Generosity in bargaining: Fair or fear?

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Abstract

Are "generous" bargaining offers made out of fairness or in fear of rejection? We disentangle risk and social preferences by analyzing experimental behavior in three majority bargaining games: (1) a random-proposer game with infinite time horizon; 2) a one round proposer game with disagreement payoffs equal to the infinite horizon continuation payoffs; and, (3) a demand commitment game. Inequity aversion predicts very differently across these games, but risk aversion does not. Observed strategies violate neither stationarity nor truncation consistency. This allows us to use structural models of bargaining behavior to estimate the latent type shares of subjects with CES, inequity averse, and Prospect theoretic preferences. The Prospect theoretic, i.e. reference-dependent, model of utility explains the observations far better than any mixture of alternative models.

JEL–Codes: C72, C78, D72

Keywords: coalitional bargaining, non-cooperative modeling, random utility model, quantal response equilibrium, laboratory experiment

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1 Introduction

Group decisions reached by bargaining entail compromise. For example, legislatures may agree on actions that benefit some more than others. Although expected payoffs should increase with power (Snyder Jr et al., 2005), proposers often make overly generous offers and realize less power than predicted, e.g. in bilateral (Camerer and Thaler, 1995) or multilateral (Fréchette et al., 2005a,b) bargaining. Knight (2005) provides empirical evidence from US Congress data. Generosity yields equity, but it can also be instrumentally used to buy votes for pushing proposals through, e.g. in congressional elections (Levitt and Snyder Jr, 1997). Ultimatum game experiments suggest that this is due to the fear of rejection rather than fairness (Croson, 1996; Kagel et al., 1996; Straub and Murnighan, 1995). These results, however, can neither exclude fairness nor ascertain the degree to which each explanation holds. Separating these motives in the ultimatum game is difficult as both operate in the same direction.

In this paper, we seek a parsimonious explanation of generosity in bargaining. To distinguish between motives, we experimentally test games across which inequity aversion (in the sense of Fehr and Schmidt, 1999) operates in different directions. Candidate models are then econometrically estimated and compared. Our tests are based on the random-proposer model of Baron and Ferejohn (1989) and Harrington (1990), the predominant approach of modeling decision making in committees and parliaments. Fréchette et al. (2005a) showed that the results of laboratory tests on this game resemble those of the field, while Knight (2005) applied it to estimating the value of proposer power from US Congress data. This model is a generalization of alternating-offers bargaining (Ståhl, 1972, and Rubinstein, 1982) to n players and majority voting rule. In each round, a player is randomly recognized as proposer, this player makes a proposal on how to divide a dollar, and all players vote on the proposal. If a majority votes in the affirmative, the proposal is implemented, otherwise a new round begins.

The set of subgame perfect equilibrium payoffs is vast, but the stationary equilibrium payoffs are unique (Eraslan, 2002). Stationarity follows if players choose the least complex strategies (Baron and Kalai, 1993), but it has not yet been verified experimentally. Building on the assumption that stationarity is valid, the random-proposer model has been extended in a variety of dimensions. Examples include one-dimensional ideological decisions (Cho and Duggan, 2003; Cardona and Ponsatí, 2007), decisions with both ideological and distributive dimensions (Jackson and Moselle, 2002), bicameral legislatures (Ansolabehere et al., 2003), weighted voting (Snyder Jr et al., 2005), and costly recognition (Yildirim, 2007). Our other objective is to test the validity of stationarity.

Our experiment comprises three treatments: *PB95*, *PB00*, and *DB95*. *PB95* is a random-proposer game with the continuation probability .95 if a proposal is not accepted by the majority (with probability .05, all players would then get nothing). The "dollar" to be divided is worth €24, three players participate per game, and two out of three players are required to implement a proposal (i.e. the proposer requires one opponent to vote in the affirmative). *PB00* is a random-proposer game with a continuation probability of 0 if a proposal gets rejected, but with €7.60 disagreement payoffs in this case. This disagreement payoff is equal to the continuation payoff in the stationary SPE of *PB95*. *DB95* inverts the random-proposer game toward a specific demand commitment game analyzed by Breitmoser (2009). In each round, a proposer is drawn randomly again, but instead of making the proposal first, the opponents simultaneously state their "voting strategies" (payoff demands) first. The proposer is informed of the demands, makes a proposal, and if his proposal satisfies at least one of these demands, then it is implemented. Otherwise a new round begins (with probability .95). In equilibrium, the demands are €.02 or less (our smallest currency unit is .01 Euro), and the proposer gets at least €23.98.

Montero (2007) theoretically showed that "inequity aversion may increase inequity" in the random proposer game. In particular, this applies to *PB95* where inequity averse players make less equitable offers than payoff maximizers (in equilibrium), while they make more equitable offers than payoff maximizers in *PB00*, and equally inequitable offers in *DB95* (assuming Fehr-Schmidt preferences). If the players deviate toward equitable demands in all three games, then they do so for other reasons than inequity aversion. Further, the relation between *PB00* and *PB95* allows us to study truncation consistency as discussed by Binmore et al. (2002), and the differences between rounds in *PB95* allows us to examine stationarity.[1] Thus,

[1]Note that non-stationarity (and delay) is plausible both empirically and theoretically, for example

our study also sheds light on whether insights from truncated bargaining games, e.g. one-shot ultimatum games (Güth et al., 1982) or proposer games (Okada and Riedl, 2005), extend to non-truncated (infinite horizon) majority games. Much of the literature discusses these games based on the assumption that consistency holds—and our experiment allows us to test this assumption.

At the center of discussion in many experimental analyses of truncated bargaining games had been the utility functions of subjects, however. Systematic deviations from payoff maximization have been observed and are not yet conclusively explained. The assumption of social preferences in general, and of fairness concerns in particular (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), does by itself not suffice (Forsythe et al., 1994). Noisy maximization according to random utility models (see e.g. Goeree and Holt, 2000, Costa-Gomes and Zauner, 2003, and Yi, 2005) has been found to be relevant, as well. Building on these results, we model bargainers' preferences in tandem with random utility components.

Our analysis distinguishes logit equilibria and nested logit equilibria, and it is applied to both the truncated game *PB00* and the non-truncated one *PB95*. Structural analyses of infinite horizon bargaining games have been previously unfeasible because of the immense strategy space[2] and complexity in computing stationary AQREs (agent quantal response equilibria, following McKelvey and Palfrey, 1995, 1998). Using the definition of Markov QREs, see Breitmoser et al. (2010), recent advances in parallel computing now allow random utility analyses of infinite-horizon bargaining games,[3] and exploiting these advances, the present paper constitutes the first structural analysis of behavior in infinite-horizon bargaining games. To the best of our knowledge, the only related analyses are Battaglini and Palfrey (2007), who studied dynamic majority bargaining where the proposals are generated randomly (rather than being strategic choices), and Diermeier et al. (2002, 2003), who analyzed structural models of government formation assuming rationality during the actual bargaining

due to reputation effects (Abreu and Gul, 2000), heterogeneity of prior beliefs (Yildiz, 2003), and history-dependent preferences (Li, 2007).

[2]Our analysis assumes a smallest currency unit of €0.2, and given the cake size of €24, this implies that merely the number of proposals is on the order of 10^6 in each round.

[3]The programs underlying our computations are available as supplementary material. They are based on the CUDA architecture for parallel computing on NVIDIA GPUs, and they can be adapted straightforwardly toward OpenCL.

phase.

Our main results can be summarized as follows. Proposals in the two proposer games are not significantly different, contradicting the prediction of inequity aversion. The demand commitment game results corroborate. Strategies do not significantly violate stationarity, and hence they can be modeled as stationary QREs. We then examine whether subjects utility functions are represented best as CES, Fehr-Schmidt, or Prospect theoretic utilities. To this end, we first determine which structural model captures the behavior best and find that an intuitive nested logit equilibrium model fits better than two alternative models for all of the utility functions considered. Using this nested logit model, we then conduct a latent type analysis to classify subjects into CES, Fehr-Schmidt, and Prospect theory types. We find that the shares of all types but Prospect theory are insignificant, i.e. that social preferences do not significantly matter. These results are sharpened by the fact that pseudo-R^2 of the resulting models are around .90, i.e. the model does not leave much of the data unexplained. These results are consistent with the models of reference-dependent preferences proposed and analyzed by Shalev (2000, 2002), Kőszegi and Rabin (2006, 2007), Butler (2008), and Kőszegi (2010).

Section 2 describes the experimental games and procedure. Section 3 describes our basic observations concerning stationarity, truncation consistency, and fairness concerns based on econometric estimates of the subjects' strategies. Section 4 specifies the range of structural models considered. Section 5 discusses the estimates of these models with respect to our data set. Section 6 concludes.

