Appendix I

Charness-Rabin model

We use definitions that stem from the model of Charness and Rabin (2002) who consider the following simple formulation of the preferences of $self$:

$$u_s(\pi_s, \pi_o) \equiv (1 - \rho r - \sigma s)\pi_s + (\rho r + \sigma s)\pi_o,$$

where $r = 1$ ($s = 1$) if $\pi_s > \pi_o$ ($\pi_s < \pi_o$) and zero otherwise. Notice that proportionally increasing ρ and σ indicates a decrease in self-interestedness whereas increasing the ratio ρ/σ indicates an increase in concerns for increasing aggregate payoffs rather than reducing differences in payoffs. Thus, the parameters ρ and σ allow for a range of different distributional preferences:

(i) *competitive* preferences ($\sigma \leq \rho < 0$), where utility increases in the difference $\pi_s - \pi_o$, are consistent only with the competitive allocation $\pi^c = (\pi_s^s, 0)$;

(ii) *narrow self-interest* or *selfish* preferences ($\sigma = \rho = 0$), where utility depends only on π_s, are consistent with any allocation π where $\pi_s = \pi_s^s$;

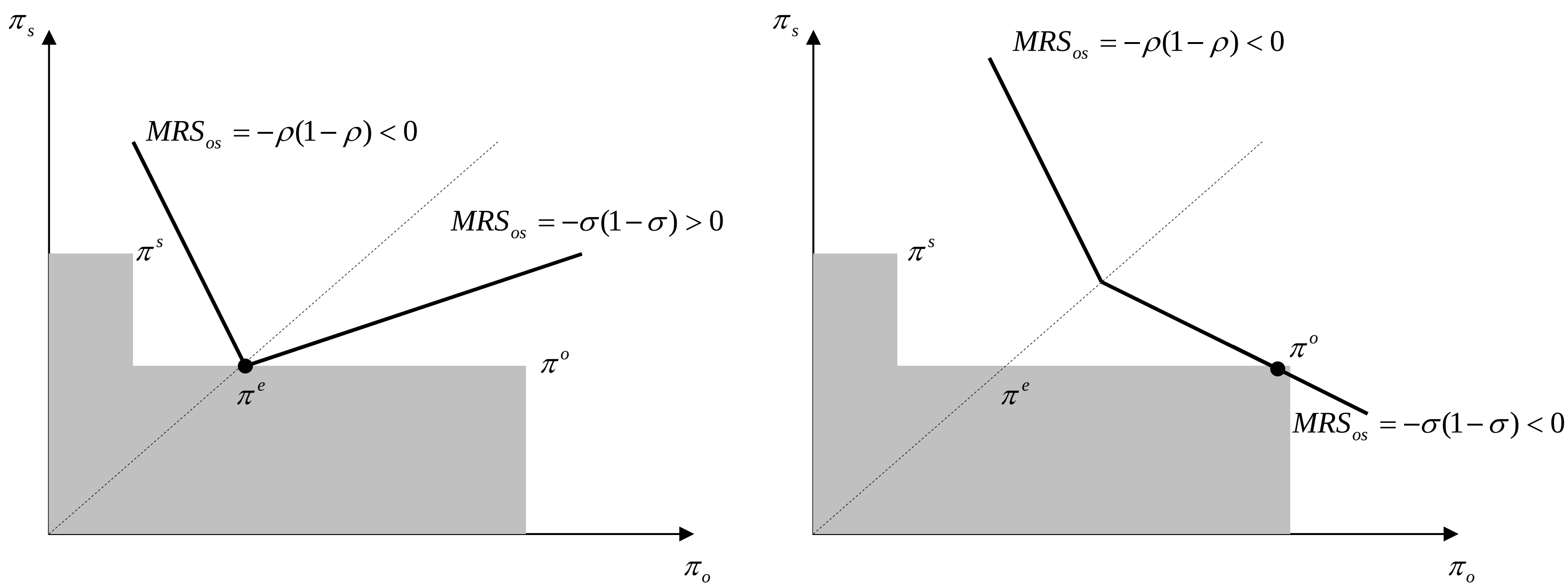
(iii) *difference aversion* preferences ($\sigma < 0 < \rho < 1$), where utility is increasing in π_s and decreasing in the difference $\pi_s - \pi_o$, are generally consistent with the allocations π^s and π^e if $\pi_s^e = \pi_s^o$;

(iv) *social welfare* preferences ($0 < \sigma \leq \rho \leq 1$), where utility is increasing in both π_s and π_o, are only consistent with π^s and π^o.

To provide a clearer intuition, Figure AI1 illustrates difference aversion and social welfare preferences and depicts the range of solutions when $\pi^e \in \Pi^3$. A typical indifference curve for difference averse preferences is represented in the left panel ($MRS_{os} > 0$ for $\pi_s < \pi_o$) and for social welfare preferences in the right panel ($MRS_{os} < 0$ for $\pi_s < \pi_o$). In these cases, the difference aversion optimum is π^s or π^e whereas the social-welfare optimum is π^s or π^o. Also notice that many allocations are not consistent with any of the above prototypical preferences. For example, any allocation $\pi \in \Pi^3$ is not consistent with any of these preferences unless $\pi = \pi^e$.

[Figure AI1 here]

Figure AI1: An example of the preferences of Charness and Rabin (2002)



Instances of social preferences and the range of solutions when $\pi^e \in \prod^3$. A typical indifference curve of a difference aversion function is represented in the left panel and of a social-welfare function in the right panel. The difference aversion optimum is π^e whereas the social-welfare optimum is π^o.

