that must decide how to allocate an exogenoulsy given budget.

[2] Partnerships account for 10.8% of business establishments and 21.5% of all establishments' revenues. Data from the economic census of 2007. Can be accessed at http://factfinder2.census.gov/ .

[3] "2002 Global Partner Compensation System Survey" by Edge International. Can be accessed at <http://www.edge.ai/>. Other compensation systems involve a lock-step scheme based on seniority within the firm, yet other firms implement an "eat-what-you-kill" plan in which partners can *sell* a client to another partner thus reducing incentives to hoard cases. See Section 2 in Lang and Gordon (1995) for a description of compensation schemes in partnerships.

production, and seniority levels. Instead, this article focuses on the effect that redistribution of profits via bargaining has on individual contributions and the specific timing of actions: Production followed by profit-sharing decisions.

In the original BF model, members of a committee meet until a division of a common fund is approved by a simple majority. In each bargaining round, one member is randomly selected to propose an allocation after which voting takes place. In case of rejection, the fund is discounted and the process repeats itself until approval. This model of sequential proposals and voting is quite stylized –as would be any model that attempts to structure the negotiation process– however, it provides three clear equilibrium predictions regarding central questions that arise in a multilateral bargaining setting.[4] First, the model predicts that the proposer forms a minimum winning coalition by disbursing funds only to the number of voters required for approval. Second, the proposer receives a larger share of the fund (proposer power), and third, approval takes place in the first round. There is strong evidence from past experimental investigations providing qualitative support for these predictions, studies that will be discussed in the literature review.

The theoretical prediction of the expanded BF model with an initial production stage is that no one should contribute to the common fund. The reason is that the ex ante value of the bargaining subgame (before anyone is selected as the proposer) is equal to the total fund divided by the number of partners. This induces the same payoff structure as the VCM (the equal split) which implies that the expected rate of return of contributing is less than the cost of doing so.

A stylized result of the experimental implementations of the VCM game is that subjects initially overinvest but there is a steady decline toward the Nash equilibrium with repetition in a strangers matching protocol. Taken together, the existing evidence in the BF and the VCM experiments suggests that contributions will deteriorate towards the theoret-

[4] These predictions correspond to the stationary subgame perfect equilibrium which will be the equilibrium refinement used throughout this article. When the discount factor is large enough and there are five or more players, any allocation can be sustained as a subgame perfect equilibrium.

ical prediction when members can bargain over the distribution of the fund. Nonetheless, endogenizing the origin of funds provides a setting suitable for context-specific norms of distributive fairness to emerge as has been reported in previous games of redistribution such as the ultimatum game (Capellen et al. 2007) and the dictator game (Bardsley 2008, Cherry et al. 2002 and List 2007).

In the present experiment, average contributions start close to 40% of subjects' endowments and steadily rise with repetition of the game (subjects are randomly matched with new partners each game). Efficiency increases to nearly 88%[5], where more than 70% of subjects are contributing all of their endowment to the common account in the last game. These investment dynamics are sustained by the fact that low contributors are more likely to be excluded from an allocation, being assigned a zero share or not enough to make a profit, and high contributors are very often rewarded by receiving more than the amount they invested. Bargaining outcomes significantly different from all previous BF experiments in which the fund is exogenous. Allocations are more inclusive, accompanied by lower proposer-kept shares. Evidence from voting regressions reveal that voters are concerned with the distribution of the fund among remaining partners and not only their individual gain, also in contrast with the findings of previous studies.

The previous findings suggest that contribution-based redistribution can sustain high investments. In order to assess the extent to which identifying each partner's contribution matters, I implement the same treatment but with unidentifiable individual investments. This modification impedes players to redistribute proportionally. Here, contributions start at about 60% of endowment but decline at the same rate as in the benchmark VCM treatment.

The paper proceeds as follows. In Section 1 provides a brief overview of the related literature. Section 2 presents a formal model and theoretical predictions. The experimental design is described in Section 3 as well as the predictions for the chosen parameters. Section 4 contains the experimental results for the treatment with full observability: Contribution

[5] Where zero efficiency means no one contributes.

dynamics, redistribution outcomes, fairness measurements, and voting behavior. The focus is on identifying differences with previous BF experiments, in particular, a treatment of Frechette, Kagel, and Morelli (2005a; FKM hereafter) is used as the benchmark of bargaining with an exogenous fund. Section 5 presents the results of the treatment with unidentifiable contributions. Section 6 concludes the paper.

I. Related Literature

The model and experiment lie at the intersection of multiple literatures: Multilateral bargaining, VCM experiments, distributive fairness, social norms, and second party punishment. The topic is also related to employee ownership and profit-sharing as well as group incentives for efficient production. Providing a comprehensive review is well beyond the scope of this study and page limit of any journal, so I will focus on a small selection of studies that are most relevant to mine.[6]

The workhorse of the present model is the BF multilateral bargaining game which has been generalized by Eraslan (2002) and provides four testable equilibrium predictions when restricting attention to stationary strategies. The first is that proposers have a significant share of power, and can keep between one half and two thirds of the total funds depending on the size of the committee and discount factor.[7] Second, minimum winning coalitions form in equilibrium, and third, allocations are approved without delay. Recent experiments show that the first two predictions hold robustly, with the caveat that proposer power is not as large as predicted. FKM present a benchmark treatment in which five subjects have equal probability of recognition and no discounting.[8] They find that minimum winning coalitions form 76% of the time and proposers in those cases keep close to 40% of the total funds.

[6] For a complete survey of public goods and VCM games see Ledyard (1995) and Chaudhuri (2011). For other-regarding preferences see Kagel and Cooper (2013).

[7] When players have different recognition probabilities, as in Eraslan (2002), the proposer's share depends on how much she must disburse to a minimal amount of players required for approval.

[8] Their work will be our source of comparisson for bargaining outcomes with an exogenous fund since their bargaining design is identical to the one here. I restrict attention to the FKM treatment with inexperienced subjects.

Regarding delay in approval, almost 40% of all elections are approved in round two or later.

A fourth equilibrium prediction of the SSPE (proved by Eraslan (2002) in a general setting) is that a member's payoff is non-decreasing in her probability of being recognized as the proposer, however there have been no direct experimental tests for this prediction.[9]

Fairness concerns are a seemingly plausible explanation for the attenuated proposer power commonly observed,[10] yet voting dynamics do not support such hypothesis. Frechette, Kagel, and Lehrer (2003; FKL), FKM, and Frechette, Kagel, and Morelli (2005b) compute regressions testing the probability that a voter accepts or rejects an offer. Their estimations show that only one's own share is significant, which validates the private utility function assumed in the BF setting.

In all the aforementioned experiments, the origin of funds to be allocated is exogenously given by the experimenter. However, other related experiment show that outcomes in redistribution of a fund differ between treatment depending on the origin of the money to be allocated. A study by Cherry et al. (2002) shows that there are differences in behavior in the dictator game when the funds to be distributed are earned as opposed to exogenous: Subjects who earn the money are much less generous than in the benchmark treatment.[11] In a similar vein, and perhaps more closely related to my experiment, Capellen et al. (2007) examine the pluralism of fairness ideals in a dictator game with investment choices that determine the stakes of the game. Their main interest is to identify how differences in individual productivities (how much one's investment adds to the common fund) alter distributive choices. Their analysis suggests that "the majority of participants care about the investment made

[9] Frechette, Kagel, and Morelli (2005b) provide a treatment in which members have different recognition probabilities. Nonetheless, their choice of parameters is such that the continuation value of the game is the same for each player regardless of her recognition probability. Moreover, their treatment with unequal recognition probabilities presents another variation: Members have different nominal bargaining power (number of votes). The authors report that experienced subjects offer coalition membership to the player with lower recognition probability more often than to the player with higher recognition probability, consistent with equilibrium mixing predictions (conclusion 6, pg. 1509).

[10] Montero (2010) incorporates inequity aversion in the legislative bargaining game by introducing players with Fehr-Schmidt preferences. Paradoxically, the theory predicts even more proposer power (more inequity). The same result holds when players have Bolton-Ockenfels preferences.

[11] See List (2007) and Bardsley (2008) for other variations of the dictator game with earned income.

by the opponent when they decide how much to offer" (pg. 823 Capellen et al. 2007).[12]

The literature on VCM experimental tests is vast, reason for which I will focus on the most pertinent papers, specifically those that analyze punishment and reward as a contribution-enhancing mechanism.[13] Fehr and Gächter (2000 and 2002) investigate whether or not subjects will incur a private cost to generate a pecuniary loss to other subjects with whom they have been matched to play the VCM game. The punishing member does not get any monetary benefit, thus, by design any punishment is economically inefficient. Fehr and Gächter (2002) report that whenever subjects are able to punish others, contributions are higher under both random and partner matching protocols. In total, 74% of punishments are executed by members that contributed above the average and are directed mainly towards those who undercontributed. Undercontributors receive more punishment points the further away their contribution is from the group's mean.[14] In a repeated interaction treatment (partner matching), Sefton et al. (2007) show that the presence of both reward and punishment possibilities increases cooperation over treatments with reward or punishment alone. Again, net reward is lowest (negative) the further away a member is from the group's mean contribution, further confirming the results in Fehr and Gächter (2000). Notice that a bargaining stage following contributions can serve as a mechanism to punish or reward without explicitly asking subjects to do so or compromising efficiency as in the studies just mentioned.[15]

[12] Since transfers in the dictator game are quite common, the main finding in Capellen et al. (2007) is not that dictators are giving, but that the amounts transferred are usually conditioned on investments.

[13] A study with exogenous group formation by Gunnthorsdottir et al. (2007) shows that sorting subjects into groups according to previous contribution rates slows down the rate of investment decay among cooperators. Various experiments have shown that endogenous partner selection mechanisms (prior to contributions) helps sustain high contributions (or slow down decay in contributions) among cooperators, see Corricelli et al. (2003), and Charness and Yang (2010).