2 Experimental design

2.1 Experimental games

In all treatments, the players in $N = \{1,2,3\}$ have to divide €24. The smallest currency unit is 0.01 Euro, and thus the set of feasible allocations is

$$\mathbf{X} = \left\{ \mathbf{x} \in \mathbb{R}^N \mid \mathbf{x} \geq 0,\ \sum_{i \in N} x_i \leq 24,\ \forall i \in N \exists n_i \in \mathbb{N}_0 : x_i = 0.01 n_i \right\}. \quad (1)$$

The first model that we implement is the random-proposer game with indefinite time horizon following Baron and Ferejohn (1989). After each round without agreement, the game stops with probability 0.05; in this case, the players receive zero payoffs. This game is outcome equivalent to the random-proposer game with time preferences (discount factor $\delta = 0.95$) if the players are risk neutral.

Game 1 (*PB95*)**.** In each round, one player is recognized as proposer by a uniform draw from N. This player chooses $\mathbf{x} \in \mathbf{X}$, and the other players vote on $\mathbf{x}$. If one of them accepts, then the players' payoffs are $\mathbf{x}$. Otherwise, the payoffs are $\mathbf{0}$ with probability .05 and a new round begins with probability .95.

All stationary SPEs of *PB95* satisfy a few intuitive restrictions (see e.g. Baron and Ferejohn, 1989, and Eraslan, 2002). In each round, the proposal allocates 16.40 to the proposer, 7.60 to one opponent, and 0 to the other opponent. The responders vote in the affirmative if and only if the own share is at least 7.60. The proposers may randomize when choosing the coalition, and the individual randomization probabilities are largely unrestricted in equilibrium. Going beyond these well-known results, Montero (2007) shows that if players have Fehr-Schmidt preferences for inequity aversion (see e.g. Fehr and Schmidt, 1999), and if preferences are common knowledge, then the equilibrium outcomes are less equitable than those without inequity aversion (essentially, because responders accept lower shares rather than risk being left out under standard formulations of inequity aversion). The Fehr-Schmidt utility function is

$$u_i(\mathbf{x}) = x_i - \alpha \sum_{j \neq i} \max\{x_j - x_i, 0\} - \beta \sum_{j \neq i} \max\{x_i - x_j, 0\}, \tag{2}$$

with $0 \leq \beta \leq \alpha < 1/3$. Specifically, Montero shows that the structure of the equilibrium proposals under inequity aversion is equal to the structure of proposals without inequity aversion, i.e. the proposer offers some $y > 0$ to $q - 1$ opponents (where $q = 2$ in our case) and zero to the rest, and that under Fehr-Schmidt preferences the value of y is (Proposition 5 of Montero, 2007, as applied to our game)

$$y = 24 \cdot \frac{\alpha(3 - 2\delta) + 2\delta(1 - \beta)}{6 + 2\alpha(3 - \delta) - \beta(3 + 2\delta)}. \tag{3}$$

Clearly, $y = 7.60$ for $\alpha = \beta = 0$, and y is decreasing in both α and β if

$$\beta \leq \frac{4\delta(3-\delta) - 6(3-2\delta)}{4\delta(3-\delta) - (3+2\delta)(3-2\delta)} \qquad \alpha \geq \frac{12\delta - 2\delta(3+2\delta)}{(3+2\delta)(3-2\delta) - 4\delta(3-\delta)}. \tag{4}$$

Since $\delta = 0.95$ in our case, this is satisfied if $\alpha \geq -0.87$ and $\beta \leq 0.495$, i.e. comfortably within the conventional restrictions $0 \leq \beta \leq \alpha < 1/3$. Hence, $y < 7.60$ for Fehr-Schmidt inequity aversion.

The second bargaining model implemented in our experiment is the corresponding one-round game.

Game 2 (*PB00*)**.** There is one round. A player is recognized as proposer by a uniform draw from N. This player chooses $\mathbf{x} \in \mathbf{X}$, and the other players vote on $\mathbf{x}$. If one of them accepts, then the players' payoffs are $\mathbf{x}$. Otherwise, the payoffs are 7.60 per player.

The disagreement payoff of 7.60 per player exactly equates with the continuation payoff in the SSPE of *PB95*. Thus, if players maximize expected payoffs, the set of SPEs of *PB00* corresponds with the set of SSPEs of *PB95* in the sense that the ex-post payoffs $(16.40, 7.60, 0)$ obtain in all cases. If players are inequity averse, however, the predictions diverge. The disagreement payoffs in *PB00* induce the utility $\tilde{u}_i = 7.60$ for all (α, β) under Fehr-Schmidt preferences, and this disagreement utility differs from the continuation utility in *PB95*. The proposal structure is as above, i.e. the proposer offers some $y > 0$ to a randomly selected opponent, zero to the other opponent, and claims $1 - y$ for himself, but the costs for buying a vote are now (using $\delta := 7.6/8$ as the "implicit" discount factor)

$$y = 24 \cdot \frac{\delta/3 + \alpha}{1 + 2\alpha - \beta}. \tag{5}$$

This value is increasing in both α and β under our assumptions. That is, the optimal proposal in *PB00* if players have Fehr-Schmidt preferences is more equitable than if players maximize pecuniary payoffs—*PB00* inverts the effect of inequity aversion under Fehr-Schmidt preferences in relation to *PB95*. This allows us to test for inequity aversion.[4]

[4] While most of the above statements relate to Fehr-Schmidt preferences, they continue to hold in a

The third model implemented in our experiment is a demand commitment game. Here, the players can pre-commit to a specific voting strategy prior to the choice of the proposer, and the proposer is informed of their "demands" prior to his choice. Define the set of possible "demands" as $D = \{n/100 \mid n \in \mathbb{N}_0, n \leq 2400\}$.

Game 3 (*DB95*)**.** In each round, a proposer is drawn uniformly from N. His opponents i and j choose $d_i, d_j \in D$, the proposer is informed of (d_i, d_j) and chooses $\mathbf{x} \in \mathbf{X}$. If $x_i \geq d_i$ or $x_j \geq d_j$, then the players' payoffs are $\mathbf{x}$. Otherwise, the payoffs are $\mathbf{0}$ with probability .05 and a new round begins with probability .95.

In all subgame-perfect equilibria, the non-proposers demand $d_i \leq 0.02$ and the proposal satisfies one of these demands. The proposers' payoff is at least 23.98 (for a more detailed discussion, see Breitmoser, 2009). This equilibrium prediction is essentially invariant to inequity aversion (under the maintained assumption of Fehr-Schmidt preferences). The equilibrium demands satisfy $d_i \leq 0.02(1+2\alpha-\beta)/(1+3\alpha-\beta)$, i.e. $d_i < 0.02$ under the maintained assumption $0 \leq \beta \leq \alpha < 1/3$ and the smallest currency unit being 0.01. The observation that inequity averse players are willing to undercut even 0.02 relates primarily to the fact that undercutting the opponent reduces the expected inequity between the two non-proposers, while the expected inequity in relation to the proposer remains constant.

To summarize, in relation to payoff maximizing players, inequity averse players deviate to less equitable allocations in the equilibria of *PB95*, to more equitable allocations in the equilibria of *PB00*, and to the same allocations as those without inequity aversion in the equilibria of *DB95*.

2.2 Procedure and logistics

The experiment was conducted in the experimental economics laboratory at the European University Viadrina, Frankfurt (Oder), Germany. The experiment was, apart from the experimental instructions and control questionnaire, fully computerized (using z-Tree, see Fischbacher, 2007). Subjects were students from various faculties

similar way for more general utility functions exhibiting inequity aversion. See for example Montero (2007) for a more general discussion of Eq. (3).

of the university. An announcement for this experiment was sent to recipients on an email database of potential subjects. Those who responded to the email were recruited accordingly. We conducted a total of 14 sessions, four sessions of the *PB00*, five sessions of *PB95*, and five sessions of *DB95*. Each session was partitioned into two sub-sessions, to each six subjects were randomly assigned. Subjects never interacted with those from other sub-sessions. We partitioned the sessions to increase the number of independent observations, and ran them simultaneously to increase the sense of anonymity. Each session contained 12 subjects. A total of 168 subjects participated. Each subject was allowed to participate only once.

Each session comprised 10 repetitions ("stages") of the same game, *PB00*, *PB95*, or *DB95*. In each stage, subjects were randomly re-matched into groups of three, so as to implement the one-shot context. Subjects were also randomly reassigned their roles at the beginning of each stage. Repetition of tasks allows for experience, while random re-matching and anonymity eliminate reputation effects. This between-subject design reduces the potential carryover effects from playing one game to another. The subjects' tasks and information during games matched precisely with the games' definitions provided above. After each stage, all subjects were informed of their earnings. Neutral language was used throughout the experiment (e.g. "A-participant" and "B-participant" instead of proposer and responder). The instructions used in *PB95* sessions can be found in the appendix.

