NONPARAMETRIC UTILITY THEORY IN STRATEGIC SETTINGS: REVEALING PREFERENCES AND BELIEFS FROM GAMES OF PROPOSAL AND RESPONSE

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Abstract. We explore conditions under which behavior in a strategic setting can be rationalized as the best response to some belief about other players' behavior. We show that a restriction on preferences, which we term quasi-monotonicity, provides such a test for a family of ultimatum games. Preferences are quasi-monotone if an agent prefers an allocation that improves her payoff at least as much as that of others. In an experiment, we find that 94% of proposers make choices that are arbitrarily close to quasi-monotone preferences and beliefs. We also find that 65% of responders are consistent with quasi-monotone preferences, and 90% of responders made inconsistent choices in no more that 5% of decision problems. Subjects who are consistent with quasi-monotone preferences as proposers are also more likely to be consistent with quasi-monotone preferences as responders and believe others act as if they had quasi-monotone preferences. Finally, we find little support for convexity of preferences.

1 Introduction

Revealed preference analysis entails the knowledge of the choice sets over which decisions are made. In strategic environments, the outcomes available to decision makers depend on the decisions of other agents. Testing rational behavior in these contexts

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sometimes requires making strong assumptions on beliefs (see Sprumont 2000, Forges and Minelli 2009, Carvajal et al. 2013). In particular, these approaches test the joint hypothesis of rationality and equilibrium behavior. As Manski (2001, 2004) illustrates, decision rules cannot be separately identified from beliefs. In this paper, we show that, in a family of simple bargaining games, imposing a minimal set of restrictions on preferences and beliefs yields a test of a well-behaved preference ordering consistent with observed behavior. Our results show that properties of preferences can be identified without assuming equilibrium behavior.

In particular, we assume bargainers possess quasi-monotone preferences and believe other bargainers also act according to preferences that are quasi-monotone. The preferences of a bargainer are *quasi-monotone* whenever the total surplus increases she prefers allocations in which her payoff increases by more than other agents' payoffs. Note that this is a monotonicity notion, it does not imply that other outcomes would be less preferred. The theory is agnostic about these alternative allocations. We also assume that bargainers have preferences over lotteries that respect first-order stochastic dominance. Quasi-monotonicity of preferences is akin to self-serving fairness. This behavior is consistent with the models of fairness (e.g., Fehr and Schmidt 1999, Bolton and Ockenfels 2000, and Charness and Rabin 2002), but these models are also consistent with other preferences as well.[1]

We study implications of the quasi-monotonicity assumption together with optimizing behavior in simple bargaining games. In this context, the choice of an allocation by a proposer is equivalent to a lottery which delivers her the chosen allocation or nothing. The setting implies that the probability of the allocation being implemented is equal to the proposer's (subjective) belief that the allocation will be accepted by the responder. We derive empirical implications when responders have quasi-monotone preferences and proposers' beliefs are consistent with this hypothesis. Our assumptions imply that, in the context of the ultimatum game, a proposers must satisfy the Generalized Axiom of Revealed Preferences (GARP). The ultimatum game also provides a direct test of the quasi-monotonicity of preferences of responders. Responders do not face any uncertainty. Their behavior should therefore be consistent with the maximization of

[1]These models would imply stronger restrictions on preferences than quasi-monotonicity. We discuss this issue in the Section 2. Quasi-monotonicity implies what Benjamin (2015) refers to as joint-monotonicity of preferences. Benjamin (2015) shows that joint-monotonicity of preferences is important in obtaining efficient outcomes in bilateral trade problems. Quasi-monotonicity also implies what Dufwenberg, Heidhues, Kirchsteiger, Riedel and Sobel (2011) refer to as social monotonicity of preferences. They show the necessity of this property to obtain Pareto optimal allocations in market economies with social preferences.

complete, transitive and quasi-monotone preference ordering. Interestingly, behavior in the ultimatum game can also reveal whether a responder has convex preferences (together with previous assumptions).[2] Consistency with quasi-monotonicity in both roles therefore provides a stronger test of our assumptions.

We test the theory by observing the choices of subjects in ultimatum games in laboratory experiments. Specifically, we observe subjects' bargaining behavior in a number of ultimatum games which differ in surplus size and the opportunity cost of dividing the surplus. This experimental design mimics real-world situations where buyers and sellers, each facing a different opportunity cost of money, bargain over the price of a non-divisible good.

We find that the behavior of proposers is consistent with quasi-monotonicity of preferences and the belief that other agents behave as if they possess quasi-monotone preferences. Sixty-nine of the 83 proposers (83%) did not violate GARP and, of the 14 who did violate it, nine did so by only an arbitrarily small amount.[3]

Regarding quasi-monotonicity of responders' preferences, we find that 54 of 83 subjects (65%) are consistent with quasi-monotone preferences, and 90% of responders make inconsistent choices in no more than 5% of decision problems. Responders' behavior is heterogeneous: thirty-one subjects (37%) accepted all offers in every game, and 41 subjects (49%) rejected, on average, one or more offers per game. Twenty-three subjects (28%) rejected three or more offers per game, on average. We find evidence against convexity of responders' preferences. Fifty-two subjects (63%) violated convexity, and 45 subjects (54%) had at least six violations. All the subjects that satisfied convexity as responders accepted all offers. Convexity was not common among responders that do reject offers. Importantly, we find that subjects who satisfy responder's rationality are more likely to satisfy proposer's rationality as well. However, we do not find similar correlation between proposer rationality and convex responder rationality.

Our theory makes specific assumptions about the beliefs of proposers. We test these assumptions using alternative belief elicitation techniques (see Section 4 and Appendix B). We find that 81% of subjects' beliefs are consistent with responder rationality and 12% of subjects' beliefs are consistent with convex responder rationality. The result is similar if we use incentivized belief elicitation techniques. In this case, we find that 75 percent of subjects have beliefs consistent with responder rationality and 3 percent of subjects are consistent with convex responder rationality. This result holds if we allow for small measurement error (5 percentage points).

[2]While convexity, as used in the usual consumption framework, implies a preference for diversity. In this context, it implies an aversion to unequal payoffs across players.

[3]That is, they have a critical cost to efficiency index (CCEI) (Afriat 1973) close to 1.

In sum, we find that suitable relaxations of assumptions on preferences and beliefs can be used to derive testable implications of rational behavior in a strategic environment. Our experimental data supports the assumptions we make. Moreover, we are able to replicate our results in two different populations. Our results can be extended to other proposal-response games under additional restrictions (e.g. reciprocal preferences[4]) using the same intuition as in Lemma 1 and Proposition 1 as well as to alternating offers bargaining games.

The paper is organized as follows: Section 2 details our behavioral assumptions; Section 3 gives the testable implications of these assumptions in ultimatum games; Section 4 describes the experiment; Sections 5 presents the experimental results; and Section 6 concludes.

2 Theory

2.1 Preferences Consider games in which players have preferences over their own monetary payoff and the monetary payoffs of other players. Let the vector of monetary payoffs in an n-player game be denoted by the n-vector $\mathbf{x} \equiv (x_i, \mathbf{x}_{-i})$, where x_i is Player i's payoff and $\mathbf{x}_{-i}$ is the $n-1$ vector of payoffs for players other than Player i. The consumption set in an n-player game is $\mathbf{R}^n_+$.

The nature of the problem requires us to consider the set of binary lotteries. The lottery has two possible outcomes from $\mathbf{R}^n_+$ and the probability q of the first outcome. Denote the set of binary lotteries by $\mathcal{L} = \mathbf{R}^n_+ \times \mathbf{R}^n_+ \times [0, 1]$, and denote a binary lottery by $\mathbf{L} \in \mathcal{L}$.

Let $\succeq_i \subseteq \mathcal{L} \times \mathcal{L}$ be the preference relation of Player i. Denote by $\succ_i$ the strict part of $\succeq_i$ and by $\sim_i$ the indifferent part of $\succeq_i$. Throughout the analysis we maintain the following assumptions:

Complete: For all $\mathbf{L}, \mathbf{L}' \in \mathcal{L}$ either $\mathbf{L} \succeq_i \mathbf{L}'$ or $\mathbf{L}' \succeq_i \mathbf{L}$ or both.

Transitive: For all $\mathbf{L}, \mathbf{L}', \mathbf{L}'' \in \mathcal{L}$ if $\mathbf{L} \succeq_i \mathbf{L}'$ and $\mathbf{L}' \succeq_i \mathbf{L}''$, then $\mathbf{L} \succeq_i \mathbf{L}''$.

Continuous: For all $\mathbf{L} \in \mathcal{L}$, the sets $\{\mathbf{L}' : \mathbf{L}' \succeq_i \mathbf{L}\}$ and $\{\mathbf{L}' : \mathbf{L} \succeq_i \mathbf{L}'\}$ are closed.[5]

Independence of impossible alternatives: $(\mathbf{x}, \mathbf{x}'', 1) \succeq_i (\mathbf{x}', \mathbf{x}'', 1)$ if and only if $(\mathbf{x}, \mathbf{x}''', 1) \succeq_i (\mathbf{x}', \mathbf{x}''', 1)$ for all $\mathbf{x}''' \in \mathbf{R}^n_+$. In words, this property requires that an agents

[4]By reciprocal preferences we mean that responders choose allocations that are more favorable to proposers whenever the choices available allow higher payoffs to responders.

[5]From here on we operate in the standard topology of open balls on $\mathbf{R}^2_+ \times [0, 1]$.

is indifferent to outcomes that occur with probability zero.[6]

Hereon, and if it does not lead to confusion, we simplify the notation by using $\mathbf{x}$ instead of $(\mathbf{x}, \mathbf{x}'', q)$. When we compare $\mathbf{x}$ and $\mathbf{x}'$ we mean the comparison of $(\mathbf{x}, \mathbf{x}'', q)$ and $(\mathbf{x}', \mathbf{x}'', q)$, i.e. two binary lotteries which differ only in the first outcome.

Stochastic Dominance Preference: For all $\mathbf{x}'' \succeq_i (\succ_i)\mathbf{x}' \succeq_i \mathbf{x}$ and $0 \leq p \leq q \leq 1$,

$$(\mathbf{x}'', \mathbf{x}', q) \succeq_i (\mathbf{x}'', \mathbf{x}, q) \succeq_i (\succ_i)(\mathbf{x}', \mathbf{x}, q) \succeq_i (\mathbf{x}', \mathbf{x}, p).$$

Stochastic Dominance Preference includes two aspects. First, Player i prefers a lottery with a higher probability of a better outcome. Second, Player i prefers a lottery with a better bundle(s), if probabilities are fixed.

Note that we are modeling the proposer's choice under uncertainty without the independence assumption of standard expected utility theory.[7]

Quasi-Monotone: For all $(x_i, \mathbf{x}_{-i}), (x'_i, \mathbf{x}'_{-i}) \in \mathbf{R}^n_+$,

$$(x_i, \mathbf{x}_{-i}) \geq (x'_i, \mathbf{x}'_{-i}),\ \forall j \neq i\ x_i - x'_i \geq x_j - x'_j\ \Rightarrow (x_i, \mathbf{x}_{-i}) \succeq_i (x'_i, \mathbf{x}'_{-i}).$$

Strictly Quasi-Monotone: For all $(x_i, \mathbf{x}_{-i}), (x'_i, \mathbf{x}'_{-i}) \in \mathbf{R}^n_+$,

$$(x_i, \mathbf{x}_{-i}) > (x'_i, \mathbf{x}'_{-i}),\ \forall j \neq i\ x_i - x'_i \geq x_j - x'_j\ \Rightarrow (x_i, \mathbf{x}_{-i}) \succ_i (x'_i, \mathbf{x}'_{-i}).$$

(Strict) Quasi-monotonicity is a relaxation of the (strict) monotonicity assumption from standard preference theory. In other words, player i has quasi-monotone preferences if she prefers a bundle in which all players' payoffs are increased, but none by more than the increase in Player i's own payoff. Notice that, unlike other properties, quasi-monotonicity is defined over the monetary outcomes and not over binary lotteries.

[6]The necessity of this assumption is driven by the formal definition of lottery used. If we use the standard definition of lotteries using the cumulative distribution function, the assumption would be automatically satisfied. However, this would significantly complicate the notation and obscure the discussion.

[7]The derivation of the expected utility property in the context of games of proposal and response can be found in Gilboa and Schmeidler (2003).

Convex: For all $\mathbf{x} \in \mathbf{R}^n_+$ and $\alpha \in [0,1]$, if $\mathbf{x}' \succsim_i \mathbf{x}$ and $\mathbf{x}'' \succsim_i \mathbf{x}$, then $\alpha \boldsymbol{x}' + (1-\alpha)\mathbf{x}'' \succsim_i \mathbf{x}$.

In the case of responders, the notion of rationality can be modified to include convexity of preferences. Convexity, in this case, is not a statement about the risk preferences of agents (responders) face no risk. Convexity, instead, refers to preferences for redistribution.

2.2 Beliefs In the context of games of proposal-response probabilities, q is endogenously determined. In particular, consider the situation in which Player i offers Player j the choice of either bundle $\mathbf{x}$ or bundle $\mathbf{x}'$ to be implemented. In the notation above, this is a lottery $(\mathbf{x}, \mathbf{x}', q)$ where q is determined by Player j.[8] The *belief function*, $q : \mathbf{R}^n_+ \to [0,1]$ is a continuous map of the proposed allocation into the proposer's subjective probability that $\mathbf{x}$ is realized. Let us state the restrictions on the belief function, which we incorporate into the notion of the proposer's rationality.

Known Preference Restrictions: For all i, Player i knows that for all $j \neq i$, Player j's preferences over allocations are complete, transitive, continuous, and quasi-monotone.

Belief Consistency: For all $\mathbf{x}, \mathbf{x}'$, if for every $j \neq i$ $\mathbf{x}' \succeq_j \mathbf{x}$, then $q(\mathbf{x}') \geq q(\mathbf{x})$.

Belief Consistency states that if a proposer knows that bundle $\mathbf{x}'$ is preferred to bundle $\mathbf{x}$ by all responders,[9] then they assign a higher subjective probability to $\mathbf{x}'$ being implemented than to $\mathbf{x}$. This is rather weak assumption on its own and is restricted by the known preference restrictions. The latter implies that the proposer is guaranteed to have information about responders' preferences and expects them to act according to responder rationality. Note that this does not imply that the proposer knows the entire preference relation of any responder.

2.3 Two-player games of proposal and response In the sequel, we confine our attention to two-player games. If Player i is the proposer, we denote $i = \mathrm{p}$ and $j = \mathrm{r}$, and if Player i is the responder, we denote $i = \mathrm{r}$ and $j = \mathrm{p}$. In the ultimatum game, an allocation $(x_{\mathrm{p}}, x_{\mathrm{r}})$ is chosen by the proposer from a given linear budget constraint, and

[8] In the sense that q is a probability with which Player j would accept allocation $\mathbf{x}$ in favor of allocation $\mathbf{x}'$ according to Player i's belief.

[9] This allows generalization of some of the analysis to games with multiple responders who take actions simultaneously or sequentially.

the responder chooses either $(x_{\mathrm{p}}, x_{\mathrm{r}})$ or $(0,0)$ as the realized allocation. For simplicity, we will refer to the lottery $((x_{\mathrm{p}}, x_{\mathrm{r}}), (0,0), q((x_{\mathrm{p}}, x_{\mathrm{r}}))) \in \mathcal{L}$ as simply $(x_{\mathrm{p}}, x_{\mathrm{r}})$.

The term *responder rationality* is used to describe a subject with complete, transitive, and quasi-monotonic preferences over allocations. The term *proposer rationality* is used to describe a subject with complete, transitive, continuous, *strictly* quasi-monotone, independent of impossible alternatives preferences over binary lotteries that exhibits stochastic dominance and a continuous belief function that satisfies the known preference restriction and belief consistency properties. Further, we assume that every proposer exhibits proposer rationality and that every responder exhibits responder rationality. Following Debreu (1964),[10] we can infer that proposer rationality implies the existence of continuous utility function over binary lotteries (U_{p}) that represents the proposer's preferences.

Before proceeding with the formal results, we elaborate on the assumptions we have adopted. Proposer rationality requires non-satiation (over the space of certain outcomes). However, non-satiation, in our context, operates in the space of lotteries. We then require that proposer's preferences satisfy stochastic dominance and strict quasi-monotonicity. This guarantees non-satiation over the space of lotteries, although we observe choices on the "projection" of the space of lotteries to the subspace defined by the belief function. In order to have empirical content, constraints on beliefs are necessary. To guarantee non-satiation of preferences (on the projection), we need to guarantee that for every allocation there is a set of outcomes that is preferred by proposers and responders. Quasi-monotonicity of responder's preferences plays a dual role: (1) it provides information about responder preferences, and (2) it guarantees that for every allocation there are some allocations which are strictly preferred by the proposer and weakly preferred by the responder.

In the ultimatum game,[11] we can obtain the following result:

Lemma 1. *For any* $(x_{\mathrm{p}}, x_{\mathrm{r}}) \in \mathcal{L}$ *and any* $a > 0$*, either* $(x_{\mathrm{p}} + a, x_{\mathrm{r}} + a) \succ_{\mathrm{p}} (x_{\mathrm{p}}, x_{\mathrm{r}})$ *or* $(x_{\mathrm{p}} - a, x_{\mathrm{r}} - a) \succ_{\mathrm{p}} (x_{\mathrm{p}}, x_{\mathrm{r}})$.