[14] Hermann et al. (2008) have shown that punishment and cooperation patterns vary accross cultures.Their results provide evidence that supports the hypothesis that "punishment opportunities are socially beneficial only if complemented by strong social norms of cooperation" (pg. 1362).

[15] If experimenter-induced effects are present in my setting, they are certainly lower than in treatments in which subjects proceed to a "point deduction" stage.

II. Theory and Equilibrium Predictions

A. The Model

The game consists of two main stages: a contribution stage which takes place at $t = 0$ and a redistribution stage via multilateral bargaining that takes place in stages $t = 1, 2, ...$ Each stage of bargaining is composed of proposal and voting substages. The t subscript is used to denote a stage and the superscript i denotes a particular player $i \in \{1, ..., n\}$ where n is odd.

In stage 0, each player is endowed with $E > 0$ tokens and chooses a contribution level $c_i \in [0, E]$. The individual contribution is scaled up by $\alpha \in (1, n)$ and added to the group's fund.[16] Initially, the fund contains $e \geq 0$ tokens[17]; hence, the total fund to distribute after contributions is given by $F(\mathbf{c}) = e + \alpha \sum_{i=1}^{n} c^i$. For notation purposes, we let $\mathbf{c} = (c^1, ..., c^n) \in [0, E]^n$ (as usual boldface letters will denote vectors).

The redistribution stage is an implementation of the BF model of legislative bargaining which proceeds as follows. First, a member denoted by j is randomly recognized as the proposer. Each member i has probability π_i of being recognized. We let $\boldsymbol{\pi}$ denote the vector of recognition probabilities. Player j submits a proposal denoted by $\mathbf{s}_t^j := (s_t^{j(1)}, ..., s_t^{j(n)})$ where $s_t^{j(i)}$ is the share that player j assigns to player i. The set of admissible proposals at time t is given by $\mathbf{S}_t = \{\mathbf{s} \in \mathbb{R}_+^n : \sum_{i=1}^{n} s_t^{j(i)} = \delta^{t-1} F(\mathbf{c})\}$ where $\delta \in [0, 1]$ is the discount factor. Each allocation must exhaust the current fund. From now on I drop the superscript j and simply refer to the proposal on the floor.

After observing the proposal on the floor in period t, each member casts a vote $v_t^i \in \{$Yes, No$\}$. A history in period $t > 1$ is denoted by h_t and includes the vector of contributions, the list of previous proposers and proposals on the floor as well as the respective distribution of votes. It is clear that in the first round of bargaining $h_1 = \mathbf{c}$ and the in period 0 we define

[16] Bounds on α are determined to rule out full contributions.

[17] The intial fund was added to the model because I was worried that in the experiments some groups would not contribute and I still wanted for a bargaining game to take place. The initial fund does not affect the theoretical predictions.

$h_0 := \emptyset$.

A player's strategy in period t is defined by $\sigma_t^j(h_t) \in \mathbf{S}_t$ if she is the proposer and $\sigma_t^i(h_t, s_t) \in v_t$ when she is not. I make the usual assumption that a voter will cast a favorable vote whenever indifferent between the offer in hand and her outside option. The payoff received by a player is linear in money; for a given contribution vector $\mathbf{c}$ and an approved proposal $\mathbf{s}$, player i's utility is given by $u^i(\mathbf{c}, \mathbf{s}) = E - c^i + s^i$. The payoff to never approving an allocation is 0. Bargaining takes place according to the closed-amendment rule[18] and the game ends whenever a proposal receives q or more votes where $q < n$.

Finally, we denote by Γ the game in which every member has equal probability of recognition ($\forall i : \pi_i = 1/n$).[19]

B. Equilibrium Analysis

The standard BF game admits any allocation of the fund as a subgame perfect equilibrium outcome reason for which I will first present an extension of this result to the game with initial contributions. Then I will focus on stationary subgame perfect equilibria (SSPE), since this refinement is commonplace in the sequential bargaining literature (see BF (1989), Eraslan (2002), Yildirim (2007, 2010), and Merlo and Wilson (1995)). By focusing on history-independent strategies, the set of equilibria is reduced and a unique payoff vector arises which makes the concept appealing from a theoretical standpoint.[20]

[18] The closed-ammendment rule refers to the fact that proposals on the floor are voted as submitted. Alternatively, the open rule allows for the next proposer to either second the current proposal, case in which voting takes place, or ammend the proposal by providing an alternative allocation. For a discussion on this issue see BF (1989).

[19] In the online appendix we consider the game Γ^P in which $\pi_i = \frac{c_i}{\sum_{j=1}^{5} c_j}$ whenever at least one members contributes and $\pi_i = 1/n$ when no one contributes.

[20] Another argument in support of the SSPE provided by Baron and Kalai (2013) and Yildirim (2007) is that this equilibrium entails the least complexity for agents. Computing continuation values is a hard task, it entails solving a complex system of equations, and even more, formulating the problem properly. Baron and Kalai (2013) explain the difficulty of defining "simplicity" and "complexity" but provide various reasons to qualify the SSPE as the simplest equilibrium. Strategies played in the current experiment do not resemble the SSPE predictions

Subgame Perfect Nash Equilibria

Proposition 2 of the Baron Ferejohn (1989) model of multilateral bargaining states that any allocation can be sustained as a subgame perfect equilibrium (SPE) if δ is sufficiently high (which will be assumed in this subsection).[21] This characterization of equilibria relies on an intricate off-equilibrium specification of punishment strategies for deviators. For any allocation on the floor it is possible to formulate a punishment strategy, such that, if the allocation is rejected and the next proposer chooses a different allocation, she is ensured a zero continuation value. Such strategy can be implemented regardless of the magnitude of the common fund and is valid for an arbitrary vector of recognition probabilities.[22] It follows that any allocation following the contribution stage can be sustained as a SPE as enunciated below.

PROPOSITION 1 (BARON AND FEREJOHN 1989) For all $\mathbf{c}$, any allocation $\mathbf{s}$ is a SPE outcome of the subgame of Γ following the contribution stage.

Now that I have characterized the equilibrium in periods $t \geq 1$, I proceed by backward induction to solve for equilibrium contributions.

PROPOSITION 2 Every $(\mathbf{c}, \mathbf{s})$ such that $s^i \geq c^i$ for all i is a SPE outcome of Γ under the following strategy: (1) Player i contributes c^i (2) Proposers assign $s^i \geq c^i$ to each player and (3) everyone votes in favor. In case some player j defects to $\hat{c}^j \neq c^j$, the proposer submits $\hat{s}^j = 0$ and $\hat{s}^i = s^i + \hat{c}^j/(n-1)$ for $i \neq j$. If someone deviates in the proposal stage, apply the punishment strategy specified in BF Proposition 2.

Proposition 2 states that as long as a player is guaranteed (in the equilibrium of the subgame) a share greater than or equal to her contribution, then it can be sustained as a SPE. Notice that a contribution vector $\mathbf{c}$ and a proposal $\mathbf{s}$ cannot be part of a SPE whenever

[21] The conditions are that $1 > \delta > \frac{n+2}{2(n-1)}$ and $n \geq 5$.

[22] An interesting feature about the punishment strategy is that it is effective even if the same proposer is recognized in every round. See the proof of Proposition 2 in BF.

there is some player such that $s^i < c^i$ because the player is better off by not contributing. Hence, Proposition 2 defines the set of all SPE outcomes with positive contributions by at least one member.

Stationary Subgame Perfect Equilibria

In order to provide a point of comparison with the current literature and as a benchmark for the experiments developed here, this section will characterize the SSPE of Γ. Notice that with the addition of the investment stage, the definition of SSPE needs to be clarified.

DEFINITION 1 We say that $(\mathbf{c}^*,\sigma^*)$ is an SSPE of Γ if the profile of bargaining strategies are history independent and σ^* depends on $\mathbf{c}$ only through $F(\mathbf{c})$. This is $\sigma_t^*(F(\mathbf{c})) = \sigma^*(F)$ for all $t \geq 1$.

Let $v_i^* := v_i(\sigma^*)$ be the expected proportion of the fund kept by each player according to strategies σ^*. Definition 1 implies that v_i^* does not depend on $\mathbf{c}$. Then, $\mathbf{c}^*$ is the equilibrium contribution vector if for every player it holds that $E - c^{i*} + F(\mathbf{c}^*)v_i^* \geq E - \hat{c}^i + F(\hat{c}^i, \mathbf{c}^{-i*})v_i^*$ for all $\hat{c}_i$.

The restriction in Definition 1 is equivalent to assuming that contributions are a sunk cost, and only affect a player's payoff by augmenting the size of the fund and her wealth holdings.

PROPOSITION 3 The unique SSPE of Γ is as follows: (1) no player contributes ($c^i = 0$), (2) the proposer keeps $(1 - \delta(q-1)/n)e$, and (3) $q - 1$ other members receive a share of $\delta\epsilon/n$.

PROOF. By the proof of Proposition 3 in BF we have that the continuation value of the game for every history h_t is $\delta^{t-1}F/n$, simply the discounted per capita share of the committee's fund. By backward induction, at $t = 0$ the contribution game possesses the same incentive structure as the standard voluntary contribution mechanism since $v_i^* = F/n$, which clearly implies that $c^i = 0$ is optimal. It follows that $F = e$ and the continuation value is offered to $q-1$ other members in order to guarantee approval. The proposer keeps the remaining fund and approval occurs with no delay due to the indifference voting assumption. ■

III. Experimental Design

The main experimental treatment corresponds to the game Γ and is labeled as ECP in all graphs and charts, which stands for "equal cost partnership". The parameter configuration is defined below.

