# 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 payoff at least as much as that of others. In an experiment, we found that 94% of proposers make choices that are arbitrarily close to quasi-monotone preferences and beliefs. We also found that 65% of responders were consistent with quasi-monotone of preferences, and 90% of responders made inconsistent choices in no more that 5% of decision problems. We found 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 sometimes requires making strong assumptions on beliefs (see Sprumont 2000, Forges

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and Minelli 2009). 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 set-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* if whenever the total surplus increases, she prefers allocations in which her payoff increases by more than other agents' payoffs. 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 or spite. 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]

The theory is tested 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. In this context, our assumptions imply that proposers must satisfy the Generalized Axiom of Revealed Preferences (GARP). Our data test whether the behavior of bargainers can be represented as the maximization of a well-behaved (though perhaps non-monotonic) preference ordering over allocations.[2]

The ultimatum game affords a direct test of the quasi-monotonicity of preferences on the behavior of responders. But, it also allows testing of the convexity of these preferences.[3] We show that responders pass the quasi-monotonicity test if and only if there

[1]These models would imply stronger restrictions on preferences than quasi-monotonicity. We discuss this issue in the Section 2. Quasi-monotonicity imply what Benjamin (2015) refers 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, Ridel and Sobel (2011) refer as social monotonicity of the preferences. They show the necessity of this property to obtain Pareto optimal allocations in market economies with social preferences.

[2] This preference representation will, necessarily, be a function of beliefs about other bargainers' preferences.

[3]In our experiment, subjects play both roles of the game.

is a complete, transitive, and quasi-monotone preference relation that generates the observed choices. Consistency with quasi-monotonicity in both roles therefore provides a stronger test of our assumptions.

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.[4] This is unlikely due to proposers treating games as simple allocations exercises. Other research has found the behavior of proposers in dictator games to differ from their behavior in corresponding ultimatum games (see Castillo and Cross 2008, and Forsythe et al. 1994). We also found considerable heterogeneity in bargainers' preferences.

Regarding the quasi-monotonicity of responders' preferences, we found that 54 of 83 subjects (65%) were consistent with quasi-monotone of preferences, and 90% of responders made inconsistent choices in no more than 5% of decision problems. As with the behavior of proposers, the responders were 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 found evidence against the convexity of responder 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.

We also measured the beliefs of bargainers and found that these beliefs were consistent with the results using choice data alone. The beliefs of 67 out of 83 subjects were consistent with responders having quasi-monotone preferences, and the beliefs of only ten subjects were consistent with responders satisfying convexity.

In sum, we found that suitable relaxations of assumptions on preferences and beliefs rendered could be used to derive testable implications of rational behavior in a strategic environment. Our experimental data supported the assumptions we make.

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

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

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.

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

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

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 similar.

Note that we are modeling the proposer's choice under uncertainty without the independence assumption of standard expected utility theory.[5]

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

$$(x_i, \mathbf{x}_{-i}) \ge (x'_i, \mathbf{x}'_{-i}), \forall_j x_i - x'_i \ge x_j - x'_j \ \Rightarrow (x_i, \mathbf{x}_{-i}) \succeq_i (x'_i, \mathbf{x}'_{-i}).$$

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

$$(x_i, \mathbf{x}_{-i}) > (x'_i, \mathbf{x}'_{-i}), \forall_j x_i - x'_i \ge x_j - x'_j \ \Rightarrow (x_i, \mathbf{x}_{-i}) \succ_i (x'_i, \mathbf{x}'_{-i}).$$

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

(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.

**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 $j$.[6] The *belief function*, $q : \mathbf{R}^n_+ \to [0, 1]$, maps 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,[7] 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 proposer.

**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 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 $(x_\mathrm{p}, x_\mathrm{r})$.

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[6] 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.

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

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-monotonic preferences over binary lotteries that exhibits stochastic dominance preference and has a 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),[8] we can infer that proposer rationality implies the existence of continuous utility function over binary lotteries ($U_{\mathrm{p}}$) that represents the proposer's preferences.

In the ultimatum game,[9] we can obtain the following result:

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

*Proof.* 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 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[10] and strict quasi-monotonicity, $(x_{\mathrm{p}} + a, x_{\mathrm{r}} + a) \succ_{\mathrm{p}} (x_{\mathrm{p}}, x_{\mathrm{r}})$. $\square$

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, and *(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

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

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

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

preferred to $\mathbf{x}^T$.

We use the following axioms of revealed preferences.

Weak Axiom of Revealed Preference (WARP): *If* $\mathbf{x}$ *is directly revealed preferred to* $\mathbf{x}'$*, then* $\mathbf{x}'$ *is not directly revealed preferred to* $\mathbf{x}$*.*

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* $\boldsymbol{x}$*; that is,* $\mathbf{x}$ *is not strictly within the budget set when* $\mathbf{x}'$ *is chosen.*

Figure 1 illustrates a test 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 $\mathbf{x}'$ 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.

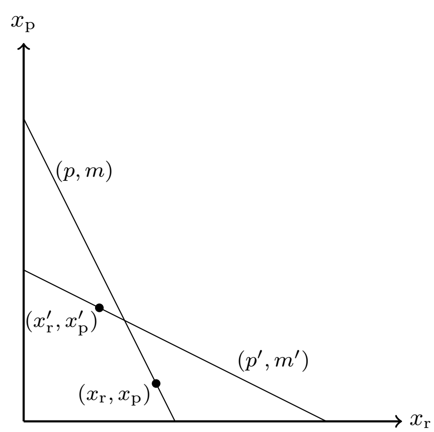


Figure 1. GARP in Ultimatum Game

**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

**Proposition 1.** *In the ultimatum game, a proposer satisfying proposer rationality makes choices from linear budget sets that satisfy GARP.*[11]

[11]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".

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[12] of $\succeq_{\mathrm{p}}$ implies similar properties for $R$.

The non-satiation of $R$ is implied by Lemma 1. 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. $\square$

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.[13] 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. Quasi-monotonicity is the greatest relaxation of the standard theory[14] that still allows for the testable implications of GARP.

Suppose we define $\varepsilon$-monotonicity as $\mathbf{x} \geq \mathbf{x}'$ and $\Delta x_i \geq \varepsilon \Delta x_j$. According to this definition, monotonicity is 0-monotonicity, and quasi-monotonicity is 1-monotonicity. The larger $\varepsilon$ is, the sharper the edge above which the allocation has to lie to be preferred

[12] 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 the closeness of the contour sets of $R$.

