Group Decision-Making and Voting in Ultimatum Bargaining: An Experimental Study*

by

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Abstract

Many rent-sharing decisions in a society result from a bargaining process between groups of individuals (such as between the executive and the legislative branches of government, between legislative factions, between corporate management and shareholders, etc.). We conduct a laboratory study of the effect of different voting procedures on group decision-making in the context of ultimatum bargaining. Earlier studies have suggested that when the bargaining game is played by unstructured groups of agents, rather than by individuals, the division of the payoff is substantially affected in favor of the ultimatum-proposers. Our theoretical arguments suggest that one explanation for this could be implicit voting rules within groups. We explicitly structure the group decision-making as voting and study the impact of different voting rules on the bargaining outcome. The observed responder behavior is consistent with preferences depending solely on payoff distribution. Furthermore, we observe that proposers react in an expected manner to changes in voting rule in the responder group.

Keywords: Bargaining games, group decision making and experimental design.
Journal of Economic Literature Classification Numbers: C92, D44, D82.

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Abstract

Many rent-sharing decisions in a society result from a bargaining process between groups of individuals (such as between the executive and the legislative branches of government, between legislative factions, between corporate management and shareholders, etc.). We conduct a laboratory study of the effect of different voting procedures on group decision-making in the context of ultimatum bargaining. Earlier studies have suggested that when the bargaining game is played by unstructured groups of agents, rather than by individuals, the division of the payoff is substantially affected in favor of the ultimatum-proposers. Our theoretical arguments suggest that one explanation for this could be implicit voting rules within groups. We explicitly structure the group decision-making as voting and study the impact of different voting rules on the bargaining outcome. The observed responder behavior is consistent with preferences depending solely on payoff distribution. Furthermore, we observe that proposers react in an expected manner to changes in voting rule in the responder group.

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1 Introduction

Many common bargaining situations, such as those that occur between the executive and the legislative branches of government, between legislative factions, between corporate management and shareholders, are interactions between groups rather than individuals. Consequently, in modeling applications of bargaining one or both sides are frequently best viewed as amalgamations of agents.[1]

We study group behavior in the context of ultimatum bargaining. In this game, one side proposes how to partition a total available payoff between itself and the other side, who, in turn can accept or reject the proposal. In case of acceptance the proposal is implemented, while in case of rejection neither side receives anything. As is well-known, the subgame-perfect equilibrium outcome is for the ultimatum-proposer to receive (almost) the entire surplus. In contrast, in laboratory implementation of the game, ultimatum-responders consistently obtain a significant, though smaller, share.

Our motivation is to explore how ultimatum bargaining between groups differs from that between individuals, and to compare the impact of different rules for aggregating individual preferences into group decisions. If such impact is non-negligible, it has general implications for bargaining between groups using different explicit voting rules to agree on intra-group decisions, and may help identify implicit preference aggregation mechanisms used in groups that do not have explicit rules. Additionally, a laboratory study of group bargaining provides a new test of the models that have been proposed to explain individual behavior in bargaining situations.

Our experimental observations can be summarized in two propositions. First, the comparison of individual responder behavior across treatments is consistent with agents caring only about distribution of payoffs. Second, we observe that proposer

[1] Chae and Heidhues [7] note that in a recent sample of papers published in the AER and the JPE, 15 out of 22 papers considered a group as one or both bargainers.

behavior significantly depends (in the manner predicted by our model) on the intra-group decision rule in force among the responders, and is generally different from the proposer behavior in the one-on-one bargaining. This suggests that subjects are able to internalize the different nature of the responders across the treatments.

While, as noted above, many bargaining situations involve interaction between groups, there are relatively few theoretical studies in economics or political science that explicitly concern themselves with the distinctions between group and individual interaction. When group bargaining situations are modeled, the above behavioral findings are frequently simply assumed. The examples are too numerous to be surveyed here. To cite a well-known study, Romer and Rosenthal [24],[25] in their work on political resource allocation assume that the monopoly agenda-setter effectively bargains with the median voter, thus internalizing the majority voting used in a democracy. A recent theoretical study comparing different intra-group decision rules in political models of intergroup bargaining by Haller and Holden [13], considers the impact of varying majority rule requirements for parliamentary ratification of international agreements. They conclude that supermajority ratification requirements may advantageously affect countries' negotiating positions and claim this to be a plausible reason for the empirical emergence of such constitutional provisions and practices in various countries. We believe that our experimental findings provide some support to their conclusion.

The issue of intergroup interaction in games has received a lot of attention from social psychologists. In a recent paper Wildschut *et al.* [28] provide a "meta-study" of a large body (some 130 studies) of experimental evidence on what is known in psychology as the *group discontinuity effect*: the general tendency of groups of agents to behave more aggressively than individuals in similar circumstances, whether due to social reinforcement of aggressive behavior, greater anonymity within the group, or fear of aggressive behavior by the opposing group. It is only recently that the issue has been taken up by economists, who compared the degree to which group and individual play conforms to the game-theoretic predictions. Bornstein and Yaniv [2] claim to observe more aggressive proposer behavior in group ultimatum games, while Bornstein *et al.* [3] see earlier group exit in the centipede game, both pointing towards the backward induction outcomes of these games. Similarly, Cox [9] observes that in an investment game group decisions correspond to those of their most aggressive members, which makes them most closely "game-theoretic" in terms of monetary payoffs. Kocher and Sutter [16] observe more aggressive group behavior to prevail in a gift-exchange experiment even when group members are not allowed any face-to-face interaction but reach a decision via a computer communication protocol. In contrast, in a context of the dictator game Cason and Mui [6] observe that more generous (other-regarding) agents dominate group decisions. Overall, the issue remains unsettled, and Camerer [5] includes further study of the manner in which groups act in games as one of the ten top open research questions in behavioral economics.

One difficulty in studies of intergroup interaction is that the intra-group decision-making may be difficult to observe or categorize, *unless it is explicitly imposed*. But imposing a preference aggregation rule may have a direct impact on the way the game is played. Thus, Wildschut *et al.* [28] conclude that when a group has to reach a single decision (typically, by consensus) agents tend to behave more in accordance with the discontinuity hypothesis than when the group decision is a sum of decentralized individual decisions. A distinct question is to what extent intra-group decision rules matter. Here the evidence so far is extremely limited. While the decision rule would affect a group's decision, it is another matter if this is understood and internalized by the opposing group. In a few studies that posed this question previously, as in Messick *et al.* [19], and in a very recent study by Bosman *et al.* [4], the answer seems to be negative: members of a group tend to view the opposing group as unitary and ignore its decision process. On the whole, the issue remains underexplored, and our study seems to challenge some of the earlier conclusions.

The one-on-one ultimatum bargaining game has been repeatedly played in laboratory settings, beginning with Guth *et al.* [12], and a number of robust regularities has emerged, as summarized in Roth [26] and Camerer [5]. In particular, it has been repeatedly observed that, at least in industrialized societies, the proposers of the ultimatum tend to offer the responders a sizeable chunk of the payoff (often in excess of 40%), while the low offers get consistently rejected by the responders.[2] While at variance with the subgame-perfect equilibrium prediction for a game with purely monetary payoffs, it could be explained by an uncontrolled non-monetary payoff component, such as utility of fairness or of punishing "insulting" offers. This is the conclusion Ochs and Roth [20] draw from a series of sequential bargaining experiments. In fact, for a number of such experiments, Prasnikar and Roth [21] suggest that ultimatum-proposers may be trying to maximize monetary payoff subject to the empirical rejection behavior of ultimatum-responders, which, in turn, might be generated by unobserved (and uncontrolled) payoffs.

Kennan and Wilson [17] suggested that "[e]ven the basic single-offer ultimatum game becomes a game of private information in which the optimal offer depends on beliefs about how much the responder is willing to forgo to punish unfair behavior". In other words, laboratory bargaining games should be modeled as incomplete information games, which in the ultimatum game context may be done by explicitly modeling rejection thresholds as responder *types.* This has been formalized in studies such as Levine [18], who incorporated altruism and/or spitefulness into individual preferences; Bolton and Ockenfels [1], who allow the agents to care about their relative position in the society; and in the fairness model of Fehr and Schmidt [10].

[2] However Henrich [14] observed that among Machiguenga Indians in Peru the bargaining outcomes are quite close to giving everything to the ultimatum proposer, which he interpreted as evidence for lack of fairness expectations among the subjects. This has led to a worldwide "anthropological" research project, reported in Camerer [5].

In these models, the agents may only be aware of the preference distribution in the population, but not of the actual types they face. In the context of the ultimatum bargaining, this generates an incomplete information game with ultimatum-proposers having beliefs about the rejection probability of any given ultimatum. In this paper we provide a simple model in the spirit of Bolton and Ockenfels [1] and Fehr and Schmidt [10], narrowly targeted to provide comparative empirical predictions for our experiment.

Until recently all laboratory ultimatum bargaining games have been implemented in a one-on-one setting. A 1998 study (Bornstein and Yaniv [2]) has suggested that when the ultimatum game is played by unstructured groups of agents, rather than by individuals, the division of the payoff is substantially affected in favor of the ultimatum-proposers (though their sample is small and they observe only two rejections). In their language, this result can be explained by thinking of groups as "more rational" agents than individuals, if rationality is viewed as being closer to the subgame-perfect outcome of the ultimatum game with pure monetary payoffs (though if the payoffs of ultimatum-responders have non-monetary components, the equilibrium prediction of the monetary-payoff game is, in fact, "incorrect"). In a concluding remark they suggest that an alternative explanation could be that ultimatum proposers take into account an implicit decision-making process of the responder group (such as, perhaps, majority voting). This conjecture cannot be tested without either a control for or an explicit model of such a process.

A couple of papers have attempted to deal with the issue of intra-group decision-making. Robert and Carnevale [23] claim to observe in a group-on-group ultimatum game that proposer groups tend to follow the preferences of its "most competitive" member.[3] The result is a substantially more aggressive proposer group behavior, as in Bornstein and Yaniv [2]. Unfortunately, their responder groups are fictitious, and the

[3] They elicit the individual preferences from observations of one-one-one play by the same agents.

proposers don't explicitly observe rejections; it is thus impossible to figure out if they are best-responding to anything on the responder side. A more explicit laboratory implementation of intra-group decision-making has been conducted by Messick *et al.* [19], who compare group-on-group bargaining under two decision-making procedures in the responder group: in one treatment responders must unanimously agree to accept the offer, while in the other the unanimity is required for rejection. Strikingly, they do not observe any difference in proposer behavior, even though the best response in the former treatment seems to imply much less aggressive ultimatums than in the latter. However, there may be an important peculiarity in their experimental design, which complicates interpretation of their results.[4]

While the previously mentioned studies look at single-shot bargaining between inexperienced subjects, Grosskopf [11] studies behavior changes as agents learn from their experience. Comparing one-on-one and one-on-group ultimatum bargaining under a group decision rule similar to one of the treatments in Messick *et al.*'s [19] (unanimity required for rejection) she finds that though the agents might not be able to figure out the difference immediately, with experience a clear difference emerges between the play against groups versus play against individuals. In particular, she observes that when playing against groups proposers eventually learn to be more aggressive.

