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ORIGINAL PAPER

The determinants of voting in multilateral bargaining games

Guillaume R. Fréchette[1] **· Emanuel Vespa**[2]

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Abstract Models of multilateral bargaining predict that agents would vote solely based on the share they are offered and that their vote is determined by whether that share is at least as high as the continuation value (CV) of the game. The standard experiment investigating behavior in multilateral bargaining is not well designed to determine if that is the case. Our experiment makes three changes to the typical design: it introduces substantial variation in the CV (using a within-subjects design and varying the discount factor), it generates variability in offers using computer-generated offers while retaining the equilibrium of the original game, and it uses belief elicitation. These changes allow us to consider whether behavioral voting rules that are independent of the CV or factors besides one's own share are important to voting decisions. We find that the main determinant of votes is the share one is offered, but that when offers are believed to come from another participant, a proposal is less likely to be approved if the proposer tries to take a lot for himself. Nonetheless, the equilibrium voting rule, which is based on the CV of the game organizes choices better than behavioral rules that are independent of the CV.

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✉ Guillaume R. Fréchette
frechette@nyu.edu

[1] New York University, New York, USA

[2] UC Santa Barbara, Santa Barbara, USA

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1 Introduction

Many situations require the division of resources among a group. In particular, elected officials have to allocate resources between districts. Models of multilateral bargaining provide theories on how a committee would divide a fixed budget among members. The model of Baron and Ferejohn (1989) (hereafter BF), has become the standard way of modeling such situations.

The BF model uses an alternating-offers procedure to determine an allocation. In its most common form, referred to as the *closed rule*, one member (the proposer) is randomly recognized to make a proposal that is presented to the committee for a vote. Given a decision rule (e.g., a simple majority), the proposal can be accepted if it gathers enough votes—in which case it is implemented or rejected otherwise. If rejected, the procedure is repeated, but with each new bargaining stage a fraction $(1-\delta) \in [0, 1]$ of the budget is lost. The closed-rule BF model has been widely used not only to study bargaining per se, but also as a building block in more involved models that, at some stage, require a group to solve a bargaining problem (e.g., Battaglini and Coate 2007).

An important feature of the equilibrium prediction is that committee members vote in favor of a proposal, as long as the share they would receive is not lower than the continuation value (CV) of the game. The CV of the game captures the payoff that the players can expect if the game moves forward. The CV depends on the fraction $(1-\delta)$ of the budget that is lost with each bargaining stage: the higher the fraction that is lost, the lower the expected value of the game. This means that members of the group other than the proposer who receive strictly positive shares (non-proposers) should be willing to accept lower shares as the fraction of the budget that is lost increases. Meanwhile, the proposer is predicted to receive a larger share as $(1-\delta)$ increases.

Numerous experiments study the BF environment McKelvey (1991), Fréchette et al. (2003), and Diermeier and Morton (2004) are some of the early studies, but many more have followed, and multiple aspects of behavior in this game are now well documented.[1] For instance, as the model predicts, the vast majority of

[1] See Fréchette et al. (2005a) for the case of a comparison between BF and an alternating-demands bargaining protocol; Fréchette et al. (2005b) for a study that contrasts BF's and Gamson's predictions; Kagel et al. (2010) for the effect of introducing veto power; Fréchette et al. (2010) for the addition of a public good; Miller and Vanberg (2013) for a comparison of decision rules (majority v. unanimity); Christiansen et al. (2014) for the addition of a policy dimension to the BF environment; Tergiman (2015) for the effect of having a vote of confidence procedure; Miller and Vanberg (2015) for the effect of group sizes; Vespa (2016) for the effect of malapportionment; and Agranov et al. (2016) for the effect of a cumulative public good. See Palfrey (2016) for a survey.

proposals are immediately accepted; the majority of proposals involve a minimal winning coalition (MWC) (i.e., they do not distribute funds to subjects whose vote is not necessary to obtain a majority of votes) and proposers exhibit proposer power on average (they take more than they give). Those studies have also systematically documented quantitative deviations from theoretical predictions. In particular, that proposers end up receiving a share substantially below equilibrium, which in turn means that a large majority of non-proposers in the winning coalition receive shares substantially *above* the CV.

However, much less is known about the determinants of voting decisions, even though they are crucial to understanding proposer behavior. Understanding the determinants of voting, for example, can help to evaluate whether proposers' behavior is optimal given responders' behavior. In addition, it also offers an interesting window into preferences—since unlike in bilateral bargaining—an agent's payoff is not tied one-for-one to the proposer's payoff.[2]

There are two major challenges to studying the determinants of voting using the standard experimental designs of multilateral bargaining. First, equilibrium offers are seldom observed. As the top panel of Fig. 1 shows, the entire dataset in Fréchette et al. (2003) (hereafter FKL) contains no case of MWC proposals in which the share offered corresponds to the equilibrium offer. In fact, there are no strictly positive shares offered below the equilibrium offer when the proposal is for a MWC. Although there are offers at the equilibrium level, not one of them is part of a MWC offer. In other words, to make inferences on whether equilibrium offers would be accepted requires extrapolating from shares offered as part of non-MWC proposals. Since it is not clear, a priori, that MWC offers are treated the same as non-MWC offers, such inference is not straightforward.

Second, previous experimental designs typically use parametrizations such that the equilibrium offer (the CV) is relatively close to $\frac{1}{N}$ (N being the number of players), which can be thought of as an alternative rule to explain voting decisions. The equilibrium offer is close to $\frac{1}{N}$ when agents are patient, and most studies consider only values of δ at or close to one. The top panel of Fig. 1 illustrates such a case. To the extent that $\frac{1}{N}$ is a compelling candidate to explain voting, having the two close to one another makes it difficult to distinguish the one that explains voting best.

