# Voluntary Contributions and Collective Redistribution

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**Abstract**

I study a multilateral bargaining game in which committee members invest in a common project prior to redistributing the total value of production. The game corresponds to a Baron and Ferejohn (1989) legislative bargaining model preceded by a production stage that is similar to a voluntary contribution mechanism. In this game, contributions reach almost full efficiency in a random rematching experimental design. Bargaining outcomes tend to follow an equity standard of proportionality: higher contributors obtain higher shares. Unlike other bargaining experiments with an exogenous fund, allocations involving payments to all members are modal instead of minimum winning coalitions, and proposer power is quite low.

In many productive activities, output is jointly generated by several partners who 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 the redistribution dynamics affect individual investment decisions?

I develop a model in which members of a group must decide how much to contribute to a common project to produce a given output, which is similar to a voluntary contribution mechanism (VCM). Subsequently, committee members proceed to redistribute the output via a multilateral bargaining game of alternating offers that is 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 certain types of business partnerships, including law firms, medical groups, and architects' consortiums, among others.[2] In the particular case of law firms, some partners secure clients with new cases while other partners provide legal analysis for active cases secured by other partners; both are important tasks from a revenue perspective. Management consulting firms sell services to partnerships pursuant to which they calculate each partner's compensation, but no clear consensus on how to do so has yet emerged. Notably, a survey reports that 65% of American law firms hold a profit-sharing meeting at the end of the year, which is the essential characteristic of the setting studied here.[3] I will abstract from the many factors that may come into play in a partnership, such as repeated interactions, inequalities in partners' respective productivities,

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

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

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

complementarities in production, and seniority. I focus on the effect that the redistribution of profits via bargaining has on individual contributions and on the specific timing of actions, i.e., production followed by profit-sharing decisions.

In the original BF model, members of a committee meet to decide upon the division of a common fund, which is approved by a simple majority. In each bargaining round, one member is randomly selected to propose an allocation after which voting takes place. If it is rejected, the fund is discounted and the process repeats itself until an allocation is approved. This model of sequential proposals and voting is quite stylized, as it is in any model that attempts to structure a negotiation process. However, it provides three clear equilibrium predictions regarding the 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 occurs in the first round. There is strong evidence from past experimental investigations that provides qualitative support for these predictions – these studies are discussed below 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 because 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 valuation 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 – with repetition – there is a steady decline toward the Nash equilibrium in a strangers matching protocol. Taken together, the existing evidence from the BF and the VCM experiments suggests that contributions should deteriorate toward the

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

theoretical prediction when members can bargain over the distribution of the fund. Nonetheless, endogenizing the origin of funds provides a suitable setting 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 at close to 40% of subjects' endowments and steadily rise with repetition of the game (subjects are randomly matched with new partners in each game). Efficiency increases to nearly 88%[5], when more than 70% of subjects are contributing all of their endowment to the common account in the last game. Bargaining outcomes are significantly different from all previous BF experiments in which the fund is exogenous. Allocations are more inclusive and are accompanied by lower proposer-kept shares. The steady growth of investments is sustained by the fact that low contributors are more likely to be excluded from an allocation by being assigned a zero share or a share that is not enough to make a profit, and high contributors are very often rewarded by receiving more than the amount that they invested. Evidence from voting regressions reveals that voters are concerned with the distribution of the fund among remaining partners and not only with their individual gain, which also contrasts with the findings from previous studies.

The aforementioned findings suggest that contribution-based redistribution leads to high investments. To assess the extent to which identifying each partner's contribution matters, I implement the same treatment but with unidentifiable individual investments, which prevents players from redistributing proportionally. Here, contributions begin at about 60% of endowment but decline at the same rate as in the benchmark VCM treatment.

The remainder of this paper is organized as follows. Section 1 provides a brief overview of the related literature. Section 2 presents the formal model and the theoretical predictions. The experimental design is described in Section 3, in addition to the predictions for the

[5]Where zero efficiency means that no one is contributing.

chosen parameters. Section 4 contains the experimental results for the treatment with full observability: Contribution dynamics, redistribution outcomes, fairness measurements, and voting behavior. The focus is on identifying the differences between my experiments and previous BF experiments; in particular, a treatment of Frechette, Kagel, and Morelli (2005a; FKM hereafter) is employed as the benchmark of bargaining with an exogenous fund. Section 5 presents the results of the treatment with unidentifiable contributions. Section 6 concludes.