Appendix II

Experimental instructions

Two-person budget set

Introduction This is an experiment in decision-making. Research foundations have provided funds for conducting this research. Your payoffs will depend partly on your decisions and the decisions of the other participants and partly on chance. Please pay careful attention to the instructions as a considerable amount of money is at stake.

The entire experiment should be complete within an hour and a half. At the end of the experiment you will be paid privately. At this time, you will receive $5 as a participation fee (simply for showing up on time). Details of how you will make decisions and receive payments will be provided below.

During the experiment we will speak in terms of experimental tokens instead of dollars. Your payoffs will be calculated in terms of tokens and then translated at the end of the experiment into dollars at the following rate: 3 Tokens = 1 Dollar.

A decision problem In this experiment, you will participate repeatedly in 50 independent decision problems that share a common form. This section describes in detail the process that will be repeated in all decision problems and the computer program that you will use to make your decisions.

In each decision problem you will be asked to allocate tokens between yourself (Hold) and another person (Pass) who will be chosen at random from the group of participants in the experiment. The other person will not be told of your identity. Note that the person will be different in each problem. For each allocation, you and the other person will each receive tokens.

Each choice will involve choosing a point on a graph representing possible token allocations. In each choice, you may choose any Hold / Pass pair that is in the region that is shaded in gray. Examples of regions that you might face appear in Attachment 1.

[Attachment 1 here]

Each decision problem will start by having the computer select such a region randomly from the set of regions that intersect with either the Hold-axis or the Pass-axis at 50 tokens or more. The regions selected for you in different decision problems are independent of each other and of the regions selected for any of the other participants in their decision problems.

For example, as illustrated in Attachment 2, choice A represents an allocation in which you Hold y tokens and Pass x tokens. Thus, if you choose this allocation, you will receive y tokens and the participant with whom you are matched in that round will receive x tokens. Another possible allocation is B, in which you receive w tokens, and person with whom you are matched receives z tokens.

[Attachment 2 here]

To choose an allocation, use the mouse or the arrows on the keyboard to move the pointer on the computer screen to the allocation that you desire. At any point, you may either right-click or press the Space key to find out the allocation that the pointer is at.

When you are ready to make your decision, either left-click or press the Enter key to submit your chosen allocation. After that, confirm your decision by clicking on the Submit button or pressing the Enter key. Note that you can choose only Hold / Pass combinations that are in the gray region. To move on to the next round, press the OK button.

Next, you will be asked to make an allocation in another independent decision. This process will be repeated until all the 50 rounds are completed. At the end of the last round, you will be informed the experiment has ended.

Payoffs Your payoffs are determined as follows. At the end of the experiment, the computer will randomly select one decision round from each participant to carry out. That participant will then receive the tokens that she held in this round, and the participant with whom she was matched will receive the tokens that she passed.

Each participant will therefore receive two groups of tokens, one based on her own decision to hold tokens and one based on the decision of another random participant to pass tokens. The computer will ensure that the same two participants are not paired twice.

The round selected and your choice and your payment for the round will be recorded in the large window that appears at the center of the program dialog window. At the end of the experiment, the tokens will be converted into money. Each token will be worth 1/3 Dollars. You will receive your payment as you leave the experiment.

Rules Your participation in the experiment and any information about your payoffs will be kept strictly confidential. Your payment-receipt and participant form are the only places in which your name and social security number are recorded.

You will never be asked to reveal your identity to anyone during the course of the experiment. Neither the experimenters nor the other participants 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.

Please do not talk with anyone during the experiment. We ask everyone to remain silent until the end of the last round. If there are no further questions, you are ready to start. An instructor will approach your desk and activate your program.

Three-person budget set

Introduction This is an experiment in decision-making. Research foundations have provided funds for conducting this research. Your payoffs will depend partly on your decisions and the decisions of the other participants and partly on chance. Please pay careful attention to the instructions as a considerable amount of money is at stake.

The entire experiment should be complete within an hour and a half. At the end of the experiment you will be paid privately. At this time, you will receive $5 as a participation fee (simply for showing up on time). Details of how you will make decisions and receive payments will be provided below.

During the experiment we will speak in terms of experimental tokens instead of dollars. Your payoffs will be calculated in terms of tokens and then translated at the end of the experiment into dollars at the following rate: 4 Tokens = 1 Dollar.

A decision problem In this experiment, you will participate in 50 independent decision problems that share a common form. This section describes in detail the process that will be repeated in all decision problems and the computer program that you will use to make your decisions.

In each decision problem you will be asked to allocate tokens between yourself (Hold) and two other persons, A (Pass A) and B (Pass B) who will be chosen at random from the group of participants in the experiment. The other persons will not be told of your identity.

Note that the persons will be chosen at around in each problem. For each allocation, you and the two other persons will each receive tokens.

Each choice will involve choosing a point on a three-dimensional graph representing possible token allocations, Hold / Pass A / Pass B. In each choice, you may choose any combination of Hold / Pass A / Pass B that is on the plane that is shaded in gray. Examples of planes that you might face appear in Attachment 3.

[Attachment 3 here]

Each decision problem will start by having the computer select such a plane randomly from the set of planes that intersect with at least one of the axes (Hold-axis, Pass A-axis or Pass B-axis) at 50 tokens or more but with no intercept exceeding 100 tokens. The planes selected for you in different decision problems are independent of each other and independent of the planes selected for any of the other participants in their decision problems.