Proof. Recall that $\succeq_{\mathrm{p}}$ is complete. Therefore, at leat one of the following assertions should be true $\mathbf{x} \succeq_{\mathrm{p}} 0$ or $x \preceq_{\mathrm{p}} 0$. We start from considering the first case. Note that $x_{\mathrm{r}} + a - x_{\mathrm{r}} = x_{\mathrm{p}} + a - x_{\mathrm{p}}$ and $(x_{\mathrm{p}} + a, x_{\mathrm{r}} + a) > (x_{\mathrm{p}}, x_{\mathrm{r}})$. Then, by quasi-monotonicity of responder $(x_{\mathrm{p}} + a, x_{\mathrm{r}} + a) \succeq_{\mathrm{r}} (x_{\mathrm{p}}, x_{\mathrm{r}})$, and this is known by the proposer (using the

[10] The original result was stated in Debreu (1954), and the corrected proof is presented in Debreu (1964).

[11] Lemma 1 and Proposition 1 apply to n-player games, with one proposer and $n-1$ responders that make decisions in an arbitrary order.

known preference restrictions) because it can be inferred from quasi-monotonicity only. Then, by belief consistency, the following is true: $q((x_{\mathrm{p}}+a, x_{\mathrm{r}}+a)) \geq q((x_{\mathrm{p}}, x_{\mathrm{r}}))$.

From stochastic dominance, we can infer that $(x_{\mathrm{p}}+a, x_{\mathrm{r}}+a) = ((x_{\mathrm{p}}+a, x_{\mathrm{r}}+a), (0,0), q((x_{\mathrm{p}}+a, x_{\mathrm{r}}+a))) \succeq_{\mathrm{p}} ((x_{\mathrm{p}}+a, x_{\mathrm{r}}+a), (0,0), q((x_{\mathrm{p}}, x_{\mathrm{r}})))$ and $((x_{\mathrm{p}}+a, x_{\mathrm{r}}+a), (0,0), q((x_{\mathrm{p}}, x_{\mathrm{r}}))) \succ_{\mathrm{p}} ((x_{\mathrm{p}}, x_{\mathrm{r}}), (0,0), q((x_{\mathrm{p}}, x_{\mathrm{r}}))) = (x_{\mathrm{p}}, x_{\mathrm{r}})$. Then, by transitivity[12] and strict quasi-monotonicity, $(x_{\mathrm{p}}+a, x_{\mathrm{r}}+a) \succ_{\mathrm{p}} (x_{\mathrm{p}}, x_{\mathrm{r}})$.

For the second case ($x \preceq_{\mathrm{p}} 0$) similar reasoning can be applied. □

Lemma 1 states that the preferences of proposers exhibit non-satiation. Hence, proposers will have a continuous and non-satiated utility function.

3 Testing Theory

Let $\mathbf{x}^1, \mathbf{x}^2, \ldots, \mathbf{x}^T$ be distinct allocations of payoffs, each lying on a linear budget constraint. Let $p^1, p^2, \ldots, p^T$ be the prices that define the linear budgets together with incomes $m^1, m^2, \ldots, m^T$. Following Varian (1992), we make the following two definitions: *(i)* $\mathbf{x}^1$ is *directly revealed preferred* to $\mathbf{x}^2$ if $\mathbf{x}^2$ is in the choice set when $\mathbf{x}^1$ is chosen; *(ii)* $\mathbf{x}^1$ is *indirectly revealed preferred* to $\mathbf{x}^T$ if $\mathbf{x}^1$ is directly revealed preferred to $\mathbf{x}^2$, which in turn is directly revealed preferred to $\mathbf{x}^3$, ..., which in turn is directly revealed preferred to $\mathbf{x}^T$ and *(iii)* $\mathbf{x}^1$ is *strictly directly revealed preferred* if $\mathbf{x}^2$ is in the interior of the choice set of $\mathbf{x}^2$. In the case of linear budgets, $\mathbf{x}^1$ is in the budget set of $\mathbf{x}^2$ if $p^2\mathbf{x}^1 \leq p^2\mathbf{x}^2$ and $\mathbf{x}^1$ is in the interior of the choice set of $\mathbf{x}^2$ if $p^2\mathbf{x}^1 < p^2\mathbf{x}^2$.

Generalized Axiom of Revealed Preference (GARP): *If* $\mathbf{x}$ *is indirectly revealed preferred to* $\mathbf{x}'$*, then* $\mathbf{x}'$ *is not strictly directly revealed preferred to* $\boldsymbol{x}$*.*

Figure 1 illustrates a violation of GARP in the case of a game of proposal and response. Note that $\mathbf{x}$ is directly revealed preferred to $\mathbf{x}'$ since it is in the budget of (p, m). In addition, $\mathbf{x}$ is strictly within the budget of $\mathbf{x}'$. Hence, there is a violation of GARP.

Theorem 1 (Afriat's Theorem)**.** *The following conditions are equivalent:*

(i) *There exists a non-satiated utility function that rationalizes the data*
(ii) *Data satisfies GARP*

3.1 Testing Proposer Rationality

[12] If a preference relation is transitive and complete, then $\mathbf{x} \succeq_i \mathbf{x}'$ and $\mathbf{x}' \succ_i \mathbf{x}''$ imply that $\mathbf{x} \succ_i \mathbf{x}''$.

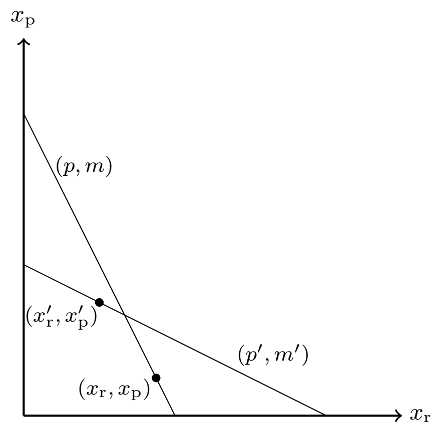


FIGURE 1. GARP in Ultimatum Game

Proposition 1. *In the ultimatum game, a proposer satisfying proposer rationality makes choices from linear budget sets that satisfy GARP.* [13]

We prove Proposition 1 by applying Theorem 1. However, the two statements operate in different spaces. The preference relation and the utility function in Theorem 1 are defined over $\mathbf{R}^2_+$, while the preference relation and the utility function in Proposition 1 are defined over $\mathcal{L}$. Hence, we denote by R the pseudo-preference relation such that, for every $\mathbf{x}, \mathbf{x}' \in \mathbf{R}^2_+$, $\mathbf{x}R\mathbf{x}'$, if and only if $(\mathbf{x}, q(\mathbf{x})) \succeq_\mathrm{p} (\mathbf{x}', q(\mathbf{x}'))$. Therefore, we are left to show that R is complete, transitive, continuous, and non-satiated.

Proof. Completeness, transitivity, and continuity of R follows from the fact that R is equivalent to the preference relation $\succeq_\mathrm{p}$ over a subset of $\mathcal{L}$. Hence, completeness, transitivity, and continuity[14] of $\succeq_\mathrm{p}$ implies similar properties for R.

The non-satiation of R is implied Lemma 1.[15] Therefore, R is a complete, transitive, continuous, and non-satiated preference relation. Using Debreu's (1964) result, we can conclude that there is a continuous, non-satiated utility function that represents R. Hence, we conclude the proof by applying Theorem 1. □

[13]Note that the proposition can be generalized for monotone, compact, and balanced budgets, as in Forges and Minelli (2009). A balanced set is such that if $\mathbf{x} \in B$, then $\alpha x \in B$ for every $\alpha \in [0, 1)$; Forges and Minelli (2009) call this property "Axiom H".

[14]To prove continuity, we appeal to the following well-known result from general topology. A set is closed with respect to the subspace if and only if it can be represented as an intersection of some closed set with the subspace. Hence, the closeness of upper and lower contour sets of $\succeq_\mathrm{p}$ implies that the contour sets of R are closed.

[15]Moreover, since every linear budget set contains the non-empty set of points which are strictly quasi-greater than zero, one can easily show that choices should lie on the boundary of the budget set.

We make two remarks about Proposition 1. First, proposer rationality implies that choices are consistent with GARP, but not vice versa. This happens because it is not possible to elicit (even with an infinite amount of experiments) the entire preference relation over $\mathcal{L}$. Hence, if choices over linear budgets satisfy GARP, there is a non-satiated, continuous, complete, and transitive preference relation over a subset of $\mathcal{L}$.

Second, there are stronger assumptions than quasi-monotonicity (e.g., monotonicity) that imply the consistency of proposer behavior with GARP.[16] However, the fact that consistency with GARP can be inferred from a weaker assumption than monotonicity implies that monotonicity has no empirical content in this context.

3.2 Testing Responder Rationality In this section, we illustrate the consequences of different assumptions on preferences on responder's behavior. In games of proposal and response, the responder chooses in a situation of certainty. The sole concern is the responder's preferences over allocations. In the ultimatum game, the responder chooses to accept or reject the proposed $(x_{\mathrm{p}}, x_{\mathrm{r}})$ allocation. Thus, the responder's choice set is $\{(x_{\mathrm{p}}, x_{\mathrm{r}}), (0,0)\}$. A responder choosing from a sequence of distinct choice sets $\{(x_{\mathrm{p}}^1, x_{\mathrm{r}}^1), (0,0)\}$, $\{(x_{\mathrm{p}}^2, x_{\mathrm{r}}^2), (0,0)\}$, $\ldots$, $\{(x_{\mathrm{p}}^T, x_{\mathrm{r}}^T), (0,0)\}$ can never violate GARP. The standard revealed preference axioms have no bite, although one can directly investigate the testable implications of the quasi-monotonicity assumption.

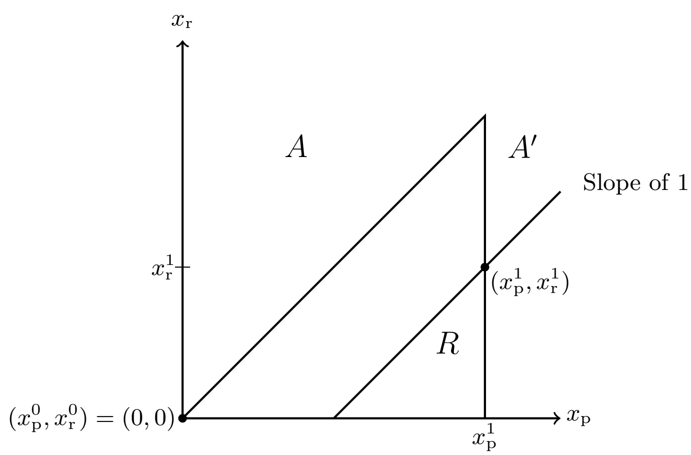


Figure 2. Testing Responder Rationality

Consider Figure 2, illustrating a typical responder's choice set. The responder chooses either to accept the allocation $\mathbf{x}^1 = (x_{\mathrm{p}}^1, x_{\mathrm{r}}^1)$ or to reject it in favor of the allocation $x^0 = (x_{\mathrm{p}}^0, x_{\mathrm{r}}^0) = (0,0)$. By quasi-monotonicity, the responder should accept everything that lies above the 45° line going through $(0,0)$; this set is denoted by A. Moreover,

[16]This is trivial, since the stronger condition would imply monotonicity and therefore, the non-satiation of pseudo-preference relation R.

if the responder accepts $\mathbf{x}^1$, then by quasi-monotonicity they would also accept any proposed $\mathbf{x}$ that lies above the 45° line going through $\mathbf{x}^1$ and is greater than $\mathbf{x}^1$ (the set A'). Denote by $A = \{\mathbf{x} \geq \mathbf{0}, x_{\mathrm{r}} \geq x_{\mathrm{p}}\}$ the area above the 45° originating at zero. The acceptance area can be formally defined as follows.

$$A^t \equiv \{\, \mathbf{x} \,:\, \mathbf{x} > \mathbf{x}^t, x_{\mathrm{r}} \geq x_{\mathrm{p}} - (x^t_{\mathrm{p}} - x^t_{\mathrm{r}}) \,\} \cup A$$

Now suppose the responder rejects $\mathbf{x}^1$, i.e. prefers $(0,0)$ to $(x^1_{\mathrm{p}}, x^1_{\mathrm{r}})$. Note that by quasi-monotonicity, every $\mathbf{x}$ that lies in R (below that 45° line that goes through $\mathbf{x}^1$) is strictly less preferred than $\mathbf{x}^1$. Then, by transitivity, it is less preferred than $\mathbf{x}^0 = (0,0)$. Hence, the responder should reject every bundle from the set R if they reject $\mathbf{x}^1$:

$$R^t \equiv \{\mathbf{x} : \mathbf{x} \leq \mathbf{x}^t,\ x_{\mathrm{r}} \leq x_{\mathrm{p}} - (x^t_{\mathrm{p}} - x^t_{\mathrm{r}}) \text{ and } x_{\mathrm{p}} \leq x^t_{\mathrm{p}}\}.$$

Denote by A_x the periods in which the responder accepted $\mathbf{x}^1$ and by R_x the periods in which responder rejected $\mathbf{x}^1$:

$$A_x \equiv \{\, t \in \{1, \ldots, T\} \,:\, \mathbf{x}^t \text{ is accepted over } (0,0) \,\},$$

$$R_x \equiv \{\, t \in \{1, \ldots, T\} \,:\, \mathbf{x}^t \text{ is rejected in favor of } (0,0) \,\}.$$

Proposition 2. *Observed choices are made by a responder who satisfies responder rationality if and only if,*

$$\{\, \mathbf{x}^t \,:\, t \in R_x\} \,\cap\, \left(A \cup \left(\bigcup_{t \in A_x} A^t \right) \right) \;=\; \emptyset$$

The proof is in the Appendix. Note that the statement is equivalent to the existence of some complete, transitive, and quasi-monotone preference relation that generates the observed choices.

In this case, monotonicity has empirical content; if responders' preferences are monotone, then they would never reject $\mathbf{x}^1 > (0,0)$. Note that for responders we can test the assumption of convexity of preferences.

Consider Figure 3 illustrating a typical responder's choice set. Similar to the previous case, consider first the case in which the responder chooses $\mathbf{x}^1$ over $\mathbf{x}^0$. Then, convexity implies that $\alpha \mathbf{x}^1 \succeq_{\mathrm{r}} \mathbf{x}^0$ for any $\alpha \in [0,1]$. This combined with quasi-monotonicity implies that the responder should accept every bundle from the set A'' (area above the line that goes through $\mathbf{x}^0$ and $\mathbf{x}^1$ such that $x_{\mathrm{p}} \leq x^1_{\mathrm{p}}$) in addition to any bundle from

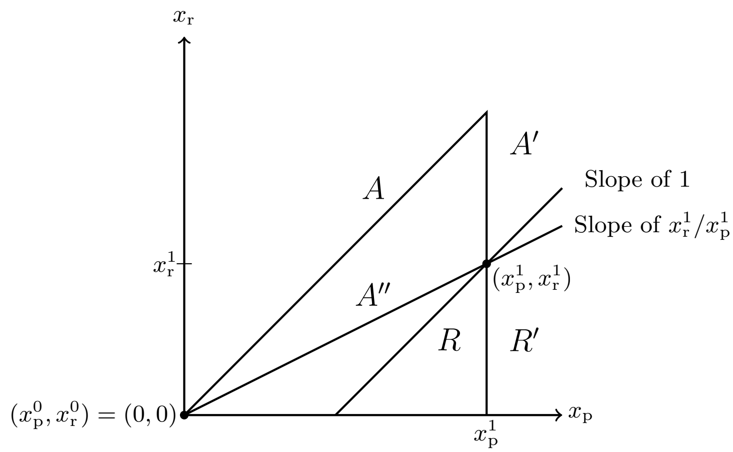


FIGURE 3. Testing Responder Convex Rationality

A. Then, the acceptance region under the assumption of convex responder rationality is $A_c = A \cup A' \cup A''$. Formally A^t_c can be defined as,

$$A^t_c \equiv A^t \cup \{\mathbf{x} : x_\mathrm{p} \leq x^t_\mathrm{p}, x_\mathrm{r} x^t_\mathrm{p} \geq x_\mathrm{p} x^t_\mathrm{r}\}.$$

If the responder rejects $\mathbf{x}^1$, then $\mathbf{x}^0 \succ_\mathrm{r} \mathbf{x}^1$. Consider $\mathbf{x} = \gamma \mathbf{x}^1$ for $\gamma \in [1, \infty)$; if $\mathbf{x} \succeq_\mathrm{r} \mathbf{x}^0$, then by convexity $\mathbf{x}^1 \succeq_\mathrm{r} \mathbf{x}^0$ because $\mathbf{x}^1$ can be represented as a convex combination of $\mathbf{x}^0$ and $\mathbf{x}$. This implies that every $\mathbf{x}$ from R' (area below the line that goes through $\mathbf{x}^0$ and $\mathbf{x}^1$, such that $\mathbf{x}_\mathrm{p} \geq \mathbf{x}^1_\mathrm{p}$) should also be rejected. Then, the rejection region under the assumption of convex responder rationality is $R_c = R' \cup R$. Formally, R^t_c can be defined as,

$$R^t_c \equiv R^t \cup \{\mathbf{x} : x_\mathrm{r} x^t_\mathrm{p} \leq x_\mathrm{p} x^t_\mathrm{r} \text{ and } x_\mathrm{p} \geq x^t_\mathrm{p}\}.$$

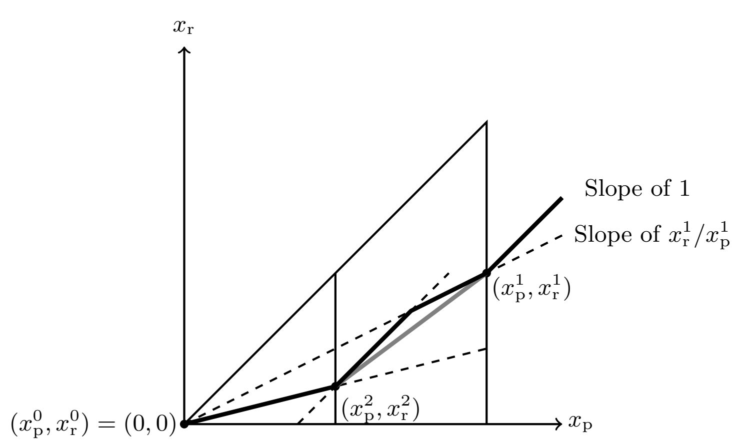


FIGURE 4. Necessity of Taking Convex Hull

Note that to test responder convex rationality, it is not enough to consider only the union of acceptance areas generated by every accepted point. Figure 4 illustrates this point. In this case, both $\mathbf{x}^1$ and $\mathbf{x}^2$ are both better than $\mathbf{x}^0$, and the union of acceptance areas would just deliver the area above the thick line. Note that the union of acceptance areas does not include the convex combinations of $\mathbf{x}^1$ and $\mathbf{x}^2$ (gray line), while by convexity we know that any convex combinations of $\mathbf{x}^1$ and $\mathbf{x}^2$ should be better than $\mathbf{x}^0$ and as a result, should not be rejected. Therefore, to generate the acceptance area we need to take the convex hull of the union of A_c^t. Let $CH(S) = \{x : x = \sum_{y_i \in A \subseteq S} \alpha_i y_i$, such that $\alpha_i \geq 0$ and $\sum \alpha_i = 1\}$ denote the **convex hull** of the set S.