# I. Related Literature

The model and experiment lie at the intersection of multiple streams of the literature, including the multilateral bargaining, VCM experiments, distributive fairness, social norms, and second party punishment streams of the literature. 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 I will thus 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 are able to keep between one half and two thirds of the total funds when there is no discounting (players are perfectly patient), depending on the size of the committee.[7] Second, minimum winning coalitions form in equilibrium. 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 strong as predicted. FKM present a benchmark treatment in which five subjects have equal probability of recognition and there is

[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 minimum amount of players required for approval.

no discounting.[8] FKM find that minimum winning coalitions form 76% of the time and that proposers in those cases keep close to 40% of the total funds. Regarding delay in approval, FKM report that 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] but 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 standard BF setting.[11]

In all the aforementioned experiments, the origin of funds to be allocated is exogenously given by the experimenter. However, other related experiments show that outcomes in the redistribution of a fund differ based on the origin of the money to be allocated. Cherry et al. (2002) show that there are differences in behavior in the dictator game when the funds to be distributed are earned as opposed to exogenously given. Subjects who earn the money are much less generous than in the benchmark treatment.[12] Similarly, and perhaps more closely related to my experiment, Capellen et al. (2007) examine the pluralism of fairness ideals

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

[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 the lower recognition probability more often than to the player with the higher recognition probability, which is 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] For exceptions in which the proposer's share does matter to voters, see the variants of the BF model implemented in Experiment 2 of FKL and the Apex Treatment of FKM.

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

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 (i.e., 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 by the opponent when they decide how much to offer" (pg. 823 Capellen et al. 2007).[13]

The literature on VCM experimental tests is vast, which is why I will focus on the most pertinent papers, specifically those that analyze punishment and reward as a contribution-enhancing mechanism.[14] 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 receive 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 at those who undercontributed. Undercontributors receive more punishment points the further their contribution is from the group mean.[15] In a repeated interaction treatment (partner matching), Sefton et al. (2007) demonstrate 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, which further confirms the results in Fehr and Gächter (2000). Note that a bargaining stage following contributions can serve as a mechanism to punish or reward without explicitly asking subjects to do so and without compromising efficiency, as in the studies

[13] 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.

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

[15] Hermann et al. (2008) have shown that punishment and cooperation patterns vary across 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).

just discussed.[16]

# 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.[17] Initially, the fund contains $e \geq 0$ tokens[18]; 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 game proceeds as follows. First, a member denoted by $j$ is randomly recognized as the proposer. Each member $i$ has probability $\pi_i$ 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,

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

[17] Bounds on $\alpha$ are determined to rule out full contributions.

[18] The initial 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.

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 in period 0 we define $h_0 := \emptyset$.

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 $E - c_i$. Bargaining takes place according to the closed-amendment rule[19] and the game ends whenever a proposal receives $q$ or more votes where $q < n$.

Finally, we denote by $\Gamma$ the game in which every member has equal probability of recognition ($\forall i : \pi_i = 1/n$).[20]

## *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.[21]

[19] 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 amend the proposal by providing an alternative allocation. For a discussion on this issue see BF (1989).

[20] In the online appendix we consider the game $\Gamma^P$ 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.

[21] 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

## 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 $\delta$ is sufficiently high (which will be assumed in this subsection).[22] 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.[23] 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 $\Gamma$ 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 $\Gamma$ 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

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.

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

[23] 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.