At the beginning of the experiment, subjects were randomly assigned computer terminals. They started by reading the experimental instructions, provided on printed sheets, followed by answering a short control questionnaire that allowed us to check their understanding. Subjects in doubt were verbally advised by the experimental assistants before being allowed to begin. Each computer terminal was partitioned, so that subjects were unable to communicate via audio or visual signals, or to look at other computer screens. Decisions were thus made in privacy. At the end of the experiment, subjects were informed of their payments, and asked to privately choose a code-name and password. This was used to anonymously collect their payments from a third party one week after the experiment. Each subject was given a €4 participation fee and the earnings from one randomly chosen "winning stage." The marginal incentives could therefore range from €0 to €24 per subject. The average payout per subject was €11.52 for, on average, less than 1 hour per session.[5]

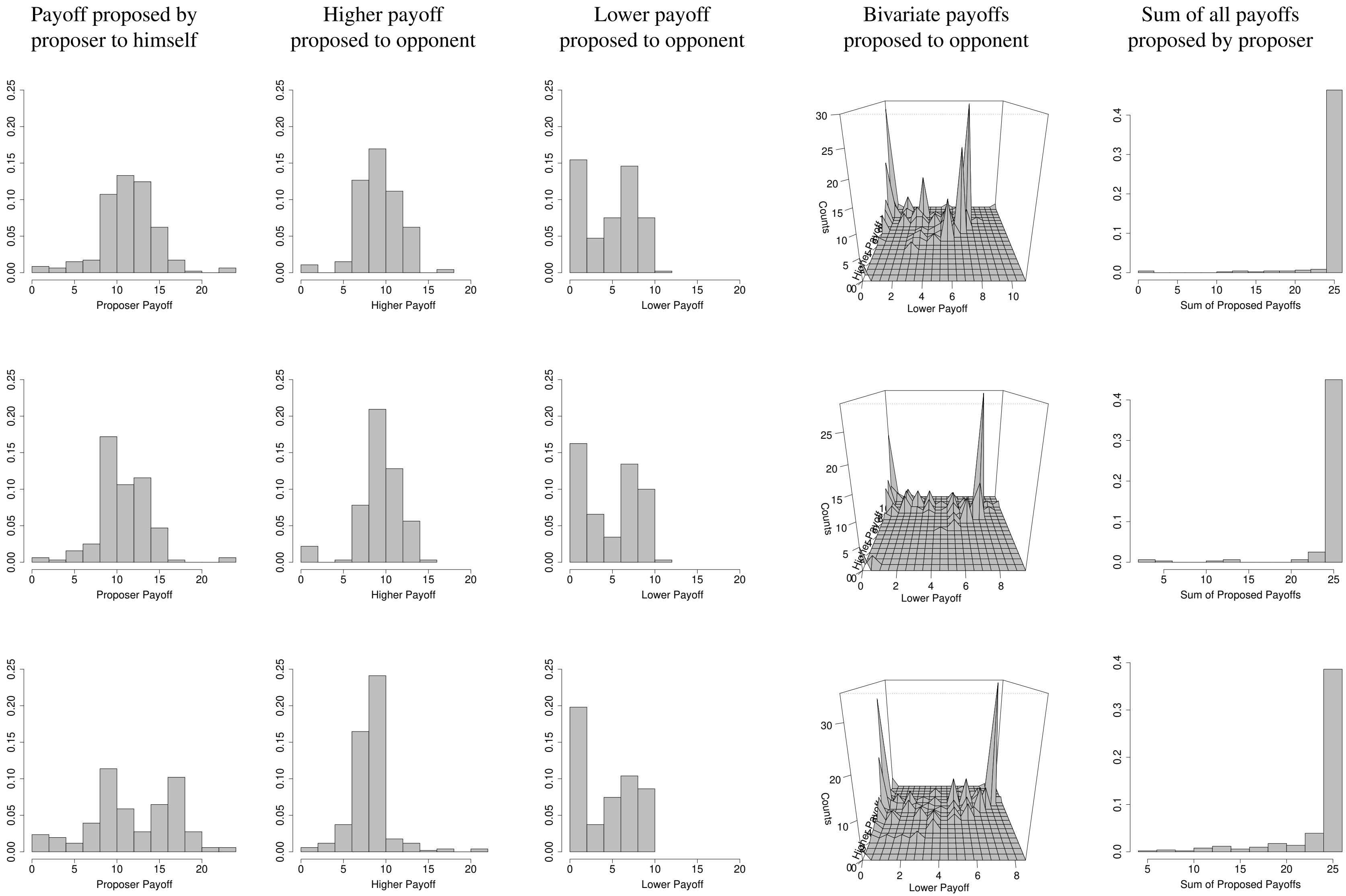
3 Overview of subjects' strategies

In this section, we describe the basic characteristics of the subjects' strategies and discuss econometric estimates of proposal, demand, and voting functions. Due to their stationarity, the games investigated here allow us to estimate these functions using standard regression models. We estimate the strategies by considering regression models that include a range of independent variables that may be relevant for the strategic task at hand, i.e. we include the variables that should be strategically relevant by theory and others that could have been relevant for the subjects. We control for the game number within the session, for the round number within the game, and for the interdependence induced by the experimental design (by considering two levels of random effects, "Session" and "Subjects within Session").

We begin with the proposal functions in *PB95*. See Figure 1 (row 1) for a graphical overview. Each proposal $\mathbf{x} \in \mathbf{X}$ consists of three terms, the payoff the proposer allocates to himself, denoted as x_p, and the duple of payoffs (x_1, x_2) allocated to the opponents. We segregate the latter into the "high payoff" $x_h = \max\{x_1, x_2\}$ and the "low payoff" $x_l = \min\{x_1, x_2\}$, since these two components generally serve different purposes in the proposer's eyes. If $x_h > x_l$, then the high payoff serves to buy the vote of the respective player and the low payoff x_l may address fairness concerns. In stationary SPEs, these values are $x_p = 16.40$, $x_h = 7.60$, and $x_l = 0$. The sample estimates are $\hat{x}_p = 10.69$ (with standard deviation $\hat{\sigma}_p = 3.44$), $\hat{x}_h = 8.61$ ($\hat{\sigma}_h = 2.39$), and $\hat{x}_l = 4.12$ ($\hat{\sigma}_l = 3.14$). Controlling for interdependence (via random effects), game number minus 1 ($= G$), round number minus 1 ($= R$), and in the case of x_l also for an interaction with x_h, our estimates are as follows (significance at the 5% level is

[5] The monetary incentives provided in our experiment are substantial by local standards. Our mean payment of about 12.00 per hour is, for example, 50% more than the mean wage of a research assistant at Frankfurt (Oder).

Figure 1: Distribution of proposals in the three treatments (Row 1: *PB95*, Row 2: *PB00*, Row 3: *DB95*)



denoted by * and significance at the 1% level by **).

$$x_p = \underset{(0.5122)}{10.340^{**}} + \underset{(0.0595)}{0.1240^{*}} \cdot G \; - \underset{(0.3624)}{0.5546} \cdot R \tag{6}$$

$$x_h = \underset{(0.3690)}{7.8921^{**}} + \underset{(0.0467)}{0.1624^{**}} \cdot G + \underset{(0.2848)}{0.2987} \cdot R \tag{7}$$

$$x_l = \underset{(0.8037)}{7.5530^{**}} - \underset{(0.0585)}{0.1416^{*}} \cdot G \; + \underset{(0.3489)}{0.3567} \cdot R - \underset{(0.0809)}{0.3358^{**}} \cdot x_h \tag{8}$$

The intersect represents the initial proposal, i.e. the average proposal in the first round of the first game (aside from the interaction with x_h). The initial value of x_h is about as predicted, but it increases significantly (albeit small in absolute terms) as the subjects gain experience. In addition, there is a strong crowding-out effect between security in vote buying (increasing x_h) and non-strategic giving to the third player (x_l). In *PB00*, the estimated proposal functions differ only slightly (note that the round effect R is dropped, since there is just a single round in these games).

$$x_p = \underset{(0.5804)}{8.7277^{**}} + \underset{(0.0701)}{0.3382^{**}} \cdot G \tag{9}$$

$$x_h = \underset{(0.4343)}{7.7435^{**}} + \underset{(0.0613)}{0.2431^{**}} \cdot G \tag{10}$$

$$x_l = \underset{(0.9673)}{6.2656^{**}} - \underset{(0.0770)}{0.3256^{**}} \cdot G - \underset{(0.0979)}{0.0648} \cdot x_h \tag{11}$$

The direct crowding out between x_h and x_l disappeared, and the increase of x_p and x_h as the subjects gain experience is slightly sharper than in *PB95*, again at the expense of the non-strategic donation x_l toward the third player. (The fact that these effects do not add up to 0 numerically relates to the observation that the subjects get better in hitting the €24 available overall as the sessions progress.)