The following refinement of Proposition 2 characterizes the empirical implications of convex responder rationality.

Proposition 3. *Observed choices are made by a responder who satisfies convex responder rationality if and only if,*

$$\{\, \mathbf{x}^t \,:\, t \in R_x \} \;\cap\; CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t \right) \right) \;=\; \emptyset$$

The proof is in the Appendix.

The tests of proposer and responder rationality are different. First, they make decisions over different spaces. We can test quasi-monotonicity of responders' preferences directly. This is not the case for proposers. For responders, we explicitly construct the sets of points that are better/worse than the choices available at each decision node. For proposers, linear budgets already include all the points which are quasi-smaller than a chosen point – this allows to test the non-satiation/monotonicity of preferences without any additional construction.

Second, while we can determine the choice sets of proposers (by varying prices and income), we cannot determine the choice set faced by the responder. This choice set is determined by the actions of the proposer. To improve our knowledge of responders' preferences we then use the strategy method.

4 Experimental Design

We implemented variations on the standard two-player ultimatum game employed by Guth et al. (1982) and Roth et al. (1991). The standard ultimatum game involves the proposers offering a division of m dollars between them (x_{p}) and the responder (x_{r}), so that $m = x_{\mathrm{p}} + x_{\mathrm{r}}$. The responder then accepts or rejects the offered $(x_{\mathrm{p}}, x_{\mathrm{r}})$ allocation. If the responder accepts, their monetary payoff is x_{r} dollars and the proposer's monetary payoff is x_{p} dollars. If the responder rejects, both players receive a monetary payoff of zero dollars.

Our experimental subjects play nine different ultimatum games with budgets, $m = x_{\mathrm{p}} + p\, x_{\mathrm{r}}$, with various endowments (m) and relative prices of offers (p). The subjects are volunteers from undergraduate economics courses. Each subject makes choices assuming both the role of the proposer and that of the responder in each of the nine games. There is a fifty-fifty chance of ultimately being assigned the role of proposer or responder, and an equal chance of each of the nine games being selected as the one whose choices determine subjects' final payoffs. Proposers choose x_{r} from the linear budget constraint $m = x_{\mathrm{p}} + p\,x_{\mathrm{r}}$, discretized into 13 dollar allocations (almost all of which are integer values). These nine budgets are presented in Figure 5.

When assuming the responder role, subjects make their accept/reject decision before they know which of the 13 allocations have been proposed. Consequently, subjects make a choice to accept or reject each of the 13 allocations, thus determining their response to whichever allocation is actually proposed.

For example, for the ultimatum game with an endowment of $m = \$24$ and a relative price of giving of $p = 1/3$, the choice sets for the proposer and the responder are,

$$\mathcal{C} = \{\,3, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, 66, 69\,\} \quad \text{and} \quad \mathcal{D} = \{\,0, 1\,\},$$

respectively. The proposer's and the responder's monetary payoffs as a function of $c \in \mathcal{C}$ and $d \in \mathcal{D}$ are $x_{\mathrm{p}}(c, d) = \big(24 - \frac{1}{3}c\big)d$ and $x_{\mathrm{r}}(c, d) = c\,d$, respectively. The other eight versions of the ultimatum games are likewise defined.

For brevity, we summarize these games by the convex, linear budget constraints (such as $\$24 = x_{\mathrm{p}} + \frac{1}{3}x_{\mathrm{r}}$) rather than the actual discretized choice set $\mathcal{C}$. To make the choice sets more transparent, subjects were presented with the final dollar allocations rather than with budget constraints and endowments.[17] Eighty-eight participants were recruited from undergraduate economics courses at Georgetown University. There were two experimental sessions with 43 and 45 participants each. One participant in each session was chosen at random to be a monitor. The monitor made no decisions but verified to the other participants that the correct procedures were followed. Once the participants were assembled, the instructions were read out loud, with participants reading along on their own copy. Subjects solved several preparatory exercises to familiarize themselves with the games, and the experimenter subsequently reviewed the correct answers. Subjects proceeded to fill out the experimental decision forms, placing their completed decisions in a plain envelope. Each of the nine games were randomly ordered on each subject's decision forms. The proposer and responder roles were, however, presented systematically for each game, with the proposer decision always presented first.

[17] Appendix C displays the decision sheets used.

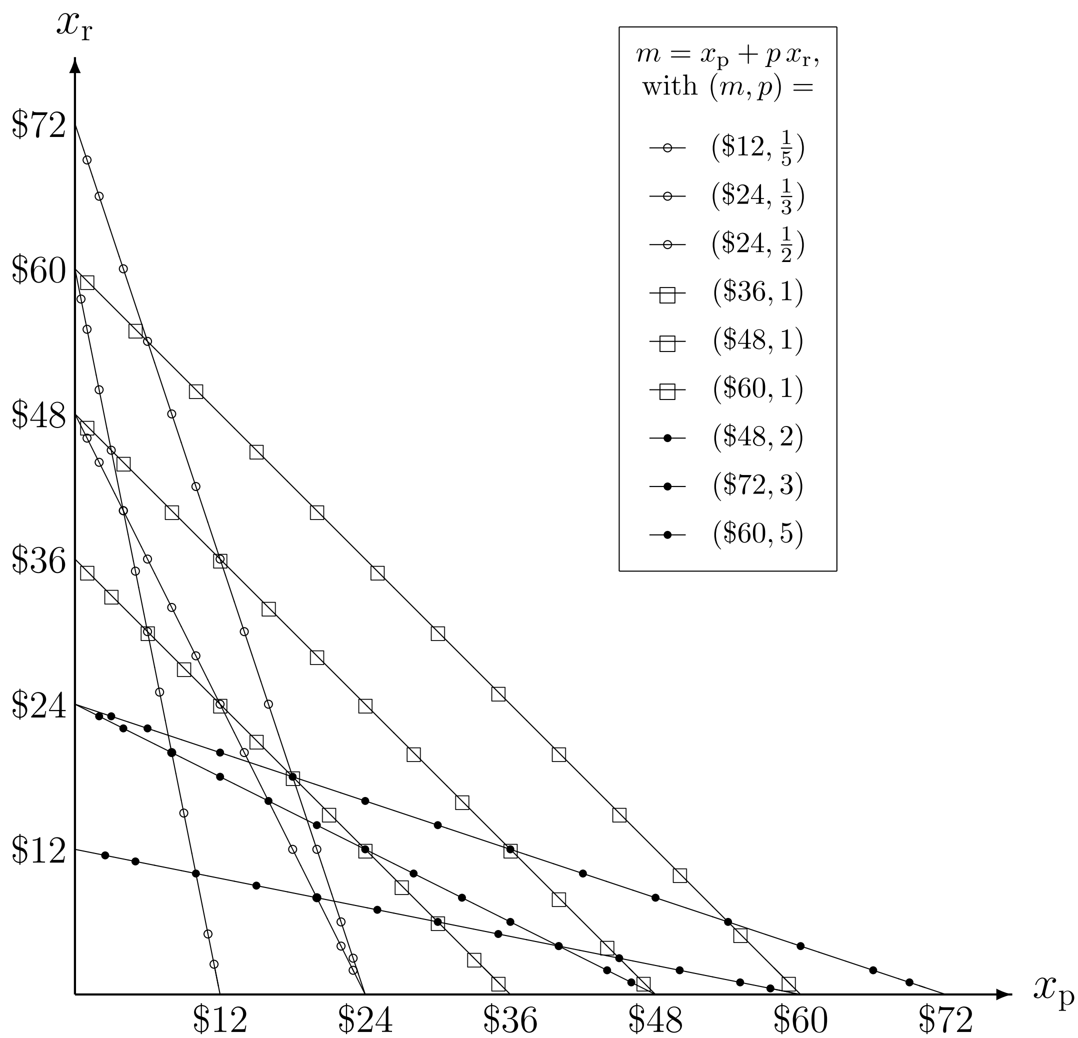


FIGURE 5. Budget Constraints Faced by Proposers

In plain view, these envelopes were collected, shuffled, and randomly separated into two equal-sized piles, one for proposers and one for responders. Once the proposer-responder pairs were formed, the forms were taken to a nearby room to calculate payments. One of the nine games was chosen at random for each pair and implemented. These payments, along with an $8 attendance reimbursement, were placed in a private envelope with only the subject's identification number on the outside. Another experimenter, not involved in the calculation of payments, handed out the envelopes to the participants, who were then escorted from the room. While payments were being calculated, subjects filled out a post-experiment questionnaire eliciting their understanding of the games, some expectations data, and some demographic covariates. The experiment lasted less than an hour, and participants earned an average of $23.08 (s.e. $1.70). Of the 88 subjects, 55 were male and 31 were female. In addition to the two monitors, three subjects did not completely fill out their decision sheets. The analysis excludes them, leaving an experimental population of 83 subjects.

5 Results

The observed choices of proposers and responders for each of the nine budgets are summarized in Table 1. Columns 2 and 3 give the means and standard deviations of the proposed x_{r} values. Column 4 shows the fraction of proposers who are *generous*, meaning their proposed x_{r} for a particular budget exceeded the minimum, and column 5 shows the mean proposals among the generous. The next four columns show behavior for responders who adhered to a *cutoff rule*, meaning for each budget there was a cutoff below which all proposed x_{r} values were rejected, and above which all proposed x_{r} values were accepted. Columns 6 and 7 show the mean and standard deviation of the highest rejected x_{r} values for each budget. Column 8 shows the fraction of *rejectors* – responders who rejected at least the minimum x_{r} – and column 9 shows the mean of the highest rejected x_{r} values for the rejectors. The final column shows the number of responders who did not adhere to a cutoff rule for each budget.[18]

$m = x_{\mathrm{p}} + p\,x_{\mathrm{r}}$,	Proposed x_{r}				Highest rejected x_{r}				No cut-
with $(m,p) =$	All proposers		Generous		All responders		Rejectors		off rule
	Mean	St.Dev	%-age	Mean	Mean	St.Dev	%-age	Mean	n
$(\$12, \frac{1}{5})$	\$10.63	\$9.27	80.7%	\$12.57	\$4.00	\$10.66	47.0%	\$8.53	3
$(\$24, \frac{1}{3})$	\$13.88	\$9.55	80.7%	\$16.48	\$5.10	\$12.96	45.8%	\$11.13	3
$(\$24, \frac{1}{2})$	\$10.72	\$6.31	81.9%	\$12.65	\$4.51	\$9.05	44.6%	\$10.11	3
$(\$36, 1)$	\$10.75	\$6.87	83.1%	\$12.72	\$4.25	\$6.86	51.8%	\$8.21	2
$(\$48, 1)$	\$13.23	\$8.72	83.1%	\$15.71	\$5.23	\$9.72	51.8%	\$10.09	3
$(\$60, 1)$	\$16.17	\$11.37	79.5%	\$20.08	\$6.39	\$12.36	56.6%	\$11.28	4
$(\$48, 2)$	\$8.61	\$5.84	79.5%	\$10.58	\$4.00	\$5.88	53.0%	\$7.54	3
$(\$72, 3)$	\$9.05	\$6.23	77.1%	\$11.44	\$4.02	\$5.77	50.6%	\$7.95	2
$(\$60, 5)$	\$5.14	\$3.63	80.7%	\$6.25	\$2.81	\$3.36	59.0%	\$4.76	3
All 9 budgets	\$10.91	\$8.39	80.7%	\$13.18	\$4.47	\$9.05	51.1%	\$8.76	5

Table 1. Summary of Proposer and Responder Behavior

The middle three rows of Table 1 show behavior in ultimatum games with budgets having a price of one and an income that increases from \$36 to \$48 to \$60. Examining these three ultimatum games clearly revealed positive income effects. Mean proposals and the variance of proposals increased with income, as does the mean proposal among the generous. The mean and the variance of the highest rejected x_{r} also increased with

[18] Table 1 shows that five responders made decisions from at least one budget that did not conform to a cutoff rule. The number of cutoff rule violations was nine for Subject 346, eight for Subject 416, seven for Subject 421 and one each for Subject 305 and Subject 443.

income, as did the mean highest rejected x_{r} among the rejectors. Compared to previous studies of unitary-price ultimatum games (Roth 1995; Camerer 2003), subjects here made slightly smaller proposals on average.

Ultimatum games with $p \neq 1$ have been previously studied by Kagel, Kim, and Moser (1995) and Castillo and Cross (2008). Both of these studies collected data on ultimatum games with relative prices of offers of $\frac{1}{3}$ and 3. In Kagel et al. (1995), subjects played ten rounds assigned to either to the proposer role or the responder role. Proposers offered 63.7% of their endowment from a $p = 3$ budget and 24.2% from a $p = \frac{1}{3}$ budget, considerably higher than the corresponding shares in the one-shot ultimatum games studied here.

5.1 Proposer Rationality Were the revealed preference axioms violated, and if so, how severely, by proposers? A useful measure of the severity of violations is Afriat's (1973) Critical Cost Efficiency Index[19] (CCEI) (see Varian 1992). The CCEI is a relative measure, with a range $[0,\ 1]$, of how much one would have to relax each budget constraint to eliminate violations. The closer the CCEI to one, the milder the relaxations of any budgets necessary to eliminate violations. No violations are indicated by a CCEI of 1, and small violations are indicated by a CCEI of $1 - \varepsilon$.[20] We refer to small violations as *ε violations* and other violations as *large violations*. The upper panel of Table 2 shows the size distribution of the CCEI across proposers. Column 2 shows that 69 of the 83 proposers (83.1%) did not violate GARP, and of the 14 violators, nine were ε violators and none had a CCEI of 0.80 or less.

How effective is GARP as a test of the hypothesis of proposers possessing well-behaved, quasi-monotonic preferences and believing responders' preferences to be likewise? Bronars' (1987) popular test compares this null hypothesis to the alternative that subjects make *uniformly random* choices from each budget—that is, (a) the choice from each budget is the realization of a draw from a uniform distribution supported by that budget line and (b) choices from separate budgets are independent. The lower panel of Table 3 reports the power of Bronars' test from a simulation of 50,000 pseudo-subjects. This power of 90% compares favorably to that computed from other studies (see Famulari 1995, Cox 1997, Sippel 1997, Harbaugh, et al. 2001, and Andreoni and Miller 2002). Indeed, we designed the experiment specifically to have a high Bronars' power—this is possible because Bronars' test is an ex ante test of rationality.

[19]The first time analog of Critical Cost Efficiency for production analysis was introduced by Afriat (1972) and was called P-efficency.

[20]That is, CCEI $> 1 - 0.00001$.

CCEI (Critical Cost Efficiency Index)	Number of Subjects	Violations per Subject
1^*	69	0
$1-\varepsilon^*$	9	1.33
$[0.9, 1-\varepsilon^*)$	3	2.67
$[0.8, 0.9)$	2	2.50
$[0, 0.8)$	0	n.a.
Power Analysis		
Test	Test Power	Average Number of Violation
Bronars' Test	0.9012	10.63
e.d.f. test	0.8136	7.42

* CCEI's of 1 and $1-\varepsilon$ denote no violations and small violations respectively

Table 2. Violations of Testable Implications for Proposers

Alternatively, one can consider an ex post test of rationality where the alternative hypothesis supposes choices are independent draws from the empirical distribution function (e.d.f.) supported by each budget line—that is, the actual distribution of proposals observed in the experiment. Note that the power of this *e.d.f. test* is tied to observed behavior, and certain patterns of observed behavior could lead to the power being quite low. Consider the extreme example where no proposers ever make a generous offer; this yields an e.d.f. test with zero power. However, the pattern proposals actually observed did not lead to an e.d.f. test with particularly low power. Column 2 in the lower panel of Table 2 shows that the e.d.f. test performed solidly in our experiment, having only a nine percentage point loss of power compared to Bronars' test.

5.2 Responder Rationality Table 3 presents the results of testing *responder rationality* and *convex responder rationality* using the empirical implications from Propositions 2 and 3. Column 3 shows that 65% of subjects satisfy responder rationality and 90% of subjects are making no more than five mistakes. The benchmark of five mistakes is important, because, formally, every subject faced 117 decision problems (13 options under nine different budget sets). Therefore, if the number of violations is no more than 5, the subject makes mistakes in no more than 5% of decision making situations. Column 5 shows that only 37% of subjects satisfy convex responder rationality and 54% of subjects make more than five mistakes, i.e., make mistakes frequently.