While the lack of equilibrium offers and the closeness of the equilibrium offer to $\frac{1}{N}$ are features of most previous studies, the design introduced in this experiment attempts to remedy both problems. Equilibrium offers are introduced using a computer that submits proposals in such a way that the CV of the game is unaffected. Only in the first stage of bargaining is it possible for the selected proposer to be replaced by a computer and the computer does not intervene in later bargaining stages. This means that the CV of the game at the time that the opening offer is under consideration is unaffected by the presence of the computer, so that the equilibrium solution is still meaningful. Moreover, when the computer makes an

[2] It is well established that, to the extent that behavior is not in line with equilibrium predictions, it is even further from the predictions of standard models of other-regarding preferences when applied to this environment (Montero 2007).

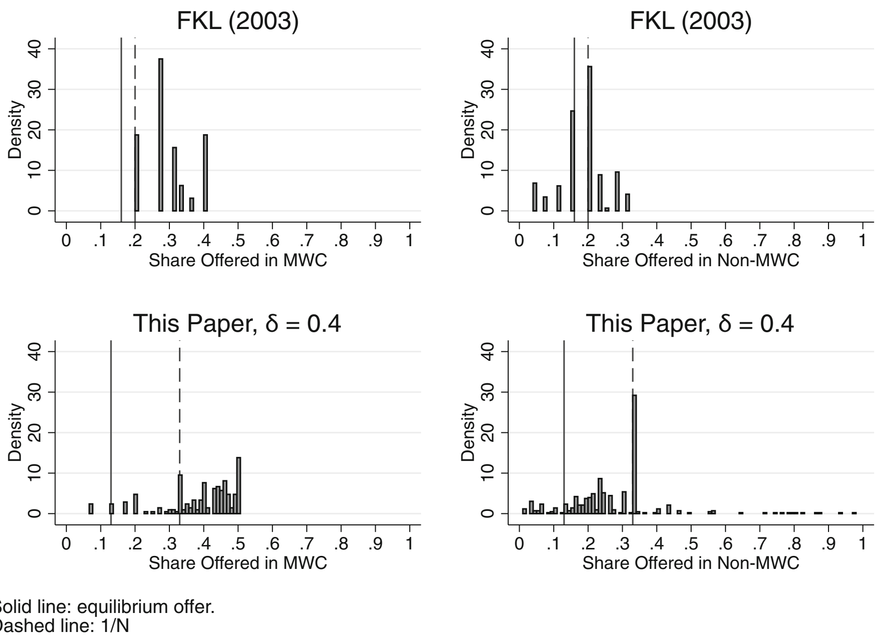

Fig. 1 Shares offered In Fréchette et al. (2003) and in one treatment of the current study (excluding offers of zero)

offer, the shares it proposes will actually be allocated to the corresponding subjects if it is accepted, which eliminates problems when subjects care about other participants' outcomes. Subjects know that proposers can be replaced by a computer, and we elicit beliefs about the likelihood that the proposal came from the computer. This allows us to control for (and investigate) the potential effect of intentions. The bottom panel of Fig. 1 shows the offers for one parameter value in the current experiment. As the figure shows, the current design increases the variability of offers among MWC proposals, including some at or below the equilibrium offer.

Another design feature allows us to evaluate whether behavioral rules that do not depend on the CV may better rationalize voting decisions. One conjecture, consistent with findings from bilateral bargaining experiments (Roth 1995), is that CVs might predict voting patterns, but only within a certain range. When the equilibrium CV moves too far below what is considered acceptable (determined, perhaps, by some kind of norm), it stops having attraction power. We assess this conjecture by varying the parameter δ within each session. The variation in δ will allow us to evaluate whether subjects follow a norm that is independent of the CV. To make the hypothesis more precise, consider the possibility that subjects follow a norm that accepts proposals only if the offered share is above some threshold T. Given the variation in δ, we can evaluate if there is a T-norm that can rationalize voting patterns across those values, and, in particular, whether such a rule performs better than the equilibrium criterion. Clearly, the $\frac{1}{N}$ rule of thumb mentioned earlier would be a special case of a T-norm, and the bottom panel of Fig. 1 illustrates one particular value of δ for which $\frac{1}{N}$ is not close to the equilibrium offer. This is the first paper to consider as large a range and as many values of δ for the BF game.

Our first main finding is that close to 90% of voting choices are consistent with the equilibrium prediction (voting in favor of a proposal whenever the offered share is at least as high as the CV). In fact, the equilibrium criterion outperforms any T-norm in terms of rationalizing voting patterns. In other words, any rule that fixes a threshold share T for all values of δ makes more mistakes in predicting votes than the equilibrium criterion makes. The exercise indicates that many subjects do not follow a voting rule independent of δ.

Our second main finding is that, although the share offered is the most important determinant of votes, there is a secondary concern that is relevant only when subjects believe the proposal came from another participant. That is, they are more likely to reject a given share when the proposer takes more for himself, but only if they believe the proposer to be a participant. This suggests that subjects may be willing not to penalize proposals that are closer to equilibrium, provided that they believe it is highly likely to have come from the computer. This finding is in line with Blount (1995) and Bolton et al. (2005), who document that in the ultimatum game, biased offers that favor the proposer are more likely to be accepted when introduced by a computer rather than a human. In addition, we find that equilibrium proposals introduced by the computer are less likely to receive favorable votes when the value of δ is relatively low and the equilibrium predicts a distribution very favorable to the proposer. In particular, this is consistent with Bolton et al. (2005), who report that in ultimatum games, when the bias in favor of the proposer is too large, proposals are rejected regardless of how they were generated.