Due to insignificance of the round index R in Eqs. (6)–(8), we conclude that stationarity is not significantly violated. In order to test for truncation consistency, we next evaluate the differences between *PB95* and *PB00*. On the one hand, the means of x_p, x_h, and x_l do not differ significantly at the 5% level (in Mann-Whitney-U tests; see also Table 2a). On the other hand, we test whether the proposal functions estimated above, Eqs. (6)–(8) and Eqs. (9)–(11), differ significantly. To this end, we compare the model where the proposal function coefficients depend on treatment (*PB95* or *PB00*) with the simpler model where the coefficients do not depend on treatment. In likelihood-ratio tests, the differences are insignificant at the .01 level in all three dimensions, but they are close to that threshold with respect to x_l (the p-values of the likelihood-ratio tests are $p = .064$ for x_p, $p = .24$ for x_h, and $p = .011$ for x_l). That is, the non-strategic donation toward the third player slightly violates truncation consistency, but the proposal functions in the other two dimensions do not violate truncation consistency.

Result 3.1. *There is no significant round effect in* PB95 *and the proposal functions differ significantly between* PB95 *and* PB00 *only with respect to the "non-strategic donation" toward the third player. Overall, neither stationarity nor truncation consistency are violated significantly.*

The interrelation between proposed payoffs is displayed in Figure 2b, which plots the bivariate proposals (x_1, x_2) to the opponents in relation to the empirical continuation payoffs. There are several cluster points in these plots, and simplifying things a bit, these cluster points satisfy either $(x, 0)$ or $(0, x)$ for some $x \in [9, 12]$ or (y, y) for some $y \approx 7.6$. In turn, there are relatively few proposals of the kind (x, x) for $x \in [9, 12]$, or $(y, 0)$ for $y \approx 7.60$. These cluster points suggest that proposals are not independent of irrelevant alternatives and that they are explicitly made in relation to the continuation payoffs. This will be picked up in the structural analysis made below.

The proposal functions in *DB95* are functions of game number G and round number R, too, and since the proposer chooses $\mathbf{x} \in \mathbf{X}$ in response to a profile (d_1, d_2) of demands, they also depend on these demands. The lower of the two demands $d_l = \min\{d_1, d_2\}$ is strategically relevant for the proposer (assuming $d_l \leq 16.40$), while the higher one $d_h = \max\{d_1, d_2\}$ is strategically irrelevant. The following strategy estimates therefore control for d_l and d_h rather than (d_1, d_2). Using this notation, the theoretically predicted proposals are $x_p = 24 - d_l$, $x_h = d_l$, and $x_l \approx 0$ (notably, this

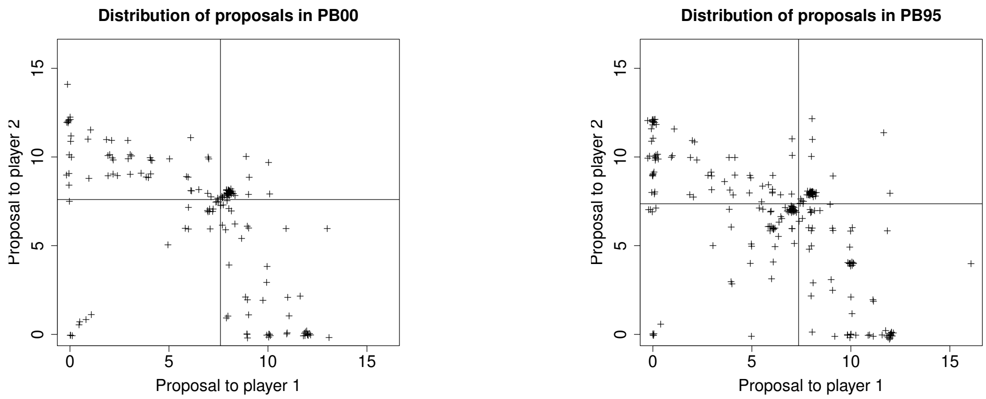
Figure 2: Further information on the distribution of proposals

(a) Means (and standard errors) of the proposals

	Proposer payoff		Higher payoff		Lower payoff	
	G 1–5	G 6–10	G 1–5	G 6–10	G 1–5	G 6–10
PB95	10.266	10.992	8.365	8.911	4.676	3.548
	(0.5465)	(0.6411)	(0.3369)	(0.3976)	(0.5542)	(0.5554)
PB00	9.57	10.899	8.273	9.403	4.887	3.484
	(0.7255)	(0.531)	(0.5503)	(0.3458)	(0.6133)	(0.6421)
DB95	10.983	11.921	7.89	7.511	4.083	3.359
	(0.5751)	(0.7104)	(0.322)	(0.2421)	(0.4795)	(0.3603)

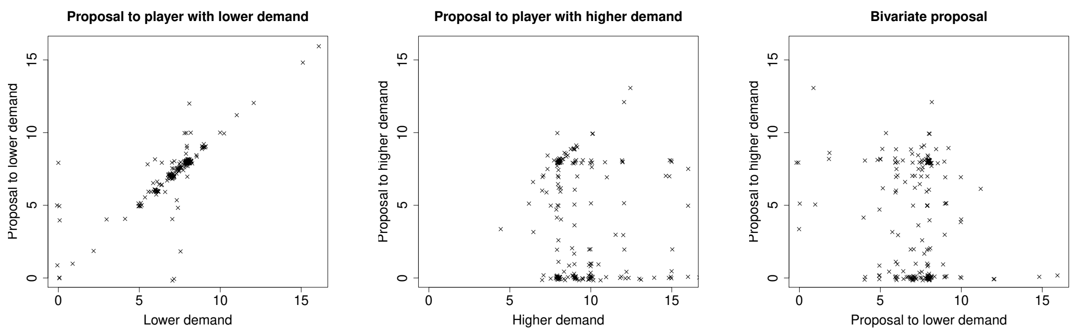
Note: The standard errors are computed using the subsession means as independent observations. The values for "G 1–5" refer to the first five games per session, those for "G 6–10" refer to the last five games per session.

(b) Proposals in relation to the (empirical) continuation payoffs in *PB00* and *PB95*



Note: The points are slightly perturbed to improve visualization.

(c) Proposals in relation to the demands in *DB95*



Note: The points are slightly perturbed, and the proposals that satisfied neither demand are excluded.

holds true for both, egoistic utilities and Fehr-Schmidt utilities).

$$x_p = \underset{(1.3096)}{12.560^{**}} + \underset{(0.0799)}{0.3072^{**}} \cdot G - \underset{(0.3293)}{0.4421} \cdot R - \underset{(0.1382)}{0.4772^{**}} \cdot d_l + \underset{(0.0817)}{0.1327} \cdot d_h \tag{12}$$

$$x_h = \underset{(0.6597)}{4.5274^{**}} - \underset{(0.0463)}{0.0136} \cdot G \quad - \underset{(0.1878)}{0.0778} \cdot R + \underset{(0.0763)}{0.3789^{**}} \cdot d_l + \underset{(0.0458)}{0.0434} \cdot d_h \tag{13}$$

$$x_l = \underset{(0.9931)}{4.5787^{**}} - \underset{(0.0563)}{0.1625^{**}} \cdot G + \underset{(0.2323)}{0.4060} \cdot R + \underset{(0.1016)}{0.0655} \cdot d_l \quad - \underset{(0.0576)}{0.1217^{*}} \cdot d_h + \underset{(0.0792)}{0.0527} \cdot x_h$$

Figure 2c plots the proposals in relation to lower demand and higher demand, respectively. This shows that the proposers generally match the lower demand, while they give a more or less random amount to the third player. This close relationship does not show through in the estimate for x_h, Eq. (13), since contrary to the theoretical prediction, the higher of the payoffs is not always given to the player with the lower demand (see the points above the diagonal in the third plot of Figure 2c).

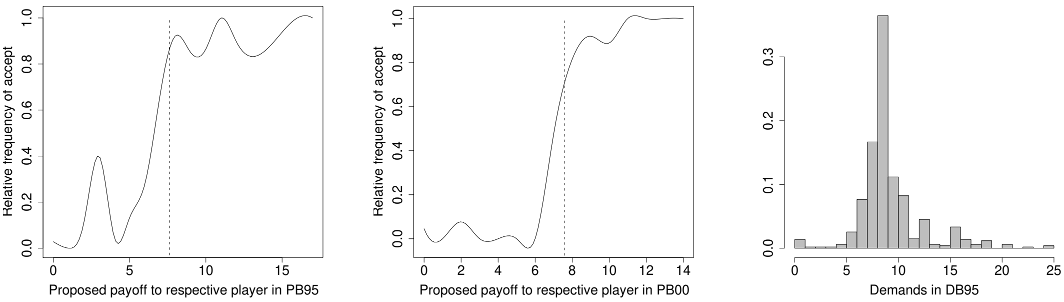
The effects of d_l show that the proposer payoffs increase only by €0.50 if the lowest demand decreases by €1. The remaining €0.50 is split in an 80–20 ratio between x_h and x_l. As predicted theoretically, the high demand is largely irrelevant, but interestingly, x_l decreases when the high demand is more greedy. There is no direct crowding out between x_h and x_l. In relation to *PB95* and *PB00*, the proposer payoff increases slightly, the high payoff decreases significantly, and the low payoff is not significantly different (in Mann-Whitney-*U* tests at the .01 level). The following summarizes the main observations concerning the proposals in *DB95*.