Number of Violations	Responder Rationality: Number of Subjects	Responder Rationality: Percent of Subjects	Convex Responder Rationality: Number of Subjects	Convex Responder Rationality: Percent of Subjects
0	54	65%	31	37%
1	6	7%	1	1%
2	8	10%	3	4%
3	2	2%	1	1%
4	4	5%	1	1%
5	1	1%	1	1%
≥ 6	8	10%	45	54%

Power of Test

Test	Proposer Rationality: Power of Test	Proposer Rationality: Average Number of Violations (std)	Convex Proposer Rationality: Power of Test	Convex Proposer Rationality: Average Number of Violations (std)
Random	1.0000	47.0850 (4.8914)	1.0000	58.6110 (5.3513)
Random Cutoff	1.0000	34.1910 (9.8979)	1.0000	62.5970 (11.1140)
e.d.f.	1.0000	7.1360 (2.4243)	1.0000	16.3290 (3.0731)
e.d.f. Cutoff	0.9960	8.1660 (3.8373)	1.0000	24.0310 (6.1289)

Table 3. Violations of Testable Implications for Responders

It is worth noting that all 31 non-violators of convexity are among the 54 non-violators of responder rationality. We note that while responder rationality does not formally require a *cutoff rule*, convex responder rationality does. Further, these 31 non-violators are subjects that accept all offers in every game. Research by Andreoni, Castillo, and Petrie (2003) using the discrete and convex version of the ultimatum game showed that convexity for a fixed price and income is common. Our experiments were consistent with this finding as well. We found that only five out of the 83 subjects violated a within-game cutoff rule. Hence, violations of convexity were not due to inconsistent responder behavior within a game, but rather inconsistent behavior across games.

To determine the power of the test we generated 50,000 pseudo-subjects who followed one of the following rules: The simple one is an analog of Bronars' test in which a pseudo-subject is equally likely to accept or reject any given alternative. Second, we considered adding a cutoff rule to the Bronars' test — each pseudo-subject followed a cutoff rule that was chosen at random for each game separately. The third test was an e.d.f. test, in which every pseudo-subject accepted an offer according to the empirical distribution of acceptances for such a particular offer. Finally, we randomly assigned cutoff rules according to their empirical distribution. Note that the power of all tests was almost 1 — none of the pseudo-subjects were consistent with the notions of rationality, and the mean number of violations was significantly higher than the mean number of violations for real subjects (2.37 for responder rationality and 16.08 for convex responder rationality). This enabled us to conclude that the test we conduct has enough power to guarantee that subjects are actually consistent with the notions of rationality and the observed results are not the false positives.

	Consistent with Responder Rationality	Inconsistent with Responder Rationality
Consistent with Proposer Rationality ($CCEI = 1$)	48 (58%)	21 (25%)
Inconsistent with Proposer Rationality ($CCEI \neq 1$)	6 (7%)	8 (10%)

TABLE 4. Cross Table: Proposer Rationality and Responder Rationality

Table 4 compares subjects' consistency with quasi-monotonicity as proposers and responders. The majority of subjects (58%) satisfied quasi-monotonicity as proposers and responders. Quasi-monotone proposers were more likely to be quasi-monotone responders that non-quasi-monotone proposers (70% v. 43%, Fisher's exact test p-value = 0.070). Note, however, that a sizable proportion of subjects (25%) satisfied quasi-monotonicity as proposers, but not as responders. Table 4 provides support for the 'Known Preference Restriction' assumption. Only 11% (6 out 54 subjects) of subjects that were quasi-monotone as responders failed quasi-monotonicity of preferences and beliefs as proposers.

	Consistent with Convex Responder Rationality	Inconsistent with Convex Responder Rationality
Consistent with Proposer Rationality ($CCEI = 1$)	30 (36%)	39 (47%)
Inconsistent with Proposer Rationality ($CCEI \neq 1$)	1 (1%)	13 (16%)

TABLE 5. Cross Table: Proposer Rationality and Convex Responder Rationality

Table 5 compares subjects' consistency with quasi-monotonicity as proposers and convexity as responders. The majority of subjects (47%) were not consistent with convexity of preferences. Quasi-monotone proposers were more likely to satisfy convexity as responders than non-quasi-monotone proposers (45% v. 7%, Fisher's exact test p-value = 0.013). Note, however, that the only subjects that satisfied convexity as responders were those subjects that never rejected offers. This calls into doubt the assumption of convexity of preferences in models of responders' behavior.

5.3 Beliefs We collected subjects' expectations after the experiment was completed and as payments were prepared. Subjects were asked to provide an estimate of the probability that a particular offer would be rejected had it been offered by a responder. In particular, subjects were asked to answer questions of the form:

What do you think is the percent chance that Proposal Rule **a** would be *Rejected* by the **Responder**?

○ 0% ○ 1%–30% ○ 31%–70% ○ 71%–99% ○ 100%.

This procedure is suggested by Manski (2004), and an incentivized version was implemented by Manski and Neri (2013) to elicit second-order beliefs in strategic games. A distinct advantage of this procedure is that it allows subjects to express uncertainty about their beliefs. Most of the literature on belief elicitation is devoted to the elicitation of *point* probabilistic beliefs (see Schotter and Treviño (2014) for a thorough discussion on the elicitation of beliefs). A potential drawback is that elicitation is not incentivized. However, we show in Appendix B that using Hossain and Okui (2013) incentivized belief elicitation task produces similar results. As importantly, Appendix B also provides a replication of our original choice experimental results.

Table 6 reports the distribution of answers for all the allocation rules we asked. We observed that subjects reported that allocations that are less favorable to responders are more likely to be rejected.

Table 7 reports whether elicited beliefs are consistent with the assumptions we make: 1) "Known Preference Restrictions" (KPR) and 2) Belief Consistency (BC). These hypotheses cannot be tested separately; therefore, we evaluate them jointly.[21]

We now describe how to tests for belief consistency. Belief consistency implies that if allocation $\mathbf{x}$ is preferred to $\mathbf{x}'$ by all proposers, then the probability that $\mathbf{x}$ is rejected should be no greater than the probability of rejecting $\mathbf{x}'$. Additional restrictions are implied by the known preference restrictions. Denote by b^t the belief that $\mathbf{x}^t$ is rejected. If beliefs are consistent with responder rationality, then if outcome $\mathbf{x}^t$ is greater than $\mathbf{x}^s$ according to quasi-monotonicity, then the probability of rejecting $\mathbf{x}^s$ should be greater than the probability of rejecting $\mathbf{x}^t$.

Corollary 1. *Let* $A = \{\mathbf{x} \geq \mathbf{0}, x_{\mathrm{r}} \geq x_{\mathrm{p}}\}$ *and* $A^t \equiv \{\, \mathbf{x} : \mathbf{x} > \mathbf{x}^t, x_{\mathrm{r}} \geq x_{\mathrm{p}} - (x^t_{\mathrm{p}} - x^t_{\mathrm{r}}) \,\} \cup A$. *A set of beliefs* $b^1, \ldots, b^T$ *is consistent with responder rationality if and only if for every* $\mathbf{x}^s \in A^t \setminus A$ *we have that* $b^s \leq b^t$.

We now present a test of beliefs that are consistent with (convex) responder rationality. Recall that subjects are randomly matched to a member of "the population of

[21]Each assumption, taken separately, does not have empirical content. If a player knows that other players are rational, but does not update beliefs correspondingly, then she still satisfies known preference restrictions assumption. If a player has a beliefs consistent with alternative preferences/notion of rationality, beliefs do not have to be consistent with the tests we propose.

Allocation	Probability $q(x)$ that offer x will be rejected:				
$(x_\mathrm{p}, x_\mathrm{r})$	$= 0$	$\in [1, 30]$	$\in [31, 70]$	$\in [71, 99]$	$= 100$
$(23, 3)$	9.6	26.5	21.7	36.1	6.0
$(22, 6)$	12.0	36.1	32.5	19.3	0.0
$(20, 12)$	30.1	55.4	12.0	2.4	0.0
$(18, 18)$	72.3	26.5	0.0	1.2	0.0
$(59, 1)$	9.6	19.3	14.5	43.4	13.3
$(50, 10)$	20.5	28.9	28.9	19.3	2.4
$(40, 20)$	27.7	47.0	21.7	3.6	0.0
$(30, 30)$	72.3	26.5	1.2	0.0	0.0
$(60, 4)$	9.6	22.9	16.9	44.6	6.0
$(40, 8)$	14.5	28.9	32.5	22.9	1.2
$(36, 12)$	27.7	42.2	22.9	7.2	0.0
$(18, 18)$	71.1	28.9	0.0	0.0	0.0
$(55, 1)$	9.6	20.5	10.8	42.2	16.9
$(40, 4)$	12.0	27.7	21.7	34.9	3.6
$(25, 7)$	20.5	39.8	24.1	15.7	0.0
$(10, 10)$	68.7	30.1	1.2	0.0	0.0

Table 6. Distribution of Elicited Beliefs

responders." Beliefs are said to be **consistent with (convex) responder rationality** if there is a population of (convex) responder rational players whose probability of rejecting the outcome $\mathbf{x}^t$ is equal to the proposer's belief.

Stating the test of belief consistency with convex responder rationality requires additional notation. We defined the *convex acceptance region* as the set of points that should be accepted by a responder with convex preferences given observed acceptances. Formally, the *convex acceptance region* is defined as: $A^t_c \equiv A^t \cup \{\mathbf{x} : x_\mathrm{p} \leq x^t_\mathrm{p}, x_\mathrm{r} x^t_\mathrm{p} \geq x_\mathrm{p} x^t_\mathrm{r}\}$. Convexity implies that the better than sets for every point should be convex In order to do that, we need to take the convex hull of of the union of all convex acceptance regions. If an allocation is in the convex hull of acceptance area of the set of points, then it should be accepted by all members of population who accepted all such points. Then probability of rejection should be below the maximum probability of rejection the allocations in the set. Denote by C the set of all chosen points such that $b^t > 0$ for every $\mathbf{x}^t \in C$ – all points rejected by some share of the population. Denote by 2^C the power set of C.

Corollary 2. *A set of beliefs $b^1, \ldots, b^T$ is consistent with convex responder rationality if and only if $x^s \in CH\left(A \cup \left(\bigcup_{x^t \in S} A^t_c\right)\right)$ implies $b^s \leq \max_{x^t \in S}\{b^t\}$ for every $S \in 2^{X \setminus \{x^s\}}$.*[22]

Corollaries 1 and 2 are statements about point beliefs, while the beliefs we elicited are interval beliefs. We therefore test the existence of point beliefs that lie within the elicited range provided to subjects and that satisfy the belief consistency criteria.

	Beliefs Consistent with Responder Rationality	Beliefs Consistent with Convex Responder Rationality
All Subjects	67 (83)	10 (83)
Satisfy Proposer Rationality	61 (69)	10 (69)
Satisfy Proposer and Responder Rationality	43 (48)	9 (48)
Satisfy Proposer and Convex Responder Rationality	25 (30)	9 (30)
* Total number of subjects falling in the corresponding category given in parenthesis		
Power of Test		
Random	0.9970	1.0000
e.d.f	0.9100	1.0000

TABLE 7. Consistency of Beliefs

Table 7 reports the degree of consistency of individual beliefs with the assumptions in the paper. The first column includes subjects who believe that responders have quasi-monotone preferences, and the second column includes subjects who believe that responders have convex preferences. Each row in Table 7 presents results according to characteristics of the person reporting beliefs. We see that 67 (81%) of all subjects have beliefs that are consistent with responder rationality. If we consider only subjects who are consistent with proposer rationality, we observe that 61 (88%) of subjects have beliefs consistent with responder rationality. Regarding beliefs that are consistent with responders having convex preferences, we see that only 10 (12%) of all subjects have beliefs consistent with the notion of convex responder rationality. Moreover, five of these subjects assigned the same belief to every allocation.

To test the robustness of these results, we performed power tests for consistency of the beliefs with responder rationality. We found that at least 91% of random subjects had beliefs that failed the test, and 100% of random subjects have beliefs that are not

[22]Though the precise test is NP, the amount of sets one should consider is 2^{T-1} for every of T observations. Moreover, at every step one has to take a convex hull of the set of points.

consistent with the notion of convex responder rationality. In sum, elicited beliefs were consistent with the assumptions we made and the analysis of choice data we provided.

In our experimental design, we asked every subject to complete three tasks: make decisions as proposers and responders and report beliefs. This allows us to identify which assumptions of proposer rationality failed. We observe that 43 (52%) subjects passed all three tests; 5 (6%) failed only consistency of beliefs; 2 (2%) failed only proposer rationality (do violate stochastic dominance). In addition, 21 subjects are consistent with proposer rationality but are not consistent with responder rationality and 18 of them passed the belief consistency test. These subjects seem to have consistent beliefs and behave rationally, but fail to have quasi-monotone preferences themselves.[23]

The empirical analysis of beliefs presented so far relies on hypothetical questions. A more robust test of our assumptions would require obtaining similar results using incentivized elicitation of beliefs. We therefore collected additional experimental data on choices and beliefs using incentivized methods (Hossain and Okui, 2013). Table B.6 presents the results on consistency of beliefs using this new data set and Table B.1 in the appendix summarizes the choice data. Tables B.2 and B.3 shows that the new experimental sessions mimic the results in Tables 2 & 3 in the paper. Further, Table B.6 shows that our results regarding beliefs mimic those using non-incentivized methods. These similarities are even clearer if we relax the test of consistency to allow for a 5 percentage measurement error. This provides further support to our assumptions and original results.

6 Conclusions

Samuelson (1938) revealed that a preference approach provides an intuitive and powerful way to test the empirical content of microeconomic theory. The usefulness of this approach has been apparent in the many applications and extensions over the years.[24]

[23]Formally, various monotonicity assumptions imply behavior consistent with GARP. For instance, subjects might prefer outcomes that increase proposers' and responders' payoffs equally. This, together with quasi-monotonicity of responders' preferences would imply behavior consistent with GARP, but it would lead to a rejection of responder rationality.

[24]Revealed preferences analysis have been used to study preferences for giving and social preferences (Andreoni and Miller 2002; Fisman, Kariv and Markovits 2007); psychiatric patients (Battalio et al. 1973); children (Harbaugh, Krause, and Berry 2001); rats, pigeons, and monkeys (Kagel, Battalio, and Green 1995; Chen, Lakshminarayanan, and Santos 2006); risk preferences (Choi et al. 2007; Andreoni and Harbaugh 2009); characteristic models (Blow, Browning, and Crawford 2010); household bargaining (Cherchye, De Rock, and Vermeulen 2007); rational expectations (Browing 1989); habits (Crawford 2010); market equilibrium (Brown and Matzkin 1996); decisions on nonlinear budget sets (Matzkin 1991; Forges and Minelli 2009; Chavas and Cox 1993); and games (Sprumont 2000).

This paper investigates the revealed preference approach in strategic environments. We show that a completely nonparametric analysis of a simple game is informative. In doing so, we identified basic restrictions on behavior to be consistent with this approach. We observe the behavior of bargainers in a number of ultimatum games and found that it strongly supports the assumption of quasi-monotone preferences. This implies that, even absent parametric assumptions about preferences or collecting data on beliefs, we can extrapolate behavior to counterfactual games. Importantly, though, measures of beliefs are strongly consistent with our assumptions.

Quasi-monotonicity is consistent with many models of fairness (Fehr and Schmidt 1999; Bolton and Ockenfels 2000; and Charness and Rabin 2002).[25] Interestingly, our approach also suggests that further assumptions in models of fairness, such as homotheticity or quasi-linearity, are testable nonparametrically. In this context, we also find evidence against convexity of preferences.

Additional assumptions beyond quasi-monotonicity are needed to rationalize behavior in other games (e.g., the investment game as in Berg, Dickhaut, and McCabe 1995). Our study illustrates that the revealed preference approach provides a framework to systematically study them.

[25]Agents with quasi-monotone preferences will never reject offers that are favorable to them while some models of fairness might allow this to occur.

Appendix A: Proofs

To prove the propositions we need to introduce additional notation. First, we use the set-theoretic notation for the preference relations. A set $R \subseteq X \times X$ is said to be a **preference relation**. We denote the set of all preference relations on X by $\mathcal{R}$. The symmetric part of R is $I(R) = R \cap R^{-1}$ and the asymmetric part is $P(R) = R \backslash I(R)$. Denote the reverse preference relation by $R^{-1} = \{(x,y)|(y,x) \in R\}$ $(P^{-1}(R) = \{(x,y)|(y,x) \in P(R)\})$. Denote the non-comparable part by $N(R) = X \times X \backslash (R \cup R^{-1})$. A relation R' is said to be an **extension** of R, denoted by $R \preceq R'$ if $R \subseteq R'$ and $P(R) \subseteq P(R')$. Note that for every $R \subseteq R'$, R' is an extension of R if and only if $P^{-1}(R) \cap R = \emptyset$ (for the proof see Demuynck (2009). Here on, we will refer to this property as **consistency** with R'.