From another perspective, our findings suggest that allowing for pre-play communication is necessary for proposals to move closer to equilibrium. Agranov and Tergiman (2014) and Baranski and Kagel (2015) show that proposals move substantially closer to equilibrium if there is pre-play communication. However, such designs cannot evaluate whether communication per-se is necessary for the finding, or if the same result would have been reached if subjects had had experience with equilibrium proposals absent communication. Our evidence is consistent with communication being necessary per-se, given that we do not see equilibrium proposals spread after the computer introduced such proposals.

2 The Baron–Ferejohn model

The BF model is intended to reflect, in a stylized manner, the sequential nature of proposal making and voting in legislative settings, modeling it as a noncooperative game. The legislature consists of (1) $n \geq 3$ (odd) members, each representing a legislative district; (2) a recognition rule that determines the standing proposal in each round of the election; and (3) a voting rule.

The legislature allocates a fixed quantity of divisible benefits among legislative districts according to majority rule, with no side payments. Each member is assumed to have risk-neutral preferences that depend only on the benefits allocated to his district. Preferences and legislative rules are assumed to be common knowledge, with all actions observable, so that the model involves perfect information.

In our experiment, we employ a random recognition rule, with each legislator being equally likely to have his proposal recognized and voted on. At the beginning of an election, each member i has a probability $p_i = 1/n$ of being recognized, and, if recognized, makes a proposal specifying how benefits will be distributed. A proposal x^i is a distribution $x^i = \left(x_1^i, \ldots, x_n^i\right)$ such that $\sum_{j=1}^{n} x_j^i \leq 1$, where $x_j^i \geq 0$ is the share that i allocates to voter j. This proposal is then the motion on the floor, which is voted on immediately.[3] If the proposal is approved, the legislature adjourns. If not, the legislature moves to the next stage and repeats the process until a proposed distribution receives a majority vote. The payoffs for member j if member i's offer is accepted at stage t are given by $u_j(x^i, t) = \delta^t x_j^i$, where $\delta \in [0, 1]$ and is usually taken to represent either the value of time or the re-election probability.

In any subgame-perfect equilibrium (SPE) of the game, a MWC of voters receives a non-zero share. BF focus on the symmetric and stationary subgame perfect equilibria (SSSPE) of the game. The solution is symmetric, in the sense that members of the MWC that are not the proposer are allocated the same share. Stationarity captures the idea that proposals submitted in stage $t > 1$ do not condition on the history of play.

In a SSSPE, benefits are always allocated in the first stage (without delay). Shares of coalition members are determined by the proposer providing payments just equal to the continuation value of the game, which is computed as the expected payoff of rejecting the proposed distribution. In a SSSPE, the ex-post distribution of payoffs is 0 for $\frac{n-1}{2}$ members, $\frac{\delta}{n}$ ($= CV$) for $\frac{n-1}{2}$ non-proposers and $\left(1 - \frac{\delta}{n}\frac{n-1}{2}\right)$ for the proposer.

3 Experimental design and hypotheses

3.1 Experimental design

The basic structure of the experiment is as follows. Subjects play a series of 18 repetitions of the game, one of which is randomly selected for payment.[4] We refer to each repetition as a round, and each round can have an indefinite number of stages. We set $n = 3$, and bargaining groups are fixed during all stages of a round, but subjects are randomly re-matched between rounds. Subjects have all the relevant information: number of participants per group, discount rate, rules of the game. The experimenter makes this information common knowledge by reading instructions aloud.[5]

One of our goals is to evaluate the effect of changing the continuation value on voting. With this aim, we face subjects with six values of δ (0, 0.2, 0.4, 0.6, 0.8, 1)

[3] In this paper we concentrate on the closed-rule version of the BF model.

[4] There is also a \$15 show-up fee.

[5] Instructions are included in the online appendix.

that, as described in the previous section, systematically affect the continuation value of the game. To implement the six values of δ, we divide the 18 rounds into three blocks of six rounds, and within each block, all six values of δ are implemented in a random order.[6]

A second objective is to evaluate subjects' voting behavior with respect to equilibrium proposals. With this goal in mind, we now explain the major design innovation in this experiment. In each stage, all group members submit proposals on how to divide a budget of \$30, and one subject is selected as the proposer (with each member having an equal probability of being chosen). In stage 1, there is a 50% probability that the proposal to be voted on corresponds to the one submitted by the selected proposer, and a 50% chance that the proposal is generated by a computer. If the proposer is replaced by the computer, the proposer is not informed of the computer's proposal and does not vote, and the computer is programmed to vote in favor of the proposal.[7] The other two committee members observe the proposal on the floor, but are not told if it comes from a computer or from another participant. If the proposal on the floor receives two or more votes, the round is over. If the proposal on the floor does not pass, there is a new stage. Before the start of the subsequent stage, subjects receive feedback on the outcome, except in the case of proposers who were replaced by the computer.[8] In stages 2 and beyond, the computer never intervenes, and the proposal is always randomly selected from the subjects' submissions. All of this is known to the participants.

From a theoretical perspective, having a computer randomly submit proposals in the first stage in no way affects the continuation value of the game since the computer never intervenes after stage 1. Hence, this design feature allows us to affect the distribution of offers being made, while preserving the equilibrium in a meaningful way.

The offers that the computer makes fall into five categories: equilibrium (15%), egalitarian (10%), quasi-equilibrium (40%), non-MWC (25%), and random (10%). Equilibrium proposals correspond to the SSSPE proposals characterized in the previous section. Egalitarian proposals divide the budget equally among the three members. Quasi-equilibrium are MWC proposals in which the proposer receives an allocation share between the SSSPE and half of the budget, and the remaining budget is allocated to one coalition member.[9] In non-MWC proposals a proposer's allocation is determined in the same manner as in quasi-equilibrium proposals, but the remaining budget is divided equally between the other two committee members. Finally, random proposals simply divide the budget randomly among the three members.