For example, as illustrated in Attachment 4, choice 1 represents an allocation in which you hold approximately 20 tokens (Hold), pass 40 tokens to person A (Pass A) and 10 tokens to person B (Pass B). Thus, if you choose this allocation, you will receive 20 tokens, the participant with whom you are matched as person A in that round will receive 40 tokens and the participant with whom you are matched as person B in that round will receive 10 tokens. Another possible allocation is choice 2, in which you receive approximately 30 tokens (Hold), the participant with whom you are matched as person A receives 10 tokens (Pass A) and the participant with whom you are matched as person B receives 20 tokens (Pass B).

[Attachment 4 here]

To choose an allocation, use the mouse to move the pointer on the computer screen to the allocation that you desire. On the right hand side of the program dialog window, you will be informed of the exact allocation that the pointer is located. When you are ready to make your decision, left-click to enter your chosen allocation. After that, confirm your decision by clicking on the Submit button. Note that you can choose only Hold / Pass A / Pass B combinations that are on the gray plane. To move on to the next round, press the OK button. The computer program dialog window is shown in Attachment 5.

[Attachment 5 here]

Next, you will be asked to make an allocation in another independent decision problem. This process will be repeated until all 50 rounds are completed. At the end of the last round, you will be informed the experiment has ended.

Earnings Your payoffs are determined as follows. At the end of the experiment, the computer will randomly select one decision round (that is, 1 out of 50) from each participant to carry out. That participant will then receive the tokens that she allocated to Hold in this round, the participant with whom she was matched as person A will receive the tokens that she allocated to Pass A and the participant with whom she was matched as person B will receive the tokens that she allocated to Pass B. The round selected depends solely upon chance. For each participant, it is equally likely that any round will be chosen.

Each participant will therefore receive three groups of tokens, one based on her own decision to hold tokens, one based on the decision of another random participant to pass tokens to her as person A and one based on the decision of another random participant to pass tokens to her as person B. The computer will ensure that the same two participants are not matched more than once.

The round selected, your choice and your payment will be shown in the large window that appears at the center of the program dialog window. At the end of the experiment, the tokens will be converted into money. Each token will be worth 0.25 Dollars. Your final earnings in the experiment will be your earnings in the round selected plus the $5 show-up fee. You will receive your payment as you leave the experiment.

Rules Your participation in the experiment and any information about your payoffs will be kept strictly confidential. Your payment-receipt and participant form are the only places in which your name and social security number are recorded.

You will never be asked to reveal your identity to anyone during the course of the experiment. Neither the experimenters nor the other participants 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.

Please do not talk with anyone during the experiment. We ask everyone to remain silent until the end of the last round. If there are no further questions, you are ready to start. An instructor will approach your desk and activate your program.

Step-shaped set

Introduction This is an experiment in decision-making. Research foundations have provided funds for conducting this research. Your payoffs will depend partly on your decisions and the decisions of the other participants and partly on chance. Please pay careful attention to the instructions as a considerable amount of money is at stake.

The entire experiment should be complete within an hour and a half. At the end of the experiment you will be paid privately. At this time, you will receive $5 as a participation fee (simply for showing up on time). Details of how you will make decisions and receive payments will be provided below.

During the experiment we will speak in terms of experimental tokens instead of dollars. Your payoffs will be calculated in terms of tokens and then translated at the end of the experiment into dollars at the following rate: 3 Tokens = 1 Dollar.

A decision problem In this experiment, you will participate repeatedly in 50 independent decision problems that share a common form. This section describes in detail the process that will be repeated in all decision problems and the computer program that you will use to make your decisions.

In each decision problem you will be asked to allocate tokens between yourself (Hold) and another person (Pass) who will be chosen at random from the group of participants in the experiment. The other person will not be told of your identity. Note that the person will be different in each problem. For each allocation, you and the other person will each receive tokens.

Each choice will involve choosing a point on a graph representing possible token allocations. The y-axis and x-axis are labeled Hold and Pass respectively and scaled from 0 to 100 tokens. In each choice, you may choose any Hold / Pass pair that is in the step-shaped region that is shaded in gray. Examples of regions that you might face appear in Attachment 6.

[Attachment 6 here]

Each decision problem will start by having the computer select such a step-shaped region randomly. That is, the region selected depends solely upon chance and is equally likely to be any step-shaped region. The regions selected for you in different decision problems are independent of each other and of the regions selected for any of the other participants in their decision problems.

For example, as illustrated in Attachment 7, choice A represents an allocation in which you Hold q tokens and Pass r tokens. Thus, if you choose this allocation, you will receive q tokens and the participant with whom you are matched in that round will receive r tokens. Another possible allocation is B, in which you receive s tokens, and person with whom you are matched receives t tokens.

[Attachment 7 here]

To choose an allocation, use the mouse or the arrows on the keyboard to move the pointer on the computer screen to the allocation that you desire. At any point, you may either right-click or press the Space key to find out the allocation that the pointer is at.

When you are ready to make your decision, either left-click or press the Enter key to submit your chosen allocation. After that, confirm your decision by clicking on the Submit button or pressing the Enter key. Note that you can choose only Hold / Pass combinations that are in the gray region. To move on to the next round, press the OK button.

Next, you will be asked to make an allocation in another independent decision. This process will be repeated until all the 50 rounds are completed. At the end of the last round, you will be informed the experiment has ended.

Payoffs Your payoffs are determined as follows. At the end of the experiment, the computer will randomly select one decision round from each participant to carry out. That participant will then receive the tokens that she held in this round, and the participant with whom she was matched will receive the tokens that she passed.

Each participant will therefore receive two groups of tokens, one based on her own decision to hold tokens and one based on the decision of another random participant to pass tokens. The computer will ensure that the same two participants are not paired twice.