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

[14] Note that keeping all other assumptions equal, we can assume a "strong preferences for equality," i.e., a bundle is preferred only if it equally benefits both the proposer and the responder. However, this assumption seems to be artificial and is included in quasi-monotonicity. Otherwise, there is no relaxation of monotonicity that guarantees non-satiation of $R$ that is not stronger than quasi-monotonicity.

would be. In other words, larger $\varepsilon$ indicates the more averse an agent is to increments in others' agent payoffs. All the values of $\varepsilon \in [0,1]$ imply rational behavior because, for all of them, the preferred areas for the proposer and the responder intersect. While for every $\varepsilon > 1$ behavior, is not necessarily consistent with rational behavior as preferences are not necessarily non-satiated over the space of allocations. Quasi-monotonicity is the maximum $\varepsilon$ that allows the theory to remain testable.

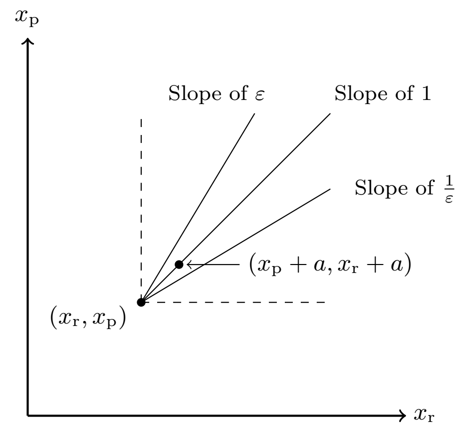


FIGURE 2. Quasi-Monotonicity and $\varepsilon$-Monotonicity

Figure 2 illustrates the need for $\varepsilon \leq 1$. In this case, both proposer and responder are $\varepsilon$-monotone for $\varepsilon > 1$, and the proposer knows that the responder is $\varepsilon$-monotone. The only preferred allocations for the responder lie between the horizontal line and the line with a slope of $\frac{1}{\varepsilon}$. The only preferred allocations for the proposer lie between the vertical line and the line with a slope of $\varepsilon$. There is no allocation that is jointly preferred by both the proposer and the responder, and the non-satiation of preferences cannot be guaranteed in this case. Consider instead that both the proposer and the responder are quasi-monotone (1-monotone). In this case, every allocation along the line with a slope of 1 is jointly preferred by proposer and responder. Note that the smaller $\varepsilon$ is the larger the area of allocations, which are jointly preferred by proposer and responder.

Note that other restrictions to monotonicity are possible. In particular, define $\eta$-monotonicity as $\mathbf{x} \geq \mathbf{x}'$ and $\Delta x_j \geq \eta \Delta x_i$. In this case, if $\eta = 0$, agent $i$ has no concern for the differences in payoff that favor them and if $\eta = 1$ agent $i$ dislikes any allocation that favors them. In this case, non-satiation would fail if $\eta > 1$ for all agents. The failure in this case is due to extreme concerns for others.

**3.2 Testing Responder Rationality** 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.

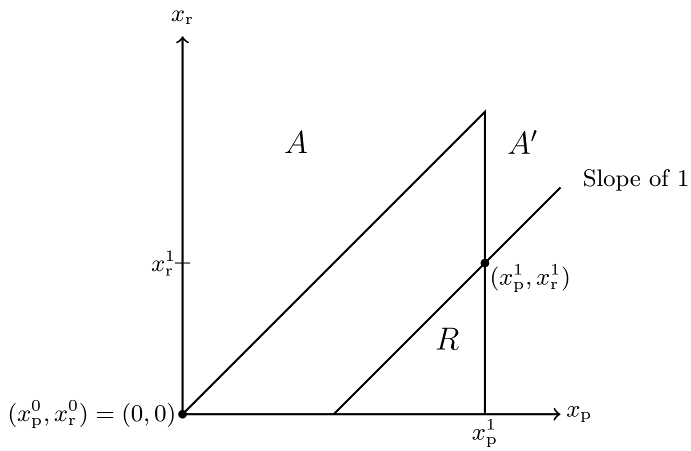


FIGURE 3. Testing Responder Rationality

Consider Figure 3, 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, 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 $A'$). Denoting the area between two 45° lines by $A = \{\mathbf{x} \geq \mathbf{0}, x_{\mathrm{r}} \geq x_{\mathrm{p}}\}$, $A^t \equiv A \cup A'$:

$$A^t \equiv \{\, \mathbf{x} \,:\, \mathbf{x} > \mathbf{x}^t, x_{\mathrm{r}} \geq x_{\mathrm{p}} - (x_{\mathrm{p}}^t - x_{\mathrm{r}}^t) \,\} \cup \{\, \mathbf{x} \,:\, \mathbf{x} \geq \mathbf{0}, x_{\mathrm{r}} \geq x_{\mathrm{p}} \,\}.$$

Now suppose the responder rejects $\mathbf{x}^1$, i.e. prefers $(0,0)$ to $(x_{\mathrm{p}}^1, x_{\mathrm{r}}^1)$. 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 $\mathbf{x}^1$:

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

Denoting 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,*

$$\{\mathbf{x}^t : t \in R_x\} \cap \left(A \cup \left(\bigcup_{t \in A_x} A^t\right)\right) = \emptyset \qquad \textit{and} \qquad \{\mathbf{x}^t : t \in A_x\} \cap \left(\bigcup_{t \in R_x} R^t\right) = \emptyset.$$

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.

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 $\alpha\boldsymbol{x}' + (1-\alpha)\mathbf{x}'' \succsim_i \mathbf{x}$.

Responder is said to satisfy *convex responder rationality* if their preferences satisfy responder rationality and convexity. This is not a statement about the risk preferences of agents. Responders face no risk when deciding to accept or reject offers. But, convexity is a statement about the relationship between rejection rates along a ray, holding the ratio of payoffs constant. If an allocation is ever rejected, no other allocation giving more to all agents but keeping relative payoffs constant will be accepted.