[6] To make it easier for subjects to understand implications of a particular value of δ in stage t, the interface reminds them of the budget that would result in stage $t+1$ in case the proposal did not pass in stage t.

[7] Notice that the computer's voting rule, of which subjects are informed, prescribes what is a natural assumption: that the proposer is expected to vote in favor of her own proposal.

[8] Proposers who were replaced by a computer would learn their payoff in the computer's proposal only once the session is over and if such a proposal passed in the round selected for payment.

[9] Specifically, to implement the quasi-equilibrium proposal, the computer randomly selects a value $\alpha \in [0, 1]$, which is the weight that corresponds to the proposer's share in the SSSPE. When $\alpha = 1$, the proposer's share is equal to the proposer's share in the SSSPE, while when $\alpha = 0$, the proposer's share is half of the budget.

Starting in round 7 (the beginning of the second block of six rounds) and until the end of the session, subjects are asked in stage 1 of each round how likely they believe the proposal is to come from a computer.[10] We can then test when subjects are more likely to detect proposals coming from computers. By eliciting beliefs, we can control for them when studying voting behavior.

3.2 Main hypotheses

Our two main hypotheses evaluate central aspects of voting behavior. The aim of our first hypothesis is to evaluate the extent to which the CV can explain voting patterns. The equilibrium described in Sect. 2 predicts that subjects would vote in favor of a proposal whenever their share is at least as high as the CV, which depends on δ. An alternative criterion is that subjects have a threshold for an acceptable share. Presumably, this can be rationalized with a norm that is independent of δ: vote in favor of a proposal whenever the offered share is at least as high as $T\%$, with $T \in [0, 100]$. Because our experimental design varies the value of δ, we can assess whether the CV or a T-norm can better explain subject's choices. We now explicitly state our first hypothesis, following the theoretical prediction.

Hypothesis 1 A subject votes in favor of a proposal whenever the share offered is higher than or equal to the $CV = \frac{\delta}{2}$. In particular, a subject does not follow a voting rule independent of δ.

Our second hypothesis evaluates the determinants of voting from a broader perspective. The theory predicts that proposals involve MWC and that voting should only depend on the share offered to the subject. In the data, however, not all proposals may involve MWCs and it is in principle possible that subjects condition their voting on other characteristics of the proposals such as the proposer's allocation. Provided that not all proposals satisfy equilibrium properties, our second hypothesis evaluates the extent to which the theoretical determinant of voting can explain voting patterns.

Hypothesis 2 Whether a subject votes in favor of a proposal or not depends only on the share offered to the subject. Since the equilibrium share offered to non-proposers (the CV) depends positively on δ, subjects should require a higher share to accept an offer as δ increases.

4 Results

Five sessions with a total of 72 participants were conducted at the Center for Experimental Social Science (CESS) at New York University.[11] The average payment was \$20.80. In this section, we first provide a summary of findings relative to general properties, focusing on describing the proposals that subjects submit. The

[10] Having a few rounds without belief elicitation was meant to allow subjects to first get accustomed to the bargaining procedures. In rounds with belief elicitation we use the method described by Karni (2009), which does not rely on risk neutrality to be incentive-compatible.

[11] There were two sessions with 18 participants and three with 12 participants.

second part of the section centers on proposals that were selected to be voted on and on evaluating the main hypotheses.

4.1 Proposals

This short section on proposals simply confirms that well-established results from prior experiments with a fixed δ extend to this within-subject design that also includes atypical features such as some computer-generated proposals and belief elicitation. To begin, we note that, as in other experiments on the topic, behavior changes with experience. This can be visually assessed easily by simply looking at the changes in shares that proposers ask for themselves over time (see Figure OA-1 in the Online Appendix). As such, our analysis will focus on data from the last six rounds.Note: Bars display 95% confidence intervals

Prior research has established that players in BF games make offers that tend to be immediately accepted and mostly involve MWCs, as predicted by the SSSPE; however, the share that players allocate to themselves is less than predicted. These results for our experiment can be evaluated in Fig. 2. The left panel confirms that most proposals are immediately accepted. The theoretical prediction is computed conditional on the proposal on the floor, x (with equilibrium offers, proposals should always be accepted), and indicated by $SSSPE|x$. As can be seen, the data closely track the theoretical prediction.

The middle panel of Fig. 2 indicates the fraction of proposals that are almost MWC (A-MWC), where the lowest share is no greater than 10% of the budget. Previous research has found that, depending on the number of players and discount factor, between 61 and 94% of proposals are for A-MWCs (Fréchette et al. (2003), Fréchette et al. (2005a), Fréchette et al. (2005b), Agranov and Tergiman (2014), and Baranski and Kagel (2015).[12] Similarly, here, the most common proposals are A-MWCs for all values of δ.[13]

The right panel of Fig. 2 indicates the share that proposers take for themselves in accepted proposals that are A-MWCs. This is also consistent with earlier findings that proposers exhibit proposer power (take more than they give) but not nearly as much as predicted.[14] One new result to emerge is that the share that the proposer obtains in these proposals decreases with δ, as predicted by the equilibrium.

[12] These numbers are obtained excluding initial rounds of play and treatments with communication.

[13] A more detailed view of the offers can be obtained by consulting Figure OA-2 in the Online Appendix. It reports the kernel density estimates of the smallest share in an offer for each δ. As one can see, the types of proposals do not depend much on δ.