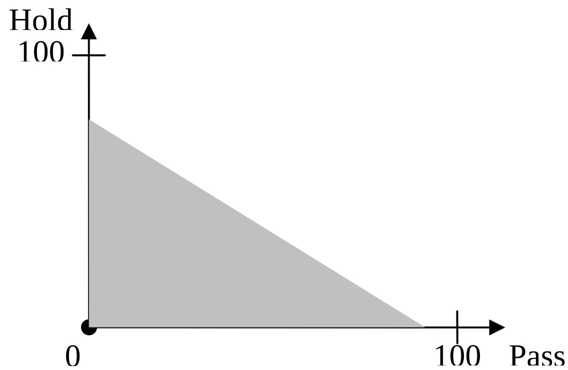
The round selected and your choice and your payment for the round will be recorded in the large window that appears at the center of the program dialog window. At the end of the experiment, the tokens will be converted into money. Each token will be worth 1/3 Dollars. You will receive your payment as you leave the experiment.

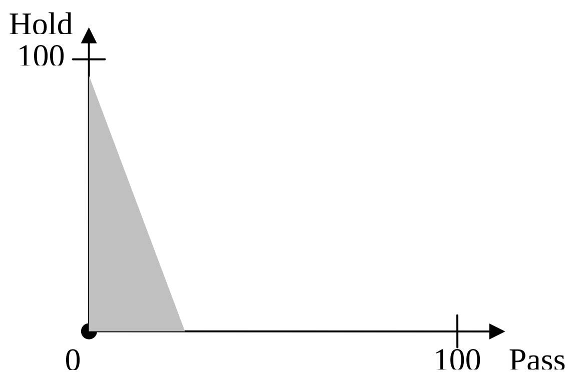
Rules Your participation in the experiment and any information about your payoffs will be kept strictly confidential. Your payment-receipt and participant form are the only places in which your name and social security number are recorded.

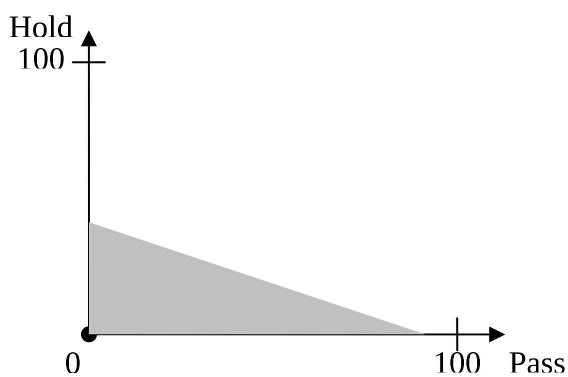
You will never be asked to reveal your identity to anyone during the course of the experiment. Neither the experimenters nor the other participants will be able to link you to any of your decisions. In order to keep your decisions private, please do not reveal your choices to any other participant.

Please do not talk with anyone during the experiment. We ask everyone to remain silent until the end of the last round. If there are no further questions, you are ready to start. An instructor will approach your desk and activate your program.

Attachment 1







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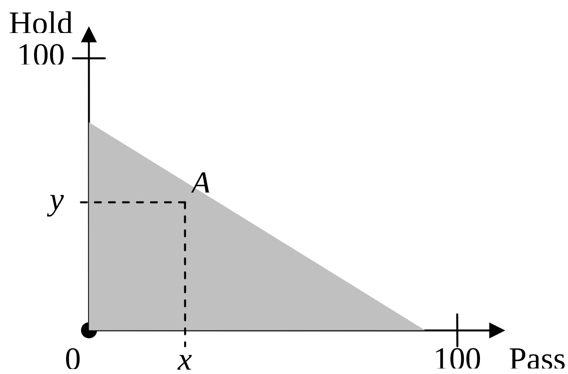

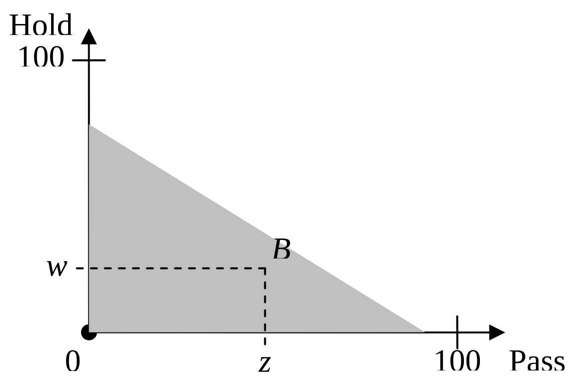

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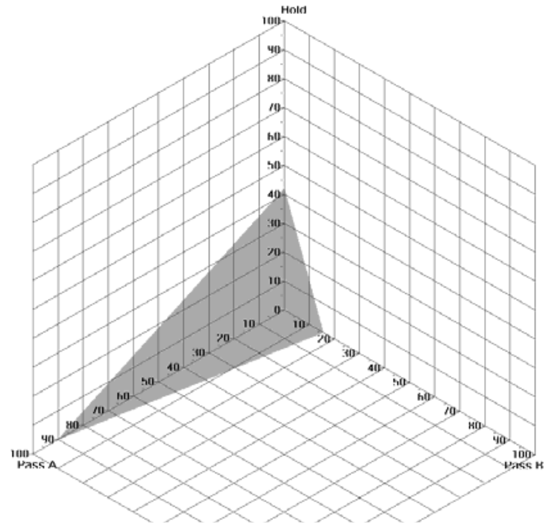