We formally define the revealed preference relation. Let $(x^t, B^t)_{t=1\ldots T}$ be a **finite consumption experiment** where x^t are chosen points and B^t are budgets. We assume all budgets to be compact and monotone.[26] Denote by R_E the **revealed preference** relation. $(x^t, y) \in R_E$ if $y \in B^t$, $(x^t, x^t) \in I(R_E)$ and $(x^t, y) \in P(R_E)$ for any $y \in B^t \backslash \{x^t\}$. Recall that in the case of the responder choice problem $B^t = \{(x_\mathrm{p}, x_\mathrm{r}), (0,0)\}$. To simplify notation, let $x \trianglerighteq_i y$ denote that $x \geq y$ and for every $j \neq i$ $x_i - y_i \geq x_j - y_j$. With this additional nomenclature we can state quasi-monotonicity as follows:

Observation A.1. *R is quasi-monotone if and only if $\trianglerighteq_\mathrm{r} \subseteq R$.*

Proof of Proposition 2

Definition A.1. *Denote a* **transitive closure** *by $T : \mathcal{R} \to \mathcal{R}$. Then $(x,y) \in T(R)$ if there is a sequence of elements $S = s_1, \ldots, s_n$, such that for every $j = 1, \ldots, n-1$ $(s_j, s_{j+1}) \in R$.*

Demuynck (2009) shows that there is a complete and transitive extension of preference relation if and only if $R \preceq T(R)$.[27] Observation A.1, implies that $R \preceq T(R \cup \trianglerighteq_\mathrm{r})$ if and only if there is a complete, transitive and quasi-monotone extension of R. In the context we consider, x is chosen if and only if it is strictly better than y, therefore, there is a complete, transitive and quasi-monotone relation that generates the observed choices if and only if there is a complete, transitive and quasi-monotone extension of the revealed preference relation. This implies the following result.

Lemma A.1. *There is a complete and weakly quasi-monotone preference relation that generated observed choices if and only if $R_E \preceq T(R_E \cup \trianglerighteq_\mathrm{r})$.*

[26] $x \in B^t$, then any $y \leq x$ is also in B^t. And since we work on $\mathbf{R}^n$ it will also include elements with negative coordinates.

[27] A similar result can be found in earlier papers by Szpilrajn (1930) and Richter (1966).

Hence, we are only left to prove that the proposed test is equivalent to $T(R_E \cup \trianglerighteq_{\mathrm{r}})$ being an extension of R_E.

Lemma A.2. *$R_E \preceq T(R_E \cup \trianglerighteq_{\mathrm{r}})$ if and only if*

$$\{x^t : t \in R_x\} \ \cap \ \left(A \cup \left(\bigcup_{t \in A_x} A^t \right) \right) = \emptyset$$

Before we start the proof, note that for any $(x, y) \in T(R \cup \trianglerighteq_{\mathrm{r}})$ there is a shortest sequence that adds (x, y) to $T(R \cup \trianglerighteq_{\mathrm{r}})$. Note that by the transitivity of $\trianglerighteq_{\mathrm{r}}$ the shortest sequence can not contain more than one pair such that $s_j \trianglerighteq_{\mathrm{r}} s_{j+1}$. Moreover, since every element is directly compared with $x^0 = (0, 0)$ only, then the shortest sequence can not contain more than one pair such that $(s_j, s_{j+1}) \in R_E$. Hence, the following Observation is true.

Observation A.2. *If $(x, y) \in T(R_E \cup \trianglerighteq_{\mathrm{r}})$ and $x \neq y$, then the length of shortest sequence that add (x, y) is at most three. Moreover, it can not contain more than one element such that $(s_j, s_{j+1}) \in R_E$ and no more than one element such that $s_j \trianglerighteq_{\mathrm{r}} s_{j+1}$.*

Using this Observation we would further only refer to the sequences no longer than three. Further we use the equivalent definition of being an extension. That is, $P^{-1}(R_E) \cap T(R_E \cup \trianglerighteq_{\mathrm{r}}) = \emptyset$.

Proof of Lemma A.2. **(⇒)** Let us show that if $R_E \preceq T(R_E \cup \trianglerighteq_{\mathrm{r}})$ then there is no violation of the test. On the contrary assume that at least one of the conditions is violated. We will show that any of these violations causes violation of consistency with $T(R_E \cup \trianglerighteq_{\mathrm{r}})$.

Assume there is x^t such that $x^t \in \bigcup_{t \in A_x} A^t$ and $t \in R_x$. The first part implies, that there is a x^k such that $(x^k, x^0) \in R_E$ and $x^t \trianglerighteq_{\mathrm{r}} x^k$. Then, $(x^t, x^0) \in QM(R_E)$. While the second part implies that x^t was rejected - $(x^0, x^t) \in P(R_E)$. Therefore, $(x^t, x^0) \in T(R_E \cup \trianglerighteq_{\mathrm{r}}) \cap P^{-1}(R_E) \neq \emptyset$ - R_E is not consistent with $T(R_E \cup \trianglerighteq_{\mathrm{r}})$.

(⇐) Let us show that if the data pass the test then R_E is consistent with $T(R_E \cup \trianglerighteq_{\mathrm{r}})$. On the contrary assume that there is $(x, y) \in T(R_E \cup \trianglerighteq_{\mathrm{r}}) \cap P^{-1}(R_E) \neq \emptyset$. Hence, $(x, y) \in T(R_E \cup \trianglerighteq_{\mathrm{r}})$ and $(y, x) \in P(R_E)$. Note that by the nature of data (binary choice between x^t and x^0), either $x = x^0$ or $y = x^0$. Let us show that either of cases will result in failing the test.

Case 1: Assume that $x = x^0$ and let $y = x^t$. Then there is a shortest sequence $S = s_1, s_2, s_3$ such that $s_1 = x^0$, $s_3 = x^t$. Then $(x^0, s_2) \in R_E$ since there is no element that $\trianglerighteq_{\mathrm{r}}$ in $\mathbf{R}^2_+$. This implies that $s_2 = x^s$, i.e. some chosen point. Therefore,

$(x^s, x^t) \in \trianglerighteq_{\mathrm{r}}$, that is $x^s \in A^t$ at the same time $(x^0, x^s) \in R_E$ implies that $s \in R_x$. That immediately implies a contradiction.

Case 2: Assume that $x = x^t$ and let $y = x^0$. Then there is a shortest sequence $S = s_1, s_2, s_3$ such that $s_1 = x^t$, $s_n = x^0$. Then, $(s_2, x^0) \in R_E$, that is $s_2 = x^s$ and it is an accepted point.[28] Moreover, $x^t \trianglerighteq_{\mathrm{r}} x^s$, that is $x^t \in A^s$ and x^t is a rejected point. That immediately implies the contradiction. □

Proof of Proposition 3 Let us start from the proof of necessity.

Proof of Necessity. On the contrary assume that choices satisfy convex responder rationality – there is a complete, transitive, quasi-monotone and convex preference relation R that is an extension of R_E. Consider two following cases.

Let $x^t \in \{x^t : t \in R_x\} \cap CH\left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right)$. This implies that $(x^0, x^t) \in P(R_E)$, because x^t is rejected. Considering the second part, let us assume that $x^t \in \left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right)$, that is there is x^k that is accepted - $(x^k, x^0) \in P(R)$, such that (i) $x^t > 0$ and $x^t_{\mathrm{r}} \geq x^t_{\mathrm{p}}$, (ii) $x^t \geq x^k$ and $x^t_{\mathrm{r}} - x^k_{\mathrm{r}} \geq x^t_{\mathrm{p}} - x^k_{\mathrm{p}}$, (iii) $x^t_{\mathrm{p}} \leq x^k_{\mathrm{p}}, x^t_{\mathrm{r}} x^k_{\mathrm{p}} \geq x^t_{\mathrm{p}} x^k_{\mathrm{r}}$. Quasi-monotonicity and (i) imply that $(x^t, x^0) \in R$. Quasi-monotonicity and (ii) imply that $(x^t, x^k) \in R$ and by transitivity $(x^t, x^0) \in P(R)$. Convexity, quasi-monotonicity, transitivity and (iii) imply[29] that $(x^t, x^0) \in R$. Another possibility is $x^t \in CH\left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right) \setminus \left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right)$. Therefore, there are $x^{k_1}, \ldots, x^{k_n}$ which are accepted and $x^t = \sum_{i=1}^n \alpha_i x^{k_i}$ such that $\alpha_i \geq 0$ and $\sum_{i=1}^n \alpha_i = 1$, then by convexity $(x^t, x^0) \in R$. □

The proof of sufficiency is analogous to the proof of Proposition 1. We use the function that induces convexity and transitivity, which also satisfies conditions from Demuynck (2009). Therefore, the analog of Lemma A.2 is satisfied. Finally we show that R_E is consistent with its convex and transitive extension if and only if the convex responder rationality test is passed.

Denote the **upper contour set** of x by $U_R(x) = \{y : (y, x) \in R\}$. Denote the **lower contour set** of x by $L_R(x) = \{y : (x, y) \in R\}$. A preference relation R is said to be **convex** if for every $x \in X$, $U_R(x)$ is convex.

[28] Alternative case is $s_2 \trianglerighteq_{\mathrm{r}} x^0$, this immediately implies that $x^t \trianglerighteq_{\mathrm{r}} s_2 \trianglerighteq_{\mathrm{r}} x^0$, i.e. $x^t \in A$ and is a rejected point.

[29] There is $x = \alpha x^0 + (1-\alpha) x^k$, hence $(x, x^0) \in R$. Moreover, $x^t \geq x$ and $x^t_{\mathrm{r}} - x_{\mathrm{r}} \geq x^t_{\mathrm{p}} - x_{\mathrm{p}}$, hence $(x^t, x) \in R$.

For any finite set $A \subseteq X$, we denote by $V(A)$ the **interior of the convex hull** spanned by elements of A:

$$V(A) = \left\{ x \in X : x = \sum_{y_i \in A} \alpha_i y_i \right\}$$

where for all i, $\alpha_i > 0$ and $\sum_i \alpha_i = 1$.

We introduce Demuynck (2009) function $C(R)$ used to prove the existence of complete, transitive and convex extensions of preferences. Consider a finite number of sequences $S^1, \dots, S^m$. For an element $s^i_j < n_{S^i}$ we say that set A is **compatible** with s^i_j if

- $A \subseteq \{s^k_v : k \in \{1, \dots, m\},\ v \in \{1, \dots, n_{S^k}\}\}$ and,
- $s^i_{j+1} \in A$.

Given the sequence $S^1, \dots, S^m$. We denote by $\mathcal{A}(s^i_j; S^1, \dots, S^m)$ the collection of all sets A which are compatible with s^i_j. Set A is compatible with an element s^i_j means that there is a set of points (taken from the family of sequences) which are no worse than s^i_j including itself and s^i_{j+1}. This allows us to represent s^i_j as a convex combination of the points which are no worse than s^i_{j+1}. By convexity this would imply that s^i_j is no worse than s^i_{j+1}.

Definition A.2. *Denote the* ***convex and transitive closure*** *by $C(R)$. Then $(x, y) \in C(R)$ if there is a family of sequences $S^1, \dots, S^m$ such that for all $i = 1, \dots, m$: $s^i_1 = x$, $s^i_{n_{S^i}} = y$ and for all $i = 1, \dots, m$ and $j = 1, \dots, n_{S^i} - 1$:*

- *$(s^i_j, s^i_{j+1}) \in R$, or*
- *there is a set $A \in \mathcal{A}(s^i_j; S^1, \dots, S^m)$ such that $s^i_j \in V(A)$.*

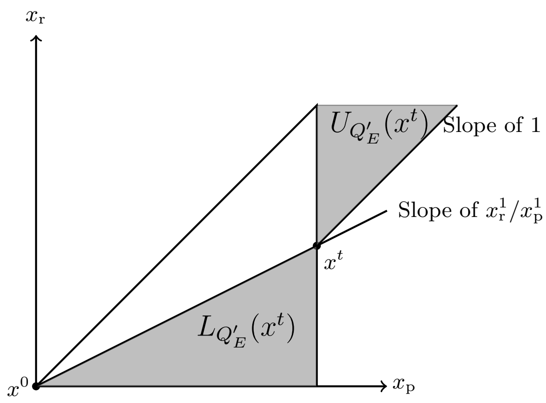
The following result can be immediately deduced from the results in Demuynck (2009) and Observation A.1.

Lemma A.3. *There is a complete, convex and weakly quasi-monotone preference relation that generated observed choices if and only if $R_E \preceq C(R_E \cup \trianglerighteq_{\mathrm{r}})$.*

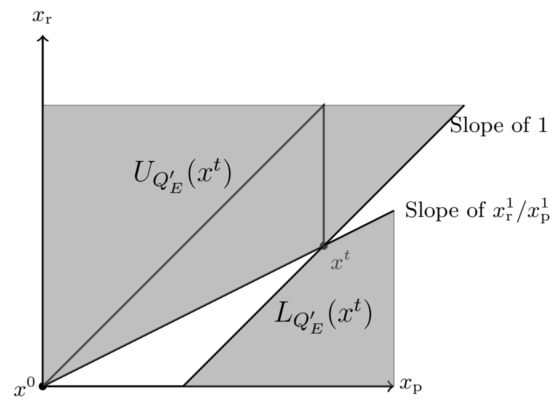
Therefore, we need to prove that consistency with C is equivalent to the test of convex responder rationality. Demuynck (2009) shows that $C(R) = R$ if and only if R is transitive and convex. Therefore, the following corollary follows from Lemma A.3.

Corollary A.1. *If R is convex and transitive, then it is consistent with $C(R)$.*

We now construct a convex, transitive and quasi-monotone extension of R_E and show that if the test of convex responder rationality is satisfied, then R_E is consistent with it. This allows us to complete the proof by applying Corollary A.1. We construct convex, transitive and quasi-monotone extension of R_E in two steps. First, we construct Q_E which is quasi-monotone and convex, but not yet transitive. Second, we construct $TC(Q_E)$ which is convex, transitive, and quasi-monotone.



(a) x^t is accepted



(b) x^t is rejected

FIGURE A.1. Constructing Q'_E

We now construct relation Q_E which is a convex and quasi-monotone extension of R_E. For that purpose we need to construct the intermediate relation Q'_E, which is a substantial sub-relation of Q_E. If allocation $x^t \in CH\left(A \cup \left(\bigcup_{t\in A_x} A^t_c\right)\right)$, then $L_{Q'_E}(x^t) = \{x : x_{\mathrm{p}} \leq x^t_{\mathrm{p}}, x_{\mathrm{r}}x^t_{\mathrm{p}} \leq x_{\mathrm{p}}x^t_{\mathrm{r}}\}$ and $U_{Q'_E}(x^t) = \{x : \ x \trianglerighteq_{\mathrm{r}} x^t\}$. If allocation $x^t \in \bigcup_{t\in R_x} R^t_c$, then $L_{Q'_E}(x^t) = \{x : x^t \trianglerighteq_{\mathrm{r}} x\} \cup \{x : x_{\mathrm{p}} \geq x^t_{\mathrm{p}}, x_{\mathrm{r}}x^t_{\mathrm{p}} \geq x_{\mathrm{p}}x^t_{\mathrm{r}}\}$ and $U_{Q'_E}(x^t) = \{x : x_{\mathrm{p}} \leq x^t_{\mathrm{p}}, x_{\mathrm{r}}x^t_{\mathrm{p}} \leq x_{\mathrm{p}}x^t_{\mathrm{r}}\} \cup \{x : \ x \trianglerighteq_{\mathrm{r}} x^t\}$. In addition to that, $L_{Q'_E}(x^0) = \left(\bigcup_{t\in R_x} R^t_c\right)$ and $U_{Q'_E}(x^0) = CH\left(A \cup \left(\bigcup_{t\in A_x} A^t_c\right)\right)$. Figure A.1 illustrates the construction of Q'_E, the upper and lower contour sets are the shadowed areas. Denote by $Q_E = Q'_E \cup \trianglerighteq_{\mathrm{r}} \cup R_E$. Q'_E is an intermediate relation which is the most important addition to R_E (the revealed preference relation). Then we construct Q_E as the union of Q'_E, R_E and the quasi-monotone relation. Note that $\trianglerighteq_{\mathrm{r}}$ is also a binary relation, therefore we can take their union. This guarantees us that Q_E is quasi-monotone, as well as every preference relation that extends Q_E. Moreover, one can easily see that Q_E is convex since all the upper contour sets are convex by construction.

To define the convex and transitive extension, we use the following inductive procedure. Let $C_0 = T(R)$, and $C_i = T\left(C_{i-1}(R) \cup \left[\bigcup_{x\in\Theta(C_{i-1}(R))}\{(x,y) : x \in CH(U_{C_{i-1}}(y))\}\right]\right)$, where $\Theta(R) = \{x : L_R(x) \neq \emptyset \text{ and } L_R(x) \neq \{x\}\}$. Then $TC(R) = T\left(\bigcup_{i\in\mathbf{N}} C_i(R)\right)$. This procedure simply takes, at every step, the transitive closure of the convexification of the previous relation $C_{i-1}(R)$. Convexification is simply taking the convex hull of every upper contour set. We next show that $TC(R)$ is convex and transitive, hence, it is consistent with C.

Lemma A.4. *$TC(R)$ is convex and transitive.*

Proof. By construction $TC(R)$ is transitive since it is defined as a transitive closure of the union of preference relations. Hence, we are left to show that $TC(R)$ is convex. Assume the contrary, that is there is $x \in X$, such that there are $y_1, \ldots, y_n \in U_{TC(R)}(x)$ and there is $y = \sum_i \alpha_i y_i,\ a_i \geq 0, \sum_i \alpha_i = 1$ such that $y \notin U_{TC(R)}(x)$.

First, we show that $TC(R) \setminus \left(\bigcup\limits_{i \in \mathbf{N}} C_i(R) \right) = \emptyset$. On the contrary assume that there is $(y_i, x) \in TC(R) \setminus \left(\bigcup\limits_{i \in \mathbf{N}} C_i(R) \right)$. By definition of transitive closure that means that there is a sequence $S = s_1, \ldots, s_n,\ s_1 = y_i$ and $s_n = x$, such that for every $j = 1, \ldots, n-1$, $(s_j, s_{j+1}) \in \bigcup\limits_{i \in \mathbf{N}} C_i(R)$. By the construction of $\bigcup\limits_{i \in \mathbf{N}} C_i(R)$ for every $j = 1, \ldots, n-1$, there is k_j such that $(s_j, s_{j+1}) \in C_{k_j}(R)$. Let m be the maximum of such that $m \geq k_j$ for every j.[30] Therefore, $(y_i, x) \in C_{m+1}(R)$.