[14] For the case $\delta = 0$, our findings are consistent with findings reported for the three-person ultimatum game (Güth and Van Damme 1998). In a three-person ultimatum game, the player in the role of proposer offers a split of the budget between three players, and if the responder accepts the division, it is implemented. Otherwise, payoffs for all players are equal to zero. The third player is passive. In the condition in which the responder is fully informed of the proposal, the finding is that the proposer keeps approximately two-thirds of the budget, which is close to the empirical average reported for $\delta = 0$ in the right panel of Fig. 2.

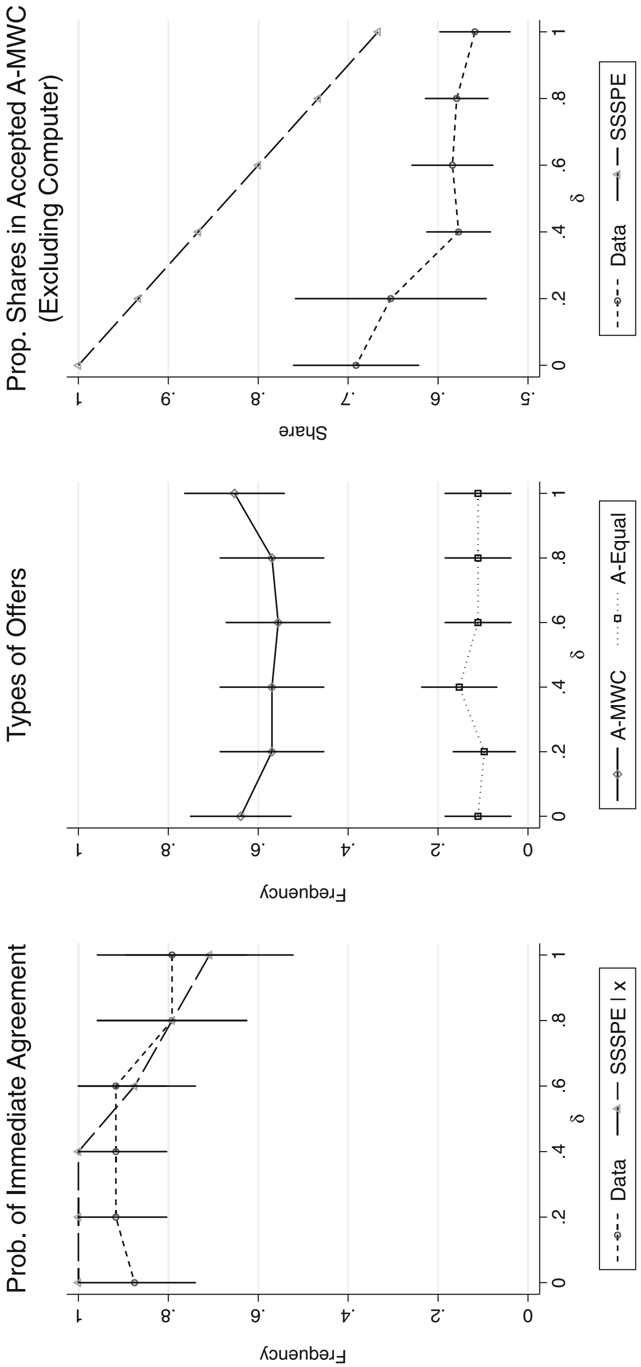

Fig. 2 Stage one results

However, the effect is extremely muted in comparison to what the theory suggests.[15]

4.1.1 *Do subjects anticipate when a proposal is coming from a computer?*

Before we analyze voting behavior, we briefly study the extent to which subjects anticipate proposals on the floor that are submitted by the computer. Consider, first the center graph of Fig. 3, which restricts the sample to A-Equal proposals. These are proposals that are close to an equal split, where the difference between the highest share and the lowest share is not more than 10%. The figure presents the CDFs of subjects' reported beliefs that the proposal comes from the computer, depending on whether the proposal does indeed come from the computer (solid line) or does not (dotted line).

The distributions in the case of A-Equal proposals largely overlap, which indicates that when subjects face such proposals, they have difficulty distinguishing whether the proposal comes from a computer or a human. In the case of A-MWC proposals, presented in the left-most graph, subjects are, on average, more likely to believe that A-MWCs proposals come from the computer when proposals actually come from the computer. The average belief when the A-MWC proposal is indeed from the computer is about 14% points higher than when it is not, and the difference is statistically significant (*p* value 0.046).[16] However, note that there is some overlap between the two distributions, indicating that subjects are far from perfectly anticipating when A-MWC proposals come from a computer.

Finally, information on other proposals is presented in the right-most graph. In this case, there is a clear difference between the two distributions throughout the domain, which shows that, in these cases, subjects are better able to distinguish when a proposal comes from the computer than from a human. An important driver of this difference is the case where the computer submits a random proposal. For such proposals, the median reported belief that the proposal is indeed from the computer is 90%.

4.2 Voting

4.2.1 *Continuation value of the game as a predictor of voting decisions*

To evaluate Hypothesis 1, we need not focus on the average accepted shares, but on the minimum accepted shares. In particular, we would need to assess whether the

[15] Notice that the pattern of proposals that we observe cannot be explained by risk aversion. If all players share the same risk aversion and this is common knowledge, then the continuation value of the game is lower with risk aversion than without risk aversion. This happens because there is a risk of being excluded from the winning coalition in future rounds of the bargaining process that the proposer can exploit by offering lower shares to coalition members and keep even more for himself than predicted by the risk-neutral equilibrium. See (Harrington 1990) for further details.