The rest of this paper is organized as follows: section 2 develops a simple model of ultimatum bargaining under incomplete information and derives testable predictions; section 3 discusses experimental design; section 4 presents laboratory results; section

[4] The problem is in their technique for eliciting responders' strategies. In standard ultimatum bargaining, the experimenter observes only acceptance or rejection of the actual offer, but not the entire strategy, which should specify what the agent would have done if he were to get a different offer. To overcome this, Messick et al. [19] require responders to report their entire strategies *before they see the offer* (in fact, they explicitly tell this to the proposers). Unfortunately, this forces responders to commit, thereby destroying the sequential nature of the game. As a result, subgame perfection provides no refinement of the Nash equilibrium, leaving us with a continuum of Nash equilibria, with pretty much any division of the surplus being a possible equilibrium outcome.

5 concludes.

2 The Model

We start by providing a simple incomplete information model of ultimatum bargaining, specified to the extent we shall be able to implement it in the lab. Our model most closely resembles those of Bolton and Ockenfels [1] and Fehr and Schmidt [10].

For simplicity, we shall assume that proposers care only about their monetary payoff, while responders may have other motivations. Though relaxable, this assumption can be somewhat justified by earlier experimental results, such as Prasnikar and Roth [21], as discussed in Roth [26]. Likewise, Kagel *et al.* [15] observe that proposers behave more aggressively, if they know that responders don't know the payoff size and so can't figure out if they are treated "unfairly" or "insultingly" by the proposers. This suggests that when unfairness works in one's favor, agents might not dislike it so much, as long as they can't be observed as unfair or punished for it. In the same vein, Fehr and Schmidt [10] cite psychological literature to support the assumption that people dislike unfairness that works in their favor less than they dislike the same when it works against them. Since in ultimatum games proposers typically get at least half the total payoff, we shall go further and suppress the fairness component of their utility. Incorporating some sort of "fairness" preference in proposers' utility does not present a serious difficulty, since it would only affect quantitative, but not qualitative predictions as to the comparative behavior of agents in different treatments of our experiment. Therefore, we assume that each (weakly) risk-averse proposer has a strictly increasing and concave Bernoulli utility function of money $u_p(x_p)$, where x_p is how much money she gets.[5]

[5] We are aware of the problems with assuming risk-aversion for experimental-sized stakes, or, more specifically, the apparent inconsistency between the small-stake and large-stake estimates of risk-aversion (see Rabin[22]). Since our results do not depend on it, and since the problem refers more to the overall appropriateness of the standard expected utility model in this setting, rather

The responder also likes money, but in addition she gets utility from being treated fairly. If she is facing a bad offer, she will prefer to reject, since that would result in a fairer distribution, or since it will punish the "insolent" proposer. We shall remain agnostic on the true nature of the possible rejection since our experiment is not designed to elicit this information. One possibility here is that the difference between the payoffs of the proposer and the responder enters his utility, which is thus $u_r(x_r, x_r - x_p)$, where x_r is her monetary wealth. To the extent that there are only two agents involved in actual play, the pair $(x_r, x_r - x_p)$ describes the entire monetary payoff distribution between them. Therefore, our approach is equivalent both to the Bolton and Ockenfels [1] assumption that the agents care about their share of the total and the Fehr and Schmidt [10] assumption that they care about absolute differences. We assume the function u_r to be increasing in both arguments.

The total payoff size available for sharing between a proposer and a responder is $\pi > 0$. The proposer has to choose a number $x \in [0, \pi]$ that she will offer to the responder, with the balance of $\pi - x$ being left to herself. The responder will accept the offer whenever

$$u_r(x, 2x - \pi) \geq u(0, 0)$$

and reject otherwise.[6]

If the proposer knows preferences of the responder, the subgame-perfect equilibrium is obvious. The proposer should choose $x^* \in [0, \pi]$ that solves.

$$u_r(x^*, 2x^* - \pi) = u(0, 0)$$

and the responder should only accept offers as high as, or higher than this x^*, where

than risk-aversion per se, we choose to allow the possibility of it.

[6] We assume acceptance in case of indifference; since it is a zero-probability event in the incomplete information version of the game, this assumption is innocuous.

$x^* \in \left[0, \frac{\pi}{2}\right)$.

Of course, the proposer can't *ex ante* observe (and experimenter can't exactly control) the responder's preferences. The only things subject to observation and experimental control are the monetary offer x and the total prize π. Therefore, the only thing known to the proposer is that each responder τ will reject offers below a certain cut-off value x_τ and that this x_τ is drawn from some probability distribution with the support $[0, \pi]$ with the distribution function $F(x)$.[7] Clearly, $F(x)$ can be interpreted as the acceptance probability of offer x.

We shall denote the probability of rejection $P(x) = 1 - F(x)$. Suppose that $P(\pi) = 0$ (if you give everything to the responder she always accepts) and $P(0) = 1$ (offers of nothing are always rejected), both of which are very robust empirical regularities observed in ultimatum game experiments. These assumptions clearly imply impossibility of corner solutions to the proposer's maximization problem. The proposer's expected payoff from the ultimatum x is

$$\Pi(x) = u_p(\pi - x)(1 - P(x))$$

Assuming differentiability of u_p and P, clearly $u_p' \geq 0$ and $P' \leq 0$. The first order necessary condition for expected utility maximization in the interior is

$$u_p'(\pi - x)(1 - P(x)) = -u_p(\pi - x)P'(x)$$

Furthermore, a necessary condition for maximization is $P(x) < 1$ (since $P(x) = 1$ would guarantee a zero payoff). The first order conditions are easily seen to be

[7] As noted above, $x_\tau \in \left[0, \frac{\pi}{2}\right)$. This seems to be confirmed empirically, since large offers almost never get rejected. On the other hand, large offers (above half of the total prize), though rare, do occur, which can't be explained as a best response under the belief that cutoffs are distributed with the support $x_\tau \in \left[0, \frac{\pi}{2}\right]$. Perhaps, some proposers have a different model of recipients in mind, which allows for higher cutoffs.

sufficient if $P(x)$ is convex at x.[8]

2.1 Group bargaining

The group bargaining framework has to be designed as closely as possible to the one-on-one treatment in order to minimize any unmodelled difference in behavior. For this reason, we preserve the symmetry between the sides by assuming the same group size of proposers and responders and equipartition of the monetary payoff within each side. This avoids either payoff scale differences or public good/ efficiency aspects which would be inevitable if the symmetry were to be broken.

Consider the ultimatum bargaining between groups of three proposers and three responders for a prize 3π. The proposers' share of the prize will be divided equally between the proposers and the responders' share between the responders. An ultimatum x shall mean that each proposer gets $\pi - x$, and each receiver gets x. Under these conditions the pair $(x, \pi - x)$ continues to completely describe the distribution of the monetary payoffs in case of acceptance.

In what follows we explore consequences of three intra-group decision rules among the responders: majority decision to accept/ reject; unanimity needed to overturn acceptance; unanimity needed to overturn rejection.[9]

In general, the voting games played by the responders will have multiple equilibria, since, for instance, if I believe that all my partners in a group always vote to accept and the decision rule is majority, I am indifferent between voting to accept and

[8] Since we do not observe $P(x)$ directly, there is a possibility of multiple local maxima, though multiplicity of global maxima is clearly non-generic in the space of utility functions and rejection probabilities.

[9] We could have considered another alternative: the dictatorship (one agent chosen to make the decision to accept or reject for the entire group). Note though a recent paper by Charness and Jackson [8], who find in the context of the Stag Hunt games that the dictator group-on-group game may be played differently from the one-on-one game (at least as far as equilibrium selection is concerned) due to a feeling of responsibility on the part of the dictator. We do not model it here though, so the dictator rule would be equivalent to the one-on-one game.

to reject. Note, however, that such equilibria in a one-shot voting game involve playing weakly dominated strategies. In fact, for a voter facing an ultimatum x doing anything other than voting sincerely is weakly dominated by sincere voting (this is an election between just two alternatives). Therefore, we shall only consider sincere voting equilibria. Clearly, in such equilibria the outside observer's *ex ante* probability $P(x)$ of an agent voting to reject an offer x is *constant across the treatments.* We shall take this to be the first comparative static prediction of our model.

The above discussion provides an additional reason to give up on eliciting the entire strategies of responders (as attempted, for instance, by Messick *et al.* [19]): even the simple cut-off acceptance/ rejection strategies are relatively complex objects and if voting over them would be allowed, empirically disentangling the multiple equilibria could be hard. On the other hand, at their action node the responders face a simple binary decision: accept or reject the offer in front of them. Unfortunately, the action of proposers is more complicated: they have to choose a number in the $[0, \pi]$ interval. As in the responder case, we want to avoid voting complications and/or having to impose an elaborate voting protocol in the lab. For this reason, given a more complicated decision facing the proposers, we shall let each proposer make his ultimatum ignorant of the rest, and then randomly choose one of the ultimatums to be presented to the responders, making it optimal for each proposer to act as if he were a dictator on their side of the game.