Result 3.2. *The proposer payoff is not significantly higher in* DB95 *than in* PB95*, the "non-strategic donation"* x_l *is not significantly different, but the expenses for vote buying* x_h *fall significantly. Again, stationarity is not violated.*

The close relationship between the lower demand and the payoff of the player with the lower demand strongly suggests that the overpayment effect with respect to the high payoff x_h in *PB95* and *PB00* is not related to generosity, but to risk aversion—as it disappears if we take away the risk. Generosity shows through in the positive expense x_l, however, and hence, neither risk aversion nor social preferences alone can explain our observations.

We now turn to the voting and demand functions. See Figure 3 for a graphical

Figure 3: Voting functions (relative acceptance frequencies) and distribution of demands



overview of the voting functions (the relative frequency of "accept" as a function of the allocated payoff) and distribution of demands. The voting decisions are modeled using binomial logit regression, and the demands are modeled using a linear model, both with random effects as described above. The independent variables considered in the following are, aside from G and R, the own payoff x_i according to the proposal on the table, the proposer's payoff x_p, an indicator I_{CP} that is 1 iff $x_i \geq 7.60$ (which is the expected continuation payoff), and indicator I_h that is 1 iff one has the high payoff under the proposal in the sense $x_i = \max\{x_1, x_2\}$. Theoretically, only I_{CP} should be significant. The estimated voting function in *PB95* is (where $\hat{=}$ represents the logit link)

$$\begin{aligned}\sigma_v \hat{=} & -\underset{(0.6869)}{1.4469} -\underset{(0.0450)}{0.1052^{*}}\cdot G +\underset{(0.2679)}{0.1869}\cdot R +\underset{(0.3756)}{1.7571^{**}}\cdot I_{CP} \\ & +\underset{(0.0876)}{0.5537^{**}}\cdot x_i -\underset{(0.0492)}{0.2660^{**}}\cdot x_p +\underset{(0.3840)}{1.1541^{**}}\cdot I_h \end{aligned} \tag{14}$$

and the voting function in *PB00* is

$$\sigma_v \hat{=} -\underset{(1.2271)}{3.1558^{*}} -\underset{(0.0884)}{0.1311}\cdot G +\underset{(0.7292)}{2.7040^{**}}\cdot I_{CP} \tag{15}$$

$$+\underset{(0.1573)}{0.4821^{**}}\cdot x_i -\underset{(0.0967)}{0.0702}\cdot x_p -\underset{(0.7554)}{0.5231}\cdot I_h. \tag{16}$$

Similar to above, the hypothesis that the coefficients of these voting functions equate between the treatments ("truncation consistency") is tested in likelihood-ratio tests,

Figure 4: Number of rounds in *PB95* and *DB95*

but again it cannot be rejected at the .01 level ($p = 0.026$). The main difference is that the acceptance probability in *PB95* depends negatively on the proposer's payoff x_p and on whether $x_i \geq x_j$ (i.e. that one has been offered the high payoff). Both of these influences suggest fairness-like concerns. Stationarity is not violated, since the round effect remains insignificant.

Result 3.3. *The voting functions in* PB95 *and* PB00 *violate neither truncation consistency nor stationarity (at* $\alpha = .01$*). The voting decisions seemingly exhibit fairness concerns in* PB95*, while they are largely as predicted in* PB00*.*

Finally, we describe the estimated demand functions in *DB95*. Similarly to the proposal functions in *PB95*, their only independent variables are game number within the session G and the round number within the game R.

$$x_d = \underset{(0.3230)}{9.4550^{**}} - \underset{(0.0382)}{0.1403^{**}} \cdot G - \underset{(0.1643)}{0.0873} \cdot R \tag{17}$$

Result 3.4. *The demands in* DB95 *do not violate stationarity, but they are far higher than predicted and decrease only slowly as subjects gain experience.*

The following section introduces the structural models that we use to describe the above observations. These models will allow us to understand exactly how and why the subjects deviated from the equilibrium predictions.

4 Structural models of random-proposer bargaining

The present section introduces the family of structural models that we consider to describe subjects' behavior. The purpose of our analysis is to explore the reason for the abovely documented—and essentially anticipated—deviations from the equilibrium predictions in the proposer games. In particular, we seek to find out why the proposers are more generous than seems necessary. Qualitatively, generosity can be explained by both risk aversion (as generosity increases the possibility of an affirmative vote) and social preferences (i.e. altruism on the side of the proposer), and in line with previous bargaining experiments that have been debated for several decades, the descriptive results above suggest that both of these influences are relevant indeed.

The structural approach described next allows us to shed light on this discussion from a novel perspective, and beyond that, the majority game allows for analyses that are novel in the following ways. First, our experimental design requires the proposer to state all cake shares without enforcing that they sum up to 1. This allows us to gauge their taste for efficiency and their numerical prowess, which in turn is needed to distinguish deviations from best response from deviations from risk-neutral payoff maximization. Second, we consider one-round games and infinite-horizon games in a joint analysis, to gauge the subjects' sense of their continuation payoffs (i.e. their numerical prowess, again). Third, and most importantly, our analysis is the first to consider risk aversion and altruism in quantal response equilibria of infinite-horizon bargaining games altogether.

4.1 Possible forms of risk aversion and altruism

The motives that we are interested in distinguishing can be formalized in a variety of ways. We will consider subject heterogeneity with respect to the four motives discussed next. All four of them can be defined using two-parameter utility functions. The first of them is the model of inequity aversion following Fehr and Schmidt (1999). If $\pi \in \mathbb{R}^N$ denotes the payoff profile, then the utility of $i \in N$ is

$$u_i(\pi) = \pi_i - \alpha \cdot \sum_{j \neq i} \max\{\pi_j - \pi_i, 0\} - \beta \cdot \sum_{j \neq i} \max\{\pi_i - \pi_j, 0\}. \tag{18}$$

As we discussed above (based on Montero, 2007), inequity aversion alone cannot explain the observed deviations from equilibrium, but in a model of quantal response equilibrium, it may at least explain the motivation of a fraction of the subject pool. An alternative explanation of equitable proposals, and in particular of the central proposals in Figure 2b, is that subjects have more general distributive preferences, e.g. Leontief preferences over payoff profiles. We capture this possibility using the following family of CES utility functions.

$$u_i(\pi) = \Big((1-\alpha)\cdot(1+\pi_i) + \alpha/2\cdot(1+\pi_j)^{\beta} + \alpha/2\cdot(1+\pi_k)^{\beta}\Big)/\beta. \tag{19}$$

CES utilities have been found to be descriptive in several studies, e.g. Andreoni and Miller (2002), and the particular CES family considered here has been proposed by Cox et al. (2007).

Alternatively, risk preferences can explain generous proposals. In SPEs, voters accept if and only if their continuation payoffs are covered. However, the empirical voting functions are continuous (see Figure 3), and thus more generous proposals have a higher probability of being accepted. In this context, risk aversion may explain the clustering of proposals around $(x,0)$ and $(0,x)$ for $x \approx 10$ in Figure 2b, but an idea of risk diversification may also explain the equitable proposals in the center of Figure 2b. To capture a general form of risk and loss aversion, we consider the following prospect theoretic utility function.

$$u_i(\pi) = \begin{cases} (\pi_i - 8)^{\alpha}, & \text{if } \pi_i \geq 8 \\ -\beta\cdot(8-\pi_i)^{\alpha}, & \text{if } \pi_i < 8 \end{cases} \tag{20}$$

Note that we assume that subjects "aspire" to get a third of the cake (i.e. a payoff of 8), which is reasonable in this context as it constitutes the ex-ante payoff in equilibrium. This "aspiration point" could also be considered a free parameter, but for comparability with the other utility functions, we stick to this parsimonious two-parameter variant. As a final alternative, we allow for a utility function containing elements of both risk aversion and altruism (i.e. Cobb-Douglas altruism and constant relative risk aversion).

$$u_i(\pi) = \Big((1+\pi_i)^{1-\alpha} \cdot (1+\pi_j)^{\alpha/2} \cdot (1+\pi_k)^{\alpha/2}\Big)^{1-\beta} / (1-\beta) \tag{21}$$

4.2 Quantal response proposal functions

The above set of utility functions will allow us to discuss the (mixture of) motives shaping subjects' behavior, but to obtain unbiased estimates of these motives, we also have to specify the (possible) random component in the utility function. The existence of a random component allows us to explain why proposals vary in seemingly equivalent circumstances. Random utility modeling has a long tradition in choice theory, see e.g. the survey of McFadden (1984), and has been introduced to game theory by Rosenthal (1989) and McKelvey and Palfrey (1995). First, we describe the nested logit model of the proposal choice, and further below how this model is extended to a stationary quantal response equilibrium in bargaining games.