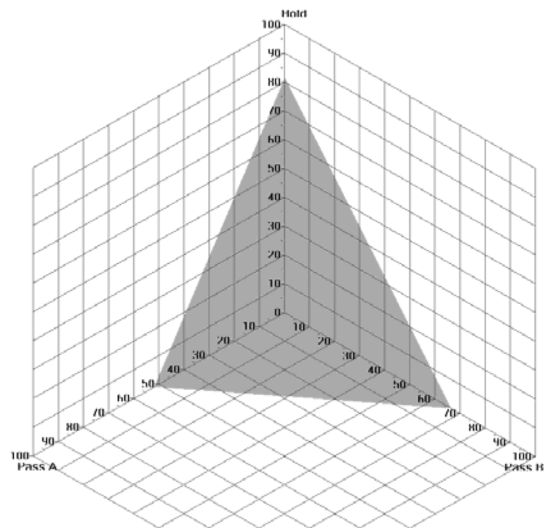

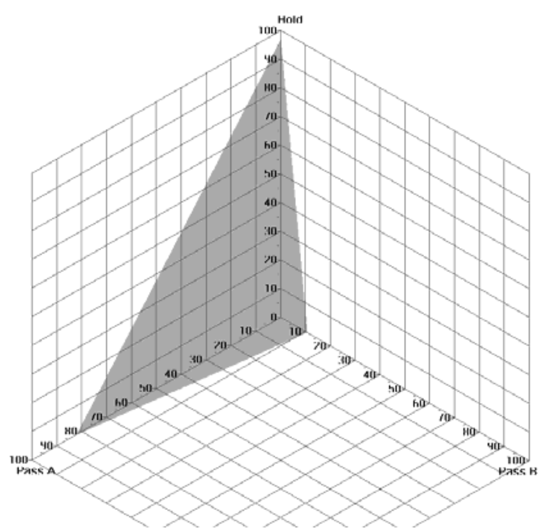

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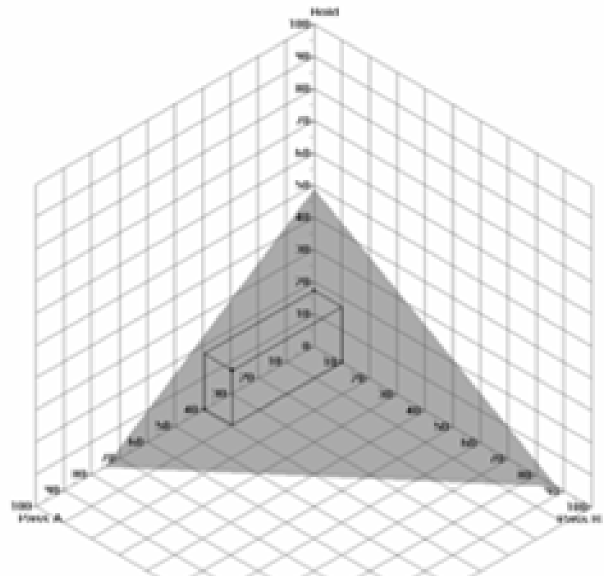

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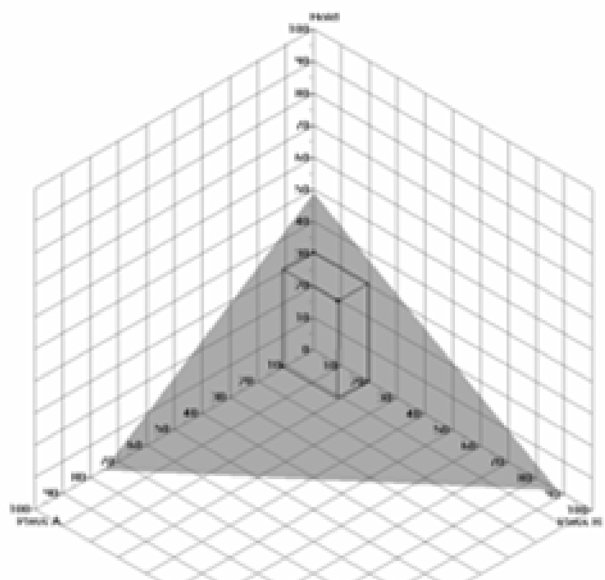