SPE. Notice that a contribution vector $\mathbf{c}$ and a proposal $\mathbf{s}$ cannot be part of a SPE whenever 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 $\Gamma$. 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 $\Gamma$ if the profile of bargaining strategies are history independent and $\sigma^*$ 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 $\sigma^*$. 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 $\Gamma$ 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 $\Gamma$ and is labeled as ECP in all graphs and charts, which stands for "equal cost partnership". The parameter configuration is defined below.

| | | |
|---|---|---|
| $(\alpha)$ | Contribution Factor: | 2 |
| $(n)$ | Committee Size: | 5 |
| $(q)$ | Votes Required: | 3 |
| $(E)$ | Endowment: | 40 ECUs |
| $(e)$ | Initial Fund: | 30 ECUs |
| $(\delta)$ | 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.

After every member has entered an allocation, everyone (including the proposer) proceeds to a voting screen that displays whose proposal was chosen, each member's contribution, and 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.[24] 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"*.[25]

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".[26]

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

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

[25]Instructions were kept very close to those in experiments with exogenous funds performed by FKM in order to control for possible "instruction effects". Instructions can be found in the author's webpage.

[26]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 |

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

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 approximately 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, which replicates a standard result in the literature. In sharp contrast, subjects steadily raise their contributions in the ECP treatment, averaging 84.8% of endowment over the last 5 periods. By the last period of play, 44 out of 60 subjects contribute all their endowment, whereas full contribution was never observed in the last VCM game, in which 17 out of 20 of subjects instead contributed 5 tokens or less. Figure 1 depicts the evolution of the average

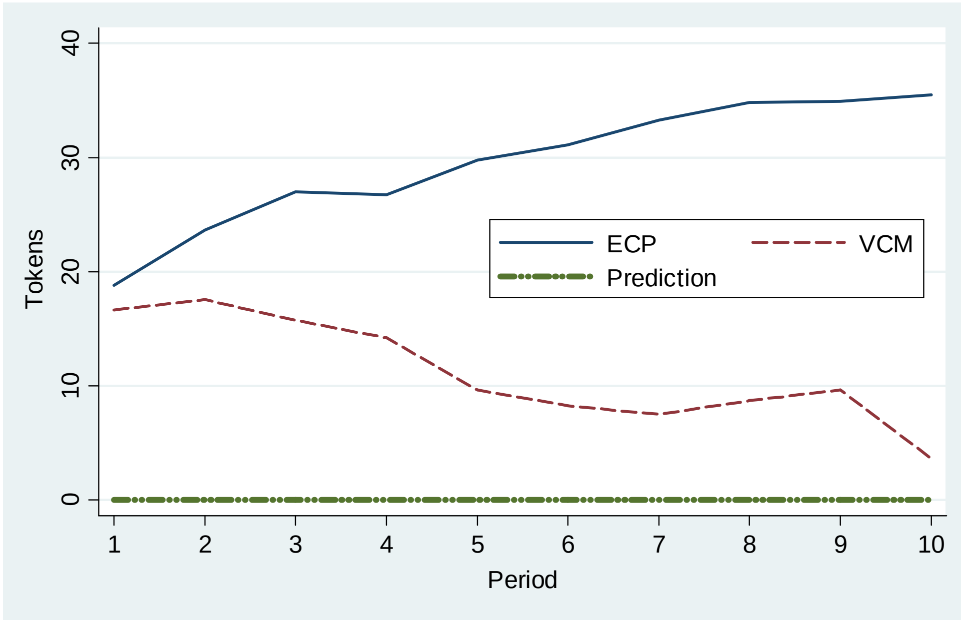


Figure 1: Average Contributions

contribution per period in each treatment.

Notably, subjects' initial perceptions of the posterior bargaining outcomes do not alter contribution levels relative to those in the VCM because there is no statistical difference between first period contributions. We cannot reject the null hypothesis that mean contributions in the ECP and VCM treatments are equal in period 1 (two-sided t-test, $p$-value=0.53), which means that the reason for sustained cooperation is the 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, contributions in the VCM game steadily decline toward the equilibrium prediction of zero contributions.

The following two subsections are devoted to explaining the virtuous cycle that reinforces the high contributions that arise throughout the ECP experimental sessions. I begin by showing that the bargaining outcomes do not resemble the SSPE predictions.

