Voluntary Contributions and Collective Redistribution

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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,

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

[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.

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 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

[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

[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).

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 $\pi = (1 - \pi_1)/(n - 1)$.

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 $\hat{c} - \epsilon$,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

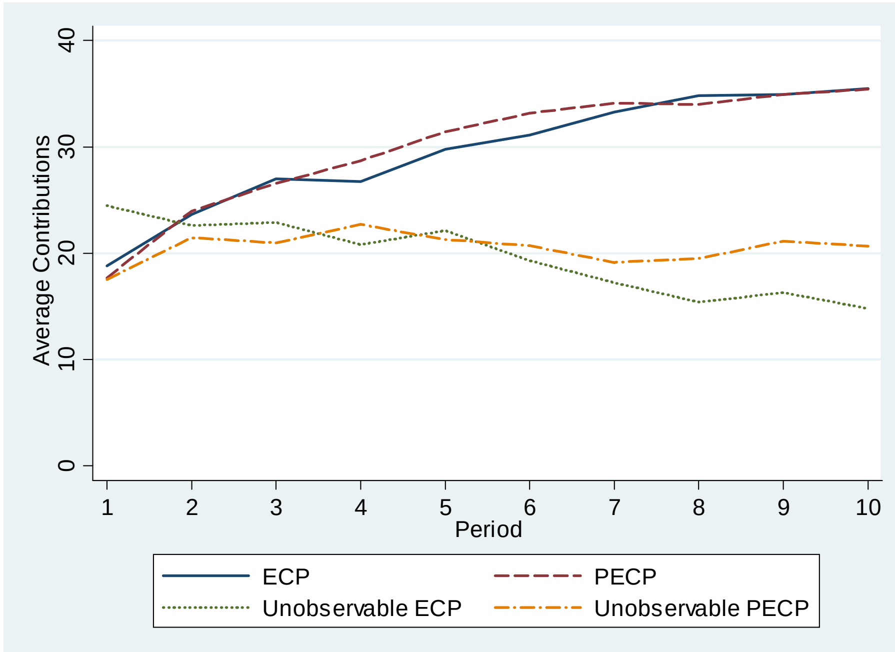

Figure 1: Average Contributions

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

[5]Proof is available upon request.

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

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.

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 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$\geq$Contribution)		Double Contribution (Share$\geq 2\times$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.

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.

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.

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

[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 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.

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).

B. Alternative Statistical Tests

Throughout the main body of the text, I have presented standard t-tests to determine the rejection or not of the null hypotheses posed. Each observation was treated as being independent. Here I depart from this assumption, and conduct OLS regressions clustering

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

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.

standard errors at the subject level. These tests are presented for robustness and we find no relevant changes in the significance of the results presented.[9]

- Footnote 29: p-value$= 0.692$.
- Footnote 30: p-value$= 0.411$.
- Footnote 31: p-value$= 0.344$.
- Footnote 32: p-value$= 0.002$.
- Footnote 33: p-value≈ 0.
- Footnote 39: p-value$= 0.019$.

[9] One anonymous referee suggested that this should be done for consistency since part of the voting analysis takes into account subject specific effects.