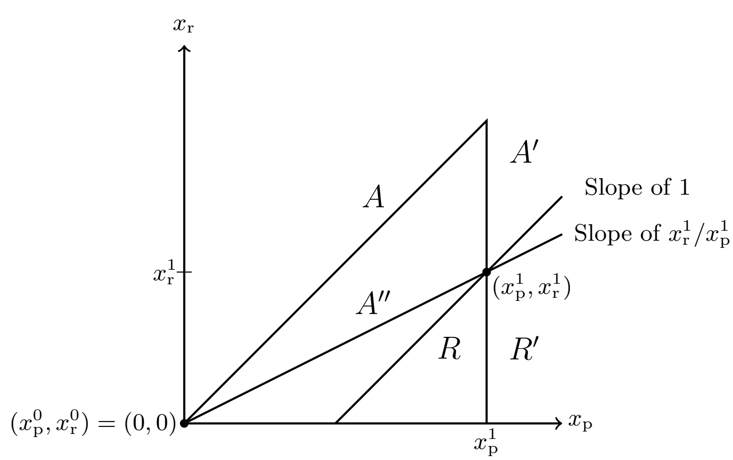


Figure 4. Testing Responder Convex Rationality

Consider Figure 4 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 $A$. 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,

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

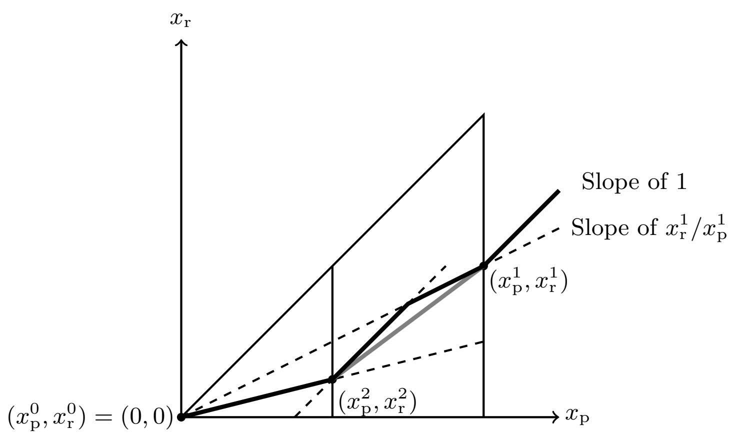


FIGURE 5. Necessity of Taking Convex Hull

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 5 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 $A^t_c$. 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,*

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

The proof is in the Appendix.

## 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 proposer offering a division of $m$ dollars between them ($x_{\mathrm{p}}$) and the responder ($x_{\mathrm{r}}$), 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 $x_{\mathrm{r}}$ dollars and the proposer's monetary payoff is $x_{\mathrm{p}}$ 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 $x_{\mathrm{r}}$ 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 6.

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 $x_{\mathrm{p}}(c, d) = \left(24 - \frac{1}{3}c\right)d$ 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

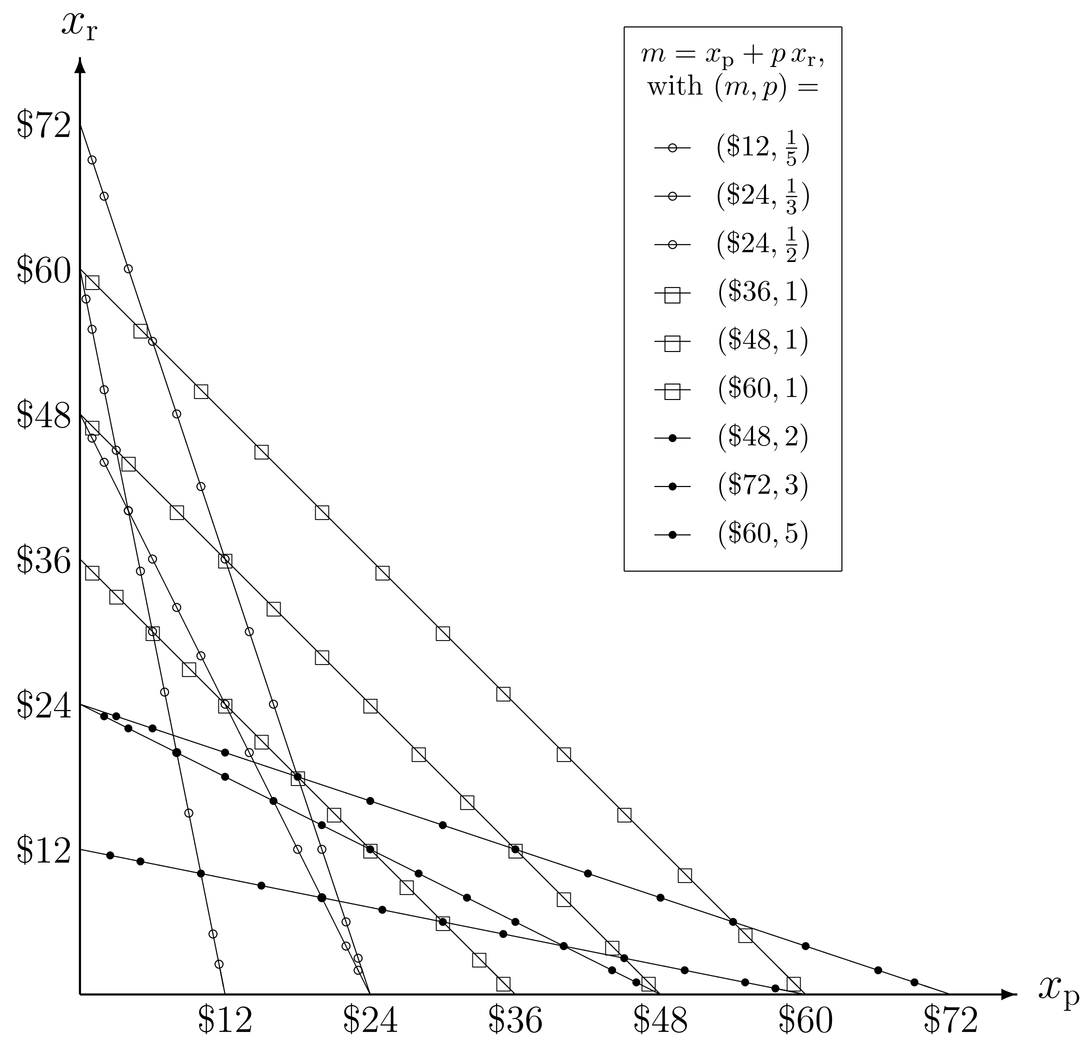


FIGURE 6. Budget Constraints Faced by Proposers

more transparent, subjects were presented with the final dollar allocations rather than with budget constraints and endowments.[15] 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.

[15]Appendix B displays the decision sheets used.