Second, we show that if $y_1, \ldots, y_n \in U_{TC(R)}(x)$ then $y \in U_{TC(R)}(x)$ for all $y = \sum_i \alpha_i y_i$ such that $\alpha_i > 0$ and $\sum_i \alpha_i = 1$. Assume to the contrary that there is $y = \sum_i \alpha_i y_i$ such that $\alpha_i > 0$, $\sum_i \alpha_i = 1$ and $y \notin U_{TC(R)}(x)$. Note that by construction of $TC(R)$, for every for every $i = 1, \ldots, n-1$, there is k_i such that $y_i \in U_{C_{k_i}(R)}(x)$. Let m be the maximum of such that $m \geq k_i$ for every i. Therefore, $y \in U_{C_{m+1}(R)}(x)$, since the upper contour set of $C_{m+1}(R)$ is obtained by taking a convex hull of all upper contour sets of $C_m(R)$. □

Therefore, $TC(Q_E)$ is a convex, transitive and quasi-monotone relation (see Lemma A.4 and Observation A.1). Hence, we are left to show that $R_E \preceq TC(Q_E)$. Let us start from the supplementary result which shows that $R_E \preceq Q_E$.

Lemma A.5. *If*

$$\{\, x^t \,:\, t \in R_x \} \;\cap\; CH \left(A \cup \left(\bigcup_{t \in A_x} A_c^t \right) \right) \;=\; \emptyset$$

Then $R_E \preceq Q_E$.

Proof. On the contrary assume that there is $(y, x) \in P(R_E)$ and $(x, y) \in Q_E$ and consider the following cases.

Case 1: $y = x^t$ and $x = x^0$. If $(x^0, x^t) \in Q_E$, then $x^0 \in U_{Q_E}(x^t)$. But by the construction of Q_E there are only three following possibilities of $x^0 \in U_{Q_E}(x^t)$: (i) $(x^0, x^t) \in R_E$ - impossible because $(x^t, x^0) \in P(R_E)$ (ii) $(x^0, x^t) \in Q'_E$ - impossible because implies that x^t is rejected and (iii) $(x^0, x^t) \in \trianglerighteq_{\mathrm{r}}$ - impossible, because we $x^t > x^0$.

[30] m exists because all the sequence are finite.

Case 2: $y = x^0$ an $x = x^t$. If $(x^t, x^0) \in Q_E$, then $x^t \in U_{Q_E}(x^0)$. But by the construction of Q_E there are only three following possibilities: (i) $(x^t, x^0) \in R_E$ – impossible because $(x^0, x^t) \in P(R_E)$, (ii) $(x^t, x^0) \in Q'_E$ – impossible because x^t is a rejected point, (iii) $(x^t, x^0) \in \trianglerighteq_{\mathrm{r}}$ – impossible because this implies that $x^t \in A$. □

Lemma A.6. *If*

$$\{\, x^t \;:\; t \in R_x\} \;\cap\; CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right) \;=\; \emptyset$$

Then $R_E \preceq TC(Q_E)$.

Before proceeding with the proof, we make two observations.

Observation A.3. *If*

$$\{\, x^t \;:\; t \in R_x\} \;\cap\; CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right) \;=\; \emptyset$$

Then for every $t \in A_x$, $U_{Q_E}(x^t) = U_{TC(Q_E)}(x^t)$.

Observation A.3 says that if data are consistent with the test, then the upper contour sets of the accepted points remains unaffected by taking the convex closure. This follows from the construction of Q_E. Moreover, the only points which can be better than x^t are other accepted points. Hence, if data are consistent with the test then the only points which can be preferred to the accepted point are $y \trianglerighteq_{\mathrm{r}} x^t$.

Observation A.4. *If*

$$\{\, x^t \;:\; t \in R_x\} \;\cap\; CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right) \;=\; \emptyset$$

Then $U_{Q_E}(x^0) = U_{C(Q_E)}(x^0)$.

Observation A.4 says that if data are consistent with the test, then the upper contour set of x^0 remains unaffected by taking the convex closure. This also follows from a construction of Q_E. If data are consistent with the test, then the only points which are better than x^0 are the accepted points, points which are better than the accepted points and $y \trianglerighteq_{\mathrm{r}} x^0$, however, $U_{Q_E}(x^0)$ already includes the convex hull of these points. Therefore, since the upper contour sets of accepted points remain unchanged the upper contour set of zero remains unchanged as well.[31]

[31]An additional observation is implicit in this explanation, that is the upper contour sets of $y \trianglerighteq_{\mathrm{r}} x^0$ remain unchanged as well.

Proof of Lemma A.6. On the contrary assume that $(y, x) \in P(R_E)$ and $(x, y) \in TC(Q_E)$. Note that $(x, y) \notin Q_E$ since $R_E \preceq Q_E$.

Case 1: $y = x^t$ and $x = x^0$. Note that $(x^0, x^t) \in TC(Q_E)$ implies that $x^0 \in U_{TC(Q_E)}(x^t)$. However, x^t is accepted point, therefore, Observation A.3 implies that $U_{TC(Q_E)}(x^t) = U_{Q_E}(x^t)$. Hence $(x^0, x^t) \in Q_E$ that is a contradiction.

Case 2: $y = x^0$ and $x = x^t$. Note that $(x^t, x^0) \in TC(Q_E)$ implies that $x^t \in U_{TC(Q_E)}(x^0)$. However, x^t is accepted point, therefore, Observation A.4 implies that $U_{TC(Q_E)}(x^0) = U_{Q_E}(x^0)$. Hence $(x^t, x^0) \in Q_E$ that is a contradiction. $\square$

Applying Lemma A.6 and Lemma A.3 we can complete the proof.

Proof of Corollary 1 Without loss of generality assume that all the beliefs can be expressed as integer numbers between 0 and 100. While we assume a finite population size to avoid complicating the notation, all the results hold for continuous population. We then construct an incomplete preferences relation that is consistent with $T(R \cup \trianglerighteq_{\mathrm{r}})$ and apply Lemma A.1 which guarantees the existence of a complete transitive and quasi-monotone extension of it. The construction is done in a way that guarantees that the frequency of an outcome being accepted corresponds to the elicited beliefs. Denote by $\mathcal{P}(x^t)$, with typical element a, the set of agents who prefer x^t to zero. We assume that if x^t is an element on 45° line and $a \notin \mathcal{P}(x^t)$ then she is indifferent between zero and x^t. This guarantees that she would reject it, but keeps her preference relation consistent with $\trianglerighteq_{\mathrm{r}}$.

Since the set of beliefs is well-ordered, we reorder its elements such that $1 - b^t < 1 - b^s$ if $t < s$. Let $\mathcal{P}(\mathbf{x}^1)$ be such that $|\mathcal{P}(\mathbf{x}^1)| = 1 - b^1$, this can be done by taking random set of $1 - b^1$ subjects from the population. $\mathcal{P}(\mathbf{x}^t)$ can be constructed using the following recursive rule: (1) $|\mathcal{P}(\mathbf{x}^t)| = 1 - b^t$ (2) $\mathcal{P}(\mathbf{x}^s) \subseteq \mathcal{P}(\mathbf{x}^t)$ for all $s < t$ (3) if $1 - b^t = 1 - b^s$, then $\mathcal{P}(\mathbf{x}^s) = \mathcal{P}(\mathbf{x}^t)$.

Lemma A.7. *For every player a in the population, the constructed preference relation is consistent with $T(R \cap \trianglerighteq_{\mathrm{r}})$.*

Proof. We prove this Lemma using Lemma A.2. On the contrary assume that there are $\mathbf{x}^t$ and $\mathbf{x}^s$ such that $\mathbf{x}^s \trianglerighteq_{\mathrm{r}} \mathbf{x}^t$, $a \notin \mathcal{P}(\mathbf{x}^s)$ and $a \in \mathcal{P}(x^t)$. The last two conditions imply that $\mathbf{x}^t$ is preferred to zero and zero preferred to $\mathbf{x}^s$ by the construction of preference relation. However, the conditions also imply that $\mathcal{P}(\mathbf{x}^t) \subseteq \mathcal{P}(\mathbf{x}^s)$, therefore, $a \in \mathcal{P}(\mathbf{x}^s)$, which is a contradiction. $\square$

Hence, the proof can be completed using Lemma A.1.

Proof of Corollary 2 We first establish the necessity of the conditions. Assume there is a population of convex responder rational agents such that the frequency of choices coincides with elicited beliefs. Denote $CH\left(A \cup \left(\bigcup_{x^t \in S} A_c^t\right)\right)$ by $A_c(S)$ and denote by $\partial A_c(S)$ the south-west border of the convex hull. Then, $\bigcap_{x^s \in S \cap \partial A_c(S)} \mathcal{P}(x^s)$ is the set of people who prefer x^s to zero for every point that lies in the boundary of convex hull. Then, convexity of preferences imply that $\mathcal{P}(x^t) \subset \bigcap_{x^s \in S \cap \partial A_c(S)} \mathcal{P}(x^s)$ for every $x^t \in A_c(S) \setminus \partial A_c(S)$. Therefore, $b^t \leq \max_{x^s \in S \cap \partial A_c(S)} \{b^s\}$ for every $x^t \in A_c(S)$. In particular this implies that $\max_{x^s \in S \cap \partial A_c(S)} \{b^s\} = \max_{x^s \in S} \{b^s\}$. Therefore, we can conclude that $b^t \leq \max_{x^s \in S} \{b^s\}$ for every $x^t \in A_c(S)$.

We now show the sufficiency of the conditions. Since the set of beliefs is well-ordered we reorder its elements such that $1 - b^t < 1 - b^s$ if $t < s$. Let $\mathcal{P}(x^1)$ be such that $|\mathcal{P}(x^1)| = 1 - b^1$, this can be done by taking random set of $1 - b^1$ subjects from the population. $\mathcal{P}(x^t)$ can be constructed using the following recursive rule: (1) $|\mathcal{P}(x^t)| = 1 - b^t$ (2) $\mathcal{P}(x^s) \subseteq \mathcal{P}(x^t)$ for all $s < t$ (3) if $1 - b^t = 1 - b^s$, then $\mathcal{P}(x^s) = \mathcal{P}(x^t)$.

Lemma A.8. *For every player a in the population, the constructed preference relation is consistent with convex responder rationality*

Proof. On the contrary assume that there is a violation, i.e. $x^s \in S \in 2^{C \setminus x^t}$ and $x^t \in A_c(S)$. That is $a \in \mathcal{P}(x^s)$ for every $x^s \in S$ and $a \notin \mathcal{P}(x^t)$. These conditions imply that $b^t \leq \max_{x^s \in S} \{b^s\} = b^r$. Therefore, $\mathcal{P}(x^r) \subseteq \mathcal{P}(x^t)$ by construction. That is a contradiction. □

Hence, we can complete the proof by applying Proposition 3.

Appendix B: Additional Data

We conducted two additional experimental sessions in Texas A&M University with a total of 40 subjects. In addition to the ultimatum games we conducted incentivized point belief elicitation using the binarized scoring procedure from Hossain and Okui (2013).

Table B.1 reproduces Table 1 in the paper. We call proposers *generous* if they offered more than the minimum possible allocations. We call responders *rejectors* if she rejected at least one allocation (minimum one). Table B.1 shows that subjects at A&M offer more money as proposers and reject higher offers as responders. These suggests that the two populations have different preferences and play according to different equilbria. In what follows, we analyze proposer and responder rationality and subjects' beliefs.

$m = x_\mathrm{p} + p\,x_\mathrm{r}$, with $(m,p) =$	Proposed x_r: All proposers Mean	St.Dev	Generous %-age	Mean	Highest rejected x_r: All responders Mean	St.Dev	Rejectors %-age	Mean	No cut-off rule n
$(\$12, \frac{1}{5})$	\$16.44	\$16.21	97.5%	\$16.80	\$3.90	\$1.78	100.0%	\$3.90	4
$(\$24, \frac{1}{3})$	\$20.85	\$12.65	100.0%	\$20.85	\$7.30	\$2.98	100.9%	\$7.30	5
$(\$24, \frac{1}{2})$	\$16.35	\$8.36	97.5%	\$16.72	\$6.72	\$3.16	100.0%	\$6.72	6
$(\$36, 1)$	\$15.83	\$4.95	97.5%	\$16.20	\$8.24	\$4.04	100.0%	\$8.24	6
$(\$48, 1)$	\$20.40	\$7.99	97.5%	\$20.90	\$8.81	\$4.00	100.0%	\$8.81	6
$(\$60, 1)$	\$24.68	\$8.12	95.0%	\$25.92	\$10.31	\$6.37	100.0%	\$10.31	6
$(\$48, 2)$	\$12.55	\$5.03	90.0%	\$13.83	\$7.79	\$3.61	100.0%	\$7.79	5
$(\$72, 3)$	\$13.85	\$5.92	90.0%	\$15.28	\$9.00	\$4.20	100.0%	\$9.00	5
$(\$60, 5)$	\$7.84	\$3.08	92.5%	\$8.43	\$6.44	\$2.02	100.0%	\$6.44	7
All 9 budgets	\$16.53	\$10.00	95.28%	\$17.30	\$7.65	\$4.28	100.0%	\$7.65	7

Table B.1. Summary of Proposer and Responder Behavior

CCEI	Number of Subjects	Bronars' power	e.d.f. power
1	34	.9012	.7870
$[1-\varepsilon, 1)$	4	.8352	.4893
$[.9, 1-\varepsilon)$	1	.5882	.3368
$[.8, .9)$	0	.3018	.1196
$[0, .8)$	1		

Table B.2. Proposer Rationality

Table B.2 shows the pass rates for proposer rationality conditions. The exact pass rate is 85% and the past rate allowing small violations is 95%. Pass rates are not significantly different from those obtained in the original data.[32]

Table B.3 presents the results regarding responder rationality and convexity of preferences for the new data. The results are qualitetively similar to the original sample. Allowing for small mistakes, 78% of subjects are consistent with responder rationality and 80% of subjects have at least 6 violations of convexity. The pass rate of the test of rationality is larger than in the original sample if we do not allow for mistakes, while the difference is not significant if we compare pass rates that allow for no more than five violations. Regarding convexity, there is no significant difference if we compare pass rates with number of violations equal to zero, while if we allow for no more that five violations difference becomes significant.

[32] Here is further we compare pass rates using t-test, Wilcoxon rank sum test and estimated confidence intervals based on Clopper-Pearson procedure.

Number of Violations	Responder Rationality		Convex Responder Rationality	
	Number of Subjects	Percent of Subjects	Number of Subjects	Percent of Subject
0	18	45%	8	20%
≤ 5	31	78%	8	20%
≥ 6	9	22%	32	80%
Power of Test				
	Proposer Rationality		Convex Proposer Rationality	
Test	Power of Test	Average Number of Violations (std)	Power of Test	Average Number of Violations (std)
Random	1.0000	47.0850 (4.8914)	1.0000	58.7460 (5.6078)
Random Cutoff	1.0000	34.1910 (9.8979)	1.0000	62.8880 (10.8994)
e.d.f.	0.9990	15.4810 (3.3961)	1.0000	32.4580 (3.7548)
e.d.f. Cutoff	0.9180	11.4410 (4.5483)	1.0000	38.0280 (6.1267)

TABLE B.3. Responder Rationality

	Consistent with Responder Rationality	Inconsistent with Responder Rationality
Consistent with Proposer Rationality ($CCEI = 1$)	17 (42%)	21 (52)
Inconsistent with Proposer Rationality ($CCEI \neq 1$)	1 (3%)	1 (3%)

TABLE B.4. Cross Table: Proposer Rationality and Responder Rationality

	Consistent with Responder Rationality	Inconsistent with Responder Rationality
Consistent with Proposer Rationality ($CCEI \geq 1 - \varepsilon$)	29 (73%)	9 (22%)
Inconsistent with Proposer Rationality ($CCEI < 1 - \varepsilon$)	2 (5%)	0 (0%)

TABLE B.5. Cross Table: Weak Proposer Rationality ($CCEI \geq 1 - \varepsilon$) and Responder Rationality (number of violations ≤ 5)

Tables B.4 and B.5 present the results for dependence between the proposer and responder rationality. Results are similar to one obtained in the original data, especially if we relax the notion of rationality to one which allows for small violations.

We now present results on the consistency of elicited belief.