[16] We run a regression restricted to A-MWC proposals, in which the left-hand side variable is the reported belief and the right-hand side includes a constant and a dummy that takes value 1 if the proposal comes from the computer and 0 otherwise. The reported *p* value corresponds to the dummy coefficient's estimate. Standard errors are clustered by session (see Fréchette (2012) for a discussion of session-effects).

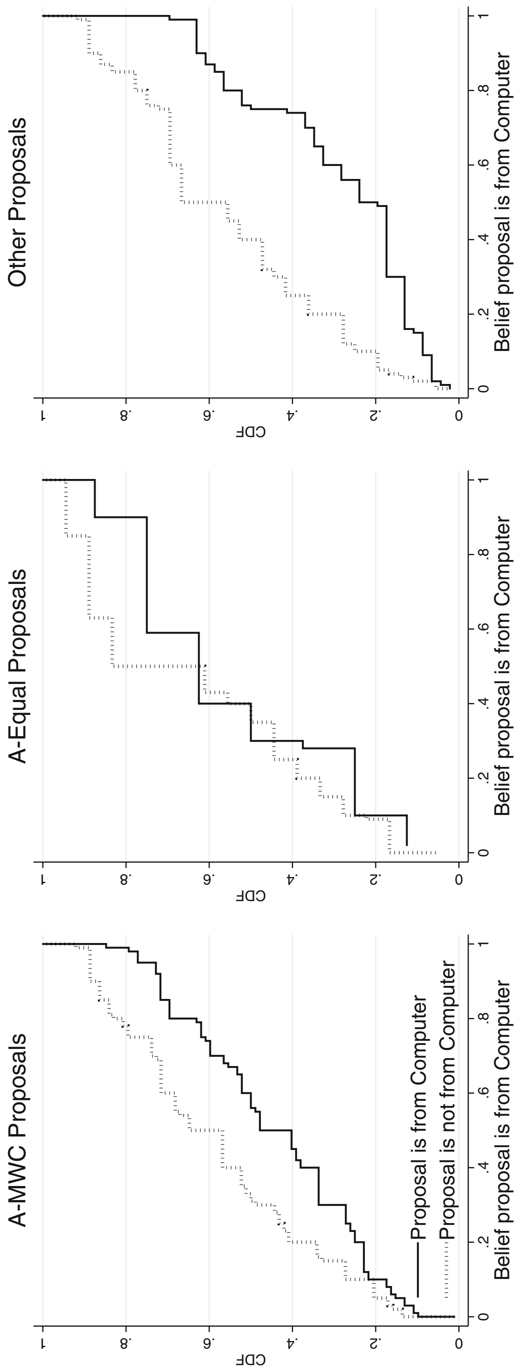

Fig. 3 Reported beliefs that the proposal is from the computer, by proposal type

Table 1 Votes classified correctly using CV or a T-norm as criteria and theoretical CV (in %)

Criterion	$\delta = 0$	$\delta = 0.2$	$\delta = 0.4$	$\delta = 0.6$	$\delta = 0.8$	$\delta = 1$	Aggregate
$T = 5$	77.1	87.5	87.5	85.4	68.8	72.9	79.9
$T = 10$	77.1	87.5	89.6	85.4	70.8	79.2	81.6
$T = 15$	75.0	81.3	89.6	87.5	72.9	81.3	81.3
$T = 20$	72.9	85.4	86.6	91.7	83.3	85.4	84.7
$T = 25$	62.5	77.1	77.1	85.4	83.3	93.8	79.9
CV	83.3	89.6	91.7	91.7	83.3	93.8	88.9
Theoretical CV (as % of budget)	0.0	6.7	13.3	20.0	26.7	33.3	–

Includes all stage 1 proposals of the last six rounds. Sample restricted to subjects who were not the proposer. According to a T-norm, a subject votes in favor of a proposal if offered at least a share of T%

According to the equilibrium rule, the subject should vote in favor of a proposal when the share offered is at least as high as the continuation value, which depends on δ

Each cell in the table reports the percentage of votes (either in favor of or against the proposal) classified correctly according to the corresponding rule

minimum that subjects consider acceptable depends on δ, as prescribed by the CV. Alternatively, a subject may vote in favor whenever offered a share at least as high as T%, with $T \in [0, 100]$, a criterion which is independent of δ.

In Table 1, we present the percentage of votes that are classified correctly for five values of T. The table shows the computation for each value of δ and the aggregate. The $T-$norm criterion performs best in the case $T = 20$, when in the aggregate, it can rationalize 84.7% of subjects' votes.[17] However, the CV criterion performs better for most values of δ, and it does not rationalize fewer votes than the T-norms in Table 1 for any value of δ.[18]

Finding 1 The CV criterion for voting—i.e., accept a proposal only if the share offered is at least as high as the CV—predicts voting correctly in almost 90% of cases. This criterion also outperforms the predictions of behavioral voting rules that do not depend on δ.

4.2.2 Aspects of offers that determine voting

We now turn to evaluating Hypothesis 2. Column (1) of Table 2 reports the marginal effects of a random-effects probit regression of the vote of non-proposers

[17] The case $T = 20$ leads to the highest aggregate percentage of rationalized votes when allowing for T to take on any number between 0 and 100.

[18] We use a McNemar test to evaluate if for any T-norm the CV criterion does not perform better. The null hypothesis of the test is that the number of cases in which the the vote is classified incorrectly by the CV criterion but correctly by the T-norm is equal to the number of cases in which the vote is classified correctly by the CV criterion but incorrectly by the T-norm. Not rejecting the null hypothesis is evidence that the CV criterion does not perform better than the T-norm. We reject the null hypothesis for $T \in \{5, 10, 15, 25\}$ at the 1% confidence level and at the 10% confidence level when $T = 20$. Tables OA-2, OA-3 and OA-4 in the Online Appendix present the same information as in Table 1, but is separated to reported beliefs in intervals: $[0, \frac{1}{3})$, $[\frac{1}{3}, \frac{2}{3}]$, and $(\frac{2}{3}, 1]$. In all cases, the CV criterion performs better in the aggregate than any T-norm.