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 $x_{\mathrm{r}}$ values. Column 4 shows the fraction of proposers who are *generous*, meaning their proposed $x_{\mathrm{r}}$ 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 $x_{\mathrm{r}}$ values were rejected, and above which all proposed $x_{\mathrm{r}}$ values were accepted. Columns 6 and 7 show the mean and standard deviation of the highest rejected $x_{\mathrm{r}}$ values for each budget. Column 8 shows the fraction of *rejectors*—responders who rejected at least the minimum $x_{\mathrm{r}}$—and column 9 shows the mean of the highest rejected $x_{\mathrm{r}}$ values for the rejectors. The final column shows the number of responders who did not adhere to a cutoff rule for each budget.[16]

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 $x_{\mathrm{r}}$ also increased with

[16] 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.

| $m = x_{\mathrm{p}} + p\,x_{\mathrm{r}}$, | Proposed $x_{\mathrm{r}}$ | | | | Highest rejected $x_{\mathrm{r}}$ | | | | 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

income, as did the mean highest rejected $x_{\mathrm{r}}$ 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[17] (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 $1 - \varepsilon$.[18] We refer to small violations as *$\varepsilon$ 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

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

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

proposers (83.1%) did not violate GARP, and of the 14 violators, nine were $\varepsilon$ violators and none had a CCEI of 0.80 or less.

| 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

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, Harbaug, 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.

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.

| | Responder Rationality | | Convex Responder Rationality | |
|---|---|---|---|---|
| Number of Violations | Number of Subjects | Percent of Subjects | Number of Subjects | 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% |
| $\geq 6$ | 8 | 10% | 45 | 54% |

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 | 58.6110 (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 both 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.

| 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

**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. We therefore take the following results with caution.

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 the consistency of elicited beliefs with the assumptions we make: 1) "Known Preference Restrictions" and 2) Belief Consistency. These hypotheses cannot be tested separately; therefore, we evaluate them jointly. These assumptions imply that if $\mathbf{x} \geq \mathbf{x}'$ and $x_{\mathrm{r}} - x'_{\mathrm{r}} \geq x_{\mathrm{p}} - x'_{\mathrm{p}}$, then the probability of acceptance of $\mathbf{x}$ should be as large as the probability of acceptance of $\mathbf{x}'$. Note that convexity can also be tested. In this case, we need to look at the convex hull of points revealed preferred to $\mathbf{x}$. Points in this area should be believed as least as acceptable as $\mathbf{x}$.

| | Beliefs Consistent with Responder Rationality | Beliefs Consistent with Convex Responder Rationality |
|---|---|---|
| All | 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 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 the Known Preference Restrictions and Belief Consistency assumptions

(KPBC). If we consider only subjects who are consistent with proposer rationality, we observe that 61 (88%) of subjects are consistent with KPBC assumptions. 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 KBPC assumptions. We found that at least 91% of random subjects had beliefs that failed KBPC assumptions, and 100% of random subjects have beliefs that are not 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.

## 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.[19] 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.

Quasi-monotonicity is consistent with many models of fairness (Fehr and Schmidt 1999; Bolton and Ockenfels 2000; and Charness and Rabin 2002).[20] Interestingly, our approach also suggests that further assumptions in models of fairness, such as homotheticity or quasi-linearity, are testable nonparametrically. Convexity of preferences is a common assumption in demand theory. We find evidence against this in our data.

[19]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).

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

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

## 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 $P(R) \subseteq P(R')$.

Second, we use the notion of function over preference relations. A convenient example of such function is the *transitive closure*, which adds $(x, z)$ to $R$ for each $(x, y) \in R$ and $(y, z) \in R$. Being more precise $(x, y) \in T(R)$ if there is a sequence of elements $S = s_1, \dots, s_n$, such that for every $j = 1, \dots, n-1$ $(s_j, s_{j+1}) \in R$, where $T$ stands for transitive closure. That is, the transitive closure of a preference relation is a transitive preference relation, since the transitive closure is idempotent ($R = F(R)$) and applying transitive closure to the transitive closure of the relation does not add anything to the relation. The functions we propose are generalizations of the transitive closure that guarantee that every fixed point of them satisfy responder rationality and convex responder rationality.

Let $F : \mathcal{R} \to \mathcal{R}$ be a function over preference relations. For a given function $F(R)$, a preference relation $R$ is said to be $F$**-consistent** if $F(R) \cap P^{-1}(R) = \emptyset$. In words, function $F(R)$ is $F$**-consistent** if it does not lead to a contradiction with the original strict preference relation.

**Lemma 2.** *A preference relation $R \subseteq F(R)$ is $F$-consistent if and only if $R \preceq F(R)$.*

We omit the proof since it can be found in Demuynck (2009). Recall that $R \preceq F(R)$ ($F(R)$ is an extension of $R$) if $R \subseteq F(R)$ and $P(R) \subseteq P(F(R))$. Henceforth, we use $F$**-consistency** and $R \preceq F(R)$ as equivalent definitions.

We use the following definition throughout the section.

**Definition 1.** *A function $F : \mathcal{R} \to \mathcal{R}$ is said to be an* ***algebraic closure*** *if the following holds:*

(1) *For all $R, R' \in \mathcal{R}$, if $R \subseteq R'$ then $F(R) \subseteq F(R')$*
(2) *For all $R \in \mathcal{R}$, $R \subseteq F(R)$*
(3) *For all $R \in \mathcal{R}$, $F(F(R)) \subseteq F(R)$*
(4) *For all $R \in \mathcal{R}$ and all $(x, y) \in F(R)$, there is a finite relation $R' \subseteq R$, s.t. $(x, y) \in F(R')$.*

Properties (1) to (3) are those that define **closure** and are connected to the extrapolation of the relation by $F(R)$. Property (1) is *monotonicity*, it states that from larger amount of information we can get better extrapolation. Property (2) is *extensiveness*, that is function adds additional information about preference relation. Property (3) is *idempotence*, that is the function delivers all the information after the first application of it to the binary relation. Property (4) is one that makes the closure **algebraic**. This property is the one that eventually allows us test our theory with finite data, i.e. if $F$ is a closure and $R$ is not $F$**-consistent**, algebraicity of $F$ guarantees us that there is a finite consumption experiment which would elicit this inconsistency.

We will need the following definition. For any function $F : \mathcal{R} \to \mathcal{R}$, let $\mathcal{R}^*_F = \{R \in \mathcal{R} | R \preceq F(R)\}$. A function $F : \mathcal{R} \to \mathcal{R}$ is said to be **weakly expansive**[21] if for any $R = F(R)$ and $N(R) \neq \emptyset$, there is $T \subseteq N(R)$ such that $R \cup T \in \mathcal{R}^*_F$. This property states that $F$ is non-satiated, i.e. for any incomplete fixed point ($F(R) = R$) preference relation, there is $F$-consistent extension of this relation. This property is crucial to secure that the extension of the revealed preference relation is also complete.