Since, as discussed above, we expect *individual* responder behavior $P(x)$ to be constant across treatments, *group* rejection probabilities should vary predictably with the group decision rule. The following table summarizes the rejection probability under each of the four intra-group decision rules on the ultimatum responder side:

Group Decision Rule	Default	Probability of Rejection
Individual Response	-	$P(x)$
Majority Rule	-	$P^3(x) + 3P^2(x)(1 - P(x))$
Unanimity Rule	Accept	$P^3(x)$
Unanimity Rule	Reject	$1 - (1 - P(x))^3$

This implies, that the *proposer's* expected utilities for the ultimatum x are as follows:

Group Decision Rule	Default	Expected Utility: $\Pi(x)$
Individual Response	-	$u_p(\pi - x)(1 - P(x))$
Majority Rule	-	$u_p(\pi - x)(1 - P(x))^2(1 + 2P(x))$
Unanimity Rule	Accept	$u_p(\pi - x)(1 - P^3(x))$
Unanimity Rule	Reject	$u_p(\pi - x)(1 - P(x))^3$

The first order necessary conditions for expected utility maximization, simplified by noticing that $P(x) < 1$ in the optimum and dividing both sides by equal positive factors, are as follows:

Group Decision Rule	Default	FOC Expected Utility Maximization
Individual Response	-	$u_p'(\pi - x)(1 - P(x)) = -u_p(\pi - x)P'(x)$
Majority Rule	-	$u_p'(\pi - x)(1 - P(x))(1 + 2P(x)) = -6u_p(\pi - x)P'(x)P(x)$
Unanimity Rule	Accept	$u_p'(\pi - x)(1 - P^3(x)) = -3u_p(\pi - x)P'(x)P^2(x)$
Unanimity Rule	Reject	$u_p'(\pi - x)(1 - P(x)) = -3u_p(\pi - x)P'(x)$

Without a further assumption on P, multiple local maxima are possible. Though global maximum, generically (in either P or u), would be unique, multiplicity of local maxima might allow the global maximum to "jump" depending on the voting rule, which might create problems with identifying the impact of the rules. Unfortunately, P is not directly observable, either by the experimenters or by the subjects. The following assumption, which is satisfied by most "symmetric" models of rejection probability (such as linear, logit or probit), would avoid this problem.

Assumption A: $P(x)$ is (weakly) convex whenever $P(x) \leq \frac{1}{2}$.

We can now state the following proposition

Proposition 1 *Let assumption A hold. The optimal offers by any risk-averse individual in each treatment will be ranked as follows (where the subscript UAD stands for unanimity with acceptance default, URD - for unanimity with rejection default, MR - for majority rule and I - for the one-on-one case):*

$$x_{UAD} < x_I < x_{MR} < x_{URD}, \quad \textit{if } P(x) > \frac{1}{4}$$

$$x_{UAD} < x_{MR} < x_I < x_{URD}, \ \textit{if } P(x) < \frac{1}{4}$$

Proof. The proof is done by comparing the first order conditions. Since it has been assumed that $P(0) = 1; P(\pi) = 0$, the solution is interior. Furthermore, assumption A ensures that, as long as $P(x) \leq \frac{1}{2}$, the first order conditions are sufficient and that there is at most one local maximum for each voting rule in this range. But for all voting rules, other than unanimity with acceptance default, this must be the global maximum, since the proposer can always ensure the payoff equal to $u_p\left(\frac{\pi}{2}\right)$ by offering to share the prize equally, which, as has been discussed above, will always be accepted.

Consider now the optimal offer x_I in the one-on-one game. Then

$$u_p'(\pi - x_I)(1 - P(x_I)) = -u_p(\pi - x_I) P'(x_I)$$

Comparing this with the first order condition for the unanimity with acceptance default game, observe that

$$u_p'(\pi - x_I)\left(1 - P^3(x_I)\right) > -3u_p(\pi - x_I) P'(x_I) P^2(x_I)$$

as long as $P(x_I) < 1$. Since offering a proposal that would spur rejection with probability one cannot be optimal for the proposer, the inequality must hold. The right-hand side is decreasing in x, the left is increasing in x, hence to restore equality x has to be decreased for the optimum in the unanimity (with acceptance default) case to be achieved. Though unanimity with acceptance default is the only rule considered here for which the true global maximum might involve $P(x) > \frac{1}{2}$, that would imply even more aggressive behavior by the proposers, so that the conclusion that $x_{UAD} < x_I$ is maintained.

Similarly, for the unanimity with rejection default game

$$u_p'(\pi - x_I)(1 - P(x_I)) < -3u_p(\pi - x_I) P'(x_I)$$

and x has to be increased to get to the optimum (unique, since in this case, as noted above, $P(x) \leq \frac{1}{2}$ must hold at the maximum).

We have established that $x_{UAD} < x_I < x_{URD}$. It can be similarly shown that

$x_{UAD} < x_{MR} < x_{URD}$. To establish the position of x_{MR} vis a vis x_I observe that

$$u_p'(\pi - x_I)(1 - P(x_I))(1 + 2P(x_I)) \quad > \quad -6u_p(\pi - x_I) P'(x_I) P(x_I)\,,\ \textit{if}\ P(x) < \frac{1}{4}$$

$$\text{and}$$

$$u_p'(\pi - x_I)(1 - P(x_I))(1 + 2P(x_I)) \quad < \quad -6u_p(\pi - x_I) P'(x_I) P(x_I)\,,\ \textit{if}\ P(x) > \frac{1}{4}$$

To see the necessary direction of change of x divide both sides of the previous inequality condition by $P(x) > 0$ to get

$$\frac{u_p'(\pi - x_I)}{P(x_I)}(1 - P(x_I))(1 + 2P(x_I)) < (>) - 6u_p(\pi - x_I) P'(x_I)$$

with the left-hand side increasing and the right hand side decreasing in x. ■

Empirical predictions summarized by the Proposition 1 admit a broad array of the shapes of u and P. Furthermore, the (weak) risk-aversion and (weak) convexity of P in the relevant part of the domain are not necessary and could be further relaxed.

Predictions for the play against the unanimity groups are very straightforward; less so with the case of the majority rule. The equilibrium rejection probability of observed offers depends on the proposers' degree of risk-aversion and the shape of the rejection probability $P(x)$, both of which are hard to control in an experiment. Both offers that face higher and lower rejection probability than $\frac{1}{4}$ are likely to be observed. However, we do have a clear qualitative prediction in that the less aggressive proposers in the one-on-one treatment should become somewhat more aggressive when playing against majority-rule groups, while the initially more "aggressive" proposers are predicted to moderate their behavior somewhat in this case (though they would still be relatively more aggressive than the initially less aggressive types).

Our comparative statics prediction on group action is contingent on the individual rejection probability $P(x)$ being constant across treatments. This, in turn, crucially depends on the agents caring *only* about monetary payoff *distributions* in the game. Thus, for instance, if the agents get utility from voting to reject even when it has no impact on payoff distribution (one could term this "punishment" or "expression of annoyance" utility), then being in a group would make negative votes likelier, since whenever an agent is non-pivotal the “no” vote is costless. Clearly, this would imply a higher $P(x)$ in group treatments, as compared to the one-on-one case. Alternatively agents might want to rely on their group partners to figure out the “right” behavior. While no communication between agents within a group is allowed, an agent who thinks his or her partners “know better” could let them decide by avoiding casting a determining vote. Of course, this would imply avoiding to vote for the default option in each of the unanimity treatments, thus leading to higher $P(x)$ when default is acceptance, and lower $P(x)$ when default is rejection. We shall keep in mind these alternative comparative statics when analyzing the experimental results.[10]

3 Experimental Design

3.1 Structure of the Ultimatum Bargaining

Our experimental design looks at the outcomes of the ultimatum bargaining game when two groups of players have to bargain over an amount of money: a group of 3 players ("proposers") suggests a division of a fixed amount of money, and a second group of 3 players ("responders"), accepts or rejects it. After observing the proposal, responders must decide whether to accept or reject it following a pre-determined voting rule. If responders reject the proposal, no group receives any pay, and if responders accept, each group receives the amount specified in the proposal.

[10]It is quite straightforward to develop the relevant comparative statics for each of the alternative theories proposed in this paragraph. The reason we decided not to make the model in this paper general enough to incorporate these possibilities is simply that in our experimental results we find no evidence for the individual rejection probability $P(x)$ varying across treatments, so that the simpler model introduced in this section is indeed the one most consistent with our observations.

Each voting rule specifies a treatment for our group-on-group ultimatum bargaining. We consider the following three voting rules:

Unanimity with Rejection Default (URD): An offer is considered accepted when every member of the responder group votes to accept it. Otherwise it is considered rejected.

Unanimity with Acceptance Default (UAD): An offer is considered rejected when every member of the responder group votes to accept it. Otherwise it is considered accepted.

Majority Rule (MR): An offer is considered accepted when at least two members of the responder group votes to accept it. Otherwise it is considered rejected.

As a control treatment, we use a standard one-on-one ultimatum bargaining, where an agent, the proposer, suggests a division of a fixed amount of money, and a second agent, the responder, accepts or rejects it. If the responder rejects, no individual receives any pay, and if he accepts, each individual receives the amount specified in the proposal.

In order to test the model's prediction that a less (more) aggressive proposer in a one-on-one ultimatum bargaining becomes somewhat more (less) aggressive when playing against groups, we consider a sequential design with two treatments: in the first treatment, a one-on-one ultimatum bargaining is followed by a group-on-group ultimatum bargaining where the responder groups have to decide whether to accept using the majority voting rule. In the second treatment, we reverse the order by having the subjects play majority-rule group-on-group bargaining game before the one-on-one game.

Tables 1 and 2 summarize each experimental design, the treatments, the group size, and the number of subjects per session.

Table 1: Independent Design

Experimental Treatments of the Ultimatum Bargaining	Group Size	# of Subjects per Session
Standard One-on-One	1	24 and 30
Unanimity with Rejection Default	3	30 and 30
Unanimity with Acceptance Default	3	30 and 30
Majority Rule	3	24 and 30

Table 2: Sequential Design

First Ultimatum Bargaining	Group Size	# of Subjects per Session	Second Ultimatum Bargaining	Group Size	# of Subjects per Session
One-on-One	1	28^+	Majority Rule	3	24
Majority Rule	3	24	One-on-One	1	24

$^+$: Four subjects were randomly excluded after the one-on-one session in order to have an even number of groups in the group-on-group ultimatum bargaining.

3.2 Design Parameters

This section describes the general experimental procedure.

Participants and Venue. Subjects were drawn from a wide cross–section of undergraduate students at Instituto Tecnológico Autónomo de México (ITAM) in Mexico City. The recruitment was done from among those enrolled in introductory classes, in order to avoid those exposed to higher-level economics courses, such as game theory. Each subject participated in only one session. The experiment was run at ITAM using computers.

Number of Periods. In order to familiarize subjects with the procedures, two practice periods were conducted before the 10 real (affecting monetary payoff) periods. For the sequential design, two practice periods were conducted before the 10 real periods in the first ultimatum bargaining, and one practice period was conducted before the 10 real periods in the second ultimatum bargaining.

Agent Types. For each of the group-on-group treatments, each participant was designated as a member of a type A group (i.e., proposers) or a member of a type B group (i.e., responders). For the one-on-one treatment, each participant was designated either as a type A agent (i.e., proposer) or as a type B agent (i.e., responder) before the beginning of the practice periods. All designations were determined randomly by the computer at the beginning of the experimental session, and remained constant during the entire session. For the sequential design, each participant type was determined at the beginning of a session and preserved across bargaining situations.