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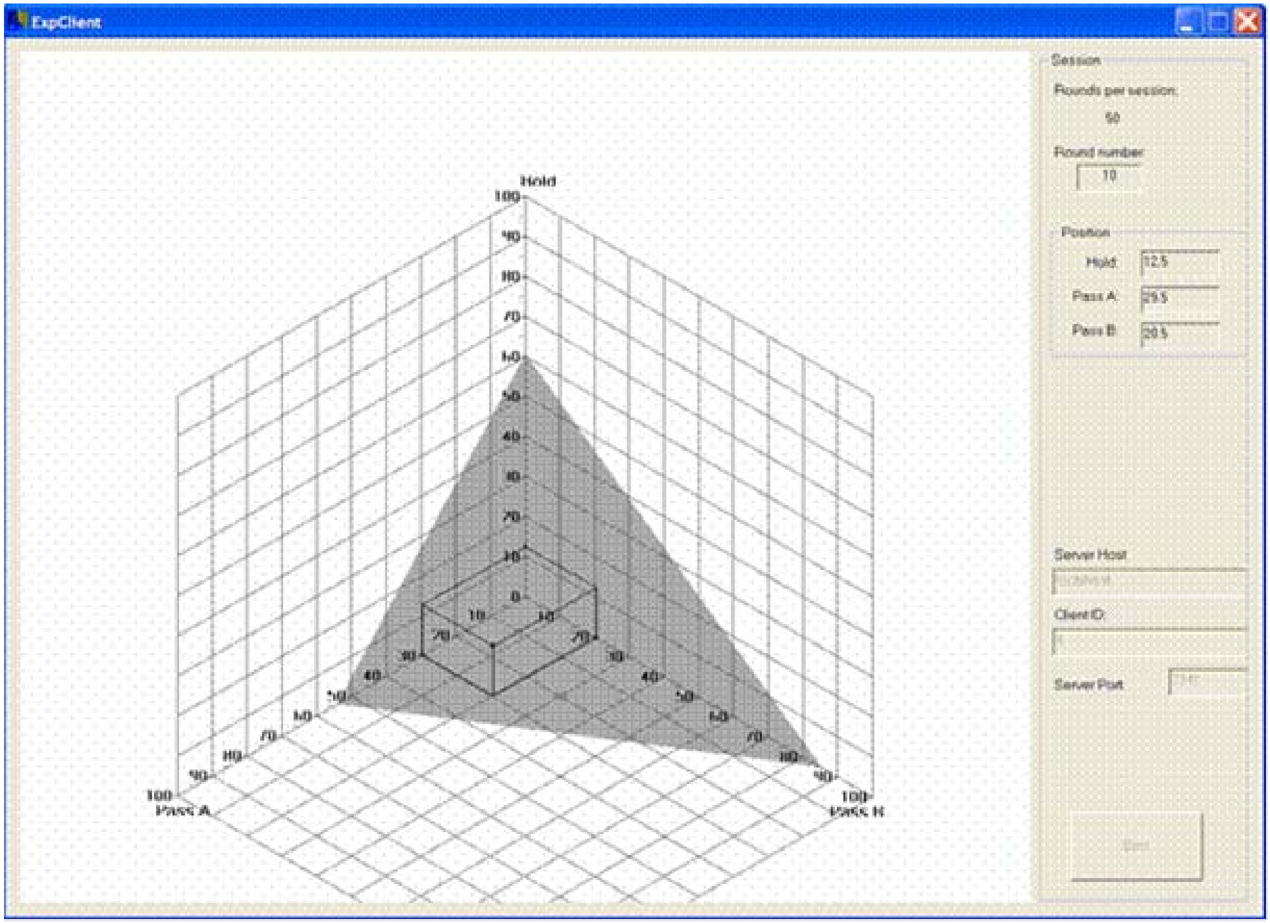
Attachment 5



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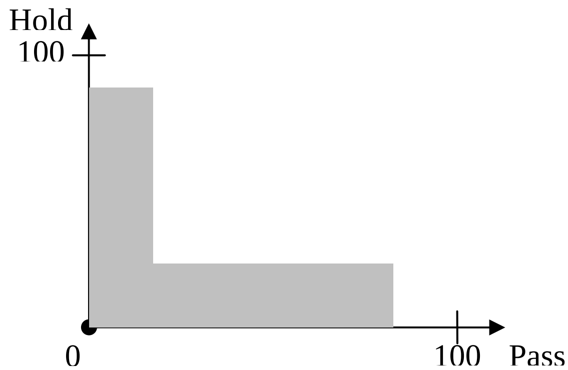

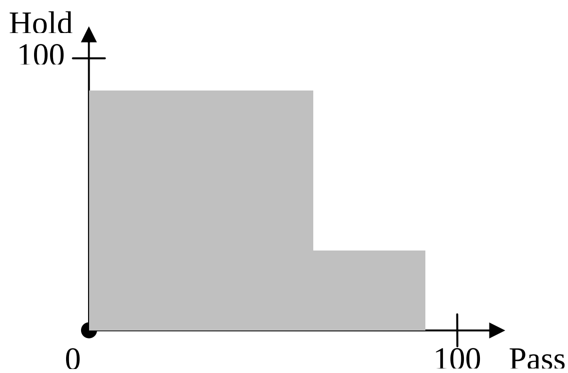

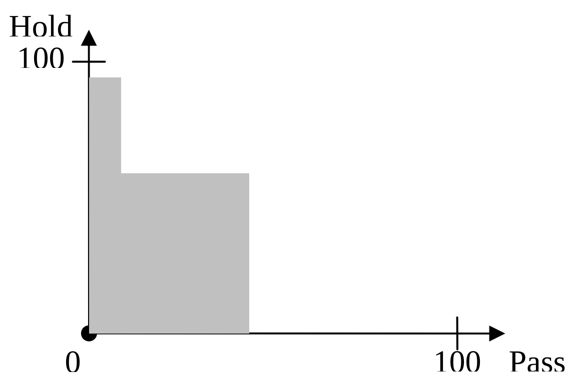

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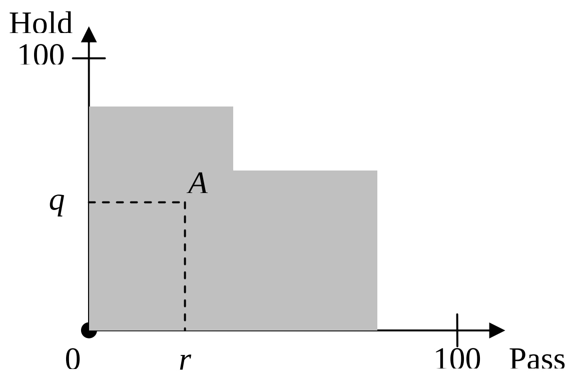
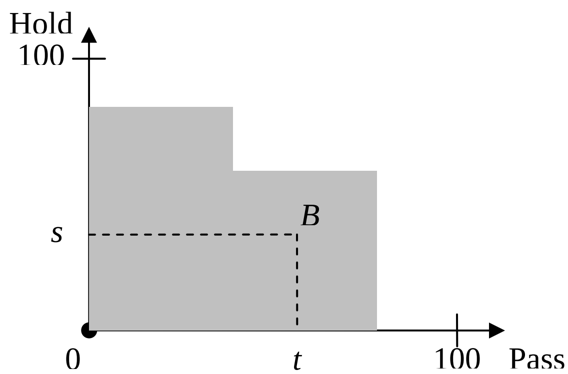