**Theorem 2** (Demuynck 2009)**.** *Let $F$ be a weakly expansive algebraic closure. Then, a relation $R \in \mathcal{R}$ has a complete extension $R^* = F(R^*)$ if and only if $R$ is $F$-consistent.*

To provide intuition for the proof of Theorem 2 consider the algorithm that can be used to construct a fixed point complete extension. Let $R_0 = R$. For any $a > 0$, if $R_a \neq F(R_a)$, let $R_{a+1} = F(R_a)$. For any $a > 0$, if $R_a = F(R_a)$ and $N(R_a) \neq \emptyset$ then let $R_{a+1} = R_a \cup T$, where the existence of a $T$ such that $R_a \cup T \in \mathcal{R}^*_F$ is guaranteed by weak expansiveness. The existence of the limit relation which is a fixed point of $F$ is guaranteed by the fact that $F$ is algebraic closure.

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.[22] 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 $y \in B^t \setminus \{x^t\}$. 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 $j \neq i$ $x_i - y_i \geq x_j - y_j$.

**Proof of Proposition 2** The proof has the following structure:

[21] Weak expansiveness is equivalent to the condition C7 in Demuynck (2009).

[22] $x \in B^t$, 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.

(1) We show that the function, $QM(R)$, over the preference relation induces quasi-monotonicity and transitivity[23]
(2) We show that this function is a weakly expansive algebraic closure
(3) We show that a preference relation is $F$-consistent if and only if the condition from proposition is satisfied
(4) We apply Theorem 2 to conclude the proof.

**Definition 2.** *Denote the* ***quasi-monotone and transitive closure*** *by $QM(R)$. Then $(x, y) \in QM(R)$ if there is a sequence $S = s_1, ..., s_n$, s.t. $s_1 = x$, $s_n = y$ and $\forall j = 1..n-1$*

- $(s_j, s_{j+1}) \in R$, *or*
- $s_j \trianglerighteq_i s_{j+1}$.

**Lemma 3.** *$QM(R) = R$ if and only if $R$ is transitive and weakly quasi-monotone.*

*Proof.* **(⇒)** Let us show that if $QM(R) = R$, then $R$ is transitive and quasi-monotone. First, we show that $R$ is transitive, i.e. for any $x, y, z \in X$ if there is $(x, y) \in R$ and $(y, z) \in R$, then $(x, z) \in R$. Then, take a sequence $S = x, y, z$ such that $(x, y) \in R$ and $(y, z) \in R$. Hence, by the definition of $QM(R)$, $(x, z) \in QM(R)$. Second, we show that $R$ is quasi-monotone, i.e. if $x \trianglerighteq_i y$, then $(x, y) \in R$. This also follows from the definition of $QM(R)$, since if $S = x, y$ and $x \trianglerighteq_i y$, then $(x, y) \in R$.

**(⇐)** Let us show that if $R$ is transitive and quasi-monotone, then $QM(R) = R$. From the definition of $QM(R)$ it is clear that $R \subseteq QM(R)$. Hence, we are left to show that $QM(R) \subseteq R$ if $R$ is transitive and quasi-monotone. To prove this we need to show, that if there is $(x, y) \in QM(R)$, then $(x, y) \in R$. That is, take $(x, y) \in QM(R)$ and show that $(x, y)$ is in $R$ as well. We prove this by the induction on the length of sequence that adds $(x, y)$ to $QM$. If the length of the shortest chain is 2 it is immediately true since $R$ is transitive and quasi-monotone. Now suppose that every element $(x, y) \in QM(R)$, such that it can be added to the $QM(R)$ by a chain of the length no more than $k$ is in $R$ as well. To do the induction step, consider an element $(x, y) \in QM(R)$ that is added to the $QM(R)$ by a chain of the length of $k + 1$. Let us show that the length of the chain can be reduced, i.e. the same element can be added to the $QM(R)$ by a chain of the length no more than $k$. Take a $j \in \{1, \ldots, n-1\}$ and consider the four following cases:

[23] This step is extremely important since formally Theorem 2 only guarantees that the obtained complete relation is a fixed point of $F$, but not that the fixed point inherits the desired properties of the original preference relation.

**Case 1:** $(s_{j-1}, s_j) \in R$ and $s_j \trianglerighteq s_{j+1}$. Then, by the quasi-monotonicity of $R$, $(s_j, s_{j+1}) \in R$ and by the transitivity of $R$ $(s_{j-1}, s_j) \in R$ and $(s_j, s_{j+1}) \in R$ implies that $(s_{j-1}, s_{j+1}) \in R$. Therefore, length of the chain can be reduced.

**Case 2:** $s_{j-1} \trianglerighteq_i s_j$ and $(s_j, s_{j+1}) \in R$. This case is symmetric to Case 1.

**Case 3:** $s_{j-1} \trianglerighteq_i s_j$ and $s_j \trianglerighteq_i s_{j+1}$. Note that relation $\trianglerighteq_i$ is transitive, hence, $s_{j-1} \trianglerighteq s_{j+1}$. Then, by the quasi-monotonicity of $R$, $(s_{j-1}, s_{j+1}) \in R$. Therefore, length of the chain can be reduced.

**Case 4:** $(s_{j-1}, s_j) \in R$ and $(s_j, s_{j+1}) \in R$. Then, by the transitivity of $R$, $(s_{j-1}, s_j) \in R$ and $(s_j, s_{j+1}) \in R$ implies that $(s_{j-1}, s_{j+1}) \in R$. Therefore, length of the chain can be reduced. □

**Lemma 4.** *$QM(R)$ is an algebraic closure*

Note that $QM(R)$ is algebraic (satisfies condition (4)) by construction, since every element can be added using a finite sequence. According to the Lemma 5 from Demuynck (2009) $F(R)$ is a closure if and only if $F(R) = \bigcap\{Q \supseteq R : \ Q = F(Q)\}$. Hence, it is enough to prove that $QM(R) = \bigcap\{Q \supseteq R : \ Q = QM(Q)\}$

*Proof.* ($\subseteq$) Let us show that if $(x, y) \in QM(R)$, then $(x, y) \in \bigcap\{Q \supseteq R : \ Q = QM(Q)\}$. If $(x, y) \in QM(R)$, then there is a sequence $S = s_1, \dots, s_n$, such that $s_1 = x$, $s_n = y$ and for $j = 1, \dots, n-1$ either $(s_j, s_{j+1}) \in R$ or $s_j \trianglerighteq_i s_{j+1}$. Since $Q \supseteq R$, then every $(s_j, s_{j+1}) \in R$ implies that $(s_j, s_{j+1}) \in Q$. Therefore, $(x, y) \in QM(Q) = Q$ for every $Q \supseteq R$.