Matching Procedure and Group Size. For each of the group-on-group treatments, membership of each group was changed in a random fashion, so that each participant formed part of a new group (of the same type) at the beginning of each period. Each group consisted of three participants. For the one-on-one treatment, a type A agent was paired with a type B agent, and each pairing was randomized for each period. Furthermore, agents did not know who they were paired with in any given period.

Bargaining Procedure. Subjects were informed that they had to bargain over 100 points. For the group-on-group treatments, the task of each pair of groups was to divide 100 points in each period using the following rules: a) group A had to make a final offer of points to group B; b) to make a final offer, each group A member had to write and send an offer via computer, each offer being in the range from 0 to 100 points; c) one of these offers was chosen randomly by the computer as group A final offer to group B; d) upon receiving the final offer, group B members had to decide whether to accept or reject the offer according to the voting rule announced for this session. No communication, except as explicitly discussed in this and next paragraph, was allowed among participants. For the one-on-one treatment a type A agent had to make and send an offer to a type B agent, and after receiving the offer, the type B agent had to decide on his own whether to accept or reject it.

Information Feedback. For the group-on-group treatments, group A members observed only their own offer and the final offer sent to group B (in case the final offer equaled an agent's own proposal, he had no way of telling if he was chosen or somebody else offered the same amount). Group B members observed the final offer, but not the other offers made by group A members. At the end of each round, members of both groups were informed whether the final offer was accepted or rejected, the number of individual acceptance and rejection votes (between 0 and 3) in the responder group, and the number of points obtained by their group in that round. For the one-on-one treatment, each agent learned whether the offer was accepted or rejected and her own amount of points obtained for that round.[11]

Payoffs. The final payoff for each treatment in the independent design was determined by randomly selecting one of the 10 real rounds. For the sequential design, the final payoff for each bargaining situation was determined by randomly selecting one round out of 10 real periods of each game played. The pay for the chosen period was calculated as follows: Each group member got $2.6 Mexican pesos (about 23 US cents) for each point obtained by her own group, in addition to the basic amount of $20 pesos (roughly US$1.75) for participation. Thus, each pair of groups effectively bargained over $780 pesos (around US$68 in year 2004 when the experimental sessions where conducted). For the one-on-one treatment, each pair of agents had to bargain over $260 pesos. In the sequential design one period was chosen for each of the games played, so that size of the pie was equal to $780 pesos ($260 pesos) for *each* game.

4 Experimental Results

This section compares the experimental results from the four treatments of ultimatum bargaining discussed in the previous section. We concentrate on measuring how

[11] Note that the proposer group is observing the decision made by each member of the responder group. Revealing this information could help proposers to update their beliefs about the probability of individual and group rejection, and thus may induce some kind of learning behavior across periods.

Table 3: Summary of Experimental Results: One-on-One and Group Majority Rule

Offer	One-on-One		Majority Rule			
Range	Ind. Off.	Ind. Rej.	Ind. Off.	Grp. Off.	Ind. Rej.	Grp. Rej.
> 50	1.6	0.0	1.2	1.2	0.0	0.0
	(8)	(0)	(6)	(2)	(0)	(0)
$= 50$	11.8	1.7	13.7	13.7	3.0	0.0
	(60)	(1)	(66)	(22)	(2)	(0)
45 - 49	18.4	5.3	17.4	17.4	7.1	3.6
	(94)	(5)	(84)	(28)	(6)	(1)
40 - 44	29.4	7.3	19.9	19.9	17.7	9.4
	(150)	(11)	(96)	(32)	(17)	(3)
35 - 39	16.7	21.2	18.6	18.6	32.2	33.3
	(85)	(18)	(90)	(30)	(29)	(10)
30 - 34	9.2	12.8	9.3	9.3	24.4	20.0
	(47)	(6)	(45)	(15)	(11)	(3)
25 - 29	8.6	38.6	12.4	12.4	30.0	25.0
	(44)	(17)	(60)	(20)	(18)	(5)
< 25	4.3	77.3	7.5	7.5	58.3	58.3
	(22)	(17)	(36)	(12)	(21)	(7)
All Off.	100.0	17.0	100.0	100.0	21.5	18.0
	(510)	(75)	(483)	(161)	(104)	(29)
Statistics						
Avg.	40	31	38	38	32	30
Med.	40	30	40	40	35	33
Var.	73	78	99	100	94	87
# Excl.	2		2			

Note: The number in parentheses below each percentage represents the number of times the occurrence was observed.

Table 4: Summary of Experimental Results: Group Unanimity Rules

Offer	Unanimity with Rejection Default				Unanimity with Acceptance Default			
Range	Ind. Off.	Grp. Off.	Ind. Rej.	Grp. Rej.	Ind. Off.	Grp Off.	Ind. Rej.	Grp. Rej.
> 50	14.0	10.0	0.0	0.0	8.0	6.0	5.6	0.0
	(42)	(10)	(0)	(0)	(24)	(6)	(1)	(0)
$= 50$	12.7	10.0	0.0	0.0	2.3	3.0	0.0	0.0
	(38)	(10)	(0)	(0)	(7)	(3)	(0)	(0)
45 - 49	33.7	32.0	5.2	15.6	11.0	17.0	5.9	0.0
	(101)	(32)	(5)	(5)	(33)	(17)	(3)	(0)
40 - 44	18.0	20.0	13.3	25.0	16.3	19.0	19.3	0.0
	(54)	(20)	(8)	(5)	(49)	(19)	(11)	(0)
35 - 39	9.7	12.0	22.2	50.0	27.3	20.0	35.0	5.0
	(29)	(12)	(8)	(6)	(82)	(20)	(21)	(1)
30 - 34	7.0	9.0	33.3	66.7	15.7	17.0	49.0	17.6
	(21)	(9)	(9)	(6)	(47)	(17)	(25)	(3)
25 - 29	2.3	3.0	66.7	100.0	8.0	5.0	33.3	0.0
	(7)	(3)	(6)	(3)	(24)	(5)	(5)	(0)
< 25	2.7	4.0	91.7	100.0	11.3	13.0	59.0	23.1
	(8)	(4)	(11)	(4)	(34)	(13)	(23)	(3)
All Off.	100.0	100.0	15.7	29.0	100.0	100.0	29.7	7.0
	(300)	(100)	(47)	(29)	(300)	(100)	(89)	(7)
Statistics								
Avg.	44	43	29	33	36	37	31	26
Med.	47	45	30	35	36	38	33	33
Var.	113	121	174	139	125	143	118	110
# Excl.	0				0			

Note: The number in parentheses below each percentage represents the number of times the occurrence was observed different voting rules affect individual and group rejection rates and proposals.

Table 3 describes for the one-on-one treatment the distribution of individual proposals and rejections aggregated across all ten periods. The offer range indicates the amount of points a proposer is willing to give to a responder. Consider, for example, the offer range from 35 to 39. In the one-on-one treatment the number of proposals within this range was 49 out of a total of 390 observations, *i.e.*. 12.6% (49/390). Likewise, the number of offers in this range rejected by the responders was 14, resulting in the empirical rejection rate of 28.6% (14/49).

In the same table we also provide the data for majority rule group-on-group treatment. As in the one-on-one case, consider the offer range from 35 to 39. The total number of individual proposals within this range was 90, which makes up 18.6% of the total of 483 offers in this treatment. Since just 1 out of 3 proposals was randomly chosen to be sent to a responder group, the group proposals are simply a random selection of the individual ones. The number of group proposals within this range was 30 out of a total of 161 offers sent. Therefore, the group offers proportion was 18.0% (30/161). Since all 3 members of a responder group received the same offer, the individual rejection number within this range was 29; with a total of 90 observations (30×3), the individual rejection rate for this range was 32.2% (29/90). At group level, the number of rejections within this range was 10 out of 30, resulting in a 33.3% (10/30) group rejection rate. Table 4 provides the same information for both unanimity treatments.

At the bottom of Tables 3 and 4 some summary statistics are shown for the offers made and offers rejected. For the one-on-one and majority rule, the statistics exclude some subjects' offers. For the one-on-one case, two subjects were excluded: one subject that offered 100 for 8 consecutive periods and then 45 twice and another subject that offered 1 for 6 consecutive periods and then 15, 50, 30, 20.[12] For the

[12] For the one-on-one treatment we excluded subjects 63 and 74. We believe the former of these

majority rule, offers of two subjects were excluded: one subject that offered 5 times more than 90 then 50 and then 4 times less than 15, and one that offered 5 times more than 90, 3 times between 70 and 80, twice at 50 and then offered 1.[13] For both unanimity treatments, no subjects were excluded.

4.1 Responder Behavior

We begin by checking whether individual voting behavior and group rejection rates differ across treatments, conditional on the offer size. In particular, the model suggests that individual rates of voting for rejection should not differ across different treatments and that the group rejection rate for unanimity with rejection default should be higher than for the one-on-one treatment, and these two higher than for the unanimity with acceptance default. Meanwhile, majority rule rejection rate should be higher than for the one-on-one treatment for $P(x) < 1/2$ and lower, otherwise.

At individual level, each *individual decision* to (vote to) accept or to reject a specific offer is treated as one observation. At group level, each *group decision* to accept or to reject a specific offer is treated as one observation. At each level we have a total of six different treatments for which we observe rejection behavior: i) decisions to accept/ reject by individuals who played a one-on-one ultimatum bargaining only;[14] $ii - iv$) decisions by individuals/groups who played a group-on-group ultimatum bargaining under a specific voting rule only; v) decisions by individuals who played a one-on-one ultimatum bargaining having previously experienced play-

to be confused about the meaning of the offer (i.e., whether it was the offer to the responder or the fraction retained by him). The latter, probably, took a game theory class and was aware of the ultimatum bargaining game (in fact, one subject cried out as they were leaving the room after that session: "it is not rational!").

[13] Excluded for the majority rule treatment were subjects 359 and 368. Subject 359 offers were picked as a final group offer five times. These offers were equal to 100, 100, 95, 50 and 5. Subject 368 offers were picked as a group final offer in four periods. These offers were equal to 90, 97, 95, and 1. As in the other case, the subjects might have been confused about the meaning of the offer.

[14] Here and in case (v) below, group and individual decisions are clearly tautologically the same.

ing group-on-group ultimatum bargaining under the majority voting rule; and *vi*) decisions by individuals/groups who played a group-on-group ultimatum bargaining under the majority voting rule having previously experienced playing one-on-one ultimatum bargaining game.