Table 2: Bargaining Summary Statistics

| | Prediction SSPE | Endogenous Fund (ECP) Periods 1-5 | Endogenous Fund (ECP) Periods 6-10 | Exogenous Fund (FKM) 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 that results from a distribution proportional to each member's contribution and the observed distribution. See the subsection on fairness for a detailed explanation. For the case of the exogenous fund, the fairness index is the Euclidean distance between the approved proposal and an equal split.

## *B. Overview of Bargaining Outcomes: Rejection of SSPE Predictions*

This section presents the bargaining outcomes that unequivocally refute the equilibrium predictions of the SSPE. The analysis regarding 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[27] experiment and serves as a point of comparison between endogenous and exogenous fund bargaining outcomes.

In the present experiment, the double-zero strategy[28] accounts for one-third of the approved allocations, and there is no significant variation as subjects gain experience in the game.[29] The single-zero strategy is lower in the beginning, starting at 16.7% and rising to

[27] Two sessions with 15 inexperienced subjects each 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.

[29] We reject the alternative hypothesis that the proportion of MWCs in the first half is different than the proportion in the second half of the experiment (two-sided t-test, $p$-value= 0.705). See the online appendix

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 possibility that these proportions are equal.[31] 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%, and there is 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.[32]

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, which is a difference that is not significant.[33]

Conclusion 2 When the fund to distribute is endogenous and contributions are efficiency enhancing, bargaining outcomes deviate more strongly for the SSPE prediction than when the fund is exogenous. On average, proposers keep 28% of the fund in comparison with 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 is the modal allocation when the fund is exogenous. Rates of delay are similar regardless of the origin of the fund.

Since this article focuses on endogenous funds produced by efficiency-enhancing contributions, we will simply use the dichotomy *endogenous versus exogenous* when comparing results with the previous literature.[34] In the following subsections, I will explain the mech-

(section B) for $p$-values of the statistical tests based on OLS regressions clustering at the subject level. I find no changes in significance.

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

[31] Two-sided t-test, $p$-value=0.364.

[32] 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 because we reject the equality of means hypothesis ($p$-value=0.02, two-sided t-test).

[33] Two-sided test, $p$-value 0.874.

[34] One referee has rightly noted that additional treatments are necessary to fully isolate endogeneity.

anism behind the virtuous cycle that 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 that are 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 the group's mean (excluding own contribution), yielding a 65% chance of recovering their investment compared to 85% for those contributing at or above the mean. These results echo the findings of Fehr and Gächter (2000) in which members that contribute below the group mean in a standard VCM game are more likely to be punished by others.[35] If subjects were to characterize their returns to contributing as a gamble, the high probability of obtaining a positive return already promotes investments that are further reinforced by the fear of exclusion due to undercontribution.

To obtain a more nuanced description of redistributive dynamics, a tobit regression is computed to explain the factors that have 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.[36]

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.

Nonetheless, this is a difficult task because without efficiency gains from contributing, there is no incentive to invest in the common fund unless someone is willing to risk losing her tokens.

[35] 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 Figure 4 in Appendix B.

[36] A similar regression was computed including a variable that measures 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 significant 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.

Note that as subjects play the game, each additional period requires them to contribute more than in the previous period to obtain an equivalent share (the coefficient on the period of play is negative and its interaction with own contribution is positive). This growing contribution provides a link between bargaining dynamics and the trend of growing contributions throughout the session. Notably, 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.[37]

Proposers have an advantage over voters that is not explained by the amount contributed, but 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, which is slightly more than doubling her investment of 40 tokens.

A closer look at acceptance rates of proposals provides a better context to understand

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

the magnitude of the proposer dummy coefficient. Higher contributing proposers have better chances of 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 might help account for a portion of the proposer dummy coefficient.

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

To provide a measure of allocative fairness based on contributions, I construct an index that ranks proposals according to an equity standard based on contributions. This index will later be included 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 use $s^i$ to denote 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

$$\text{FI} := \sqrt[2]{\sum_{i=1}^{5} (\gamma^i - s^i)^2} \quad . \tag{1}$$

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

In other 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 higher $FI$ leads to a less proportional allocation.