Table 2 Marginal effects of random-effects probit regression of determinants of voting

	(1)	(2)	(3)	(4)
δ	-0.235^{**} (0.095)	-0.234^{**} (0.100)	-0.240^{**} (0.100)	-0.249^{**} (0.105)
Own share	0.017^{***} (0.001)	0.017^{***} (0.001)	0.019^{***} (0.001)	0.018^{***} (0.004)
Proposer's share	0.000 (0.001)	0.000 (0.001)	-0.004^{**} (0.002)	-0.004^{***} (0.002)
MWC	−0.005 (0.036)	−0.007 (0.033)	0.064 (0.106)	0.089 (0.110)
Belief		−0.012 (0.074)	-0.292^{*} (0.157)	-0.263^{*} (0.138)
Belief × own share			-0.005^{**} (0.002)	-0.005^{***} (0.000)
Belief × proposer's share			0.007^{*} (0.004)	0.007^{**} (0.003)
Belief × MWC			−0.107 (0.154)	−0.142 (0.159)
Experienced proposals that failed				-0.055^{*} (0.031)

Standard errors clustered (at the session level) in parentheses***1%, **5%, *10% significance

We use non-proposers' choices in rounds 13–18 and the sample size in all regressions equals 288

Dependent Variable: 1 if subject voted positively

Controls: (a) δ: discount rate corresponding to the proposal on the floor, (b) Own share: share allocated to subject in proposal on the floor, (c) Proposer's share: share allocated to proposer in proposal on the floor, (d) MWC: 1 if proposal on the floor involves a MWC, (e) Belief: Reported Belief that the proposal is from the computer, (f) Experienced proposals that failed: Number of times that the subject voted in favor of proposals that were rejected in rounds 1–12

on δ, the share offered, the proposer's share, and whether the proposal on the floor is a MWC. The coefficient estimate on the own share is positive and statistically significant, and the estimate on δ is negative and statistically significant. This indicates that subjects condition their support for the proposal on their own share and require a higher share to accept an offer as δ increases, in line with Hypothesis 2. In addition, other controls are not statistically significant.

How do these findings change if we control for subjects' beliefs that the proposal was generated by the computer? Columns (2)–(3) add controls for subjects' reported beliefs. In both cases, the signs and magnitude of the δ and own share coefficients are unchanged, indicating that the finding reported in (1) does not change when we control for beliefs. Likewise, the coefficient on MWC is not statistically significant in either regression in line with the finding in (1).

When we do not include interactions [(as in (2)], the reported beliefs coefficient is not statistically significant, but this masks that in some cases beliefs may actually affect voting outcomes. When we control for beliefs and the interaction of beliefs and regressors [(in (3)], we find that the coefficient on beliefs itself is negative and significant. The overall effect of beliefs depends on this coefficient and on the coefficients of the interactions.

Interestingly, beliefs have an effect in terms of the amount that subjects are willing to accept for the proposer's share. Consider the case when the subject is fairly certain that the proposal is coming from a human (the reported belief is close to zero). In that case, the interaction between beliefs and the proposer's share only plays a minor role and the full effect is determined by the direct estimate on the proposer's share, which is negative and statistically significant. Meanwhile, when the subject is relatively sure that the proposal comes from the computer there is basically no effect of the proposer's share on voting. That is, adding the coefficient on the proposer's share and the interaction between proposer's share and beliefs leads to a coefficient close to zero. From another perspective, when the subject is fairly convinced that the proposal is from the computer, she's willing to vote in favor of a proposal that is more generous with the proposer (coefficient on the interaction between beliefs and proposer's share is positive), which is compensated by the subject willing to accept a relatively lower share for herself (coefficient on the interaction between own share and beliefs is negative). Overall, this indicates that subjects demand a lower share for the proposer only when they feel fairly certain that the proposal came from a human.[19]

Finally, column (4) controls for the possible effect of previous experience. The regression includes an additional variable that equals the number of times that the subject voted in favor of a proposal that failed in rounds 1–12. All subjects who were in that situation were proposers who ended up receiving a lower payoff in a later bargaining stage (or a payoff of 0 in case delta = 0). The estimated coefficient is negative and significant at the 10% level. This finding is consistent with negative reciprocity, as the more times the other two players voted against proposals in which the third player would have received the higher amount, the more often the third player subsequently voted against the other players' proposals. The main results that we have reported for other coefficients remain unchanged.

The left panel of Fig. 4 shows the predicted probability that a MWC offer is accepted based on a probit estimation of column (1) that restricts the sample to cases with reported beliefs equal or lower than one-third (subjects that are confident that the proposal comes from a human).[20] The Figure shows the impact of δ, which is in the predicted direction; but it also shows that for low values of delta, the offer that is accepted 50% of the time is far from the SSSPE. For instance, when $\delta = 0$, any offer should be accepted, but the offer that is accepted 50% of the time is a share of approximately 12%.

The panel on the right shows the impact of beliefs for the case of $\delta = 0.4$. When subjects believe that an offer is more likely to come from a computer, the response is noisier, but the offer that generates a 50% acceptance rate is lower. Similarly, the equilibrium offer of $13.\overline{3}\%$ is more likely to be accepted if the subject believes that it was computer-generated.