Figure B.1 shows the mean and 95% confidence intervals of elicited beliefs. Higher numbers mean higher probabilities of rejection. The large confidence intervals imply a high degree of heterogeneity of beliefs. At the same time beliefs are monotone within the menu (blocks of four). Note that the probability of accepting equal split outcomes $(18, 18)$ and $(30, 30)$ are the same, regardless of the difference price regimes ($p = 1$ in the first case and $p = 3$ in the second case). We also find that beliefs not only depend

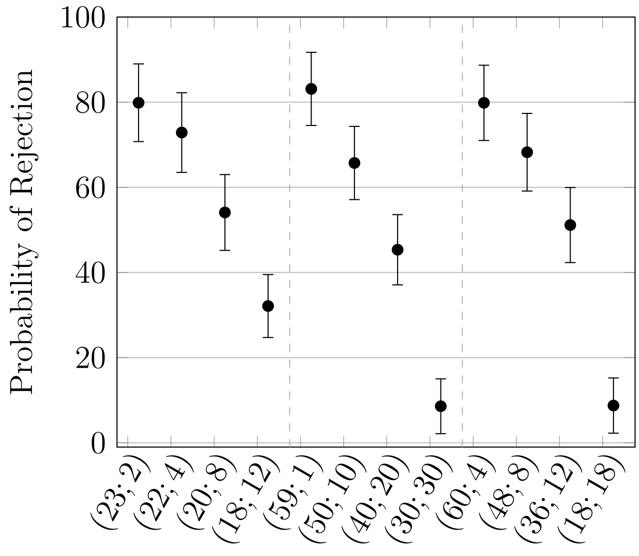


Figure B.1. Average Beliefs and Confidence Intervals

on the responder's outcome. The probability of rejecting is higher for $(36; 12)$ than for $(18, 12)$. Average beliefs are consistent with both responder rationality and convexity.[33]

We now turn to the analysis of beliefs at the individual level. To make it comparable to the original experiment, which elicited beliefs in intervals, we introduce a slack variable e or measurement error term for beliefs. Without measurement error, the probability of rejecting offer x, $q(x)$, is higher than probability of rejecting offer x', $q(x')$, if and only if $q(x) > q(x')$. Given the slack variable, the probability of rejecting offer x, $q(x)$, is higher than probability of rejecting offer x', $q(x')$, if and only if $q(x) > q(x') + e$ (we denote this case as $q(x) >_e q(x')$). We consider three levels of slack: no slack, five percentage points and thirty percentage points. The slack of 5 percentage points reflects the observed variation in the experiment. The slack of 30 percentage points reflect the span of intervals in the original experiment.

Table B.6 presents the results on belief consistency. Without any slack, 40% of subjects have consistent beliefs. This proportion is statistically different from the proportion of subjects with consistent beliefs in the original experiment (81%). Allowing a slack of 5 percentage points, the number of subjects with consistent beliefs increases

[33] An average belief b_i is greater than b_j if it is greater at the 5% significance level. For instance probability of rejecting $(23; 2)$ is significantly greater than probability of rejecting $(20; 8)$ while it is not significantly greater than probability of rejecting $(22; 4)$. If we do not account for confidence intervals, then average beliefs are not consistent with responder rationality. In addition we conduct power estimates using Bronars and e.d.f. test, using the repeated sampling of 40 observations out of the populations of 10000 simulated observations. All power tests return 1.0000 – there is zero chance that e.d.f. or uniform random subjects would generate beliefs that would be on average consistent.

Slack	Beliefs Consistent with Responder Rationality	Beliefs Consistent with Convex Responder Rationality
$e = 0$	22 (40%)	1 (2.5%)
$e \leq 5$	30 (75%)	1 (2.5%)
$e \leq 30$	37 (93%)	3 (8.5%)
Power Analysis Test	Responder Ratonality	Convex Responder Rationality
Bronars & $e = 0$	0.9900	1.0000
Bronars & $e \leq 5$	0.9830	1.0000
Bronars & $e \leq 30$	0.8610	0.8610
e.d.f. & $e = 0$	0.8822	1.0000
e.d.f. & $e \leq 5$	0.8214	1.0000
e.d.f. & $e \leq 30$	0.4982	1.0000

Table B.6. Belief Consistency

to 75%. This difference is not statistically different from the proportion of subjects with consistent beliefs in the original data. The hypothesis that beliefs are consistent with convex responder rationality is rejected decisively. We find that even allowing for a slack of 30 percentage points slack only 3 out of 40 subjects have beliefs consistent with convex responder rationality. The difference in pass rates for convex responder rationality is not statistically significant from the original data for any of the levels of slack presented. Finally, power analysis conducted using Bronars' and e.d.f. power tests shows that the tests can successfully distinguish between real consistent behavior from the randomly consistent behavior.

Finally, we investigate which assumptions of proposer rationality are more likely to fail by looking at the patterns of behavior in the three experimental tasks. We find that 23 (58%) subjects passed all three tests; 6 (15%) failed only consistency of beliefs; 2 (5%) failed only proposer rationality (do violate stochastic dominance preferences). In addition, 9 subjects are consistent with proposer rationality but are not consistent with responder rationality. Five of these 9 subjects passed the belief consistency test. These subjects seem to have consistent beliefs and behave rationally, but they do not have quasi-monotone preferences.

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Appendix C: Experimental Instructions

C.1: Decision Task

INSTRUCTIONS

Welcome

This is an experiment about decision making. You will be paid for your participation. The amount of money you earn depends on your decisions and the decisions of others. If you make good decisions, you could earn a considerable amount of money. The experiment should take about an hour. At the end of the experiment you will be paid privately and in cash for your decisions. A research foundation has provided the funds for this experiment.

Thanks For Showing Up

Just for being willing to participate, you will automatically earn $8. Whatever you earn in the rest of the session will be in addition to this $8.

Your Identity

You will never be asked to reveal your identity to anyone during the course of the experiment. Your name will never be recorded. Neither the experimenters nor anyone else in the room will be able to link you to any of your decisions. In order to keep your decisions private, please do not reveal your choices to any other participant.

Claim Check

At the top of this page is a number on a yellow piece of paper. This is your Claim Check. Each participant has a different number. Please verify that the number on your Claim Check is the same as the Claim Check Number on the top of page X.

You will present your Claim Check to an assistant at the end of the experiment to receive your cash payment.

Please remove your claim check now and put it an a safe place.

THIS EXPERIMENT

You and the other person will be paired randomly and anonymously. No one will know the identity of the other person in your pair. In this experiment you are asked to make a series of choices about how to allocate a sum of money between yourself and one other person in the room.

The task of each pair is to divide from $0 to up to $70 between the two of you. How much money you end up with at the end of the experiment depends on the decisions both people in the pair make.

In each pair, one person will be the Proposer and the other will be the Responder. Your role will be determined at the end of the session , hence you must understand both roles to make good choices. In each of the series of choices the Proposer chooses a Proposal Rule. A Proposal Rule determines how much money will go to the Proposer and how much will go to the Responder. Given the Proposal Rule the Proposer chooses, the Responder responds by choosing whether to Accept or Reject the proposal. If the Responder responds with Accept, then the Proposer and the Responder receive the sums of money determined by the chosen Proposal Rule. If the Responder responds with Reject, then the Proposer and the Responder both receive nothing.

IMPORTANT: The Proposer chooses the Proposal Rule without knowing whether the Responder will respond by Accepting or Rejecting the Proposal Rule.

The Proposal Rules must be chosen from a table like this:

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $59 and **Responder** gets $1
b	**Proposer** gets $55 and **Responder** gets $5
c	**Proposer** gets $50 and **Responder** gets $10
d	**Proposer** gets $45 and **Responder** gets $15
e	**Proposer** gets $40 and **Responder** gets $20
f	**Proposer** gets $35 and **Responder** gets $25
g	**Proposer** gets $30 and **Responder** gets $30
h	**Proposer** gets $25 and **Responder** gets $35
i	**Proposer** gets $20 and **Responder** gets $40
j	**Proposer** gets $15 and **Responder** gets $45
k	**Proposer** gets $10 and **Responder** gets $50
l	**Proposer** gets $5 and **Responder** gets $55
m	**Proposer** gets $1 and **Responder** gets $59

So, out of the thirteen Proposal Rules in the table, the Proposer must choose only one of them.

Given that the Proposer has selected a Proposal Rule, then the Responder responds by Accepting or Rejecting the proposal.

However, the Responder must respond before finding out the Proposal Rule chosen by the Proposer. So, for all possible Proposal Rules, the Responder must decide whether to Accept or Reject.

The Responder will make the thirteen choices from a table like this:

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets $59 and **Responder** gets $1	*Accept*	*Reject*
b	**Proposer** gets $55 and **Responder** gets $5	*Accept*	*Reject*
c	**Proposer** gets $50 and **Responder** gets $10	*Accept*	*Reject*
d	**Proposer** gets $45 and **Responder** gets $15	*Accept*	*Reject*
e	**Proposer** gets $40 and **Responder** gets $20	*Accept*	*Reject*
f	**Proposer** gets $35 and **Responder** gets $25	*Accept*	*Reject*
g	**Proposer** gets $30 and **Responder** gets $30	*Accept*	*Reject*
h	**Proposer** gets $25 and **Responder** gets $35	*Accept*	*Reject*
i	**Proposer** gets $20 and **Responder** gets $40	*Accept*	*Reject*
j	**Proposer** gets $15 and **Responder** gets $45	*Accept*	*Reject*
k	**Proposer** gets $10 and **Responder** gets $50	*Accept*	*Reject*
l	**Proposer** gets $5 and **Responder** gets $55	*Accept*	*Reject*
m	**Proposer** gets $1 and **Responder** gets $60	*Accept*	*Reject*

EXAMPLES

We now consider some examples.

Example One: Suppose the Proposer circles Proposal Rule k: "Proposer gets $10 and Responder gets $50." Suppose also that the Responder circles Accept on line k. Then, since the Responder chose to Accept, the Proposer receives $10 and the Responder receives $50.

Example Two: Suppose the Proposer circles Proposal Rule d: "Proposer gets $45 and Responder gets $15." Suppose also that the Responder circles Accept on line d. Then, since the Responder chose to Accept, the Proposer receives $45 and the Responder receives $15.

Example Three: Suppose the Proposer circles Proposal Rule g: "Proposer gets $30 and Responder gets $30." Suppose also that the Responder circles Reject on line g. Then, since the Responder chose to Reject, the Proposer receives $0 and the Responder receive $0.

EXERCISES

While calculating payoffs seems easy, it is important that everyone understand how to calculate payoffs of both the Proposer and the Responder. So, below we ask you to calculate the payoffs of both players for some specific examples. After you have finished, we will go over the correct answers together.

<u>Case One</u>: Suppose the Proposer chooses:

f	Proposer gets	\$35	and Responder gets	\$25

and for Proposal rule f the Responder chooses:

f	Proposer gets	\$35	and Responder gets	\$25	Accept	Reject

Payoff for the Proposer is \$______. Payoff for the Responder is \$______.

<u>Case Two</u>: Suppose the Proposer chooses:

e	Proposer gets	\$10	and Responder gets	\$28

and for Proposal rule f the Responder chooses:

e	Proposer gets	\$10	and Responder gets	\$28	Accept	Reject

Payoff for the Proposer is \$______. Payoff for the Responder is \$______.

<u>Case Three</u>: Suppose the Proposer chooses:

b	Proposer gets	\$44	and Responder gets	\$2

and for Proposal rule f the Responder chooses:

b	Proposer gets	\$44	and Responder gets	\$2	Accept	Reject

Payoff for the Proposer is \$______. Payoff for the Responder is \$______.

YOUR ROLE

You will be randomly assigned either to the role of the Proposer or to the role of the Responder. After you are assigned a role, you will be randomly matched with another person in the room, and your decision for only the role assigned to you will be carried out. One of your decisions will be chosen randomly and carried out.

IMPORTANT

You must make all your decisions before you know to which role you will be assigned.

Since you won't know to which role you will be assigned until the very end, you must make decisions for both roles. After all decisions are made, there is a 50% chance you will be assigned the Proposer role and a 50% chance you will be assigned the Responder role.

HOW THE PAIRINGS ARE MADE

Attached are decision forms for the Proposer and the Responder. Complete all forms, imagining as being chosen for each role. Place the completed forms and instructions back on the envelope.

After you have finished making your decisions, you will put the completed forms in your envelope. We will collect the envelopes, shuffle them, and separate them into two piles of equal size; Pile 1 and Pile 2.

If, by chance, your envelope is in Pile 1, you will be a Proposer – we will use only your decisions in the Proposer role, and ignore your decisions in the Responder role.

If, by chance, your envelope is in Pile 2, you will be a Responder – we will use only your decisions in the Responder role, and ignore your decisions in the Proposer role.

After shuffling the envelopes in each pile again, each envelope in Pile 1, the Proposers, will be matched with an envelope in Pile 2, the Responders. This is the way each of you will be randomly paired with another person in the room.

RECEIVING YOUR PAYMENT

After all pairings are made, we will randomly select one of the 9 possible decisions for each pairing. We will use the alternatives chosen by the Proposer and the Responder to determine the payoffs for that pair. Your payoff from the pairing will be placed in your earnings envelope with your Claim Check Number written on the outside of the envelope. You will present your Claim Check, and we will hand you your earnings envelope.

To further guard your anonymity, an assistant who was not involved in determining the payoffs, and thus has no idea what is in each envelope, will hand you your earnings envelope.

Finally, to verify that the procedures we describe are followed, a monitor, who was chosen at the beginning of the experiment, will be present during the determination of payments.

Preparing your payments will take about 15 minutes.

SUMMARY

Step 1: You will eventually assume the role of either Proposer or Responder. However, before you are randomly assigned a role, you must make choices for <u>both</u> the Proposer role and the Responder role.

Step 2: <u>After</u> your choices are made, we will <u>randomly</u> assign you the role of either Proposer or Responder.

Step 3: You will be randomly paired with another person in the room, who has been assigned the other role. Your choice <u>only for the role assigned to you</u> will be carried out with the other person in your pairing.

Step 4: For each pair, one of the 8 decisions will be chosen at random and both of your decisions will be carried out.

Step 5: Everyone will receive cash payments in private envelopes at the end of the experiment.

You can begin making your decisions
Good luck!

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $35 and **Responder** gets $1
b	**Proposer** gets $33 and **Responder** gets $3
c	**Proposer** gets $30 and **Responder** gets $6
d	**Proposer** gets $27 and **Responder** gets $9
e	**Proposer** gets $24 and **Responder** gets $12
f	**Proposer** gets $21 and **Responder** gets $15
g	**Proposer** gets $18 and **Responder** gets $18
h	**Proposer** gets $15 and **Responder** gets $21
i	**Proposer** gets $12 and **Responder** gets $24
j	**Proposer** gets $9 and **Responder** gets $27
k	**Proposer** gets $6 and **Responder** gets $30
l	**Proposer** gets $3 and **Responder** gets $33
m	**Proposer** gets $1 and **Responder** gets $35

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):
a	**Proposer** gets $35 and **Responder** gets $1	*Accept* *Reject*
b	**Proposer** gets $33 and **Responder** gets $3	*Accept* *Reject*
c	**Proposer** gets $30 and **Responder** gets $6	*Accept* *Reject*
d	**Proposer** gets $27 and **Responder** gets $9	*Accept* *Reject*
e	**Proposer** gets $24 and **Responder** gets $12	*Accept* *Reject*
f	**Proposer** gets $21 and **Responder** gets $15	*Accept* *Reject*
g	**Proposer** gets $18 and **Responder** gets $18	*Accept* *Reject*
h	**Proposer** gets $15 and **Responder** gets $21	*Accept* *Reject*
i	**Proposer** gets $12 and **Responder** gets $24	*Accept* *Reject*
j	**Proposer** gets $9 and **Responder** gets $27	*Accept* *Reject*
k	**Proposer** gets $6 and **Responder** gets $30	*Accept* *Reject*
l	**Proposer** gets $3 and **Responder** gets $33	*Accept* *Reject*
m	**Proposer** gets $1 and **Responder** gets $35	*Accept* *Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $47 and **Responder** gets $1
b	**Proposer** gets $44 and **Responder** gets $4
c	**Proposer** gets $40 and **Responder** gets $8
d	**Proposer** gets $36 and **Responder** gets $12
e	**Proposer** gets $32 and **Responder** gets $16
f	**Proposer** gets $28 and **Responder** gets $20
g	**Proposer** gets $24 and **Responder** gets $24
h	**Proposer** gets $20 and **Responder** gets $28
i	**Proposer** gets $16 and **Responder** gets $32
j	**Proposer** gets $12 and **Responder** gets $36
k	**Proposer** gets $8 and **Responder** gets $40
l	**Proposer** gets $4 and **Responder** gets $44
m	**Proposer** gets $1 and **Responder** gets $47

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets $47 and **Responder** gets $1	*Accept*	*Reject*
b	**Proposer** gets $44 and **Responder** gets $4	*Accept*	*Reject*
c	**Proposer** gets $40 and **Responder** gets $8	*Accept*	*Reject*
d	**Proposer** gets $36 and **Responder** gets $12	*Accept*	*Reject*
e	**Proposer** gets $32 and **Responder** gets $16	*Accept*	*Reject*
f	**Proposer** gets $28 and **Responder** gets $20	*Accept*	*Reject*
g	**Proposer** gets $24 and **Responder** gets $24	*Accept*	*Reject*
h	**Proposer** gets $20 and **Responder** gets $28	*Accept*	*Reject*
i	**Proposer** gets $16 and **Responder** gets $32	*Accept*	*Reject*
j	**Proposer** gets $12 and **Responder** gets $36	*Accept*	*Reject*
k	**Proposer** gets $8 and **Responder** gets $40	*Accept*	*Reject*
l	**Proposer** gets $4 and **Responder** gets $44	*Accept*	*Reject*
m	**Proposer** gets $1 and **Responder** gets $47	*Accept*	*Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $59 and **Responder** gets $1
b	**Proposer** gets $55 and **Responder** gets $5
c	**Proposer** gets $50 and **Responder** gets $10
d	**Proposer** gets $45 and **Responder** gets $15
e	**Proposer** gets $40 and **Responder** gets $20
f	**Proposer** gets $35 and **Responder** gets $25
g	**Proposer** gets $30 and **Responder** gets $30
h	**Proposer** gets $25 and **Responder** gets $35
i	**Proposer** gets $20 and **Responder** gets $40
j	**Proposer** gets $15 and **Responder** gets $45
k	**Proposer** gets $10 and **Responder** gets $50
l	**Proposer** gets $5 and **Responder** gets $55
m	**Proposer** gets $1 and **Responder** gets $59