For the case of an exogenous fund, I assume that $FI = 0$ 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 Murningham (1982)) show that subjects tend to appeal to self-serving norms of fairness.[38] A proportional allocation is not as appealing in terms of payoffs to low contributors as it is to high contributors. To investigate whether similar behavior occurs 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 that we used the strategy method in the proposal stage). High contributing members propose fairer allocations compared to members that contribute below 30 tokens. The same result holds when we examine members whose contributions are at or above their group's median.[39,40]

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

## D. Voting Behavior

In this section, I report the results of a voting probit. 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. With the introduction of a contribution stage, investments might be implicitly creating a sense of

[38] A series of experiments by Al Roth on unstructured bargaining study a situation in which two people must decide how to split the odds of winning a lottery. Each individual has a prize of different monetary value. 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 those 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).

[39] The FI for members contributing above 75% of endowment is 0.18, while it is 0.25 for the rest, we reject the null hypothesis that both means are equal (two-sided t-test, p-value$\approx$ 0). For those contributing at or above the group median, the FI is 0.18 and 0.28 for those contributing below, which is also significantly different.

[40] 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), whereas lower contributors tend to appeal to an equal outcome norm. Supporting tables and graphs are available upon request.

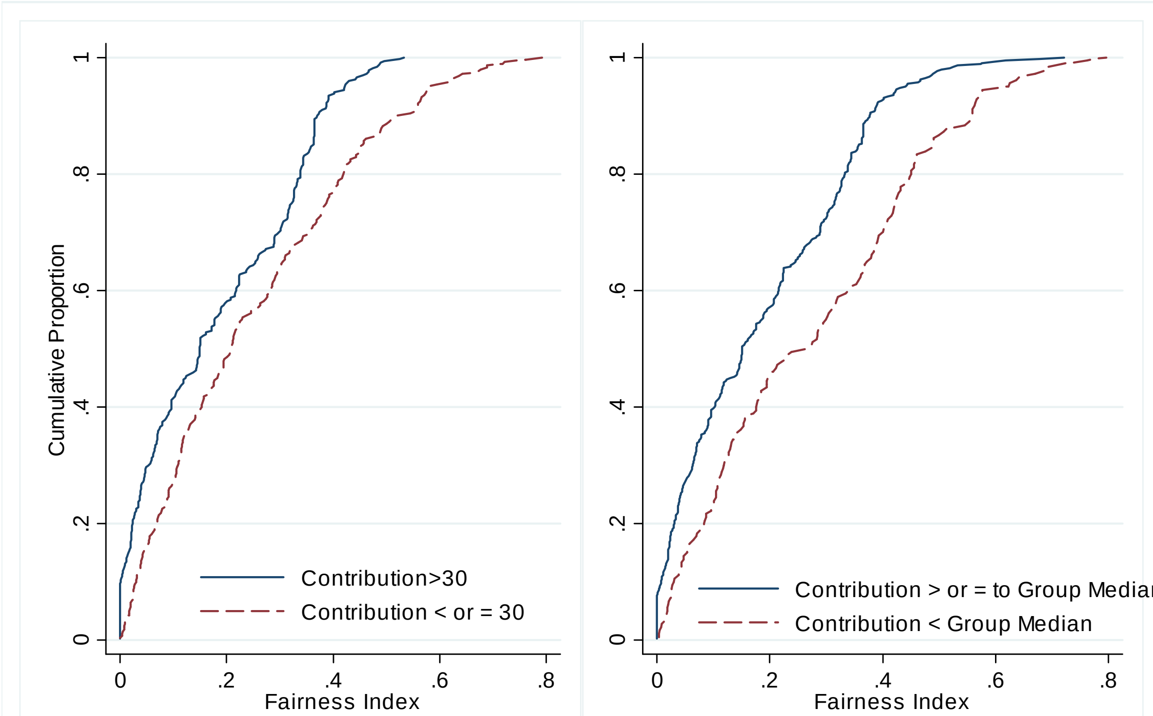


Figure 2: Cumulative Distribution of the Fairness Index by Contribution Level for all Proposals

property rights over the common fund which would have an impact on voters' preferences regarding money and the overall distribution of the fund. Since the BF game can be thought of as a zero sum game at every stage, when there are strong preferences for additional money, it must be the case that a voter also prefers strongly for others to have less. I introduce an interaction between own gain and the fairness index to measure such tradeoff.