[19] Results are qualitatively unchanged (sign and statistical significance) if we instead use A-MWC on the floor as the regressor. Table OA-1 in the Online Appendix we reports a similar analysis but with dummy variables for each δ. As these show, few dummies are statistically significant on their own. Nonetheless, looking at them together does suggest a decreasing trend, and thus, we speculate that this is simply an issue of power.

[20] See Table OA-1 in the Online Appendix.

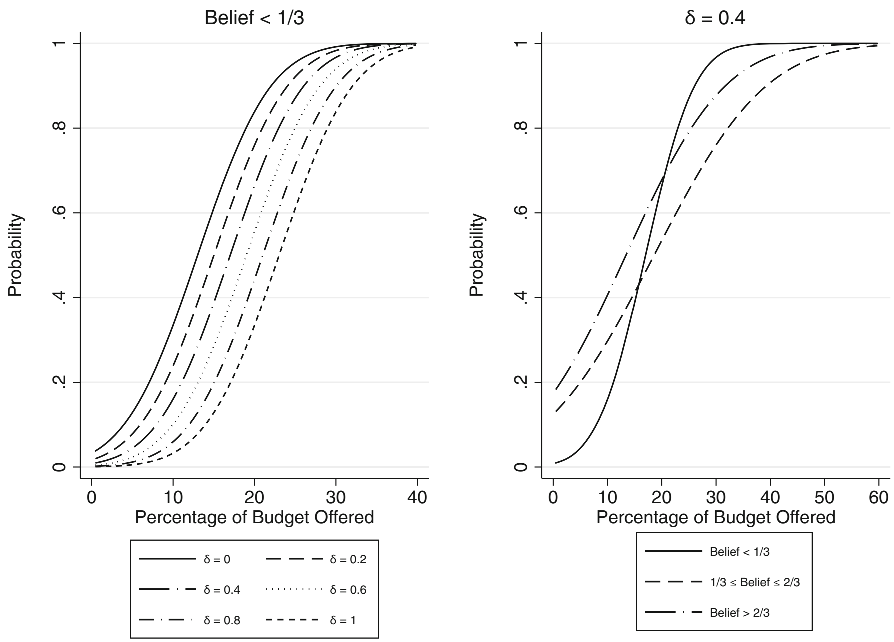

Fig. 4 Implied probability that a MWC offer will be accepted

Table 3 Votes on equilibrium offers

	$\delta = 0$	$\delta = 0.2$	$\delta = 0.4$	$\delta = 0.6$	$\delta = 1$
Percentage accepted	25.0	50.0	50.0	66.7	100.0
Theoretical CV (as % of budget)	0.0	6.7	13.3	20.0	33.3
N	12	2	2	3	5

Looking specifically at decisions on equilibrium offers could reveal more direct evidence. However, the sample is too small to condition on beliefs. Nonetheless, Table 3 reports the percentage of votes in favor of SSSPE offers. Approximately 88% of equilibrium proposals pass for values of δ at 0.6 or higher, but the figure is 31.3% for values of 0.4 or lower. A similar finding holds if we include data from rounds 7–12.[21]

These findings are in line with the left panel of Fig. 4; that is that for low δ's, equilibrium offers are likely to be rejected, but the opposite is true for high δ's. Recall that the difference between observed and theoretical proposers' shares in MWCs decreases as δ increases (see the right panel of Fig. 2). In the limiting cases of $\delta = 0$ and $\delta = 1$, the CVs equal zero and $\frac{1}{3}$ respectively, but the corresponding

[21] We run a probit regression with the non-proposer's vote on the left-hand side, and a constant and a dummy that takes value 1 if $\delta \geq 0.6$. We constrain the sample to equilibrium proposals submitted in the first stage of the last 12 rounds to increase power ($N = 54$). Standard errors are clustered by session. The coefficient on the dummy is positive and significant at the 5% level.

average offers to a non-proposer are approximately 30 and 45%. In other words, the evidence suggests that subjects are more likely to vote in favor of an equilibrium proposal for values of δ when the CV—while still lower—is not far from typically accepted offers.

Finding 2 To vote in favor of a proposal:

1. Subjects demand a higher share as δ increases;
2. Subjects demand a lower share for the proposer, but only when they think the proposal comes from a human.

5 Conclusion

In this paper, we study the standard alternating-offers model of multilateral bargaining in the laboratory, with special attention to a few key equilibrium properties. Our experimental design allows us to evaluate whether non-proposers who are members of the winning coalition follow a fixed threshold norm when deciding whether to accept or reject a proposal. An alternative hypothesis, which is predicted by equilibrium play, is that support for a proposal depends on $(1-\delta)$, the fraction of the budget that would be lost upon rejection of the proposal on the floor. We find that the equilibrium criterion rationalizes subjects' votes better than any norm that does not depend on δ.

While our first finding suggests that equilibrium play should be commonplace, we find that non-proposers typically receive shares substantially above the equilibrium prediction for all values of δ. Is it possible for subjects to vote in favor of proposals that allocate a proposer's share closer to equilibrium? Our second main finding is that subjects are less likely to vote in favor of a proposal as the proposer's share increases, but only if they believe that the proposal comes from another participant.

Recent experimental tests of multilateral bargaining models that allow for pre-play communication (Agranov and Tergiman 2014; Baranski and Kagel 2015) have documented behavior that is closer to equilibrium. These papers do not establish whether communication is strictly necessary for the result or if it works simply as a way to introduce equilibrium proposals. Our design forces subjects to consider equilibrium proposals without communication. We find that subjects are less likely to vote in favor of proposals that give high shares to the proposer if such proposals are believed to come from a human. This finding suggests that, indeed, communication is necessary for behavior to move closer to equilibrium.

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