(α)	Contribution Factor:	2
(n)	Committee Size:	5
(q)	Votes Required:	3
(E)	Endowment:	40 ECUs
(e)	Initial Fund:	30 ECUs
(δ)	Discount Factor:	1

In the contribution stage, subjects are asked to enter an amount between 0 and 40 ECUs which is doubled and added to the initial fund. Next, each subject is able to observe the individual contribution of every other member in her committee and asked to enter a redistribution proposal that must exhaust the total fund. A calculator button is provided to expedite arithmetic calculations.

After every member has entered an allocation, everyone (including the proposer) proceeds to a voting screen that displays (1) whose proposal was chosen, (2) each member's contribution, and (3) the amount allocated to each member. In case of rejection, subjects proceed to enter a new allocation. The history of rejected proposals and voting results is displayed in each proposal screen. Notice that the strategy method is implemented in the proposal stage only.

The game is played for ten periods with random rematching, so that subjects are not identifiable between periods of play. One of the approved allocations (10 in total) is randomly selected for payment.[23] The exchange rate is ten experimental currency units (ECUs) per dollar. A show-up fee of $5 dollars was advertised in the recruitment E-mail and paid to each participant.

The instructions were written with neutral language wherever possible in order to avoid priming subjects into thinking of the game as a business partnership, otherwise, collaboration might arise as a demand-induced effect. Examples were provided in order to explain how actions mapped onto outcomes and outcomes onto payments. Subjects were guided through a dry run to familiarize them with the screens in order to diminish experimental confusion. The closing line in the instructions reads: *"What should you do? If we knew the answer to this question we would not need to conduct an experiment"*.[24]

With respect to the VCM benchmark treatment, subjects are told that each token contributed is doubled and the total fund is divided in equal parts. The parameters in the experiment correspond to a marginal per capita return (MPCR) of 0.4 (recall that $MPCR = \alpha/n = 2/5$). A difference between the VCM in this paper and other implementations is that I maintain the existence of an initial fund, so even in the absence of contributions, members will receive a positive share. The instructions, guiding examples, and screen layouts were kept as close as possible to the ECP treatment.

In the online appendix, we present a variant in which a member's probability of being selected as the proposer depends positively on her contribution. We call this treatment "Proportional ECP".[25]

[23] See Azrieli et al. (2014) for an explanation of compensation schemes in experiments and incentive compatibility.

[24] Instructions were kept very close to those in experiments with exogenous funds performed by Kagel and his coauthors in order to control for possible "instruction effects". Instructions can be found in the online appendix.

[25] The PECP game introduces a contest for proposal rights where one's recognition probability is given by $\pi_i = \frac{c_i}{\sum c_j}$ if some contribution is positive and $\pi_i = 1/n$ when no one contributes. Since it was not possible to draw clear theoretical predictions regarding equilibrium contributions, the editor and the referees suggested it should be relegated to the online appendix. In a previous working paper version (available from the author) the experimental analysis pooled the data from both ECP and PECP. Subject behavior was virtually identical in all respects of redistribution, contribution, and voting strategies.

Table 1: Experimental Sessions

Treatment	# Sessions	Subjects per Session	Average Compensation
ECP	4	15	$ 14.6
VCM	1	20	$ 9.8

A total of 80 subjects participated in 5 experimental sessions. Subjects were undergraduate students from The Ohio State University whom had no previous experience in VCM or bargaining games according to our experimental database. Sessions of the ECP treatments lasted on average 70 minutes and mean compensations were close to $14.6 while the VCM session only lasted 35 minutes with an average payment of nearly $10. A single VCM session was conducted because this is just a replication of a very popular game, and by reproducing the previous results we can conclude that our subject pool is not different in this regard.

IV. Experimental Results

In order to clarify the nomenclature that will be used throughout the analysis a few definitions are necessary. A *period* is composed of a contribution stage and a bargaining game. Each bargaining game can in principle have multiple *rounds*. For each round, the experimenter observes a redistribution proposal for every subject, yet subjects only observe the proposal on the floor.

A. Contributions

In each treatment including the benchmark VCM game, the first period's average contribution is around 44% of the total endowment. Rather quickly, contribution levels in the standard VCM decline to an average of 18.9% in the last five periods of play thus replicating a standard result in the literature. In sharp contrast, subjects steadily raise their contributions in the ECP treatment, averaging 84.8% of endowment in the last 5 periods. By the last period of play, 44 out of 60 subjects contribute all their endowment while full contribution

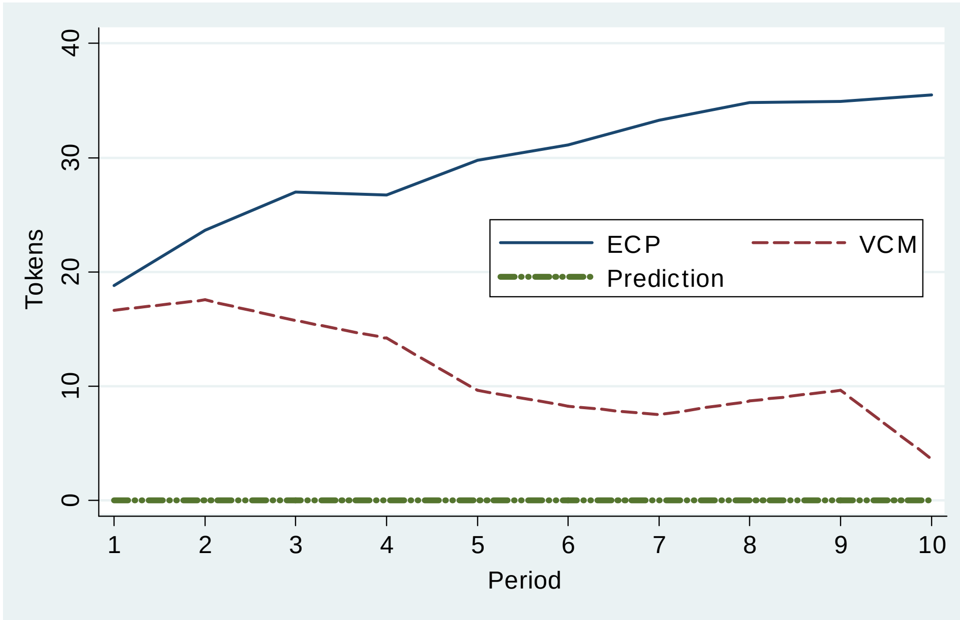

Figure 1: Average Contributions

was never observed in the last VCM game, instead 17 out of 20 of subjects contribute 5 tokens or less. Figure 1 depicts the evolution of the average contribution per period in each treatment.

Interestingly, subjects initially do not internalize the effects of the posterior bargaining stage in their contribution levels as there is no statistical difference between first period contributions.[26] This means that the reason for sustained cooperation is a result of the endogenously evolving expected payoffs.

Conclusion 1 In the ECP treatment, contribution levels rise to 85% of subjects' endowments in the last five periods of play due to the possibility to bargain over the redistribution of the common fund. Meanwhile in the VCM game, contributions steadily decline toward the equilibrium prediction of zero contributions.

The following two subsections are devoted to explain the virtuous cycle reinforcing high contributions that arises throughout the ECP experimental sessions. I start by showing that

[26] We cannot reject the null hypothesis that mean contributions in the ECP and VCM treatment are equal in period 1 (two-sided ttest, p-value=0.53).

Table 2: Bargaining Summary Statistics

	Prediction SSPE	Endogenous Fund (ECP)		Exogenous Fund (FKM)[b]
		Periods 1-5	Periods 6-10	Periods 6-10
Double Zero	100	33.3	36.7	83.4
Single Zero	0	16.7	21.7	3.3
Payments to all	0	50.0	41.7	13.3
Approval				
Round 1	100	63.3	68.3	70.0
Round 2	0	23.3	16.7	10.0
Round $\geq$ 3	0	13.4	15.0	20.0
Proposer Share as % of Fund	60	26.3 (0.0119)	28.7 (0.0102)	37.7 (0.0153)
Two Lowest Shares as % of Fund	0	13.9 (0.0171)	14.8 (0.0206)	3.9 (0.0179)
Fairness Index[a]	0.490	0.203	0.216	0.345

The standard errors of the mean are reported in parentheses.
[a] The fairness index is the Euclidean distance between the allocation resulting from a distribution proportional to each member's contribution and the observed distribution. See the subsection on fairness for a detailed explanation. For the exogenous fund case, the fairness index is the Euclidean distance between the approved proposal and the equal split.
[b] Data for the exogenous fund treatment was obtained from FKM.

the bargaining outcomes do not resemble the SSPE predictions.

B. Overview of Bargaining Outcomes: Rejection of SSPE Predictions

This section presents the bargaining outcomes which unequivocally refute the equilibrium predictions of the SSPE. The analysis on how bargaining outcomes relate to contributions follows. Table 2 provides a summary of the bargaining outcomes. The last column is computed based on data available from the FKM experiment and serves as a point of comparison between endogenous and exogenous fund bargaining outcomes.[27]

In the present experiment, the double-zero strategy[28] accounts for one third of approved

[27] Two sessions with 15 inexperienced subjects each that played a total of 10 games. This treatment is very close to the current experiment: $n = 5$, $\delta = 1$, and $q = 3$ with random rematching. The fund to distribute is $60.

[28] Double-zero allocations are those in which two members receive a zero share, and single-zero are those in which only one member receives a zero share.

allocations, with no significant variation as subjects gain experience in the game.[29]. The single-zero strategy is lower at the beginning, starting at 16.7% and rising to 21.7% in the second half.[30] Although the percentage of allocations disbursing funds to all members falls from 50% to 41.6% we cannot reject the that these proportions are equal (p-value=0.364). With an exogenous fund, 83.4% of allocations follow the double-zero strategy and 13.3% of allocations include payments to every member.