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 that takes the value 1 when its argument is greater than or equal to 0 and the value 0 otherwise. As a normalized measure of personal gain, I 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

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) |
| $\rho$ [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 $\sigma_\alpha^2$ 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.

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 with regard to the remaining members.[41] Since fairness concerns can be at odds with personal gain incentives, I introduce the interaction variable $VS_{it} \times FI_{it}$. The terms $\alpha_i$ and $v_{it}$ denote the subject-specific and idiosyncratic errors, respectively.[42]

Table 4 presents the estimation results for equation (2).[43] The first column shows the estimated coefficients based on the full sample (except proposers), whereas the second column includes only voters who receive a share greater than or equal to own contribution.[44]

The probability of casting a favorable vote increases as a member receives a larger benefit net of contribution ($\hat{\beta}_1 > 0$), which reaffirms previous results in which individual gain is a key determinant of voters' decisions. However, voters do care about the distribution of the fund to the remaining partners. The probability of voting in favor of an allocation falls as

[41] In the regression, we have FI:= $\sqrt[2]{\sum_{j\in\{1,\ldots 5\}\setminus\{\text{Proposer},\ i\}} (\gamma^j - s^j)^2}$ .

[42] We also include dummies to control for possible session effects. $S_k = 1$ in session $k$ and 0 otherwise, and 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.

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

[44] Members rarely vote in favor of an allocation in which they are at a loss after contributing. This happens in only 6 out of 195 cases.

the proposer's net benefit increases ($\hat{\beta}_2 < 0$); however, the significance of this result depends on the specification (see Table 5 in Appendix B).

Voters exhibit preferences for equitably distributed funds among the remaining partners ($\hat{\beta}_3 < 0$). Recall that a smaller $FI$ means that the proposal is closer to the proportional allocation; thus, the negative sign of $FI$ coefficient indicates a preference for a proportionally distributed fund. Nonetheless, the impact of $FI$ diminishes as one's benefit of contributing increases, which highlights the existence of a utility trade-off between individual gain and equitable redistribution.

The fairness index does not discriminate among the potential sources of unfairness because offering a large share to a low contributor has the same effect as offering a low share to a high contributor. To examine another potential measure of fairness, I included dummy variables for the number of members receiving a share greater than or equal to their investment, who are henceforth referred to as *included members*. None of the coefficients for these dummies were significant and the statistical significance of the other variables did not change.

To analyze the effect of including an additional member on the proposal's chances of being approved, I compute the probability of a proposal obtaining a majority vote when there are 3, 4, and 5 members included (including the proposer). For this purpose, I focus on partnerships in which members have fully invested their endowment. Furthermore, I assume that the funds are split equally within the coalition of included members.[45] When three members are included, the proposal has a 73.8% chance of being approved. By including an additional member, the odds of approval fall to 70%, which implies that the loss in personal gain dominates the effects of increasing fairness and lowering the proposer's gain. However, when five members are included (an equal split among all partners), the proposal has an 89.5% chance of receiving at least three votes. This increase in the odds of approval is mainly

[45] The calculations are based on the results of the probit specification in column 3 of Table 4, in which the sample is restricted to included voters. We assume that partners receiving a share less than their contribution vote against the proposal and that the proposer always votes in favor of the proposal, requiring only two more votes for approval.

due to the fact that there are more possible combinations of voting decisions resulting in approval of the proposal.[46]

CONCLUSION 5 In the presence of an endogenous fund, personal gain is not the only determinant of voting decisions. 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. There is evidence that suggests that the probability of casting a favorable vote decreases as the proposer's gain increases.