Given a utility function $u_i : \mathbb{R}^N \to \mathbb{R}$ for player $i \in N$ and well-defined continuation strategies, let $v_i(\mathbf{x})$ denote the expected utility of i as a proposer when proposing $\mathbf{x} \in \mathbf{X}$. Player i chooses the proposal to maximize the random utility

$$\tilde{v}_i(\mathbf{x}) = v_i(\mathbf{x}) + \varepsilon_{i,\mathbf{x}}, \tag{22}$$

where $\varepsilon_{i,\mathbf{x}}$ has generalized extreme value (GEV) distribution. This model of random utility maximization gives rise to the family of GEV proposal functions. If we would restrict our attention to the case that $\varepsilon_{i,\mathbf{x}}$ has the extreme value distribution, then the choice density would have the simpler multinomial logit form. That is, for all $\mathbf{x} \in \mathbf{X}$,

$$\sigma_i(\mathbf{x}) = \exp\{\lambda \cdot v_i(\mathbf{x})\} / \sum_{\tilde{\mathbf{x}} \in \mathbf{X}} \exp\{\lambda \cdot v_i(\tilde{\mathbf{x}})\}. \tag{23}$$

We do not restrict our attention to this special case, as it seems unrealistic that subjects come up with a three-dimensional proposal just like this. It seems much more reasonable to at least allow for the possibility that they decide sequentially about its components or its characteristics—not the least because these values are entered sequentially in the form at the computer terminal. Much of the existing literature in experimental game theory tends to neglect the choice theoretic implications that sequential (i.e. "hierarchical") decision procedures can have, but as indicated, to enable an unbiased analysis of the motives, we allow for such hierarchical "nested logit" choice patterns.

As for proposal making in three-player games, two three-level choice hierarchies seem particularly intuitive. According to the first one, the proposer decides *sequentially* on the three components of his proposal. That is, first he chooses $x_p \in [0,24]$, second he chooses $x_1 \in [0,24-x_p]$, and third he chooses $x_2 \in [0,24-x_p-x_1]$. We formalize this procedure by defining, given $\mathbf{X}$ as the initial choice set of the proposer, a partition $\overline{\mathbf{Y}}$ of the choice set $\mathbf{X}$, and for all $\mathbf{Y} \in \overline{\mathbf{Y}}$, partitions $\overline{\mathbf{Z}}(\mathbf{Y})$ of $\mathbf{Y}$. The proposer first chooses $\mathbf{Y} \in \overline{\mathbf{Y}}$, second he chooses $\mathbf{Z} \in \overline{\mathbf{Z}}(\mathbf{Y})$, and finally he chooses the actual proposal $\mathbf{x} \in \mathbf{Z}$. Using this notation, the sequential choice procedure can be defined as follows.

Definition 4.1 (Sequential proposal refinement (SeqRef))**.** Two proposals $\mathbf{x}', \mathbf{x}'' \in \mathbf{X}$ are in the same subset $\mathbf{Y} \in \overline{\mathbf{Y}}$ if and only if $x'_p = x''_p$. Given $\mathbf{Y}$, two proposals $\mathbf{x}', \mathbf{x}'' \in \mathbf{Y}$ are in the same subset $\mathbf{Z} \in \overline{\mathbf{Z}}(\mathbf{Y})$ if and only if $x'_1 = x''_1$.

The second choice procedure that we consider is inspired by the theoretical arguments made in the existing literature. Here, the proposer first chooses the quadrant in relation to the continuation payoffs (i.e. whom to pay his continuation payoff, see Figure 2b). To extend this to a three-level hierarchy, we assume that he secondly chooses the approximate region of his proposal within the chosen quadrant (with an accuracy of €2), and that he thirdly chooses the actual proposal. In this second model, the proposal maker refines his proposal *simultaneously* over all three dimension, rather than sequentially.

Definition 4.2 (Simultaneous proposal refinement (SimRef))**.** Let $\tilde{u}$ denote the continuation utilities of the voters. Two proposals $\mathbf{x}', \mathbf{x}'' \in \mathbf{X}$ are in the same subset $\mathbf{Y} \in \overline{\mathbf{Y}}$ if and only if $u_i(\mathbf{x}') \geq \tilde{u} \Leftrightarrow u_i(\mathbf{x}'') \geq \tilde{u}$ for $i = 1,2$. Given $\mathbf{Y}$, two proposals $\mathbf{x}', \mathbf{x}'' \in \mathbf{Y}$ are in the same subset $\mathbf{Z} \in \overline{\mathbf{Z}}(\mathbf{Y})$ if and only if $\lfloor x'_i/2 \rfloor = \lfloor x''_i/2 \rfloor$ for $i = 1,2$.

Given these nested choice procedures, the choice probabilities follow from the standard definitions of nested logit response functions (see McFadden, 1984, and the references cited therein). For the following, let $\tilde{u}$ denote the continuation utility, and given a proposal $\mathbf{x} = (x_p, x_1, x_2)$, let $u_1(\mathbf{x})$ and $u_2(\mathbf{x})$ denote the utility of voter 1 and 2, respectively. The probability of choosing $\mathbf{x} \in \mathbf{X}$ is

$$\sigma_i(\mathbf{x}) = Q(\mathbf{x} \mid \mathbf{Z}) \cdot Q(\mathbf{Z} \mid \mathbf{Y}) \cdot Q(\mathbf{Y}) \tag{24}$$

for $\mathbf{x} \in \mathbf{Z}$, $\mathbf{Z} \in \overline{\mathbf{Z}}(\mathbf{Y})$, and $\mathbf{Y} \in \overline{\mathbf{Y}}$, with

$$\begin{aligned} Q(\mathbf{x} \mid \mathbf{Z}) &= \exp\left\{\lambda^p \cdot v_i(\mathbf{x})\right\} / p_{\mathbf{Z}} & \qquad p_{\mathbf{Z}} &= \sum_{\tilde{\mathbf{x}} \in \mathbf{Z}} \exp\left\{\lambda^p \cdot v_i(\tilde{\mathbf{x}})\right\} \\ Q(\mathbf{Z} \mid \mathbf{Y}) &= \exp\left\{\rho' \cdot \ln p_{\mathbf{Z}}\right\} / p_{\mathbf{Y}} & p_{\mathbf{Y}} &= \sum_{\tilde{\mathbf{Z}} \in \overline{\mathbf{Z}}(\mathbf{Y})} \exp\left\{\rho' \cdot \ln p_{\tilde{\mathbf{Z}}}\right\} \\ Q(\mathbf{Y}) &= \exp\left\{\rho'' \cdot \ln p_{\mathbf{Y}}\right\} / p & p &= \sum_{\tilde{\mathbf{Y}} \in \overline{\mathbf{Y}}} \exp\left\{\rho'' \cdot \ln p_{\tilde{\mathbf{Y}}}\right\}, \end{aligned}$$

where $(\lambda^p, \rho', \rho'')$ are precision and interdependence parameters. McFadden (1984, p. 1422ff) also defines the distribution of the random utility component that gives rise to this three-level nested logit model. Further, since the nested logit model is a GEV model, a nested logit equilibrium (see below) is a special case of a quantal response equilibrium as defined by McKelvey and Palfrey (1995).