The SSPE predicts that 60% of the fund should stay in the proposer's hands. The average share kept by proposers in the ECP (as a percentage of the total fund) is close to 27.5%, with no significant difference between the first and second half. In the FKM treatment with an exogenous fund, proposers retain 37.7% of the amount to distribute in the last five games, which represents a 34% increase from the ECP.[31]

Evidence from previous bargaining experiments with exogenous funds suggests that delays in approval are also common. In FKM, 30% of proposals are rejected in the first round compared to 31.7% in the ECP, a difference which is not significant (two-sided test, p-value 0.874)

Conclusion 2 When the fund to distribute is endogenous, bargaining outcomes deviate more strongly for the SSPE prediction compared to when the fund is exogenous. Proposers keep 28% of the fund on average compared to 37.7% when the fund is exogenous. Allocations characterized by payments to all members are the modal allocation and not minimum winning coalitions, the latter being the modal allocation when the fund is exogenous. Rates of delay are very similar regardless of the origin of the fund.

In the following subsections I will explain the mechanism behind the virtuous cycle that

[29] We reject the alternative hypothesis that the proportion of MWCs in the the first half is different than the proportion in the second half of the experiment (p-value= 0.705). All p-values in this section correspond to a two-sided t-test.

[30] We cannot reject the null hypothesis of equality (one-sided t-test the p-value=0.491).

[31] The difference in proposer power between treatments diminishes when we focus on MWC allocations, which are much lower in the ECP treatment. In the second half of the experiment, proposers keep 34.8% of the fund in the ECP treatment and 39.9% in the FKM treatment. Nonetheless, proposers still retain a larger share in MWCs of the FKM treatment as we reject the equality of means hypothesis (p-value=0.01, one-sided t-test).

progressively gives rise to efficient contributions by analyzing redistributive dynamics and voting behavior.

C. Returns to Contributions

The trend of increasing contributions can be explained by the incentives that arise from bargaining outcomes, mainly due to the positive relationship between investments and shares received. In almost 80% of cases in which subjects contribute a positive amount, the share retrieved from the fund yields a profit to the investor (share≥contribution). The probability of recovering one's investment is lower for those who contribute below their group's mean (excluding own contribution), facing a 65% chance of recovering their investment compared to 85% for those contributing at or above the group's mean. These results echo the findings of Fehr and Gächter (2000) in which members that contribute below the group's mean in a standard VCM game are more likely to be punished by others.[32] If subjects were to perceive their contributions as a gamble, the high probability of obtaining a positive return already promotes investments which are further reinforced by the fear of exclusion due to undercontribution.

In order to obtain a more nuanced description of redistributive dynamics, a tobit regression is computed to explain the factors that play a role in determining a player's share. In the regression, the share received (in tokens) depends on the amount contributed, whether the subject is a proposer or a voter (proposer is equal to 1 when the subject plays that role), a time trend (period), and pairwise interactions between these variables.[33]

The estimated coefficients of the model are reported in Table 3 and tell a clear story. Higher contributions yield higher shares, evidencing a reciprocity principle of redistribution. Notice that as subjects play the game, each additional period requires them to contribute

[32] Above-mean contributors are more likely to be rewarded as observed in a VCM treatment with punishment and reward possibilities (Sefton et al. 2007). See Table 4 in Appendix B.

[33] A similar regression was computed including a variable that measured the size of the total fund excluding the individual's production to control for fund size effects. This new variable was not significant and all the other estimates remained siginificant at the same levels with no relevant changes in coefficient magnitudes.

Table 3: Tobit Regression Estimates

Variable	Coefficient	Std. err.
Constant	10.377***	3.901
Contribution	1.677***	0.122
Proposer [a]	31.758***	8.003
Period	-4.846***	1.721
Proposer*Contribution	-0.746***	0.319
Proposer*Period	4.271***	1.029
Period*Contribution	0.121***	0.044
Pseudo-R^2	0.042	
F Statistic	32515.77	
Num. Obs.	600	

***,**, and * denote significance at the 1%, 5%, and 10% levels respectively. Standard errors are clustered for each period of play. Session dummies are included but not shown and are not significant.

[a] When a player is a proposer this variable takes a value equal to 1.

more than in the previous period in order to obtain an equivalent share (the coefficient on the period of play is negative and its interaction with own contribution is positive). This provides a link between bargaining dynamics and the trend of growing contributions throughout the session. Interestingly, there is no time effect for proposers, as we cannot reject the hypothesis that the sum of the period coefficient and its interaction with the proposer coefficient is zero.[34]

Proposers possess an advantage over voters which is not explained by the amount contributed, yet their contribution still relates positively to the share they are able to keep for themselves. For example, a player that contributes all her endowment (40 tokens) in period 10 is predicted to receive a share of 122 tokens if she was a proposer and 77 tokens if she was a voter. Weighing these payoffs by the probability of playing the proposer and voter roles – 1/5 and 4/5 respectively– the contributor's expected profit is 86 tokens, slightly above doubling her investment of 40 tokens.

A closer look at acceptance rates of proposals provides a better context to understand the magnitude of the proposer dummy coefficient. Higher contributing proposers face better

[34] An F-test yields a p-value of 0.716.

chances approval. In the last five periods, the difference in acceptance rates is quite marked between contribution categories. Only 20% of proposals emanating from low contributors (0-10 tokens) are accepted, gradually increasing to a 71.4% approval rate for the highest contributing proposers (31-40 tokens). This selection effect accounts for the magnitude of the proposer dummy coefficient.

CONCLUSION 3 Contribution-based redistribution creates the incentives for subjects to invest in the common fund, as the more they invest, the higher the shares they receive.

In order to provide a measure of allocative fairness based on contributions, I construct an index that ranks proposals which will be used in the voting regressions. Let $\gamma^i = \frac{c^i}{\sum_{j=1}^{5} c^j}$ represent i's contribution as a proportion of the total contributions in the committee and denote by s^i player i's observed share as a proportion of the total fund.

DEFINITION 2 The *fairness index* (FI) of a proposal $(s^1, ..., s^5)$ is given by

$$\text{FI} := \sqrt[2]{\sum (\gamma^i - s^i)^2} \quad . \tag{1}$$

We say an allocation is *proportional* if $\forall i \in \{1, ...5\}$ we have that $s^i = \gamma^i$.

In simple words, the fairness index is the Euclidean distance between the proposal and the proportional allocation. It should be clear that $FI = 0$ for a proportional allocation and that the higher FI , the less proportional an allocation is.

For the case of an exogenous fund, I assume that the $FI = 0$ when every player receives one fifth of the fund, which is equivalent to assuming that everyone produced equal parts of the fund. As expected, the FI is lower in the ECP than in the FKM treatment (see Table 2).

Previous studies in bilateral bargaining (Roth and Malouf (1979), Roth and Murnighan (1982)) show that subjects tend to appeal to self-serving norms of fairness.[35] A

[35] A series of experiments by Al Roth on unstructured bargaining study a situation in which two people

proportional allocation is not as appealing in terms of payoffs to low contributors as it is to high contributors. To investigate if a similar behavior takes place in the current experiment, members are divided into two categories: those contributing at or above 30 tokens (75% of endowment) and the rest. Figure 2 shows the cumulative distribution of the FI for all proposals (recall we used the strategy method in the proposal stage). High contributing members propose more fair allocations compared to members that contribute below 30 tokens. The same result holds when we look at members whose contributions are at or above their group's median.[36,37]

CONCLUSION 4 Higher contributing members propose allocations that follow more closely a fairness standard of proportional redistribution than members contributing less.

D. Voting Behavior

A stylized result in the multilateral bargaining experimental literature is that own payoffs play a central role in determining one's vote, always at the 1% significance level. Furthermore, coefficients measuring the impact of others' shares on a member's voting decision yield non-significant results. Since the BF game at every stage can be thought of as a zero sum game, in the presence of strong preferences for additional money, it must be the case that a voter also prefers strongly for others to have less.

With the introduction of a contribution stage, investments could be implicitly creating

must decide how to split the odds of winning a lottery. Each individual has a prize of different monetary values. Roth and Malouf (1979) find that there are two modal allocations in the bargaining outcomes: Equal probability of winning (50-50 split) or shares yielding equal expected value. Naturally, subjects with a larger prize were the ones promoting the equal probability outcome . Roth and Murningham (1982) study the extent to which common knowledge of payoffs matters for the emergence of different norms of fairness in bargaining outcomes. A detailed discussion of the literature can be found in "Bargaining Phenomena and Bargaining Theory" (Roth 1987).

[36] The FI for members contributing above 75% of endowment is 0.18 while 0.25 for the rest, we reject the null hypothesis that both means are equal (two-sided t-test, p-value≈ 0). For those contributing at or above the groups' median the FI is 0.18 and 0.28 for those contributing below, also significantly different.

[37] In the working paper version of this article, I explored an outcome-based measurement of fairness, namely the Gini coefficient. I find that those who contribute above 30 tokens are more likely to redistribute based on contributions (closer to the proportional allocation) while lower contributors tend to appeal to an equal outcome norm. Supporting tables and graphs are available upon request.