($\supseteq$) Note that from Lemma 3 we know that $QM(QM(R)) = QM(R)$. Therefore $QM(R) \in \bigcap\{Q \supseteq R : \ Q = QM(Q)\}$. Thus, if $(x, y) \in Q$ for any $Q \in \bigcap\{Q \supseteq R : \ Q = QM(Q)\}$, then $(x, y) \in QM(R)$. □

**Lemma 5.** *$QM(R)$ is weakly expansive*

*Proof.* Take a point $(x, y) \in N(R)$ and consider the relation $R' = R \cup \{(x, y)\}$. We need to show that $QM(R') \cap P^{-1}(R') = \emptyset$. Assume to the contrary that there is a $(z, w) \in QM(R') \cap P^{-1}(R') \neq \emptyset$. Note that from the assumptions we made $(x, y) \neq (z, w)$, since $(x, y) \in N(R)$ and $(w, z) \in P(R)$. Note that $(w, z) \in P(R \cup \{(x, y)\})$ and therefore $(w, z) \in P(R)$.

Since $(z, w) \in QM(R')$, there is a sequence $S = s_1, \dots, s_n$, such that $s_1 = z$, $s_n = w$ and for every $j = 1, \dots, n-1$ either $(s_j, s_{j+1}) \in R$ or $s_j \trianglerighteq_i s_{j+1}$. Denote by $k$ the index of $y$ in this sequence, i.e. $s_k = y$. That is $S = s_1(= z), \dots, s_{k-1}(= x), s_k(= y), \dots, s_n(= w)$.

Consider the re-arranged sequence $S' = s_k(= y), \ldots, s_n(= w), s_1(= z), \ldots, s_{k-1}(= x)$. Since $(w, z) \in P(R)$, for every $j = 1, \ldots, n-1$ either $(s'_j, s'_{j+1}) \in R$ or $s'_j \trianglerighteq_i s'_{j+1}$. Therefore, $(y, x) \in QM(R)$, that is a contradiction to the fact that $(x, y) \in N(R)$. $\square$

Hence, from Lemmas 3, 4 and 5 we can conclude, that $QM(R)$ is a weakly expansive algebraic closure such that every fixed point of $QM(R)$ is transitive and quasi-monotone preference relation. Therefore, using Theorem 2 we can conclude that there is a complete, transitive, quasi-monotone extension of revealed preference relation if and only if revealed preference relation is $QM$-consistent. Hence, to complete the proof of Proposition 2 we are left to show that the test we propose is equivalent to $QM$-consistency. Recall that $QM$-consistency can be written as $QM(R) \cap P^{-1}(R) = \emptyset$.

**Lemma 6.** *$R_E$ is $QM$-consistent if and only if*

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

Before we start the proof, note that since $QM(R)$ is an algebraic closure, then for any $(x, y) \in QM(R)$ there is a shortest sequence that adds $(x, y)$ to $QM(R)$. 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 1.** *If $(x, y) \in QM(R_E)$ 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 $s_j \trianglerighteq_{\mathrm{r}} s_{j+1}$.*

*Proof of Lemma 6.* ($\Rightarrow$) Let us show that if $R_E$ is $QM$-consistent 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 $QM$-consistency.

**Case 1:** 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, $(x^t, x^0) \in QM(R_E) \cap P^{-1}(R_E) \neq \emptyset$ - $R_E$ is not $QM$-consistent.

**Case 2:** Assume there is $x^t$ such that $x^t \in \bigcup_{t \in R_x} R^t$ and $t \in A_x$. First part implies that there is $x^k$ such that $(x^0, x^k) \in R_E$ and $x^k \trianglerighteq_{\mathrm{r}} x^t$. Then, $(x^0, x^t) \in QM(R_E)$. While the second part implies that $x^t$ was accepted - $(x^t, x^0) \in P(R_E)$. Therefore,

$(x^0, x^t) \in QM(R_E) \cap P^{-1}(R_E) \neq \emptyset$ - $R_E$ is not $QM$-consistent.

**($\Leftarrow$)** Let us show that if the data pass the test then $R_E$ is $QM$-consistent. On the contrary assume that there is $(x, y) \in QM(R_E) \cap P^{-1}(R_E) \neq \emptyset$. Hence, $(x, y) \in QM(R_E)$ 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 $y = x^t$.[24] Then there is a shortest sequence $S = s_1, \ldots, s_n$ such that $s_1 = x^0$, $s_n = x^t$ and for every $j = 1, \ldots, n-1$ either $(s_j, s_{j+1}) \in R_E$ or $s_j \trianglerighteq_{\mathrm{r}} s_{j+1}$. Using the Observation 1 we can claim that there is $x^k$ (with $k$ possible being equal to $t$), such that $(x^0, x^k) \in R_E$ and $x^k \trianglerighteq_{\mathrm{r}} x^t$. Hence, $x^t \in \bigcup_{t \in R_x} R^t$. Note that $(x^t, x^0) \in P(R_E)$ implies that $t \in A_x$. Therefore, $x^t \in \{x^t : t \in A_x\} \cap \left(\bigcup_{t \in R_x} R^t\right) \neq \emptyset$.

**Case 2:** Assume that $x = x^t$ and let $y = x^0$. Then there is a shortest sequence $S = s_1, \ldots, s_n$ such that $s_1 = x^t$, $s_n = x^0$ and for every $j = 1, \ldots, n-1$ either $(s_j, s_{j+1}) \in R_E$ or $s_j \trianglerighteq_{\mathrm{r}} s_{j+1}$. Using the Observation 1 we can claim that there is $x^k$ (with $k$ possible being equal to $t$), such that $(x^k, x^0) \in R_E$ and $x^t \trianglerighteq_{\mathrm{r}} x^k$. Hence, $x^t \in \bigcup_{t \in A_x} A^t$. Note that $(x^0, x^t) \in P(R_E)$ implies that $t \in R_x$. Therefore, $x^t \in \{x^t : t \in R_x\} \cap \left(\bigcup_{t \in A_x} A^t\right) \neq \emptyset$.