4.3 Stationary quantal response equilibria

Following the majority bargaining literature, we focus on symmetric equilibria. That is, both voting functions and proposal functions are symmetric between players. Symmetric (stationary) QREs of our random-proposer games are fully characterized by a duple (σ_p, σ_v), where $\sigma_p \in \Delta(\mathbf{X})$ is the proposal function (of each player), and $\sigma_v : \mathbf{X} \to [0,1]$ is the voting function (for a general definition of stationary QREs, see Breitmoser et al., 2010). Let $u : \mathbf{X} \to \mathbb{R}$ denote the players' utility function.[6] Define $\tilde{u} \in \mathbb{R}$ as the disagreement utility under (σ_p, σ_v), i.e. the expected utility in case the next proposal is not accepted, and initially let us take it as given. The logit voting

[6]The argument of $u(\mathbf{x})$, i.e. $\mathbf{x} = (x_1, x_2, x_3)$, is understood to have the payoff of the respective player as x_1, and the opponents' payoffs as x_2 and x_3. We assume $u(x_1, x_2, x_3) = u(x_1, x_3, x_2)$.

function σ_v solves[7]

$$\sigma_v(\mathbf{x}^1|\tilde{u}) = \frac{\exp\{\lambda^v \cdot u(\mathbf{x}^1)\}}{\exp\{\lambda^v \cdot u(\mathbf{x}^1)\} + \exp\{\lambda^v(\sigma_v(\mathbf{x}^2|\tilde{u}) * u(\mathbf{x}^1) + (1-\sigma_v(\mathbf{x}^2|\tilde{u})) * \tilde{u})\}}. \quad (25)$$

The corresponding probability that $\mathbf{x}$ will be accepted, conditional on $\tilde{u}$ and σ_v, is

$$\Pr(\mathbf{x}) = 1 - \left[1 - \sigma_v\left(\mathbf{x}^1|\tilde{u}\right)\right]\left[1 - \sigma_v\left(\mathbf{x}^2|\tilde{u}\right)\right]. \quad (26)$$

and thus the expected utility of the proposer from proposing $\mathbf{x} \in \mathbf{X}$ is

$$v_i(\mathbf{x}) = \Pr(\mathbf{x}) \cdot u_i(\mathbf{x}) + (1 - \Pr(\mathbf{x})) \cdot \tilde{u}, \quad (27)$$

Given this function v_i, the proposal function σ_p is defined by Eq. (24). Note that we allow for role-specific precision parameters λ^p and λ^v for proposers and voters, respectively, because their choice problems have different complexity. Finally, let $\mathbf{u} \in \mathbb{R}^N$ denote the expected payoff of all $i \in N$ under (σ_p, σ_v), and define

$$\overline{u} = \delta \cdot (u_1 + u_2 + u_3)/3 + (1 - \delta) \cdot u(0,0,0). \quad (28)$$

In any stationary QRE of *PB95*, $\tilde{u} = \overline{u}$. We determine the equilibrium (σ_p, σ_v) by function iteration using the starting value $\tilde{u} = u(7,7,7)$. The stationary equilibrium is unique if and only if the voting equilibria (25) are unique for all proposals $\mathbf{x} \in \mathbf{X}$, but conditions for the latter do not seem available. In our computations, the function iteration generally converged quickly to the fixed point ($\tilde{u} = \overline{u}$), which suggests that the equilibrium is stable and locally unique.[8]

The strategy profile (σ_p, σ_v) is the symmetric QRE of *PB00* for $\tilde{u} = u(7.6, 7.6, 7.6)$.

[7]The following expression uses a notation of permutations of $\mathbf{x} \in \mathbf{X}$. In general, $\mathbf{x}$ is in the order (x_p, x_1, x_2), i.e. the first value refers to the proposer, the second value to the first voter, and the third value to the second voter. We define $\mathbf{x}^1 := (x_1, x_p, x_2)$ and $\mathbf{x}^2 := (x_2, x_p, x_1)$.

[8]For each proposal $\mathbf{x} \in \mathbf{X}$, the equilibrium acceptance probabilities $\sigma_1(\mathbf{x})$ and $\sigma_2(\mathbf{x})$ of the voters had also been determined by function iteration, using the starting probabilities $(0.5, 0.5)$. In this case, the function iteration was dampened to ensure robust convergence. Also note that, as stated in Footnote 2, €0.2 was used as the smallest currency unit in the structural analysis (most actual proposals had been multiples of it, and the remaining few had been rounded appropriately).

5 Model comparison

In the present section, we describe and discuss the estimates for the structural models introduced above. Each player type is fully defined by the parameter tuple $\mathbf{p} = \langle \lambda^p, \rho', \rho'', \lambda^v, \alpha, \beta \rangle$, where the meaning α and β depends on the utility function considered. We estimate the mixture of types in our subject pool, assuming that every subject plays according to the QRE of one of the types. Thus, if K denotes the set of types in the population with type shares ρ_k for all $k \in K$, $\mathbf{P} = (\mathbf{p}^k)_{k \in K}$ the parameter profile, $\mathbf{O} = (o_{s,t})$ the set of observations for all subjects $s \in S$ and periods $t \in T$, the log-likelihood function is

$$LL(\mathbf{P}|\mathbf{O}) = \sum_{s \in S} \ln \sum_{k \in K} \rho_k \prod_{t \in T} \sigma\big(o_{s,t}|\mathbf{p}^k\big), \tag{29}$$

using $\sigma\left(o_{s,t}|\mathbf{p}^k\right)$ as the probability of action $o_{s,t}$ according to the QRE defined by the parameter profile $\mathbf{p}^k$. The log-likelihood is maximized jointly over all parameters to obtain consistent and efficient estimates (see e.g. Amemiya, 1978, and Arcidiacono and Jones, 2003, for further discussion). We used the derivative-free NEWUOA algorithm (Powell, 2008) for the initial approach toward the maximum (NEWUOA is a comparably efficient and robust algorithm, see Auger et al., 2009, and Moré and Wild, 2009), and subsequently, we used a Newton-Raphson algorithm to ensure local convergence. This procedure has been restarted repeatedly with a variety of starting values. The complete list of parameter estimates, including standard errors derived from the information matrix, is provided as supplementary material. Model comparisons will be based on the Bayes Information Criterion (Schwarz, 1978), i.e. on $BIC = -LL + (\#Pars)/2 \cdot \log(\#Obs)$, and on the Cox-Snell Pseudo-R^2, which is defined as $R^2 = 1 - (L(M_{\text{Intercept}})/L(M_{\text{Full}}))^{2/N}$. As the intercept model, we use the benchmark that players randomize uniformly in all cases.

As indicated repeatedly above, we exclude the demand game from the structural analysis. Its results are important to inform us that we can rule out neither risk aversion nor social preferences as an explanation for overpayment in the proposer games (see e.g. Figure 2b in relation to Figure 2c), but the proposals in demand games do not seem amenable to structural modeling using a nested logit formulation similar to the ones introduced above. For, the proposal to the player with the lower demand degenerates almost all the way to the pure strategy of paying the lower demand (see Figure 2c), and in relation to the variance of the proposal to the other player, this degenerateness does not seem explainable in a random utility model similar to the ones described above.[9]

First, we analyze whether the proposers tend to refine their choices sequentially or simultaneously over the three dimensions, or whether they actually determine all components without violating IIA. At this point, we focus on one-type models for simplicity, but the results are similar in finite mixture models allowing for multiple types. The goodness-of-fit measures obtained for the various model estimated are reported in Table 1a and can be summarized as follows.

Result 5.1. *The SimRef model of nested logit choice explains proposal making far better than the SeqRef model, regardless of the utility function considered.*

Since both nested logit formulations, SimRef and SeqRef, are generalizations of multinomial logit, the multinomial logit model fits worse than these nested logit models. But the differences of their goodness-of-fits in relation to multinomial logit are drastic by any standard. To be precise, the two additional parameters ρ', ρ'' would be significant at the .001 level (in likelihood-ratio tests) if the log-likelihood would improve by a mere 7 points—but the improvements found here (between multinomial logit and the SimRef formulation of nested logit) are at least 500 points, for every utility function. The SeqRef formulation fits worse than the SimRef formulation, but still it improves upon multinomial logit highly significantly.

In turn, this shows that focusing on multinomial logit may strikingly obstruct the validity of one's model, and thus it would also bias one's identification of the underlying motive. The latter can be seen in Table 1a, according to which the most descriptive motive is CES for multinomial logit, Inequity Aversion for SeqRef nested logit, and Prospect theory for SimRef nested logit. There is no ambiguity with respect to the choice structure, however, as SimRef nested logit fits better than both SeqRef

[9] A reasonable model seems to be one where the proposer first decides whose demand to pay, similar to choosing a quadrant, and secondly whether to pay the demand exactly or generously. The fact that generosity applies (almost) exclusively with respect to the player whose demand is not explicitly paid suggests an asymmetry that requires finer parameterization than used above.

Table 1: The Bayes Information Criteria (BICs) of the various models

(a) Comparison of the multinomial logit and nested logit models

	Utility model			
Choice model	Inequity Aversion	CES	Prospect theory	Altr-CRRA
Multinomial logit	4580	4513	4788	5096
SeqRef Nested logit	4187	4483	4631	4502
SimRef Nested logit	3836	3993	3402	3827

Note: Inequity aversion as defined in Eq. (18), CES utility as in Eq. (19), Prospect theory as in Eq. (20), and altruistic CRRA as in Eq. (21). The parameter estimates are reported in the appendix.