Subjects played multiple rounds of the bargaining game and each individual's actions over time are clearly not independent. For this reason, as well as for comparison with such earlier studies as Bornstein and Yaniv [2] and Messick *et. al.* [19], in which subjects played the game only once, we initially attempted to test our hypotheses using only first period data.[15] However, the results of our statistical analysis using single period data are inconclusive.[16] While we are unable to reject the hypothesis that individual probabilities of voting to reject, conditional on offer size, are the same across the treatments, neither do group rejection probabilities vary across treatments in a statistically significant way. But if agents' individual voting behavior is the same in different treatments, this immediately implies that the group outcomes have to be different (simply plugging numbers into a formula in section 2 one would observe that if the probability of individual voting to reject a given offer is, say 25%, then under unanimity with acceptance default the three-person group will only reject with less than 2% probability, while the unanimity with rejection default will result in the rejection probability of nearly 58%). Therefore, we infer that our sample size is insufficient to make any conclusions from the single-period observations.[17] In what

[15]We also attempted doing the same with last period data only, with the same inconclusive results.

[16]Detailed regression results are available from the authors upon request.

[17]It should be noted, that our sample size is not particularly small by the literature standards. Thus, Bornstein and Yaniv [2] have only 20 one-on-one and 20 group-on-group observations (they only observe final group decisions). In all, they observe only 2 rejections, making it difficult to make conclusions about rejection probabilities. Our failure to establish significant results using just first period data also closely parallels that of Slonim and Roth [27] in their study of high-stakes ultimatum bargaining. As discussed in detail in that paper, a major problem here is lack of exogenous variation of offers, which makes it hard to estimate the difference in conditional rejection probabilities across treatments from one period data only, without observing many more subjects than is typical in a laboratory experiment.

follows we instead present results of the statistical analysis involving data from all 10 experimental rounds.[18]

We consider the following model for estimating individual rejection probability:

$$\begin{aligned}\Pr(Reject_i = 1) = F(\alpha + \beta_{offer} Offer_i + \beta_{urd} URD + \beta_{uad} UAD + \beta_{mr} MR \\ + \beta_{expgog} EXPGNG + \beta_{expono} EXPONO + \sum_{j=2}^{20} \alpha_j Per_j)\end{aligned} \quad (3)$$

where $Offer_i$ is the offer *individual* i receives from 0 to 100; URD, UAD and MR are dummies for each of the voting rules, $EXPGNG$ is a dummy for those individuals who played one-on-one ultimatum bargaining having first experienced playing group-on-group ultimatum bargaining under the majority voting rule. $EXPONO$ is a dummy for those individuals who played group-on-group ultimatum bargaining under the majority voting rule having first experienced playing one-on-one ultimatum bargaining. Per_j is a dummy variable for every period, treating time as a discrete variable; $F(z_i) = \frac{1}{1+e^{-z_i}}$ is the cumulative logistic distribution function; and $Reject_i = 1$ means that an offer was rejected.[19] We use a random effect logit model to account for individual agent variability. This specification checks whether different voting rules affect *individual* rejection probability in addition to the offer size. We expect the offer size coefficient to be less than zero ($\beta_{offer} < 0$), meaning that the rejection probability should be lower for higher offers. At individual level, we expect all treatment coefficients be equal to zero ($\beta_{urd} = \beta_{uad} = \beta_{mr} = 0$).

In the first column of Table 5 we present the logit estimations for rejection rate probability at individual level. A χ^2 test for this model indicates that the null hypothesis of all the estimated coefficients being equal zero can be rejected for a $p < 0.001$.

[18] Of course, in doing this we have to adjust our statistical analysis for individual-specific effects.

[19] For these and further estimation analyses we exclude the offers made by the four subjects mentioned above.

Table 5: Probability of Offer Rejection for All Periods: Logit Estimation

Coefficients	Individual Level	Group Level
Intercept	5.580***	10.383***
Offer	-0.211***	-0.358***
Unanimity with	0.293	2.795***
Rejection Default	($p = 0.65$)	
Unanimity with	0.520	-5.102***
Acceptance Default	($p = 0.39$)	
Majority Rule	-0.335	-4.458
	($p = 0.25$)	($p = 0.08$)
Majority×Offer		0.102
		($p = 0.16$)
Experienced Group-on-Group	-1.808	-2.555***
Ultimatum Bargaining	($p = 0.07$)	
Experienced One-on-One	0.083	0.343
Ultimatum Bargaining	($p = 0.93$)	($p = 0.83$)
Dummies for Period	n.r.+	n.r.+
# of Obs.	1593	871
Log Likelihood	-533.7	-248.9

*: p<0.05, **: p<0.01 and ***: p<0.001.

+: Not reported in the estimation.

The offer size coefficient (β_{offer}) is correct in sign and significant. None of the treatment coefficients (β_{urd}, β_{uad} and β_{mr}) show individual significance for a $p < 0.05$. A χ^2 test indicates that the null hypothesis of $\beta_{urd} = \beta_{uad} = \beta_{mr} = 0$ cannot be rejected for a $p = 0.55$. None of the experience treatment coefficients (β_{expgog} and β_{expono}) show significance for a $p < 0.05$. A χ^2 test indicates that the null hypothesis of $\beta_{expgog} = \beta_{expono} = 0$ cannot be rejected for a $p = 0.09$. None of the time-period coefficients are significantly different from zero for a $p < 0.05$. A χ^2 test indicates that the null hypothesis of all time-period coefficients being jointly different from zero cannot be rejected for a $p = 0.10$. Thus, time does not seem to contribute to explaining rejection rate variations across periods. Finally, a χ^2 test indicates that the null hypothesis of the voting rules, experience and time period coefficients being jointly equal to zero can be rejected for a $p < 0.001$. This result indicates that this model performs better than a specification that does not include these dummy variables, indicating possible role, at least, for time and experience variables in explaining individual rejection probabilities.

Figure 1 shows the expected group rejection probabilities based on the individual rejection response $P(x)$ estimated in this model.

At group level, we consider the following specification:

$$\Pr(Reject_i = 1) = F(\alpha + \beta_{offer} Offer_i + \beta_{urd} URD + \beta_{uad} UAD + \beta_{mr} MR$$

$$+ \beta_{mro} MR \times Offer_i + \beta_{expgog} EXPGNG + \beta_{expono} EXPONO + \sum_{j=2}^{10} \alpha_j Per_j) \quad (4)$$

where $Offer_i$ is the offer *group i* receives from 0 to 100; URD, UAD and MR are dummies for each of the voting rules, $EXPGNG$ is a dummy for those groups that played a one-on-one ultimatum bargaining having first experienced playing within a group an ultimatum bargaining under the majority voting rule. $EXPONO$ is a

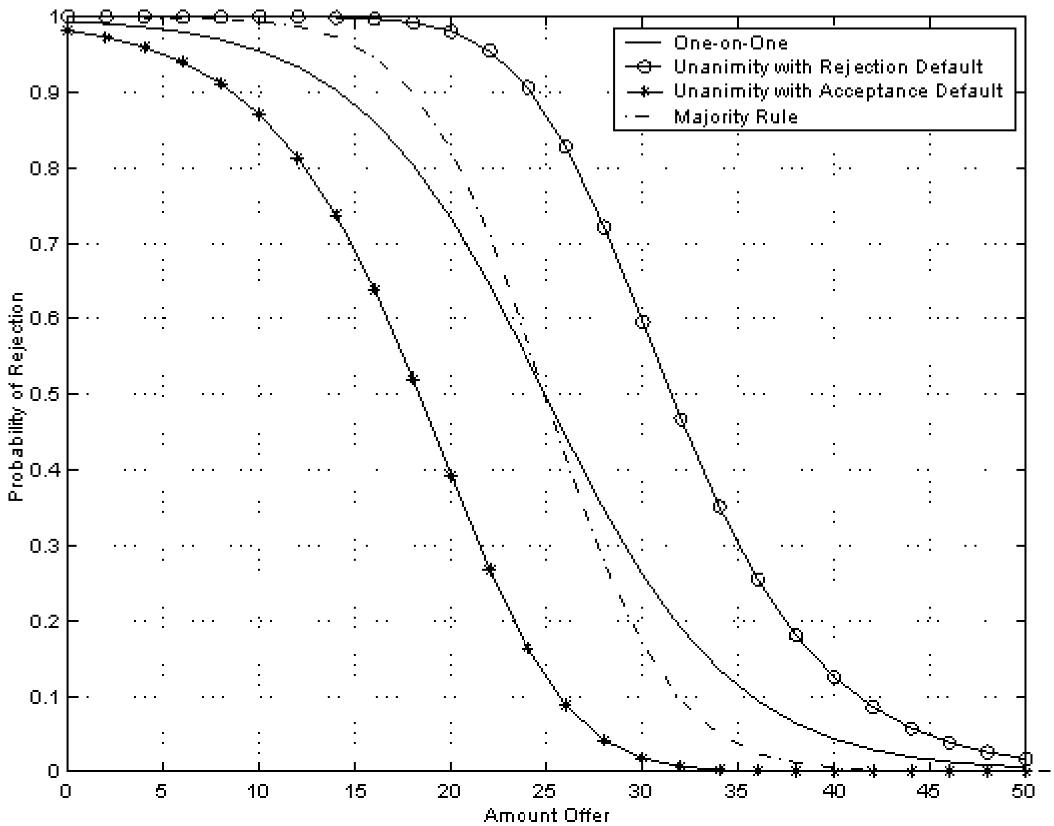

Figure 1: Expected Group Rejection Probabilities based on Individual Response Estimation from specification (3) (Column 1, Table 6)

dummy for those groups that played group-on-group ultimatum bargaining under the majority voting rule whose members experienced playing one-on-one ultimatum bargaining; $F(z_i) = \frac{1}{1+e^{-z_i}}$ is the cumulative logistic distribution function; $Reject_i = 1$ means that an offer was rejected. This model checks whether different voting rules affect *group* rejection probability in addition to the offer size. As in the previous model, we should expect the offer size coefficient be less than zero ($\beta_{offer} < 0$). On the other hand, we should expect that the unanimity treatment coefficients differ in sign ($\beta_{urd} > 0$, $\beta_{uad} < 0$), where a positive coefficient should indicate a higher probability of rejection for a given offer than a negative coefficient. This specification takes into account for majority rule the possibility of higher rejection rates for lower offers and lower rejection rates for higher offers ($\beta_{mr} > 0$ and $\beta_{mro} < 0$).