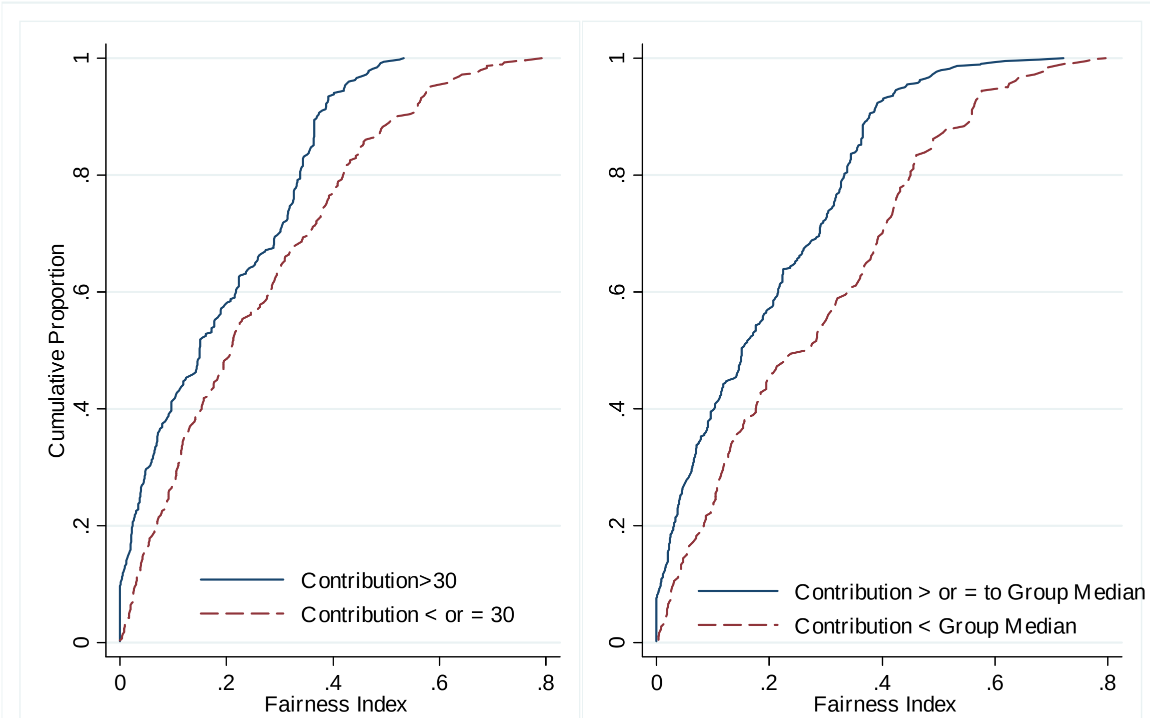

Figure 2: Cumulative Distribution of the Fairness Index by Contribution Level for all Proposals

Table 4: Random Effects Voting Probits

	All Periods		Last 5 Periods	
Variable	**All Voters**	**Included Voters** [b]	**All Voters**	**Included Voters** [b]
Voter Surplus (VS)	7.485***	5.582***	8.333***	5.302*
	(0.846)	(1.136)	(1.529)	(3.175)
Proposer Surplus (PS)	-1.554**	-1.804**	-1.487	-3.751**
	(0.720)	(0.790)	(1.137)	(1.574)
FI*VS	13.484***	23.478***	17.056**	76.913***
	(4.450)	(5.754)	(7.925)	(18.653)
FI	-3.149***	-4.967***	-4.666***	-14.575***
	(0.788)	(1.037)	(1.306)	(3.079)
Constant	-0.458*	-0.019	-0.314	0.758
	(0.251)	(0.290)	(0.386)	(0.584)
ρ [a]	0.215***	0.228***	0.306***	0.388***
Observations	793	598	379	268

***,**, and * denote significance at 1%, 5%, and 10% levels respectively. See text for a detailed explanation of the variables.

[a] $\rho = \frac{\sigma_\alpha^2}{\sigma_\alpha^2+1}$ where σ_α^2 is the variance of subject specific random effects. When $\rho = 1$ all the variance in acceptance likelihood can be explained by individual subject effects. When $\rho = 0$ there are no individual subject effects. A likelihood ratio test is used to determine statistical significance.

[b] An included voter is one whose share is greater than or equal to his contribution.

a sense of property rights over the common fund which would have an impact on voters' preferences over money and the overall distribution of the fund. In this section I report the results of a voting probit. Explicitly, the model that will be estimated is given by

$$\text{vote}_{it} = I\{\beta_0 + \beta VS_{it} + \beta_2 PS_{it} + \beta_3 FI_{it} + \beta_4 VS_{it} \times FI_{it} + \sum_{k=1}^{3} \beta_{4+k} S_k + \alpha_i + v_{it}\}, \quad (2)$$

where $I\{\cdot\}$ denotes the indicator function taking the value 1 when its argument is greater than or equal to 0 and takes the value 0 otherwise. As a normalized measure of personal gain, we include the voter's return net of contribution as a proportion of the fund ($VS_{it} = (s_{it} - c_{it})/Fund_{it}$). A similar normalized measure of gain is included for the proposer to account for how much the agenda setter is benefitting from the allocation (PS_{it}). The modified fairness index, in which one's direct impact and the proposer's impact are excluded (FI_{it}), accounts for redistributive fairness toward the rest of the members.[38] Since fairness concerns can be at odds with personal gain incentives, we introduce the interaction variable $VS_{it} \times FI_{it}$. The terms α_i and v_{it} denote the subject-specific and idiosyncratic errors respectively. We also include dummies to control for possible session effects.[39]

Table 4 presents the estimation results for equation (2).[40] The first column contains the estimated coefficients based on the full sample (except proposers) while the second column includes only voters who receive a share greater than or equal to own contribution. Members rarely vote in favor of an allocation in which they are at a loss after contributing[41], so that the estimates in the first column could be inflating the magnitude of the voter´s share coefficient.

The probability of casting a favorable vote increases as a member receives a larger benefit net of their contribution ($\hat{\beta}_1 > 0$), reaffirming previous results in which individual gain is a

[38]In the regression we have that FI:= $\sqrt[2]{\sum_{j\in\{1,\ldots5\}\setminus\{\text{Proposer, } i\}}(\gamma^j - s^j)^2}$.

[39]$S_k = 1$ in session k and 0 otherwise, session 4 is the omitted variable. We find no evidence of session effects explaining voting behavior. Omitting them does not change the results presented in this section.

[40]The same variables were regressed using a standard probit model, clustering standard errors at the subject level. There are no changes in the sign of the coefficients, but several coefficients lose statistical significance. The regression results are presented in Table 6 (see Appendix B).

[41]This happens only in 6 out of 195 cases where $c > share$.

key determinant of voters' decisions. However, voters do care about the distribution of the fund to remaining partners. The probability of voting in favor of an allocation falls as the proposer's net benefit increases ($\hat{\beta}_2 < 0$).

Voters display preferences for equitably distributed funds among the remaining partners. Recall that a smaller FI means that the proposal is closer to the proportional allocation, hence the negative sign of FI coefficient indicates a preference for a proportionally distributed fund. Nonetheless, the impact of the FI diminishes as one's benefit of contributing becomes larger, which highlights the existence of a utility trade-off between individual gain and equitable redistribution.

Conclusion 5 In the presence of an endogenous fund, personal gain is not the only determinant of voting decisions. The probability of casting a favorable vote decreases as the proposer's gain increases. Holding one's gain constant, voters are more likely to reject inequitable allocations, but this effect is smaller as the voter's individual gain increases.

In order to further verify the robustness of the results, the same model as in equation (2) is estimated with a different measure of personal gain. Instead of VS, I consider $\widetilde{VS}_{it} = s_{it}/Fund_{it} - c_{it}/\sum_{j \in \text{Group}} c_{jt}$ and the same modification for $\widetilde{PS}_{it}$. This measures how close the share specified in the allocation is to the share that should be kept under the proportional equity standard. All the estimated coefficients are in the same direction as those presented in Table 4, with some changes in significance. See Table 5 in Appendix B for these results.

E. The Effect of Identifiability of Others' Contributions

The essential characteristic of the bargaining outcomes reported thus far is that shares are redistributed, on average, according to each partner's contribution and this incentivizes highly efficient contribution levels. To further substantiate this, I conducted a treatment in which the possibility to assign shares to each member based on his or her contribution was eliminated. Subjects were aware of the contributions of others but they do not know how

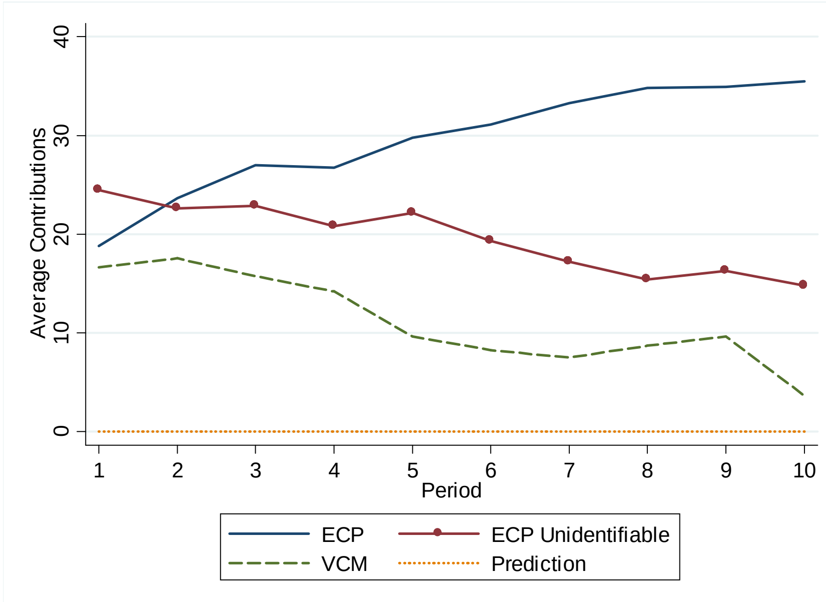

Figure 3: Mean Contributions by Period.

much each individual member invested as contributions did not have an ID.[42] The treatment is labeled ECP-U where U stands for unidentifiable contributions.