$\square$

**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.

**Case 1:** $x^t \in \{x^t : t \in A_x\} \cap \left(\bigcup_{t \in R_x} R_c^t\right)$. This implies that $(x^t, x^0) \in P(R_E)$, because $x^t$ is accepted; $x^t \in \left(\bigcup_{t \in R_x} R_c^t\right)$ implies that there is $x^k$, which is rejected - $(x^0, x^k) \in P(R)$ and either (i) $x^t \leq x^k$, $x_{\mathrm{r}}^t \leq x_{\mathrm{p}}^t - (x_{\mathrm{p}}^k - x_{\mathrm{r}}^k)$ and $x_{\mathrm{p}}^t \leq x_{\mathrm{p}}^k$ or (ii) $x_{\mathrm{r}}^t x_{\mathrm{p}}^k \leq x_{\mathrm{p}}^t x_{\mathrm{r}}^k$ and $x_{\mathrm{p}}^t \geq x_{\mathrm{p}}^k$. Quasi-monotonicity and (i) imply that $(x^k, x^t) \in R$ and by transitivity $(x^0, x^t) \in P(R)$. Convexity, quasi-monotonicity, transitivity and (ii) imply[25] that $(x^k, x^t) \in R$ and by transitivity $(x^0, x^t) \in P(R)$.

**Case 2:** $x^t \in \{x^t : t \in R_x\} \cap CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right)$. This implies that $(x^0, x^t) \in P(R_E)$, because $x^t$ is rejected. Considering the second part, let us assume that $x^t \in \left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right)$, that is there is $x^k$ that is accepted - $(x^k, x^0) \in P(R)$, such that

[24]Another possible case is that $y \trianglerighteq_{\mathrm{r}} x^0$ that causes trivial violation of the test.

[25]There is $x$, such that $x^k = \alpha x^0 + (1-\alpha)x$ for $\alpha > 0$, hence $(x^k, x) \in R_E$. Moreover, $x_{\mathrm{r}} - x_{\mathrm{r}}^t \geq x_{\mathrm{p}} - x_{\mathrm{p}}^t$, hence $(x, x^t) \in R$.

(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[26] that $(x^t, x^0) \in R$. Another possibility is $x^t \in CH\left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right) \setminus \left(A \cup \left(\bigcup_{t \in A_x} A^t_c\right)\right)$.[27] 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 $(x^t, x^0) \in R$. $\square$

We need the following corollary from Theorem 2 to proceed with sufficiency proof.

**Corollary 1.** *Let $F$ be a weakly expansive algebraic closure. If there is $R'$ such that $R \preceq R'$ and $R'$ is $F$-consistent, then, a relation $R \in \mathcal{R}$ has a complete extension $R^* = F(R^*)$.*

This follows from the fact that $R'$ has a complete extension $R^* = F(R^*)$. The transitivity of $\preceq$ implies that $R \preceq R^*$ since $R \preceq R' \preceq R^*$. Therefore, $R^* = F(R^*)$ is a complete extension of $R$ as well.

The proof has the following structure:

(1) We define function $C(R)$ that induces convexity and transitivity.
(2) This function is a weakly expansive algebraic closure (Demuynck (2009))
(3) As in Corollary 1, we construct a relation $R'$ that is $C$-consistent and show that $R_E \preceq R'$, where $R_E$ is the revealed preference relation.
(4) We apply Corollary 1 to conclude the proof.

To introduce $C(R)$ we need some additional definitions. 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.

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

[26] 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 $(x^t, x) \in R$.

[27] More generally there are $n$ points, which are better than corresponding accepted points (see reasoning from Case 1). Then, transitivity would imply similar reasoning.

sequences $S^1, \ldots, S^m$. For an element $s^i_j < n_{S^i}$ we say that set $A$ is **compatible** with $s^i_j$ if

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

Given the sequence $S^1, \ldots, S^m$. We denote by $\mathcal{A}(s^i_j; S^1, \ldots, S^m)$ 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 3.** *Denote the **convex and transitive closure** by $C(R)$. Then $(x, y) \in C(R)$ if there is a family of sequences $S^1, \ldots, S^m$ such that for all $i = 1, \ldots, m$: $s^i_1 = x$, $s^i_{n_{S^i}} = y$ and for all $i = 1, \ldots, m$ and $j = 1, \ldots, n_{S^i} - 1$:*

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

Demuynck (2009) proofs the following property of function $C(R)$.

**Lemma 7** (Demuynck 2009)**.** *$C(R) = R$ if and only if $R$ is transitive and convex.*

Lemma 7 implies the following immediate corollary:

**Corollary 2.** *If $R$ is convex and transitive, then it is $C$-consistent.*

Lemma 7 implies that if $R$ is convex and transitive, then $R = C(R)$. Recall that consistency is equivalent to $R \preceq C(R)$ and clearly $R \preceq R(= C(R))$.

**Lemma 8** (Demuynck 2009)**.** *$C(R)$ is a weakly expansive algebraic closure.*

Since $C(R)$ satisfies all the necessary properties for Corollary 1, we are left to show that there is a $C$-consistent relation $R'$ that extends $R_E$. We construct this relation 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. By Corollary 2, $TC(Q_E)$ is $C$-consistent as well. Finally, we prove that $TC(Q_E)$ is an extension of $R_E$ which allows us to apply Corollary 1 and complete the proof.

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 $x^t \in \bigcup_{t \in R_x} R^t_c$,

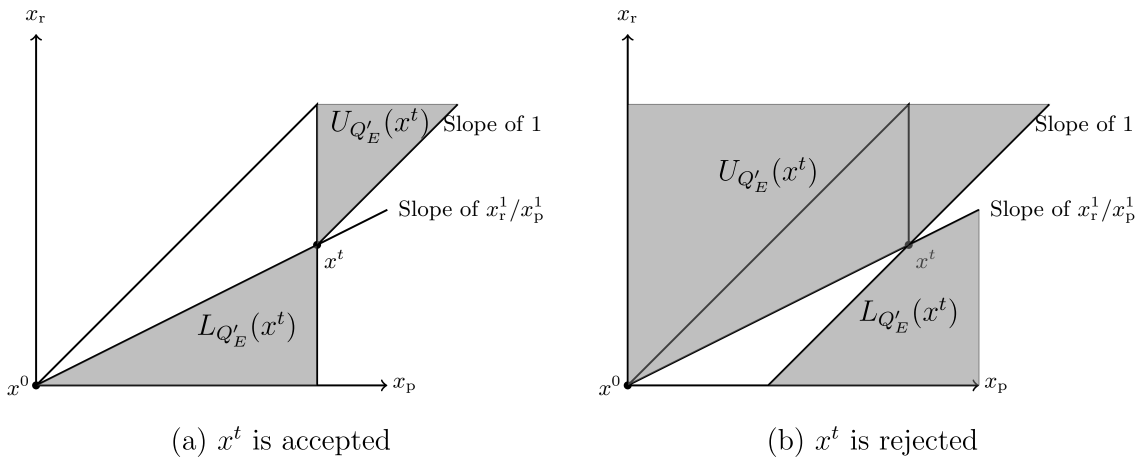


FIGURE 7. Constructing $Q'_E$

then $L_{Q'_E}(x^t) = \{x : x^t \trianglerighteq_r x\} \cup \{x : x_p \geq x^t_p, x_r x^t_p \geq x_p x^t_r\}$ and $U_{Q'_E}(x^t) = \{x : x_p \leq x^t_p, x_r x^t_p \leq x_p x^t_r\} \cup \{x : x \trianglerighteq_r x^t\}$. 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 7 illustrates the construction of $Q'_E$, the upper and lower contour sets are the shadowed areas. Denote by $Q_E = Q'_E \cup \trianglerighteq_r \cup R_E$. $Q'_E$ 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 $\trianglerighteq_r$ 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 $Q_E$.