To further verify the robustness of the results, the same model estimated in equation (2) was again estimated but with a different measure of personal gain. Instead of $VS$, I considered $\widetilde{VS}_{it} = s_{it}/Fund_{it} - c_{it}/\sum_{j\in\text{Group}} c_{jt}$ 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 were in the same direction as those presented in Table 4, albeit 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, which incentivizes highly efficient contribution levels. To further substantiate this, I conducted a treatment in which the possibility of assigning shares to each member based on his or her contribution was eliminated. Subjects were aware of the contributions of others in their group, but they did not know how much each individual member invested.[47] The treatment is labeled ECP-U

[46] At the individual level, the probabilities of voting in favor when 3,4, or 5 members are included are 85.9%, 63.7%, 67.3% respectively. Note that a small probability difference at the individual voting level between 4 and 5 members translates into a difference of 19 percentage points in the probability of approval. In all these calculations, we have assumed that the proposer votes in favor.

[47] Only after an allocation was approved did 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 regarding the fact that individual contributors were not identifiable.

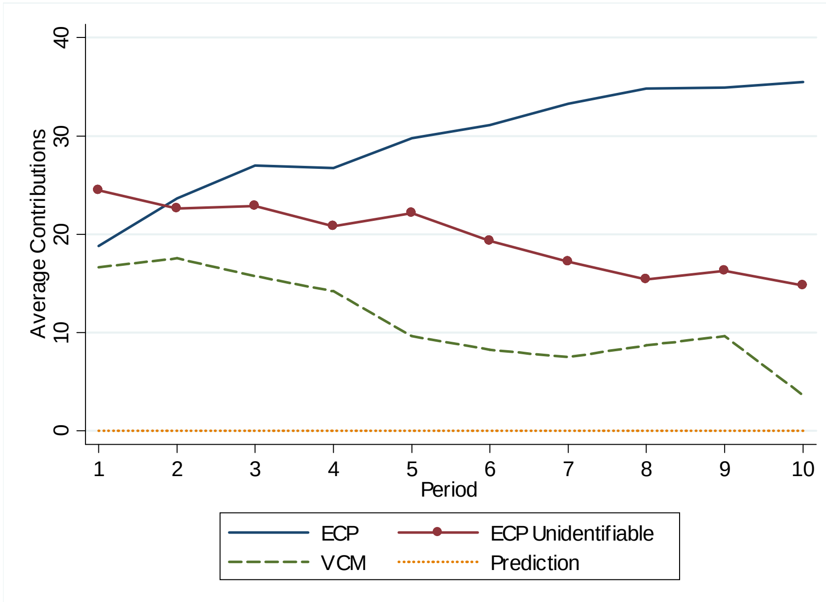


Figure 3: Mean Contributions by Period.

where $U$ stands for unidentifiable contributions.

Figure 3 shows that average contributions drop in amount over time, i.e., the mean is 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.[48]

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 than the case of an exogenous fund. Furthermore, the proportion of MWCs and payments-to-all allocations is quite similar in both ECP treatments.

The aforementioned similarities in allocations between ECP and ECP-U are not sufficient to prevent 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 that is

[48] 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 other coefficients are significant at the 1% level.

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 and yielded mainly non-significant results,[49] indicating that higher contributions did not yield higher shares.[50]

Conclusion 6 Without the possibility of identifying 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 to redistribute the jointly generated fund under 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, and minimum winning coalitions are no longer the modal proposal. The proposer's average share is also substantially lower. Reciprocity-based redistribution emerges due to the 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, which leads to increased contribution levels close to full efficiency. Voting strategies largely support these outcomes, as contributors are concerned with distributing funds among the other partners and in stopping proposers from keeping too much.

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

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

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

to allocate shares in proportion 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, accounting firms, architectural consortiums, and law firms, among others, have been reported to hold end-of-year profit distribution meetings. Partners invest personal funds and exert efforts into common projects even when strategic incentives may prescribe another course of action if revenue shares are not pre-established. 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, and implementing 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 engage in actions that yield an efficient output. This scheme should be enforceable and contracted among the parties prior to agents making their investments or exerting effort. However, even in the absence of a central authority and a pre-established effort-inducing contract, I find that 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 consider that many large partnerships have compensation subcommittees. The present findings would suggest that the compensation task should be in the hands of a committee consisting of the highest contributing partners, however a specific experiment to test this normative statement is required.[51] Another key implication is that measures of partners' contributions to the common project should be publicly available to all partners because it would induce a fairer redistributive outcome, which is a commonplace practice in large legal partnerships. However, this becomes more difficult with the specialization of labor skills and production technologies with multiple inputs.