Figure 3 shows that average contributions are falling over time, the mean being 22.5 tokens in the first half and 16.6 in the second half. The rate at which mean contributions unravel is not significantly different between the VCM and ECP-U treatments.[43]

Table 8 (in Appendix B) reports the summary statistics of bargaining outcomes for the ECP-U treatment. The mean proposer share (28% of the fund) in the ECP-U is virtually identical to that of the ECP treatment (we cannot reject equality of means p-value=0.996, two-sided t-test) and substantially lower compared to the case of an exogenous fund. Furthermore, the proportion of MWCs and payments-to-all allocations is quite similar in both ECP treatments.

However, the aforementioned similarities in allocations between ECP and ECP-U are not

[42] Only after an allocation was approved, it became known how much each member contributed. In total 2 sessions were conducted with 15 subjects each. Subjects had no previous experience in bargaining or VCM games and were exposed to only one treatment. Instructions were explicit about the fact that individual contributors were not identifiable.

[43] I compute the OLS regression $c_i = \beta_0 + \beta_1 \times Period + \beta_2 ECPU + \beta_4 ECPU \times Period + \epsilon$. The coefficient on $ECPU \times Period$ is not significant (p-value=0.473). All the others are significat at the 1% level.

enough to stop contributions from falling. The impossibility to condition shares on investments as evidenced by the increased fairness index (reduced proportionality) in the ECP-U treatment, confirms the hypothesis that contribution-based redistribution is the force driving efficiency gains in the ECP treatment. The same econometric model used to explain growing contributions in the ECP (see Table 3) was computed for unidentifiable contributions, yielding mainly non-significant results,[44] meaning that higher contributions did not give rise to higher shares.[45]

CONCLUSION 6 Without the possibility to identify partners' investments, contributions unravel over time. There is no virtuous cycle in which higher contributions are rewarded with higher shares as in the case of identifiable investments.

V. Conclusion

This article investigated the contribution and redistribution dynamics of a common fund in a committee that must bargain according to the Baron and Ferejohn (1989) closed-rule protocol. There is a clear departure from the stationary subgame perfect equilibrium predictions and previously observed laboratory results: Allocations are far more inclusive with minimum winning coalitions no longer being the modal proposal. The proposer's average share is also substantially lower. Reciprocity-based redistribution emerges due to identifiability of each member's contributions. In this sense, sunk investments matter to bargainers by creating a contextual cue for how to redistribute the common fund. Free-riding incentives diminish, giving rise to enhanced contribution levels, close to full efficiency. Voting strategies largely support these outcomes, as contributors are concerned with the distribution of funds among the other partners and in stopping proposers from keeping too much.

[44] Only the constant term and the coefficient for contribution interacted with the proposer role dummy (positive) appeared to be significant at a 5% level.

[45] As one referee pointed out, it is not too bold to conjecture that if only the fund to distribute after was displayed in subjects' screens (and not the contribution vector) contribution levels would be closer to those observed in the benchmark VCM.

An observed behavioral regularity is that low contributors propose allocations that yield lower outcome inequality. On the other hand, higher contributing members are more likely to allocate shares proportional to each players' contributions. In our context, we have enough evidence to believe that subjects abide by the most convenient norm of fairness, since redistributing proportionally favors high contributors and redistributing based on outcome equality would favor low contributors.

The essential characteristic of the model of voluntary contributions and collective redistribution that can be observed in real-world phenomena is that production occurs prior to profit-sharing decisions. Many organizations use a similar process in order to distribute –at least– a portion of their profits. Medical groups, accountant firms, architectural consortiums, and law firms, among others, have been reported to implement end of year profit distribution meetings. Partners invest personal funds and exert effort into common projects even when strategic incentives may prescribe another course of action if revenue shares are not preestablished. The results of the main treatment provide a basis to understand why such compensation systems work in practice. A key aspect from which we have abstracted is that business partnerships represent ongoing relationships. A treatment with repeated interactions (partner matching in the ECP) would very likely result in equal or higher contributions.

Another interpretation of the results is related to contract theory and incentive provision. The typical structure assumes that a principal must design a compensation scheme that induces agents to undertake actions that yield an efficient output. This scheme should be enforceable and contracted upon the parties prior to agents making their investments or exerting effort. I find that, even in the absence of a central authority and a preestablished effort-inducing contract, a group of individuals can achieve close to the maximum productive efficiency by bargaining *a posteriori* over the shares of production.

A relevant experimental extension is to take into account the fact that many large partnerships have compensation subcommittees. The present findings would suggest that the compensation task should be in the hands of a committee composed of the highest contributing partners, however a specific experiment to test this normative statement is needed.[46] Another key implication is that measures of partners' contributions to the common project should be publicly available to all partners as this would induce a more fair redistributive outcome, a a commonplace practice in large legal partnerships. However, this becomes more difficult with the specialization of labor skills and production technologies with multiple inputs.

One could think of other generalizations that may impact the contribution and redistribution process. For example, partners could have different endowments or productivity levels. In this case, the concept of *fair share* becomes less obvious (Capellen et al. 2007). It could be that in the presence of such asymmetries, contributions would be lower due to perceived unfairness in the allocation of the fund. A second direction is to consider synergies between partners since complementarities in production are an essential component of business partnerships and the integration of labor processes.

[46] See Hamman et al. (2011) for a VCM experiment with an endogenous election of dictator/allocator that chooses the contribution and the redistribution vector.

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Appendix A: Proof of Proposition 1

By Lemma 1 both allocations s and $\hat{s}$ can be sustained as a SPE. Under such redistributive strategies, it is clear that contributing is individually rational. To show that a player k deviating from c^k is strictly worse off (weakly when $c^k = s^k = 0$), notice that $u(c^{(-k)}, c^k, \mathbf{s}) = E - c^k + s^k > E - \hat{c}^k = u(c^{(-k)}, \hat{c}^k, \hat{\mathbf{s}})$.

Appendix B

Table 5: Random Effects Voting Probits

	All Periods		Last 5 Periods	
Variable	**All Voters**	**Included Voters** [a]	**All Voters**	**Included Voters** [a]
VS	7.741***	5.441***	8.424***	5.162
	(0.876)	(1.154)	(1.575)	(3.210)
PS	-0.824	-0.535	-0.903	-1.909
	(0.596)	(0.649)	(0.970)	(1.241)
FI	-2.108***	-2.569***	-2.674***	-4.856***
	(0.440)	(0.504)	(0.734)	(1.144)
FI*VS	4.864	11.772***	8.601	50.329***
	(3.520)	(4.549)	(6.603)	(15.351)
Constant	0.537**	0.675***	0.730*	1.397***
	(0.242)	(0.259)	(0.379)	(0.493)
ρ [c]	0.212	0.228	0.309	0.457
Observations	793	598	379	268

***,**, and * denote significance at 1%, 5%, and 10% levels.
[a] An included voter is one who receives a share greater than or equal to her contribution.
[c] A likelihood ratio test is used to determine statistical significance.

Table 6: Voting Probits without Random Effects

	All Periods		Last 5 Periods	
Variable	**All Voters**	**Included Voters** [a]	**All Voters**	**Included Voters** [a]
VS	6.828***	5.246	7.154***	3.515
	(2.184)	(3.446)	(1.249)	(2.394)
PS	-1.111	-1.199	-0.791	-1.892
	(0.684)	(0.820)	(1.083)	(1.518)
FI*VS	11.561	19.798	14.886	61.070***
	(9.330)	(13.662)	(9.805)	(15.406)
FI	-3.297***	-4.774**	-4.336***	-11.870***
	(1.138)	(1.903)	(1.569)	(2.414)
Constant	-0.372	-0.031	-0.264	0.643
	(0.283)	(0.469)	(0.345)	(0.458)
Observations	793	598	379	268

***,**, and * denote significance at 1%, 5%, and 10% levels. Standard errors clustered at the subject level.
[a] An included voter is one who receives a share greater than or equal to her contribution.

Table 7: Earnings by Contribution and Period in the Treatments with Unidentifiable Contributions (ECP-U)

	Equal Recognition Treatment Tokens Contributed			
Period	**0-10**	**11-20**	**21-30**	**31-40**
1-2	81.38 (19.1)	73.2 (18.8)	67.2 (12.3)	57.7 (21.7)
3-4	90.8 (31.3)	56.9 (33.7)	62.1 (37.9)	65.2 (51.3)
5-6	78.2 (27.7)	61.7 (38.3)	75.0 (26.8)	48.9 (28.6)
7-8	73.6 (23.3)	57.7 (20.5)	49.3 (23.5)	45.3 (28.7)
9-10	70.5 (31.6)	62.0 (25.0)	52.5 (28.1)	33.7 (40.3)

Approved allocations only. Standard deviations are reported in parentheses.

Table 8: Summary Statistics of ECP with Unidentifiable Contributions

	Periods 1-5	**Periods 6-10**
Double Zero	36.7	40.0
Single Zero	10.0	16.7
Payments to all	53.3	43.3
Round 1 Approval	63.3	80.0
Round 2 Approval	30.0	10.0
Round $\geq$ 3 Approval	6.7	10.0
Proposer Share as % of Fund	26.4 (0.0127)	28.7 (0.0098)
Two Lowest Shares as % of Fund	20.3 (0.0033)	13.6 (0.0301)
Fairness Index (Mean)	0.332	0.430

The standard errors of the mean are reported in parentheses.