Appendix III

Testing rationality

An allocation π is *directly revealed preferred* to an allocation π', denoted $\pi R^D \pi'$, if $p \cdot \pi \geq p \cdot \pi'$. An allocation π is *revealed preferred* to an allocation π', denoted $\pi R \pi'$, if there exists a sequence of allocations $\{\pi^k\}_{k=1}^K$ with $\pi^1 = \pi$ and $\pi^K = \pi'$, such that $\pi^k R^D \pi^{k+1}$ for every $k = 1, ..., K-1$. The Generalized Axiom of Revealed Preference (GARP) requires that if $\pi R \pi'$ then $p^j \cdot \pi' \leq p^j \cdot \pi$ (if π is revealed preferred to π', then π must cost at least as much as π' at the prices prevailing when π' is chosen). Afriat (1967) tells us that if a *finite* data set generated by an individual's choices satisfies GARP, then there exists a continuous, concave, monotonic utility function $u(\pi)$ such that for each observation

$$u(x) \leq u(\pi) \text{ for any } \pi \text{ such that } p \cdot x \leq p \cdot \pi.$$

Hence, in order to show that the data are consistent with utility-maximizing behavior we must check whether it satisfies GARP. Since GARP offers an exact test, it is desirable to measure the *extent* of GARP violations.

We report measures of GARP violations based on three indices: Afriat (1972) (CCEI), Varian (1991), and Houtman and Maks (1985) (HM). The CCEI measures the amount by which each budget constraint must be adjusted in order to remove all violations of GARP. For any number $0 \leq e \leq 1$, define the direct revealed preference relation $R^D(e)$ as $\pi R^D(e) \pi'$ if $ep \cdot \pi \geq p \cdot \pi'$, and define $R(e)$ to be the transitive closure of $R^D(e)$. Let e^* be the largest value of e such that the relation $R(e)$ satisfies GARP. Afriat's CCEI is the value of e^* associated with the data set $\{(p, \pi)\}$. It is bounded between zero and one and can be interpreted as saying that the consumer is 'wasting' as much as $1-e^*$ of his income by making inefficient choices. The closer the CCEI is to one, the smaller the perturbation of the budget constraints required to remove all violations and thus the closer the data are to satisfying GARP.

Although the CCEI provides a summary statistic of the overall consistency of the data with GARP, it does not give any information about which of the observations are causing the most severe violations. Varian (1991) refined Afriat's CCEI to provide a measure that reflects the minimum adjustment required to eliminate the violations of GARP associated with each observation π. In particular, fix an observation π and find the largest value of e such that $R(e)$ has no violations of GARP within the set of allocations π' such that $\pi R(e)\pi'$. The value e measures the efficiency of the choices when compared to the allocation π'. Varian (1991) provides an algorithm that will select the least costly method of removing all violations by changing each budget set by a different amount which allows us to say where the inefficiency is greatest or least. To describe efficiency, Varian (1991) uses $e^* = \min\{e\}$. Thus, Varian's (1991) index is a lower bound on the Afriat's CCEI.

Houtman and Maks (1985) (HM), finds the largest subset of choices that is consistent with GARP. This method has a couple of drawbacks. First, observations may be discarded even if the associated GARP violations could be removed by small perturbations of the budget constraint. Further, it is computationally very intensive and thus impractical if, roughly speaking, violations often overlap. As a result, we were unable to calculate this measure for a small number of subjects who often violated GARP, and we therefore report only lower bounds on the consistent set.

Table AIII1 reports, by subject, the values of the CCEI scores in the two- and three-person budget set experiments. The results presented in Table AIII1 allow for a narrow confidence interval of one token (for any π, π' if $|\pi, \pi'| \leq 1$ then π and π' are treated as the same allocation). Figure AIII1A compares the distributions of the CCEI scores generated by a sample of 25,000 hypothetical random subjects and the distributions of the scores for the actual subjects in the three-person experiment. The histograms show that also in the three-person case actual subject behavior has high consistency measures compared to the behavior of the random subjects. Figure AIII1B compares the distributions of the Varian efficiency index in the two- and three-person experiments and Figure AIII1C compares the distributions of the HM index.

[Table AIII1 here]

[Figure AIII1 here]

Finally, we note that there is a very high probability that random behavior will pass the GARP test if the number of individual decisions is as low as it usually has been in experiments. To illustrate this point, we calibrated the choices of random 25,000 subjects over 10, 25 and 50 two-person budgets. The results are listed in the diagram below, which reports the fractions of high CCEI scores. Bronars' (1987) test (the probability that a random subject violates GARP) has also been applied to other experimental data. Our study has the highest Bronars power of one (all random subjects had violations). Hence, our experiment is sufficiently powerful to exclude the possibility that consistency is the accidental result of random behavior. Therefore, the consistency of our subjects' behavior under these conditions is not accidental.