In the second column of Table 5 we present the logit estimations for rejection rate probability at group level. A χ^2 test for this model indicates that the null hypothesis of all the estimated coefficients being equal zero can be rejected for a $p < 0.001$. The offer size coefficient (β_{offer}) is still negative and significant. The coefficients for both unanimity treatments at group level both are significant and have expected signs: the positive unanimity with rejection default coefficient ($\beta_{urd} > 0$) indicates that rejection probability is higher when a responder group has to decide according to this voting rule, while the negative unanimity with acceptance default coefficient ($\beta_{uad} < 0$) indicates that rejection probability is lower when a responder group has to decide according to this voting rule. On the other hand, the majority rule coefficients (β_{mr} and β_{mro}) exhibit opposite signs to what was expected. However, none of these coefficients are significantly different from zero for a $p < 0.05$. Additionally, a χ^2 test result indicates that the null hypothesis of $\beta_{mr} = \beta_{mro} = 0$ cannot be rejected ($p = 0.155$), indicating that we cannot really distinguish between the on-on-one and the group-on-group majority voting rule treatment in terms of rejection probability. Overall, a χ^2 test result indicates that the null hypothesis of $\beta_{urd} = \beta_{uad} = \beta_{mr} = \beta_{mro} = 0$ can be rejected for a $p < 0.001$, favoring the joint significance of these treatment variables. Our estimation also shows significance for the subjects' prior experience playing a different version of the ultimatum bargaining game. In particular, those individuals who experienced playing the ultimatum within a group under the majority voting rule seem to reduce the group rejection probability when playing the one-on-one ultimatum. Although the reverse order of experience does not seem to be significant, a χ^2 test indicates that the null hypothesis of $\beta_{expgog} = \beta_{expono} = 0$ can be rejected for a $p < 0.01$. Among the time-period coefficients, just the last period coefficient is significantly different from zero for a $p < 0.05$ (it is significantly lower than zero, indicating a reduction in the group probability of rejection). However, a χ^2 test indicates that the null hypothesis of all time period coefficients being jointly different from zero cannot be rejected for a $p = 0.29$. Thus, time does not seem to contribute to explaining group rejection rate variations across periods. Finally, a χ^2 test indicates that the null hypothesis of the voting rules, experience and time period coefficients being jointly equal to zero can be rejected for a $p < 0.001$. This result indicates that this model performs better than a specification that does not include these dummy variables.

Figure 2 shows estimated group rejection probabilities from equation (4) and the actual rejection rates for different offer intervals.

Summing up, the rejection probability estimations using the data set from all ten periods show how different voting rules affect individual and group responses in ultimatum bargaining. On one hand, individuals tend to respond by voting in the same way whether they are deciding within a group or alone, which supports our model, as developed in the theory section. In particular, it suggests that we are justified in modeling agents as only caring about the distribution of monetary payoffs. On the other hand, different voting rules affect group rejection probabilities as expected (this is, of course, implied by the previous finding). Not surprisingly, smaller offers result in higher rejection probability. Finally, we observe that time does not matter in predicting individual behavior. In particular, the same offers are equally likely to be rejected over time. However, subjects' experience playing as a members of a group might influence rejection rates when playing as individuals. Figure 3 shows a comparison between the expected group response and the estimated group response for each treatment. We conclude that our qualitative comparative static predictions for the rejection probabilities seem to hold.

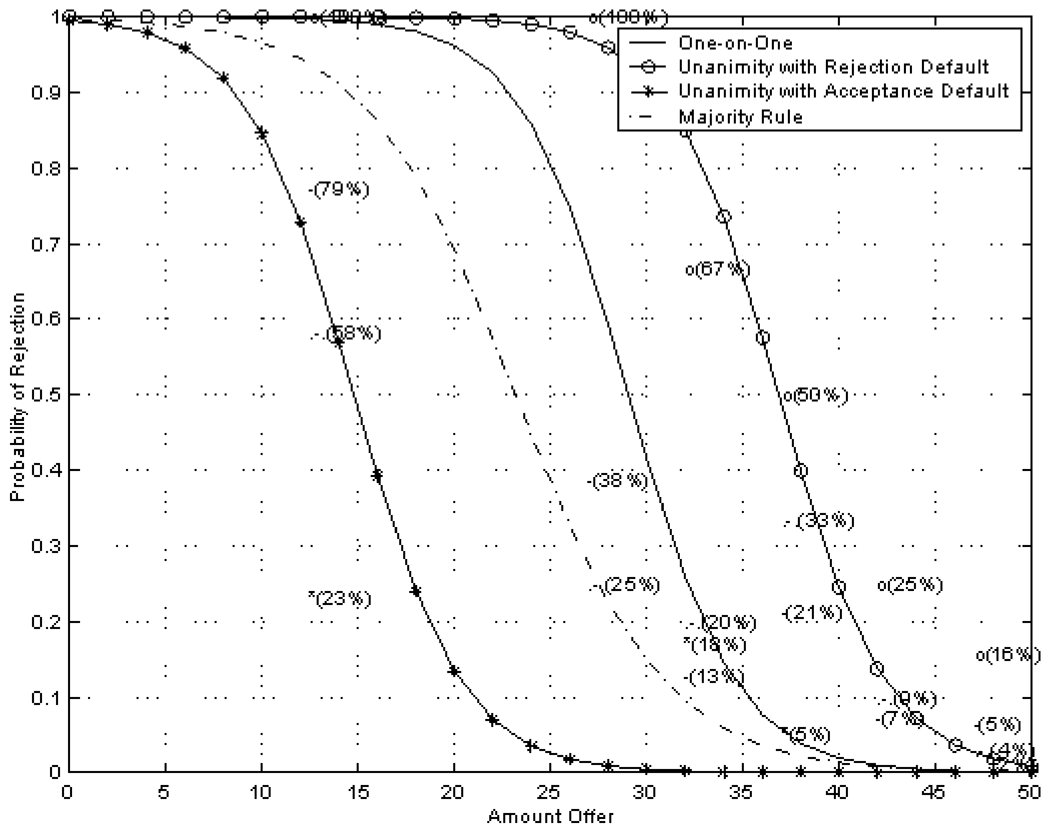

Figure 2: Estimated Group Rejection Probabilities from specification (4) (Column 2, Table 6) and the Actual Rejection Rates

4.2 Proposer Behavior

Given the differences in group rejection probabilities for different voting rules, we should expect changes in offers across treatments. We consider the following specification for estimating the offer size differences across all treatments for the all periods:

$$\begin{aligned} Offer_i = \alpha_0 + \alpha_{urd} URD + \alpha_{uad} UAD + \alpha_{mr} MR + \beta_{per} Per \\ + \beta_{perurd} Per \times URD + \beta_{peruad} Per \times UAD + \beta_{permr} Per \times MR \quad (5) \end{aligned}$$

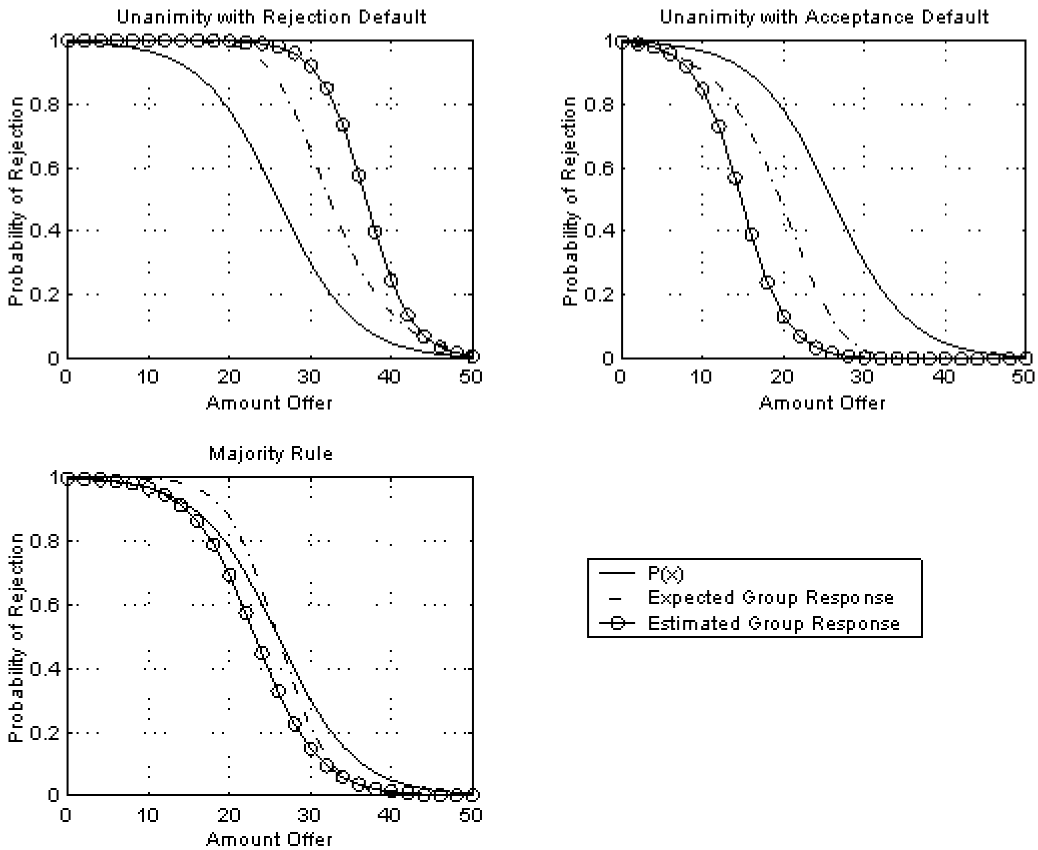

Figure 3: Expected Group Response vs. Estimated Group Response

where $Offer_i$ is the offer proposer i sent from 0 to 100; Per is the period time in which an offer was made; URD, UAD and MR are dummies for each of the voting rules. We use all individual offers made (except for those made by the four excluded subjects discussed above). Table 6 shows the results of the random effect estimation.[20]

[20] We also evaluated another model specification:

$$Offer_i = \alpha_0 + \alpha_{urd}URD + \alpha_{uad}UAD + \alpha_{mr}MR + \sum_{j=2}^{20} \alpha_j Per_j$$

This specification introduces a dummy variable for every period, treating time as a discrete variable. At the individual level, we reject the null hypothesis that all coefficients were different from zero

Table 6: Proposer Behavior

Coefficients	Proposals
Intercept	40.086***
Period	-0.263***
Unanimity with	4.075*
Rejection Default	
Unanimity with	1.097
Acceptance Default	($p = 0.59$)
Majority Rule	-2.101
	($p = 0.13$)
URD×Period	0.260
	($p = 0.06$)
UAD×Period	-0.630***
MR×Period	0.324**
# of Obs.	1600

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

We expect the offer size coefficient for unanimity with rejection default to be greater than zero ($\alpha_{urd} > 0$), meaning that compared to the one-on-one treatment proposers should be willing to offer more given the high rejection probability behind by this voting rule. For unanimity with acceptance default, we should expect a coefficient less than zero ($\alpha_{uad} < 0$), which means that compared to the one-on-one treatment proposers should be willing to offer less given the low probability of rejection. Compared to the one-on-one treatment, proposers facing majority rule should be willing to offer less when $P(x) < \frac{1}{4}$ and more otherwise. Therefore, it is difficult to clearly specify in advance the coefficient sign associated to this treatment.[21] This specification allows also the possibility of a different dynamic within each treatment.