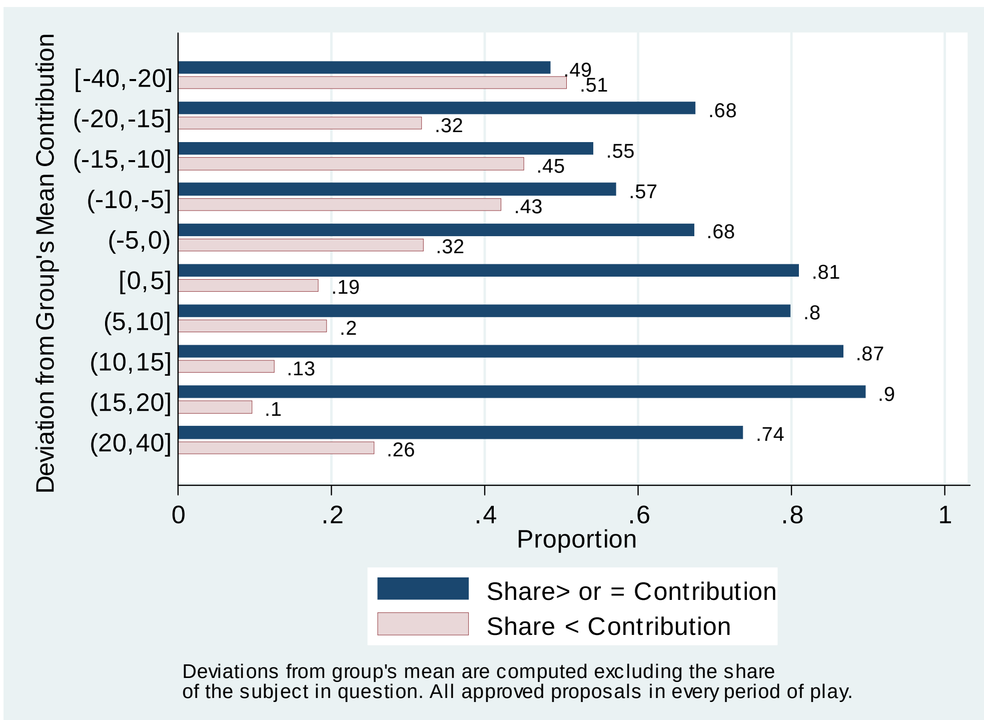

Figure 4: Proportion of Members Retrieving Investments by Deviation of Own Contribution from the Group's Mean Contribution Excluding

Voluntary Contributions and Collective Redistribution

Andrzej Baranski

Online Appendix

A. Treatment with Proportional Recognition

In this section of the appendix I will first present the theoretical analysis of a game with endogenous recognition probability. Second, I will look broadly at contribution and redistribution dynamics in the experiment (labeled PECP for *proportional* ECP), as it will be clear that contributions and redistribution outcomes are strikingly similar to those in the ECP. Then, I will pool the data and show the tables and graphs associated to the analysis in the paper (specifically returns to contributions and voting dynamics). Finally, I look at difference that arise between the ECP-U and PECP-U (PECP with unidentifiable contributions).

A.1 Theoretical Analysis

Consider the contribution and redistribution game Γ with one difference: a player's recognition probability is proportional to her contribution relative the sum of the group members' contributions.[1] Specifically,

$$\pi_i = \left\{ \begin{array}{ccc} c^i / \sum_j c^j & \text{if} & \mathbf{c} \neq \mathbf{0} \\ 1/n & \text{if} & \mathbf{c} = \mathbf{0} \end{array} \right\} . \tag{1}$$

We label this game Γ^{Prop}.

The equilibrium analysis of the game with endogenous proposer recognition presents various challenges due to the dynamics that arise when members of the committee have different probabilities of being recognized. Baron and Ferejohn had pointed out in a three-player example that continuation values can be equal in equilibrium even though recognition probabilities are asymmetric.[2] When a member is "weak" in the sense of having a low π, she is more likely to be included in a winning coalition. This generates an increase in demand for her favorable vote, which translates into a higher demanded share. In equilibrium these two forces balance to determine the continuation value, or *price*, of such player's vote.

Eraslan (2002) shows that for any vector $\boldsymbol{\pi}$ there exists an SSPE of the game Γ^{BF} which implies that every subgame of Γ^{Prop} (following the contribution stage) possesses a stationary equilibrium.[3] Moreover, if multiple equilibria exist for a given $\boldsymbol{\pi}$ all yield the

[1] Yildirim (2007) solves a game with costly but unproductive efforts to propose in a BF setting. The novelty of his model is that he incorporates an effort-exerting stage in which members are part of a Tullock contest; hence each player's effort determines the chance of being selected as the proposer but not the size of the prize.I n Yildirim's (2007) model, efforts have a temporary effect in each round. This means that if a proposal is rejected, members of the committee can compete again for the right to propose. The author provides an extension in which some members have a persistent component in their probability of recognition which is exogenously given. A major difference in our models is that in Yildirim's setting the proposer's recognition probability only depends on the player's current effort and members must exert effort at the beginning of each subsequent bargaining round. In my model, initial contributions determine the recognition probability vector once and for all. Proposition 4 provides a contrasting result with that of Yildirim (2007) since he establishes the existence of a unique SSPE with symmetric and positive efforts to propose while I obtain that no symmetric contribution exists as an SSPE in Γ^P. See Propositions 4 and 5 in Yildirim (2007).

[2] "The two largest parties would thus prefer to form a government with the smallest party. The smallest party would recognize this preference and, to join a government, would require a higher allocation of ministries than would be suggested by the likelihood it would be asked to form a government. If the smallest party were to demand more than one-third, at least one of the other parties would prefer to form a government with other than the smallest. In equilibrium the values thus must be equal" (BF pg. 1194).

[3] Moreover, Eraslan (2002) shows that the payoff vector is unique despite the fact that multiple SSPE configurations can exist

same equilibrium vector of payoffs.

The real complication arises when we consider the ex ante values of Γ^{Prop} as a function of recognition probabilities, which I will denote by v_i for each player i. These values represent the proportion of the fund that a player retains. We know that if $\pi_i > \pi_j$ holds, then in equilibrium it must be that $v_i \geq v_j$.[4] However, this condition only establishes that payoffs are weakly monotonic in π_i and moreover, there is no guarantee that the v_i functions are continuous.

I will show that a small decrease in c_i induces a minor change in π_i, a change small enough such that v_i does not fall. In other words, given a symmetric contribution vector (implying $\pi_i = \pi_j \; \forall i, j$), a member that undercontributes only forgoes the average loss in the total fund ($\alpha\epsilon/n$) which is compensated by the additional amount she keeps (ϵ). The case of $\mathbf{c} = \mathbf{0}$ is not an equilibrium either, because any deviator would become the only proposer, thus retaining the whole fund (or giving a negligible amount to two other voters).

Proposition 1 No symmetric pure strategy contribution vector is part of a SSPE of Γ^P when $q < n$.

Proof. First, consider the case in which every member contributes $\hat{c}$ and denote by $F(\hat{c})$ the size of the common fund. Each individual's expected share of the pie $v_i(\hat{\mathbf{c}}) = \frac{1}{n}$ hence each one's expected payoff (prior to being recognized) is $u = E - \hat{c} + F(\hat{c})/n = E + (\alpha - 1)\hat{c} + e/n$. Now I proceed to look at the payoff associated to a deviation by player 1 (without loss of generality).

Suppose that player 1 chooses a lower contribution level, say $\hat{c} - \epsilon$. Denote by π_1 the probability that player 1 has of being recognized given the contribution vector $(\hat{c} - \epsilon, \hat{\mathbf{c}}_{-1})$ and by v_1 her equilibrium payoff. Notice that all the remaining $n - 1$ members of the committee have the same chance of being selected, denoted by π and hence they also have the same equilibrium payoff v. Clearly $\pi = (1 - \pi_1)/(n - 1)$.

[4] This is only true when both players have the same discount factor which is true in our case. See Corollary 2 in Eraslan (2002).

Now we look at $v_1 < v$ which implies that $\pi_1 \leq \pi$ by Corollary 2 in Eraslan (2002). Clearly, player 1 will always be included in any minimum winning coalition whenever $j > 1$ proposes. The payoff to player 1 is given by $v_1 = \pi_1(1 - \delta(q-1)v) + (1 - \pi_1)\delta v_1$ and after solving we obtain for v_1 in terms of v we obtain that

$$v_1 = \frac{\pi_1(1 - \delta(q-1)v)}{1 - \delta(1 - \pi_1)} \quad . \tag{2}$$

A player $j > 1$ always includes player 1 in the coalition and randomizes over his choices of the remaining players with equal probability. The disbursement amount is given by $(v_1 + (q-2)v)\,\delta$. Whenever player 1 proposes, the probability of j's inclusion is $(q-1)/(n-1)$. Whenever another player proposes (not 1 or j) player j is invited into the coalition with probability $(q-2)/(n-2)$. Putting these facts together we obtain

$$v = \pi(1 - \delta v_1 - \delta(q-2)v) + \delta v \left[\pi_1 \left(\frac{q-1}{n-1}\right) + (n-2)\pi \left(\frac{q-2}{n-2}\right)\right]$$

which can be simplified to

$$v = \frac{\pi(1 - \delta v_1)}{1 - \delta \pi_1 \left(\frac{q-1}{n-1}\right)} \quad . \tag{3}$$

Solving simultaneously for equations (3) and (2) I obtain that

$$v = \frac{\delta\pi_1 + 1 - \delta - \pi_1}{M} \tag{4}$$

$$v_1 = \frac{(n - 1 + \delta - \delta q)\,\pi_1}{M} \tag{5}$$

where $M := n - 1 + \delta\pi_1 n - \delta\pi_1 q - n\delta + \delta$. Comparing (4) and (5) I verify that $v_1 < v$ holds whenever

$$\pi_1 < \frac{1-\delta}{n - \delta q} \quad . \tag{6}$$

Notice that $\frac{1-\delta}{n-\delta q} < \frac{1}{n} \iff q < n$.