(b) Goodness-of-fit of multi-type models without mixture of motives

	Utility model			
Number of types	Inequity Aversion	CES	Prospect theory	Altr-CRRA
1	3836	3993	3402	3827
2	3691	3881	3418	3798
3	3659	3682	3426	3801

(c) Goodness-of-fit of two-type models with mixture of motives

	Utility model 2			
Utility model 1	Inequity Aversion	CES	Prospect theory	Altr-CRRA
Inequity Aversion	3691	3736	3415	3707
CES		3881	3414	3781
Prospect theory			3418	3402
Altr-CRRA				3798

(d) Goodness-of-fit measures of heterogenous models

	Voter type			
Proposer	Prospect	CES	CRRA	IneqAv
Prospect +	3402	3714	3691	3874
CES +	3612	3996	3928	3936
CRRA +	3668	3835	3802	4046
IneqAv +	3488	3741	3692	3839

(e) Estimates for two of the best-fitting models

		Type	Share	λ_p	ρ_1	ρ_2	λ_v	α	β	LL_{BIC}	R^2
Prospect		1	1 (*NaN*)	4.822 (0.032)	0.035 (0.002)	0.054 (0.001)	2.656 (0.005)	0.002 (*NaN*)	21.888 (0.039)	−3379.3 3402.02	0.8877
CRRA Prospect	+	1	0.021 (*NaN*)	0.286 (0.005)	0.159 (0.005)	0.107 (0.014)	0.155 (0.027)	0.154 (0.001)	0.366 (0.004)		
		2	0.979 (0.012)	4.752 (0.075)	0.042 (0.002)	0.039 (0.001)	2.651 (0.008)	0.001 (*NaN*)	21.764 (0)	−3352.29 3401.51	0.8908

nested logit and multinomial logit for every motive considered.

For this reason, we now focus on the SimRef model of nested logit response and examine whether the data support finite mixtures of types. Tables 1b and 1c report the goodness-of-fit measures (BIC) for the estimated multi-type models without and with mixtures of motives, respectively. The parameter estimates for the best models found in this analysis are reported in Table 1e, the remaining parameter estimates are provided as supplementary material.

Result 5.2. *The single-type Prospect theoretic model fits better than all mixtures of non-prospect theoretic types, and in finite mixtures with the Prospect theoretic type, alternative types do not lead to improvements of the Bayes information criterion.*

This suggests that the subject pool is a rather homogenous group with Prospect theoretic utility, but to verify the robustness of this conclusion, we allow for the possibility that proposers and voters are heterogenous. The most intuitive such combination may be that proposers are risk averse and voters are inequity averse, but we allow for all sixteen such combinations. Table 1d summarizes the Bayes information criteria of the estimated models.

Result 5.3. *Regardless of how proposers are modeled, voters are clearly best modeled as Prospect theoretic types. Modeling proposers as Prospect theoretic does not improve upon the alternative models regardless of how voters are modeled, but it does improve upon the other models if voters are modeled as Prospect theoretic.*

All subjects are best modeled as Prospect theoretic types. That is, they have reference-dependent preferences as discussed by Shalev (2000, 2002) and Kőszegi (2010) with the reference point being equal to the (ex-ante) expected payoff in the game. It is particularly interesting that although the reference point coincides with the equitable payoff, the social preference functions considered here (Fehr-Schmidt and CES) cannot capture the observed behavior of either proposers or responders.

6 Concluding discussion

In this paper, we analyzed behavior in three multi-player bargaining games with varying time horizons and move structures. Doing so departs from the traditional approach of the ultimatum analyses, the closest of which have convexified decisions that reduce the risk of absolute rejection (Andreoni et al., 2003) or introduced a third player without veto power (for a survey, see Güth, 1995). The research question, however, is the same: Does genuine fairness concerns and/or the fear of rejection drive generous bargaining offers? Our design allows us to separate motives and to econometrically model the structure of proposer behavior. Inequity aversion was predicted to have very different effects on offers across these games, but we did not observe such differences. There was no significant difference between the observed outcomes in the two proposer games. Moreover, the proposer did not realize much more than his coalitional voter did, who received on average the continuation payoff, while the other voter got more than nothing—contrary to equilibrium predictions. These observations are in line with those of previous studies, which also noted the under-realization of proposer power and the generosity shown to voters outside the minimal winning coalition (Fréchette et al., 2005a,b; Knight, 2005).

The gap between proposer and secondvoter payoffs was closer than the (stationary) SPE prediction in *PB95*, implying a form of equity that is counter to the predictions of inequity aversion. Proposer and second voter shares diverged over time and thus converged toward the SPE in *PB00*, which is a relatively less equitable state and also counter to the predictions of inequity aversion. The income gap was even narrower in the demand commitment game, contrary to the prediction of maximal inequity and its invariance with respect to Fehr-Schmidt inequity aversion. Put together, these qualitative observations cast doubt on the explanatory power of inequity aversion in explaining proposal making.[10]

Generous offers thus seem more likely to be due to the proposer's anticipation of inequity averse responders than to inequity aversion of himself. The compliance to the lower of the two demands in *DB95*, both of which are higher than predicted,

[10]Similarly, Fréchette et al. (2005a) and Fréchette (2009) observed (non-)convergence of proposals (votes) and increases in the number of minimal winning coalitions in their infinite horizon games.

also suggests so. Such concern for fairness corresponds with evidence from truncated bargaining experiments, and also with Fréchette (2009) who showed how beliefs of "fairness" shape proposals over time. This practically means that outcomes are sensitive to institutional rules on group decision making, the timing of moves, and the structure of information. When demands are publicly known and can be committed to before proposals are made, for example, inequity aversion of responders may pose a resistance to convergence toward the equilibrium outcome of disadvantageous inequity, as fearful proposers pay the ransom for coalitional votes.[11]

The main contribution and novelty of our study is in the exploitation of the dichotomy between *PB00* and *PB95* to discriminate between risk aversion and inequity aversion in a structural model of majority bargaining. Behavior was best modeled as nested logit choices where players first decide whom to pay the continuation payoff and then decide how much to pay them. This approach was shown to fit unambiguously better than two alternative models (another nested model and a non-nested one) and also seems very intuitive. Using this model to describe the choice procedure, we then estimated the subjects' utility functions in an analysis allowing for latent heterogeneity. We found that subjects have Prospect theoretic preferences defined over gains and losses relative to the reference point of expected prior payoffs (in our case the equal split). The reference-dependence of preferences is particularly strong with respect to voter behavior. This equitable reference point coincides with fairness, one that is different from the inequity aversion defined in the literature. The success of the nested logit model prompts further effort in applying this pluralistic structural approach to other bargaining games (there exists extensive supplementary material containing the programs and instructions required to replicate and extend our analysis).

Okada and Riedl (2005) showed that inequity aversion is a plausible explanation for behavior in their coalition bargaining game.[12] Other studies have shown the rele-

[11] Such has been observed in Poulsen and Tan (2007) ultimatum game where proposers may disadvantage themselves by choosing to become informed of responder demands, and so many avoided information and offers fluctuated around the equal split over time.

[12] Our games differ as follows: (i) their game is a one-shot game with zero disagreement payoffs, (ii) their game has super-additive payoffs rather than being a divide-the-dollar game (implying that the grand coalition is uniquely efficient), and (iii) the proposer cannot allocate positive shares to players outside of his coalition. Point (iii) implies that non-coalition players were totally excluded and re-

vance of CES preferences of proposers in dictator games (Andreoni and Miller, 2002) and of responders in mini ultimatum games (Cox et al., 2007) when proposers were treated as "strategic dummies." We structurally tested the degree to which these alternative models explain proposer behavior in a bargaining context where responders have bargaining power.[13] The results point in favor of a (fairness-like) reference-dependence. Further research on its validity in other bargaining setups is warranted. Such structural analysis allows the precise quantitative differentiation between qualitatively different utility functions, and eventually, to conclusively discriminate the motives in games.

Many of these competing utility functions consider relative payoffs and reference points. This confluence makes identifying the motives at play challenging. Indeed, in Fréchette et al. (2005b)'s proposer game study, fairness was interpreted as a "behavioral focal point" that responders are inclined to. Our experimental and econometric results (exploiting the clean differences between *PB00* and *PB95*) together show that what appears fair to the naked eye is actually fear (or reference dependence) in disguise. Thus, while proposals do not necessarily become more equitable when proposers are more inequity averse as Montero (2007) theorized, they do become more equitable when proposers are more fearful of rejection—relative to their greed for acceptance at more favorable terms as we observed. Equity increases also when responders have a strong reputation for inequity aversion or, as in our case, fairness-like reference-dependence.

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ceived nothing, while in our experiment all voters can receive offers regardless of whether or not they eventually joined the coalition.

[13] Camerer (2003) postulated that different motives drive behavior in dictator versus ultimatum games because the proposer considers the responders' powerlessness in the former and power in the latter.

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