**Observation 2.** *$R$ is quasi-monotone if and only if $\trianglerighteq_r \subseteq R$.*

Observation 2 states that $R$ is quasi-monotone if and only if it contains $\trianglerighteq_r$. Recall that quasi-monotonicity implies that if $x \trianglerighteq_r y$ then $(x, y) \in R$. Therefore, the inclusion of $\trianglerighteq_r$ into a relation makes it quasi-monotone.

**Corollary 3.** *$Q_E$ is quasi-monotone.*

Therefore, $Q_E$ as well as any superset of $Q_E$ is quasi-monotone.

We now construct a convex and quasi-monotone relation based on $Q_E$. For any given $R$, denote its transitive closure by $T(R)$. That is, $(x, y) \in T(R)$ if there is a sequence $S = s_1, ..., s_n$, s.t. $s_1 = x$, $s_n = y$ and $\forall j = 1..n-1$ $(s_j, s_{j+1}) \in R$. To define the convex 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 $\Theta(R) = \{x : L_R(x) \neq \emptyset$ 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 $C_{i-1}(R)$. By convexified we mean that all the upper contour sets are convex. Recall that by showing that $TC(R)$ is a convex and transitive relation we can conclude, through Corollary 2, that $TC(R)$ is $C$-consistent.

**Lemma 9.** *$TC(R)$ is convex and transitive.*

*Proof.* Recall that $T(R)$ is an idempotent function. Therefore, $T(R) = T(T(R))$ is a transitive relation. Hence, for $TC(R)$ to be convex and transitive 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 $y \notin U_{C(R)}(x)$. Note that if there is an $m$ such that for all $i = 1, \ldots, n$ $(y_i, x) \in U_{C_m(R)}(x)$, then $y \in U_{TC(R)}(x)$. Note that for every $i = 1, \ldots, n$, either $(y_i, x) \in \bigcup_{i \in \mathbf{N}} C_i(R)$ or $(y_i, x) \in T\left(\bigcup_{i \in \mathbf{N}} C_i(R)\right) \setminus \left(\bigcup_{i \in \mathbf{N}} C_i(R)\right)$.

First, let us show that $(y_i, x) \in T\left(\bigcup_{i \in \mathbf{N}} C_i(R)\right)$ implies that $(y_i, x) \in \bigcup_{i \in \mathbf{N}} C_i(R)$. This is equivalent to showing that $T\left(\bigcup_{i \in \mathbf{N}} C_i(R)\right) \setminus \left(\bigcup_{i \in \mathbf{N}} C_i(R)\right) = \emptyset$. On the contrary assume that there is $(y_i, x) \in T\left(\bigcup_{i \in \mathbf{N}} C_i(R)\right) \setminus \left(\bigcup_{i \in \mathbf{N}} C_i(R)\right)$. 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 $j = 1, \ldots, n-2$, $(s_j, s_{j+1}) \in \bigcup_{i \in \mathbf{N}} C_i(R)$. By the construction of $\bigcup_{i \in \mathbf{N}} C_i(R)$ for every $j = 1, \ldots, n-2$, 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 $j$.[28] Therefore, $(y_i, x) \in C_{m+1}(R)$.

Second, let us 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 $i = 1, \ldots, n-2$, 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 $C_m(R)$. $\square$

Therefore, $TC(Q_E)$ is convex, transitive, and quasi-monotone relation, by Lemma 9 and because $\trianglerighteq_{\mathrm{r}} \subseteq Q_E \subseteq TC(Q_E)$.

Hence, we are left to show that $R_E \preceq TC(Q_E)$. We do this also in two steps, firstly showing that $R_E \preceq Q_E$ and afterwards showing that $R_E \preceq TC(Q_E)$.

**Lemma 10.** *If*

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

*Then $R_E \preceq Q_E$.*

[28] $m$ exists because all the sequence are finite.

*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 $x = x^0$. Note that since $(x^0, x^t) \in Q_E$, 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 $x^t > x^0$.

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

$\square$

Before proceeding with the proof, we make two observations.

**Observation 3.** *If*

$$\{x^t : t \in R_x\} \cap CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right) = \emptyset \qquad \text{and} \qquad \{x^t : t \in A_x\} \cap \left(\bigcup_{t \in R_x} R_c^t\right) = \emptyset.$$

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

Observation 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 $Q_E$. If data are consistent with the test then the only points which can be preferred to the accepted point are $y \trianglerighteq_{\mathrm{r}} x^t$, but the upper contour set of every $x^t$ already includes the convex hull of all such points.

**Observation 4.** *If*

$$\{x^t : t \in R_x\} \cap CH\left(A \cup \left(\bigcup_{t \in A_x} A_c^t\right)\right) = \emptyset \qquad \text{and} \qquad \{x^t : t \in A_x\} \cap \left(\bigcup_{t \in R_x} R_c^t\right) = \emptyset.$$

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

Observation 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 as well 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.[29]

**Lemma 11.** *If*

$$\{x^t : t \in R_x\} \cap CH\left(A \cup \left(\bigcup_{t\in A_x} A_c^t\right)\right) = \emptyset \qquad \text{and} \qquad \{x^t : t \in A_x\} \cap \left(\bigcup_{t\in R_x} R_c^t\right) = \emptyset.$$

*Then* $R_E \preceq TC(Q_E)$.

*Proof.* 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 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 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. □

We conclude there is a convex, transitive, quasi-monotone and $C$-consistent extension of $R_E$. And, by Corollary 1, there is also a complete, convex, transitive, and quasi-monotone extension of $R_E$.

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[29] 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.

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## Appendix B: Experimental 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.

CASE ONE: 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 $______.

CASE TWO: 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 $______.

CASE THREE: 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 both the Proposer role and the Responder role.

Step 2: After your choices are made, we will randomly 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 only for the role assigned to you 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* |