In other words, there exists a ϵ small enough, such that if player 1 contributes $\hat{c} -$

ϵ,the induced probability $\pi_1(\hat{c}-\epsilon, \hat{\mathbf{c}}_{-1})$ is greater than $\frac{1-\delta}{n-\delta q}$ and less than $\frac{1}{n}$. This implies by Corollary 2 of Eraslan (2002) that $v_1(\hat{c}-\epsilon, \hat{\mathbf{c}}_{-1}) = v(\hat{c}-\epsilon, \hat{\mathbf{c}}_{-1}) = 1/n$ for ϵ small enough. Corollary 2 in Eraslan (2002) states that payoffs are weakly monotonic in recognition probabilities, hence if the inequality between (4) and (5) is not strict, it must be that both payoffs are equal. This means that when player 1 undercontributes by a small amount, she gets to keep ϵ and forgoes $\alpha\epsilon/n$ resulting in a net gain since we have assumed that $\alpha < n$. ■

In a more recent paper, Yildirim (2010) analyzes the effect of persistent recognition with unproductive efforts to propose but in the particular setting of unanimous voting rules. He finds that a symmetric effort level equilibrium exists and a mirror result holds true for Γ^{Prop}. In particular, full contribution is the unique equilibrium investment when any player has veto power.[5]

A.2 Experimental Results

The treatment with proportional recognition probabilities (PECP) is identical to the ECP in all the parameter choices, the only difference being that subjects may have varying recognition probabilities. In total four sessions were conducted with fifteen subjects each.[6]

Figure 1 shows average contributions throughout the experiment by period. Using session averages for each period of play to perform non-parametric tests (Mann Whitney) confirms that there is no statistical difference in contributions between treatments. The differences for the treatment without identifiability will be adressed later.

Redistribution dynamics are strikingly similar, the only significant difference being that the second half of the PECP treatment exhibits a lower rate of delay compared to the ECP, but this does not entail any significant differences in terms of the distribution of funds in the approved proposal.

To further confirm the similarities between the ECP and PECP in approved allocations, Table 2 shows the frequency of allocations in which n members retrieve their contribution

[5] Proof is available upon request.

[6] None had participated in previous bargaining or VCM, ECP, or other bargaining games.

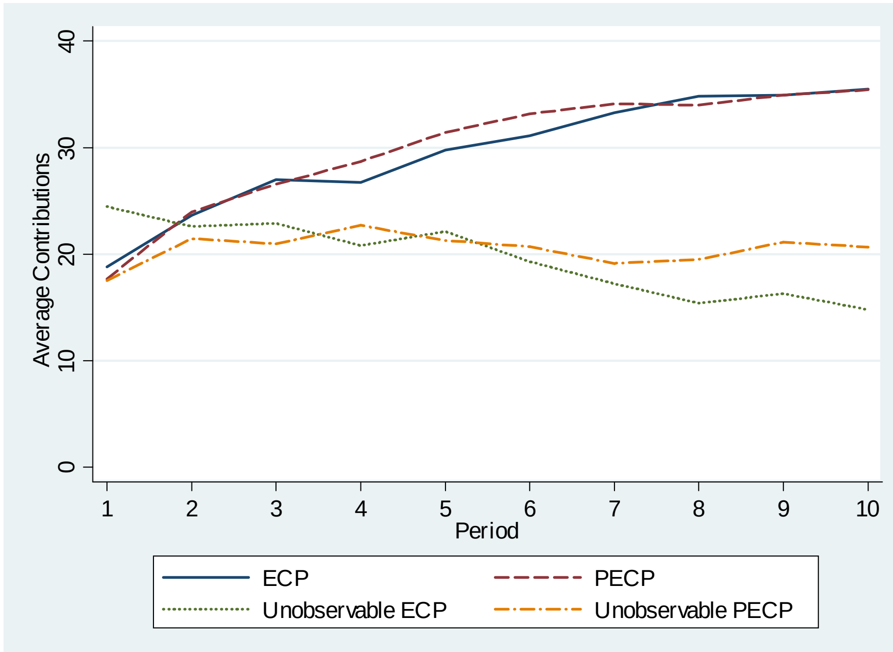

Figure 1: Average Contributions

Table 1: Bargaining Summary Statistics

	Period 1-5		**Period 6-10**	
	ECP	**PECP**	**ECP**	**PECP**
Double Zero	33.3	20.0	36.7	33.3
Single Zero	16.7	16.7	21.7	21.7
Payments to all	50.0	63.3	41.7	45.0
Round 1 Approval	63.3	60.0	68.3	85.0
Round 2 Approval	23.3	16.7	16.7	10.0
Round $\geq$ 3 Approval	13.4	23.3	15.0	5.0
Proposer Share	26.3	28.6	28.7	27.1
as % of Fund	(0.0119)	(0.0106)	(0.0102)	(0.0107)
Two Lowest Shares	13.9	14.8	18.5	15.7
as % of Fund	(0.0171)	(0.0206)	(0.0170)	(0.0200)
Fairness Index (Mean)	0.203	0.197	0.216	0.208

The standard errors of the mean are reported in parentheses.

or production (double contribution).

Table 2: Frequency of Approved Proposals According to the Number of Members that Retrieve or Double their Investments in Games 6-10

	Retrieve Contribution (Share≥Contribution)		**Double Contribution** (Share≥2×Contribution)	
# Of Members	**ECP**	**PECP**	**ECP**	**PECP**
Only 2	0	0	1	1
Only 3	27	28	30	32
Only 4	15	12	18	17
All 5	18	20	11	10

In each treatment there are 60 approved proposals in games 6-10. There are no significant differences between treatments.

The differences between the ECP and PECP treatments that one should expect according to the equilibrium predictions in the bargaining subgames are that (1) members with a high probability of recognition should on average be better off than members with a low probabilities of recognition by obtaining a larger share of the fund and (2) members with a low probability are more often offered a positive share (their continuation value) when not proposing than members with a high probability of recognition.

In order to identify cases in which we could expect differences in behavior regarding who gets offered a positive share, I look at allocations in which one member contributes below 25% of endowment, and the rest contribute above 75%. There are five such committees in each treatment in the second half of the experiment, and only once is the lowest contributor offered a positive share in the PECP treatment and never in the ECP. This reinforces the fact that redistribution is primarily based on contributions and not on strategic considerations regarding the probability of recognition.

For the remaining part of the analysis, I will pool the data in order to present the results about contribution incentives and voting strategies presented in main paper. Table 3 estimates the same tobit model presented in Section C.[7] One can notice that similar results hold.

[7] From this regression we omit the session dummies because we are clustering errors at the period level, incuding them would leave more regressors than clusters.

Table 3: Tobit Regression Estimates Pooled Data from ECP and PECP

Variable	Coefficient	Std. err.
Constant	12.678***	1.351
Contribution	1.598***	0.097
Proposer [a]	22.155***	5.659
Period	-4.196***	0.486
Proposer*Contribution	0.424*	0.233
Proposer*Period	3.794***	0.808
Period*Contribution	0.106***	0.015
Pseudo-R^2	0.039	
F Statistic	2613.1	
Num. Obs.	1200	

***,**, and * denote significance at the 1%, 5%, and 10% levels respectively.
Standard errors are clustered for each period of play.
[a] When a player is a proposer this variable takes a value equal to 1.

Table 4: Random Effects Voting Probits for ECP and PECP

	All Periods		Last 5 Periods	
Variable	**All Voters**	**Included Voters** [b]	**All Voters**	**Included Voters** [b]
VS	7.774***	6.317***	8.577***	4.102*
	(0.727)	(0.988)	(1.238)	(2.312)
PS	-1.498***	-1.742***	-1.268	-2.252*
	(0.545)	(0.589)	(0.949)	(1.168)
FIoth3$_{d}iffx$	18.078***	26.955***	19.217***	56.351***
	(3.732)	(4.791)	(6.041)	(11.570)
FIoth3	-3.464***	-4.938***	-5.034***	-11.167***
	(0.605)	(0.792)	(0.973)	(1.907)
Constant	-0.519**	-0.176	-0.301	0.682
	(0.217)	(0.251)	(0.332)	(0.453)
rho [a]	0.172***	0.190***	0.244***	0.286***
N	1512	1158	673	482

***,**, and * denote significance at 1%, 5%, and 10% levels respectively. Treatment and session dummies (interacted) are not displayed and are not significant in any model.
[a] $\rho = \frac{\sigma_\alpha^2}{\sigma_\alpha^2+1}$ where σ_α^2 is the variances of subject specific random effects. When $\rho = 1$ all the variance in acceptance likelihood can be explained by individual subject effects. When $\rho = 0$ there are no individual subject effects. A likelihood ratio test is used to determine statistical significance.
[b] An included voter is one whose share is greater than or equal to his contribution.

The results of the voting probits are presented in Table 4 and again the analysis presented in the paper holds.

Table 5: Bargaining Summary Statistics in the PECP with Unidentifiable Controbutions

	Periods 1-5	**Periods 6-10**
Double Zero	40.0	46.7
Single Zero	16.7	16.7
Payments to all	43.3	36.6
Round 1 Approval	83.3	66.7
Round 2 Approval	13.3	20.0
Round $\geq$ 3 Approval	3.4	13.3
Proposer Share	28.7	35.8
as % of Fund	(0.098)	(0.023)
Two Lowest Shares	13.5	9.7
as % of Fund	(0.030)	(0.026)
Fairness Index (Mean)	0.430	0.348

The standard errors of the mean are reported in parentheses.

A.3 Unidentifiable Contributions

We label the treatment PECP-U. There are two key differences between the equal and propportional recognition treatments with unidentifiable contributors. First, in the PECP-U contributions stay around the mean and do not unravel throughout the session.[8] Second, the mean proposer's share is larger in the PECP-U (p-value=0.007, two-sided t-test rejecting equality of means).

[8] An OLS regression with contribution as the dependent variable and period as the independent variable yields an insignificant coefficient.