Our estimation shows that the time period coefficient (β_{period}) is significant for a $p < 0.001$, implying that proposers were willing to offer less over time. The unanimity with rejection default coefficient is different from zero ($p < 0.001$), indicating that proposers tend to offer more than in the one-on-one treatment. The signs of the majority rule and unanimity with acceptance default coefficients are not significantly different from zero for a $p = 0.13$ and $p = 0.59$, respectively. However, a χ^2 test result indicates that the null hypothesis of $\beta_{urd} = \beta_{uad} = \beta_{mr} = 0$ can be rejected for a $p < 0.001$. Our specification allows for a difference in the dynamic within each treatment. A χ^2 test result indicates that the null hypothesis of $\beta_{perurd} = \beta_{peruad} = \beta_{permr} = 0$ can be rejected for a $p < 0.001$, confirming the presence of such difference. In fact, β_{peruad} is clearly negative (significance at $p < 0.001$), which, compared with the insignificant sign of α_{uad}, suggests that agents may be moving towards a correct

for a $p < 0.05$. On the other hand, we could not reject the null hypothesis that the discrete-time model is different from a continuous-time specification for a $p < 0.05$, indicating that the two may be indistinguishable; we decided to treat time as a continuos variable.

[21]We also considered a specification introducing dummies for subjects who experience making offers under different bargaining situations. However, the corresponding coefficients were not jointly different from zero for a $p < 0.05$.

Table 7: Group-on-Group Majority Rule vs. One-on-One Ultimatum Bargaining

Coefficients	Average Offer MR
Intercept	21.275^{***}
Average Offer ONO	0.521^{***}
# of Obs.	24

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

response.[22] We also observe that proposals tend to increase over time faster in the group-on-group majority rule than in the one-on-one treatment. Figure 4 shows, for each treatment and for the first ten periods, the average of the final group offers and the average of all individual offers (+/- 2 standard errors). Likewise, Figure 5 shows the estimated offers for each treatment in addition to the average of all individual offers (+/- 2 standard errors).

Summing up the results, our estimations indicate that offers decrease over time; offers are higher for the unanimity with rejection default than for other treatments; offers are not significantly different for the other two voting rules compared to the control treatment; and while offers decrease over time in the unanimity with acceptance default, they increase in the majority rule.

4.2.1 One-on-One vs. Group-on-Group Majority Rule

Sequential treatment was designed to try to distinguish between the one-on-one and majority group behavior. Since the same individuals were proposers in both the one-on-one and majority rule games, our model suggests that we should expect different

[22] From the raw data we observe that in the unanimity with acceptance default treatment proposers were exposed to a higher-than-expected number of actual group rejections in early rounds (this difference was not statistically significant), possibly making them cautious about aggressive offers. The sign of the β_{peruad} suggests that, as the impact of those early rejections wore off, the proposers did start to be more aggressive, as predicted by the model.

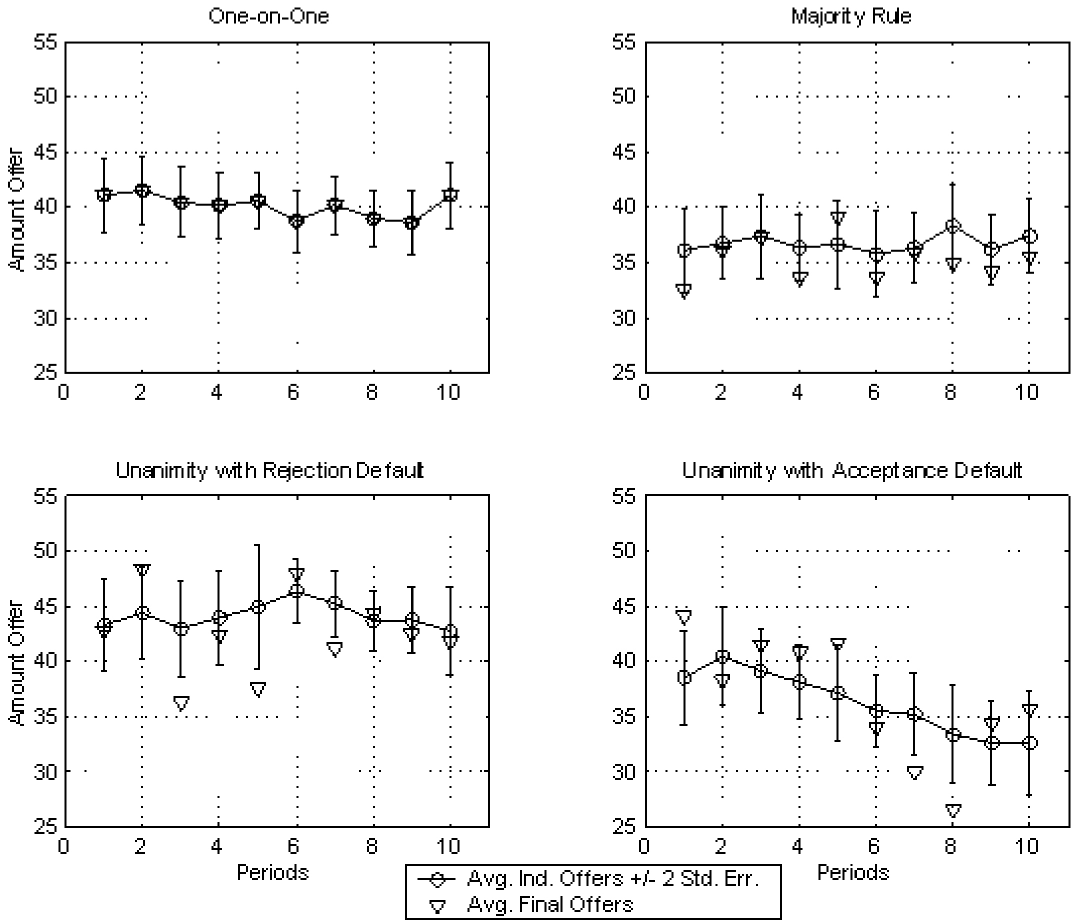

Figure 4: Average Individual and Final Offers

individual offers in the two bargaining situations. To test this hypothesis we consider the following specification:

$$Offer_i^{MR} = \alpha + \beta Offer_i^{ONO} \tag{6}$$

where $Offer_i^{MR}$ is the average offer proposer i made under the group-on-group ultimatum bargaining where the receiver group have to decide whether to accept under the majority voting rule and $Offer_i^{ONO}$ is the average offer proposer i made in the

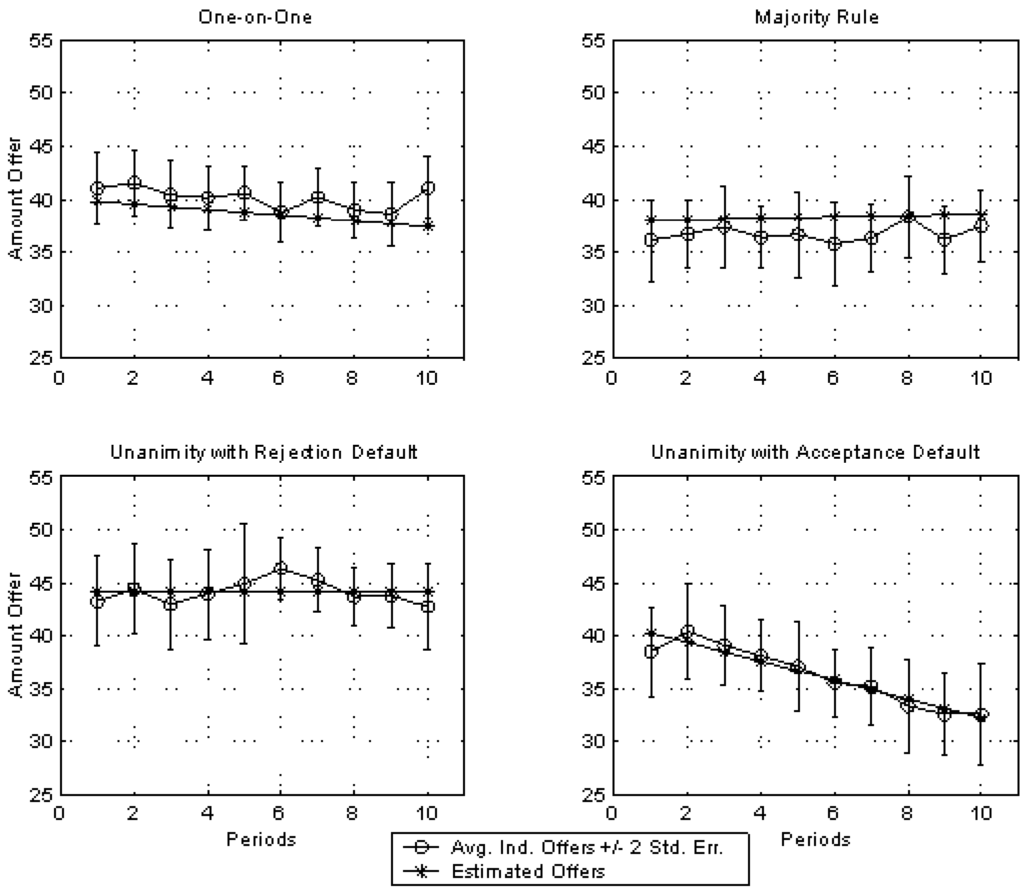

Figure 5: Average Individual Offers and Estimated Offers

one-on-one ultimatum bargaining. Table 7 shows estimation for this specification.[23]

We should expect the offer size coefficient under the on-on-one ultimatum bargaining be greater than zero and less than one ($1 > \beta > 0$), meaning that those individuals that were less (more) aggressive as proposer in a one-on-one ultimatum

[23] We also evaluated another model specification:

$$Offer_i^{MR} = \alpha_0 + \alpha_1 Order + \beta Offer_i^{MR}$$

This specification introduces a dummy variable for the order in which agents played the games. For this specification, we could not reject the null hypothesis that this coefficient was different from zero for a $p = 0.41$. Therefore, the order in which agents find themselves in different bargaining situations does not contribute to explaining offer variation.