Other generalizations might be conceived of that may impact the contribution and redistribution process. For example, partners might have different endowments or productivity levels. In this case, the concept of *fair share* becomes less obvious (Capellen et al. 2007). It might 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.

[51] 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) |
| $\rho$ [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<br>(19.1) | 73.2<br>(18.8) | 67.2<br>(12.3) | 57.7<br>(21.7) |
| **3-4** | 90.8<br>(31.3) | 56.9<br>(33.7) | 62.1<br>(37.9) | 65.2<br>(51.3) |
| **5-6** | 78.2<br>(27.7) | 61.7<br>(38.3) | 75.0<br>(26.8) | 48.9<br>(28.6) |
| **7-8** | 73.6<br>(23.3) | 57.7<br>(20.5) | 49.3<br>(23.5) | 45.3<br>(28.7) |
| **9-10** | 70.5<br>(31.6) | 62.0<br>(25.0) | 52.5<br>(28.1) | 33.7<br>(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** | 26.4 | 28.7 |
| **as % of Fund** | (0.0127) | (0.0098) |
| **Two Lowest Shares** | 20.3 | 13.6 |
| **as % of Fund** | (0.0033) | (0.0301) |
| **Fairness Index (Mean)** | 0.332 | 0.430 |

The standard errors of the mean are reported in parentheses.

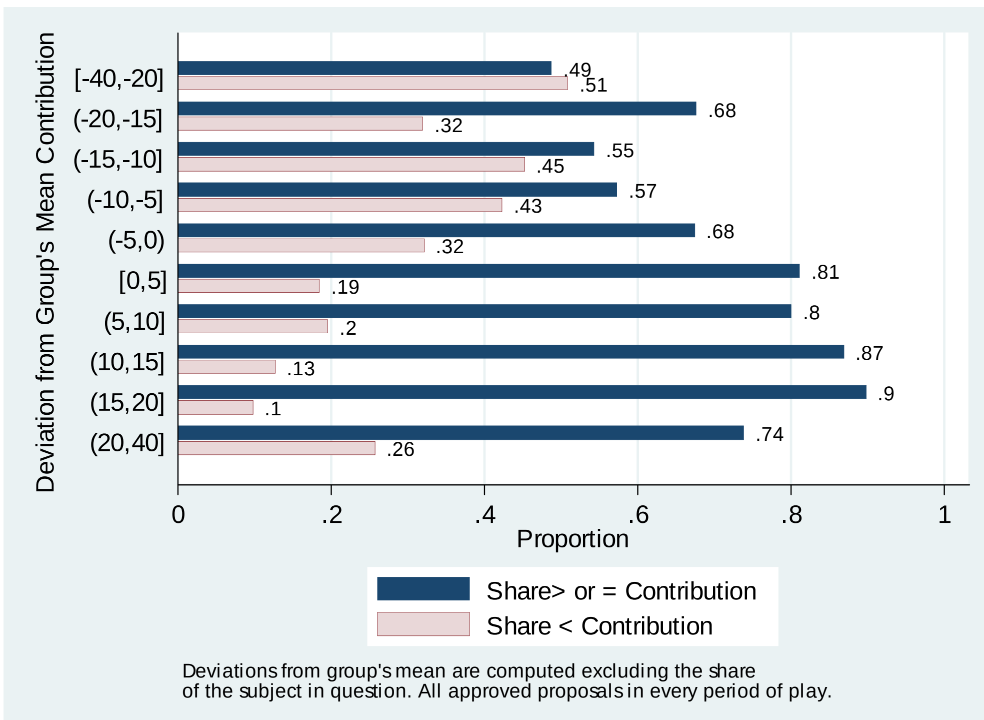


Figure 4: Proportion of Members Retrieving Investments by Deviation of Own Contribution from the Group's Mean