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):
a	**Proposer** gets $59 and **Responder** gets $1	*Accept* *Reject*
b	**Proposer** gets $55 and **Responder** gets $5	*Accept* *Reject*
c	**Proposer** gets $50 and **Responder** gets $10	*Accept* *Reject*
d	**Proposer** gets $45 and **Responder** gets $15	*Accept* *Reject*
e	**Proposer** gets $40 and **Responder** gets $20	*Accept* *Reject*
f	**Proposer** gets $35 and **Responder** gets $25	*Accept* *Reject*
g	**Proposer** gets $30 and **Responder** gets $30	*Accept* *Reject*
h	**Proposer** gets $25 and **Responder** gets $35	*Accept* *Reject*
i	**Proposer** gets $20 and **Responder** gets $40	*Accept* *Reject*
j	**Proposer** gets $15 and **Responder** gets $45	*Accept* *Reject*
k	**Proposer** gets $10 and **Responder** gets $50	*Accept* *Reject*
l	**Proposer** gets $5 and **Responder** gets $55	*Accept* *Reject*
m	**Proposer** gets $1 and **Responder** gets $59	*Accept* *Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $23 and **Responder** gets $2
b	**Proposer** gets $22 and **Responder** gets $4
c	**Proposer** gets $20 and **Responder** gets $8
d	**Proposer** gets $18 and **Responder** gets $12
e	**Proposer** gets $16 and **Responder** gets $16
f	**Proposer** gets $14 and **Responder** gets $20
g	**Proposer** gets $12 and **Responder** gets $24
h	**Proposer** gets $10 and **Responder** gets $28
i	**Proposer** gets $8 and **Responder** gets $32
j	**Proposer** gets $6 and **Responder** gets $36
k	**Proposer** gets $4 and **Responder** gets $40
l	**Proposer** gets $2 and **Responder** gets $44
m	**Proposer** gets $1 and **Responder** gets $46

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..				...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets	$23	and **Responder** gets	$2	*Accept*	*Reject*
b	**Proposer** gets	$22	and **Responder** gets	$4	*Accept*	*Reject*
c	**Proposer** gets	$20	and **Responder** gets	$8	*Accept*	*Reject*
d	**Proposer** gets	$18	and **Responder** gets	$12	*Accept*	*Reject*
e	**Proposer** gets	$16	and **Responder** gets	$16	*Accept*	*Reject*
f	**Proposer** gets	$14	and **Responder** gets	$20	*Accept*	*Reject*
g	**Proposer** gets	$12	and **Responder** gets	$24	*Accept*	*Reject*
h	**Proposer** gets	$10	and **Responder** gets	$28	*Accept*	*Reject*
i	**Proposer** gets	$8	and **Responder** gets	$32	*Accept*	*Reject*
j	**Proposer** gets	$6	and **Responder** gets	$36	*Accept*	*Reject*
k	**Proposer** gets	$4	and **Responder** gets	$40	*Accept*	*Reject*
l	**Proposer** gets	$2	and **Responder** gets	$44	*Accept*	*Reject*
m	**Proposer** gets	$1	and **Responder** gets	$46	*Accept*	*Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $46 and **Responder** gets $1
b	**Proposer** gets $44 and **Responder** gets $2
c	**Proposer** gets $40 and **Responder** gets $4
d	**Proposer** gets $36 and **Responder** gets $6
e	**Proposer** gets $32 and **Responder** gets $8
f	**Proposer** gets $28 and **Responder** gets $10
g	**Proposer** gets $24 and **Responder** gets $12
h	**Proposer** gets $20 and **Responder** gets $14
i	**Proposer** gets $16 and **Responder** gets $16
j	**Proposer** gets $12 and **Responder** gets $18
k	**Proposer** gets $8 and **Responder** gets $20
l	**Proposer** gets $4 and **Responder** gets $22
m	**Proposer** gets $2 and **Responder** gets $23

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):
a	**Proposer** gets $46 and **Responder** gets $1	*Accept* *Reject*
b	**Proposer** gets $44 and **Responder** gets $2	*Accept* *Reject*
c	**Proposer** gets $40 and **Responder** gets $4	*Accept* *Reject*
d	**Proposer** gets $36 and **Responder** gets $6	*Accept* *Reject*
e	**Proposer** gets $32 and **Responder** gets $8	*Accept* *Reject*
f	**Proposer** gets $28 and **Responder** gets $10	*Accept* *Reject*
g	**Proposer** gets $24 and **Responder** gets $12	*Accept* *Reject*
h	**Proposer** gets $20 and **Responder** gets $14	*Accept* *Reject*
i	**Proposer** gets $16 and **Responder** gets $16	*Accept* *Reject*
j	**Proposer** gets $12 and **Responder** gets $18	*Accept* *Reject*
k	**Proposer** gets $8 and **Responder** gets $20	*Accept* *Reject*
l	**Proposer** gets $4 and **Responder** gets $22	*Accept* *Reject*
m	**Proposer** gets $2 and **Responder** gets $23	*Accept* *Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $23 and **Responder** gets $3
b	**Proposer** gets $22 and **Responder** gets $6
c	**Proposer** gets $20 and **Responder** gets $12
d	**Proposer** gets $18 and **Responder** gets $18
e	**Proposer** gets $16 and **Responder** gets $24
f	**Proposer** gets $14 and **Responder** gets $30
g	**Proposer** gets $12 and **Responder** gets $36
h	**Proposer** gets $10 and **Responder** gets $42
i	**Proposer** gets $8 and **Responder** gets $48
j	**Proposer** gets $6 and **Responder** gets $54
k	**Proposer** gets $4 and **Responder** gets $60
l	**Proposer** gets $2 and **Responder** gets $66
m	**Proposer** gets $1 and **Responder** gets $69

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..				...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets	$23	and **Responder** gets	$3	*Accept*	*Reject*
b	**Proposer** gets	$22	and **Responder** gets	$6	*Accept*	*Reject*
c	**Proposer** gets	$20	and **Responder** gets	$12	*Accept*	*Reject*
d	**Proposer** gets	$18	and **Responder** gets	$18	*Accept*	*Reject*
e	**Proposer** gets	$16	and **Responder** gets	$24	*Accept*	*Reject*
f	**Proposer** gets	$14	and **Responder** gets	$30	*Accept*	*Reject*
g	**Proposer** gets	$12	and **Responder** gets	$36	*Accept*	*Reject*
h	**Proposer** gets	$10	and **Responder** gets	$42	*Accept*	*Reject*
i	**Proposer** gets	$8	and **Responder** gets	$48	*Accept*	*Reject*
j	**Proposer** gets	$6	and **Responder** gets	$54	*Accept*	*Reject*
k	**Proposer** gets	$4	and **Responder** gets	$60	*Accept*	*Reject*
l	**Proposer** gets	$2	and **Responder** gets	$66	*Accept*	*Reject*
m	**Proposer** gets	$1	and **Responder** gets	$69	*Accept*	*Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets $69 and **Responder** gets $1
b	**Proposer** gets $66 and **Responder** gets $2
c	**Proposer** gets $60 and **Responder** gets $4
d	**Proposer** gets $54 and **Responder** gets $6
e	**Proposer** gets $48 and **Responder** gets $8
f	**Proposer** gets $42 and **Responder** gets $10
g	**Proposer** gets $36 and **Responder** gets $12
h	**Proposer** gets $30 and **Responder** gets $14
i	**Proposer** gets $24 and **Responder** gets $16
j	**Proposer** gets $18 and **Responder** gets $18
k	**Proposer** gets $12 and **Responder** gets $20
l	**Proposer** gets $6 and **Responder** gets $22
m	**Proposer** gets $3 and **Responder** gets $23

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..	...then I choose to (circle one for Proposal Rule):
a	**Proposer** gets $69 and **Responder** gets $1	*Accept* *Reject*
b	**Proposer** gets $66 and **Responder** gets $2	*Accept* *Reject*
c	**Proposer** gets $60 and **Responder** gets $4	*Accept* *Reject*
d	**Proposer** gets $54 and **Responder** gets $6	*Accept* *Reject*
e	**Proposer** gets $48 and **Responder** gets $8	*Accept* *Reject*
f	**Proposer** gets $42 and **Responder** gets $10	*Accept* *Reject*
g	**Proposer** gets $36 and **Responder** gets $12	*Accept* *Reject*
h	**Proposer** gets $30 and **Responder** gets $14	*Accept* *Reject*
i	**Proposer** gets $24 and **Responder** gets $16	*Accept* *Reject*
j	**Proposer** gets $18 and **Responder** gets $18	*Accept* *Reject*
k	**Proposer** gets $12 and **Responder** gets $20	*Accept* *Reject*
l	**Proposer** gets $6 and **Responder** gets $22	*Accept* *Reject*
m	**Proposer** gets $3 and **Responder** gets $23	*Accept* *Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:				
a	**Proposer** gets	$11.50	and **Responder** gets	$2.50
b	**Proposer** gets	$11	and **Responder** gets	$5
c	**Proposer** gets	$10	and **Responder** gets	$10
d	**Proposer** gets	$9	and **Responder** gets	$15
e	**Proposer** gets	$8	and **Responder** gets	$20
f	**Proposer** gets	$7	and **Responder** gets	$25
g	**Proposer** gets	$6	and **Responder** gets	$30
h	**Proposer** gets	$5	and **Responder** gets	$35
i	**Proposer** gets	$4	and **Responder** gets	$40
j	**Proposer** gets	$3	and **Responder** gets	$45
k	**Proposer** gets	$2	and **Responder** gets	$50
l	**Proposer** gets	$1	and **Responder** gets	$55
m	**Proposer** gets	$0.50	and **Responder** gets	$57.50

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..				...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets	\$11.50	and **Responder** gets	\$2.50	*Accept*	*Reject*
b	**Proposer** gets	\$11	and **Responder** gets	\$5	*Accept*	*Reject*
c	**Proposer** gets	\$10	and **Responder** gets	\$10	*Accept*	*Reject*
d	**Proposer** gets	\$9	and **Responder** gets	\$15	*Accept*	*Reject*
e	**Proposer** gets	\$8	and **Responder** gets	\$20	*Accept*	*Reject*
f	**Proposer** gets	\$7	and **Responder** gets	\$25	*Accept*	*Reject*
g	**Proposer** gets	\$6	and **Responder** gets	\$30	*Accept*	*Reject*
h	**Proposer** gets	\$5	and **Responder** gets	\$35	*Accept*	*Reject*
i	**Proposer** gets	\$4	and **Responder** gets	\$40	*Accept*	*Reject*
j	**Proposer** gets	\$3	and **Responder** gets	\$45	*Accept*	*Reject*
k	**Proposer** gets	\$2	and **Responder** gets	\$50	*Accept*	*Reject*
l	**Proposer** gets	\$1	and **Responder** gets	\$55	*Accept*	*Reject*
m	**Proposer** gets	\$0.50	and **Responder** gets	\$57.50	*Accept*	*Reject*

DECISION SHEET FOR THE ***PROPOSER*** ROLE:

Suppose you are the Proposer. Choose one and only one alternative from the following table. Please circle the letter of your choice from the first column.

Proposer chooses **Proposal Rule** by circling one letter in this column	**Proposal Rules** to choose from:
a	**Proposer** gets \$57.50 and **Responder** gets \$0.50
b	**Proposer** gets \$55 and **Responder** gets \$1
c	**Proposer** gets \$50 and **Responder** gets \$2
d	**Proposer** gets \$45 and **Responder** gets \$3
e	**Proposer** gets \$40 and **Responder** gets \$4
f	**Proposer** gets \$35 and **Responder** gets \$5
g	**Proposer** gets \$30 and **Responder** gets \$6
h	**Proposer** gets \$25 and **Responder** gets \$7
i	**Proposer** gets \$20 and **Responder** gets \$8
j	**Proposer** gets \$15 and **Responder** gets \$9
k	**Proposer** gets \$10 and **Responder** gets \$10
l	**Proposer** gets \$5 and **Responder** gets \$11
m	**Proposer** gets \$2.50 and **Responder** gets \$11.50

DECISION SHEET FOR THE ***RESPONDER*** ROLE:

Suppose you are the Responder. Circle either Accept or Reject in the last column. Please complete the table for each possible alternative.

	If you are the **Responder** and the **Proposer** chooses Proposal Rule..				...then I choose to (circle one for Proposal Rule):	
a	**Proposer** gets	$57.50	and **Responder** gets	$0.50	*Accept*	*Reject*
b	**Proposer** gets	$55	and **Responder** gets	$1	*Accept*	*Reject*
c	**Proposer** gets	$50	and **Responder** gets	$2	*Accept*	*Reject*
d	**Proposer** gets	$45	and **Responder** gets	$3	*Accept*	*Reject*
e	**Proposer** gets	$40	and **Responder** gets	$4	*Accept*	*Reject*
f	**Proposer** gets	$35	and **Responder** gets	$5	*Accept*	*Reject*
g	**Proposer** gets	$30	and **Responder** gets	$6	*Accept*	*Reject*
h	**Proposer** gets	$25	and **Responder** gets	$7	*Accept*	*Reject*
i	**Proposer** gets	$20	and **Responder** gets	$8	*Accept*	*Reject*
j	**Proposer** gets	$15	and **Responder** gets	$9	*Accept*	*Reject*
k	**Proposer** gets	$10	and **Responder** gets	$10	*Accept*	*Reject*
l	**Proposer** gets	$5	and **Responder** gets	$11	*Accept*	*Reject*
m	**Proposer** gets	$2.50	and **Responder** gets	$11.50	*Accept*	*Reject*

C.2: Incentivized Beliefs

ADDITIONAL INSTRUCTIONS

Procedure

In this section, you will be asked what do you think is the percent chance that each of the displayed Proposal Rules is *Rejected* by the **Responder**. Please provide a number between 0 and 100 – the percentage chance with which you think the **Responder** will *Reject* the Proposal Rule.

You will make 12 predictions for different proposal rules in total. One of them will be chosen to determine your payment. Your payment in this round will depend on your decisions and a chance.

Payment

You will be able to earn **up to $10** in addition to your earnings in the decision stage. You will receive the additional payment if you are able to outperform the random machine in predicting the behavior of other participants in the room. After you submit all your *predictions*, your earnings will be calculated according to the following procedure:

(1) One of the proposal rules will be chosen at random

(2) One participant from the session (excluding you) will be picked at random and her *decision* will be retrieved

(3) Your *prediction error* is computed as $((\text{your prediction})/100)^2$ if the decision picked by the selected participant is *Accept* and $(1 - (\text{your prediction})/100)^2$ if the decision picked by the selected participant is *Reject*

(4) A uniform *random number* will be drawn form the interval from 0 to 1

(5) You will receive $10 (in addition to money you already earned) if your *prediction error* is below *random number* and will not receive any additional payment otherwise.

Examples

We now consider some examples.

<u>Example</u>: Assume you believe that 50% of **Responders** rejected the proposal rule under consideration. We will consider three cases.

Assume your predict that there is a 50% chance a **Responder** will *Reject* the offer. If the randomly retrieved decision was *Reject*, your prediction error is $(1 - \frac{50}{100})^2 = .5^2 = .25$. Since the probability a random number is drawn between 0.25 and 1 is 75%, you will get $10 with 75% probability and $0 with 25% probability. If the randomly retrieved decision was *Accept*, your prediction error is $(\frac{50}{100})^2 = .5^2 = .25$. Since the probability a random number is drawn between 0.25 and 1 is 75%, you will get $10 with 75% probability and $0 with 25% probability. Assuming that with probability .5 the randomly retrieved decision is **Reject** and with probability .5 is **Accept**. Hence, your probability of winning the additional prize is $.5 \times .75 + .5 \times .75 = .75$. That is **you will earn extra $10 with probability** 75%.

Assume instead that you report that with 0% probability a **Responder** will *Reject* the offer. If the randomly retrieved decision was *Reject*. Hence, your prediction error is $(1-\frac{0}{100})^2 = 1^2 = 1$. Since the probability a random number is drawn between 1 and 1 is 0%, you will get $10 with 0% probability and $0 with 100% probability. If the randomly retrieved decision was *Accept*. Hence, your prediction error is $(\frac{0}{100})^2 = 0^2 = 0$. Since the probability a random number is drawn between 0 and 1 is 100%, you will get $10 with 100% probability and $0 with 0% probability. That is you are winning the prize with probability 100% in this case. Assuming that with probability .5 the randomly retrieved decision is **Reject** and with probability .5 is **Accept**. Hence, your probability of winning the additional prize is $.5 \times 0 + .5 \times 1 = .5$. That is **you will earn extra $10 with probability** 50%. Which is lower than probability of winning if you would report your real expectation (75%).

Assume instead that you report that with 100% probability a **Responder** will *Reject* the offer. If the randomly retrieved decision was *Reject*. Hence, your prediction error is $(1 - \frac{100}{100})^2 = 0$. Since the probability a random number is drawn between 0.0 and 1 is 100%, you will *always* get paid is the retrieved decision if *Reject*. If the randomly retrieved decision was *Accept*. Hence, your prediction error is $(\frac{100}{100})^2 = 1^2 = 1$. In this case you will *never* get paid is the retrieved decision if *Accept*. That is you are winning the prize with probability 0% in this case. Assuming that with probability .5 the randomly retrieved decision is **Reject** and with probability .5 is **Accept**. Hence, your probability of winning the additional prize is $.5 \times 1 + .5 \times 0 = .5$. That is **you will earn extra $10 with probability** 50%. Which is lower than probability of winning if you would report your real expectation (75%).

As we illustrated above in order to maximize your probability of winning please honestly report the probability of winning which would be as close as possible to the real frequency of rejecting the offer. Since any deviation from honest report will only decrease your probability of winning.

You can continue now

Good luck!