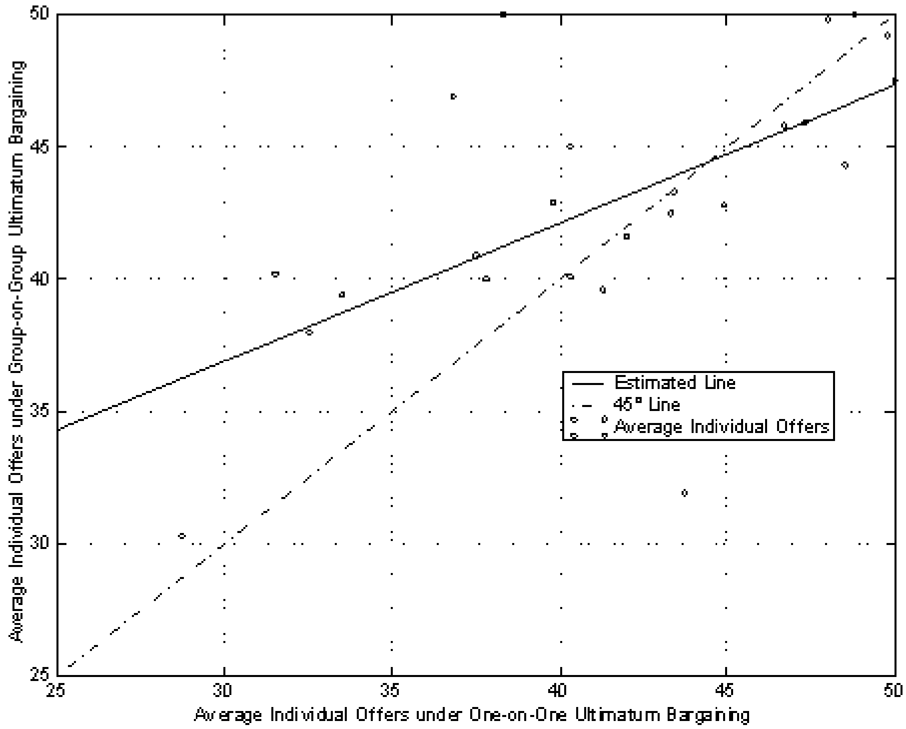

Figure 6: Average Individual Offers

bargaining becomes somewhat more (less) aggressive when playing against groups, and vice versa.[24]

Our estimation shows that average offer coefficient (β) is significant for a $p < 0.001$. We could reject the null hypothesis that this coefficient was greater than or equal to one (less than or equal to zero) for a $p < 0.001$. This result is consistent with the expected changes in the individual average offers across bargaining situations. Figure 6 shows for each individual his/her average offers under each of the bargaining situations (note our regression crossing the 45° line).

[24]This does not mean that agents "aggressiveness ranking" should switch - the same agents would be making relatively high (respectively, relatively low) offers in both situations.

5 Conclusions

In this paper we provide a comparison between four different treatments of ultimatum bargaining: the one-on-one bargaining and three different group-on-group games differentiated by the controlled decision rule used on the responder side to agree on acceptance or rejection. The results of our experiments seem to support the following conclusions:

We cannot reject the hypothesis that individual responder behavior is the same in all four treatments. The willingness to reject low offers clearly suggests existence of a non-monetary component in individual payoffs. The absence of difference between the behavior inside and outside the group suggests that this behavior could be fully explained by assuming that agents care about the *distribution* of monetary payoffs among the bargainers (in particular, by their dislike of being treated unfairly). We do not get any evidence of either preference for expressing displeasure (satisfaction) through one's vote, nor of some common non-monetary value (such as would arise if agents cared about behaving according to some social norm and "sought guidance" from their group partners): as discussed in section 2, both of these give rise to predictions on the comparative statics of responder behavior across treatments that we do not observe.

We can reject the hypothesis that the proposer behavior is the same in all four treatments. In particular, in the unanimity with rejection default treatment proposers are clearly substantially more cautious than in other treatments, which indicates that they correctly respond to the increased difficulty of obtaining acceptance of their proposals. We also observe differences in proposers' behavior between the one-on-one bargaining and the other treatments of group bargaining. In particular, while in the unanimity with acceptance default treatment we fail to observe proposers to be on average more aggressive, we do observe them becoming more aggressive with time. One reason for this delay may be that, though the observed difference in responder behavior between the unanimity with acceptance default and the one-on-one treatments is not statistically significant, the realization of the individual conditional rejection probability in this treatment happened to be somewhat high in initial rounds, possibly "training" the agents to behave somewhat more cautiously. Furthermore, results of our sequential treatment suggest that individual behavior between one-on-one and majority rule treatments is varying in a predicted fashion.

It is suggested by the previous discussion that proposers may be best-responding to empirical rejection probabilities they face. Furthermore, there does seem to be evidence that agents learn the "correct" behavior over time. Further research is needed to establish exactly the nature of this learning process and how it responds to the empirical rejection.

6 Appendix 1: Experimental Instructions

The following is the verbatim translation (from Spanish into English) of experimental instructions administered to subjects at ITAM (the Spanish original is available from the authors upon request).

6.1 Instructions Group-on-Group

This is an experiment about decision-making. The instructions are simple and if you follow them carefully and take good decisions, you can earn a CONSIDERABLE AMOUNT OF MONEY, which will be PAID YOU IN CASH at the end of the experiment

General Proceedings

In this experiment you will participate as a member of a GROUP A or a GROUP B. Your participation as a part of one of these two groups shall be determined at the beginning of the experiment and will be constant during the entire session. Each group shall consist solely of three (3) participants.

The experiment shall consist of 12 periods: two practice periods, and 10 periods played for money, one of which shall be randomly selected at the end of the experiment to determine your final pay. For this reason you should consider each period as if it were "the chosen period" for your pay.

At the beginning of each period, each TYPE A GROUP will interact with a TYPE B GROUP. The formation of pairs of GROUPS A and B will be done randomly. Likewise, the membership composition of each group will change in a random fashion, so that each participant will form a part of a new GROUP (of the same type) at the beginning of each period.

Specific Proceedings

In each period the task of each pair of groups is to try to divide 100 points using the following rules.

1) The members of GROUP A must make an offer of points to members of GROUP B.

1.1) To make the final offer from GROUP A to GROUP B each member of GROUP A must write and send an offer via the computer. Each offer must be in the range of 0 to 100 points.

1.2) After that, one of these offers made shall be chosen randomly by the computer as the final offer of GROUP A to GROUP B.

2) The final offer of GROUP A shall be sent to each member of GROUP B. After observing the offer sent, the members of GROUP B must decide if they accept of reject the offer according to the following rule:

The offer is considered accepted when every one of the members of the group votes to accept it. Otherwise it is considered rejected.[25]

---

[25] This corresponds to Unanimity with rejection default; instructions for other treatments are as follows.

Unanimity with acceptance default:

"The offer is considered rejected when every one of the members of the group votes to accept it. Otherwise it is considered accepted".

Majority rule:

"The offer is considered accepted when at least two of the members of the group vote to accept it. Otherwise it is considered rejected."

2.1) If GROUP B rejects the offer, no GROUP receives any pay.

2.2) If GROUP B accepts the offer, the GROUP A receives the amount of 100 points minus the points offered to GROUP B. In its turn, GROUP B receives the amount of points which has been offered by GROUP A.

3) Once taken, the decision to accept or reject the offer of points is final, no counter-offer shall be possible, and the next period shall start with a new grouping of participants for each group type.

Payment Proceedings

Once the 10 periods played for money are over, one of them will be chosen randomly to determine the final pay. For this reason, you should consider each period as if it were final "chosen period" for your pay.

The pay for the chosen period shall be calculated as follows: Each member of each group shall get \$2.6 pesos for each point obtained by the group to which she\he belongs, in addition to the basic amount of \$20 pesos for participation.

At the end of the session, each of the participants shall be called by the identification number assigned by the computer at the beginning of the experiment to receive his/her pay in a sealed envelope, thus ensuring the complete anonymity of his/her decisions and their results.

6.2 Instructions One-on-One

This is an experiment about decision-making. The instructions are simple and if you follow them carefully and take good decisions, you can earn a CONSIDERABLE AMOUNT OF MONEY, which will be PAID YOU IN CASH at the end of the experiment

General Proceedings

In this experiment you will participate as a TYPE A or TYPE B AGENT. Your participation as one of these agent types shall be determined at the beginning of the experiment and will be constant during the entire session

The experiment shall consist of 12 periods: two practice periods, and 10 periods played for money, one of which shall be randomly selected at the end of the experiment to determine your final pay. For this reason you should consider each period as if it were "the chosen period" for your pay.

At the beginning of each period, each TYPE A AGENT will interact with a TYPE B AGENT. The formation of pairs of TYPE A and TYPE B AGENTS will be done randomly.

Specific Proceedings

In each period the task of each pair of agents is to try to divide 100 points using the following rules.

1) Each TYPE A AGENT must make an offer of points to a TYPE B AGENT. For this each TYPE A AGENT must write and send an offer via the computer. Each offer must be in the range of 0 to 100 points.

2) After observing the offer sent by the TYPE A AGENT, the TYPE B AGENT must decide if she\he accepts or rejects it.

2.1) If the TYPE B AGENT rejects the offer, no AGENT receives any pay.

2.2) If TYPE B AGENT accepts the offer, the TYPE A AGENT receives the amount of 100 points minus the points offered to TYPE B AGENT. In its turn, TYPE B AGENT receives the amount of points which has been offered by TYPE A AGENT.

3) Once taken, the decision to accept or reject the offer of points is final, no counter-offer shall be possible, and the next period shall start with a new grouping of agent pairs.

- Payment Proceedings

Once the 10 periods played for money are over, one of them will be chosen randomly to determine the final pay. For this reason you should consider each period as if it were final "chosen period" for your pay.

The pay for the chosen period shall be calculated as follows: Each agent shall get $2.6 pesos for each point obtained, in addition to the basic amount of $20 pesos for participation.

At the end of the session, each of the participants shall be called by the identification number assigned by the computer at the beginning of the experiment to receive his/her pay in a sealed envelope, thus ensuring the complete anonymity of his/her decisions and their results.

* * *

In the sequential treatment, after the completion of the first 10 rounds the subjects were asked to move to a next-door classroom, while the computers were being reinitialized. The subjects were monitored throughout and no communication was allowed. When the subjects returned to the room where the experiment was being conducted, the appropriate instructions were read to them in their entirety before proceeding.

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