CCEI	10	25	50
$0.95-1.0$	0.202	0.043	0.001
$0.9-0.95$	0.171	0.100	0.007
$0.85-0.9$	0.133	0.146	0.026

To make this more precise, we also generate a random sample of 25,000 hypothetical subjects who implement the CES utility function

$$U_s = [\alpha(\pi_s)^\rho + (1-\alpha)(\pi_o)^\rho]^{1/\rho}$$

with an idiosyncratic preference shock that has a logistic distribution

$$\Pr(\pi^*) = \frac{e^{\gamma \cdot u(\pi^*)}}{\int\limits_{\pi : p \cdot \pi = m} e^{\gamma \cdot u(\pi)}},$$

where the parameter γ reflects sensitivity to differences in utility. The choice of allocation becomes purely random as γ goes to zero, whereas the probability of the allocation yielding the highest utility approaches one as γ goes to infinity. Figure AIII2 summarizes the distributions of CCEI scores generated by samples of hypothetical subjects with $\alpha = 0.75$ and $\rho = 0.25$, which is in the range of our estimates, and various levels of precision γ. Each of the 25,000 hypothetical subjects makes 50 choices from randomly generated two-person budget sets in the same way as the human subjects do. The data clearly show that our experiment is sufficiently powerful to detect whether utility maximization is in fact the correct model.

[Figure AIII2 here]

Table AIII1: The number of violations of GARP and the values of the three indices

Two-person

ID	GARP	CCEI	Varian	HM	ID	GARP	CCEI	Varian	HM
1	376	0.844	0.464	39	39	76	0.948	0.822	41
2	1089	0.517	0.244	42	40	4	0.998	0.978	46
3	332	0.817	0.390	35	41	5	0.990	0.984	47
4	0	1.000	1.000	50	42	0	1.000	1.000	50
5	20	0.965	0.901	44	43	248	0.811	0.510	37
6	16	0.946	0.832	47	44	15	0.972	0.938	42
7	70	0.928	0.754	34	45	191	0.931	0.707	39
8	1	0.977	0.971	49	46	57	0.902	0.802	41
9	2	0.989	0.960	48	47	359	0.798	0.533	30
10	55	0.966	0.836	42	48	1037	0.500	0.069	43
11	209	0.834	0.658	42	49	19	0.965	0.911	42
12	22	0.935	0.593	48	50	9	0.990	0.916	42
13	20	0.954	0.828	40	51	54	0.926	0.774	42
14	19	0.806	0.741	42	52	60	0.933	0.789	35
15	9	0.983	0.965	45	53	942	0.619	0.196	42
16	1005	0.606	0.205	42	54	2	0.975	0.952	48
17	0	1.000	1.000	50	55	58	0.970	0.896	39
18	7	0.978	0.937	44	56	9	0.968	0.894	45
19	497	0.710	0.256	33	57	0	1.000	1.000	50
20	2	0.996	0.974	48	58	0	1.000	1.000	50
21	539	0.845	0.486	41	59	30	0.959	0.909	43
22	2	0.998	0.980	49	60	0	1.000	1.000	50
23	3	0.978	0.931	49	61	89	0.957	0.889	38
24	5	0.985	0.967	46	62	41	0.956	0.905	45
25	3	0.981	0.963	47	63	73	0.716	0.507	47
26	797	0.272	0.185	42	64	132	0.848	0.693	36
27	2	0.989	0.969	48	65	0	1.000	1.000	50
28	34	0.957	0.886	41	66	541	0.865	0.518	40
29	63	0.900	0.812	43	67	3	0.983	0.960	47
30	15	0.971	0.933	43	68	9	0.980	0.948	46
31	0	1.000	1.000	50	69	100	0.939	0.824	40
32	4	0.991	0.982	47	70	24	0.892	0.877	42
33	3	0.990	0.973	49	71	528	0.582	0.364	38
34	26	0.928	0.716	43	72	14	0.952	0.884	45
35	3	0.985	0.948	49	73	221	0.899	0.676	34
36	181	0.916	0.795	42	74	521	0.697	0.402	40
37	480	0.930	0.590	38	75	446	0.792	0.540	38
38	14	0.977	0.947	47	76	1216	0.211	0.066	43

Three-person

ID	GARP	CCEI	Varian	HM	ID	GARP	CCEI	Varian	HM
135	0	1.000	1.000	50	168	337	0.789	0.427	30
136	57	0.982	0.822	44	169	0	1.000	1.000	50
137	608	0.699	0.273	32	170	8	0.969	0.929	47
138	0	1.000	1.000	50	171	0	1.000	1.000	50
139	0	1.000	1.000	50	172	87	0.949	0.843	47
140	1033	0.393	0.127	43	173	51	0.878	0.789	46
141	250	0.723	0.449	39	174	23	0.926	0.900	46
142	0	1.000	1.000	50	175	43	0.886	0.803	44
143	65	0.669	0.620	47	176	6	0.989	0.932	48
144	88	0.696	0.586	43	177	84	0.946	0.764	42
145	2	0.998	0.989	49	178	0	1.000	1.000	50
146	9	0.996	0.967	47	179	6	0.995	0.977	48
147	12	0.986	0.960	46	180	0	1.000	1.000	50
148	21	0.989	0.926	45	181	0	1.000	1.000	50
149	0	1.000	1.000	50	182	44	0.970	0.900	45
150	0	1.000	1.000	50	183	7	0.969	0.948	48
151	81	0.848	0.636	41	184	6	0.994	0.978	47
152	95	0.928	0.671	42	185	375	0.824	0.379	40
153	277	0.683	0.467	38	186	12	0.971	0.963	44
154	0	1.000	1.000	50	187	53	0.958	0.858	40
155	2	0.996	0.971	49	188	0	1.000	1.000	50
156	103	0.862	0.769	39	189	2	0.989	0.987	49
157	4	0.985	0.980	48	190	8	0.992	0.982	48
158	0	1.000	1.000	50	191	94	0.932	0.851	44
159	26	0.972	0.917	46	192	85	0.864	0.681	44
160	0	1.000	1.000	50	193	131	0.884	0.713	39
161	21	0.933	0.793	44	194	336	0.837	0.603	19
162	2	0.991	0.990	49	195	0	1.000	1.000	50
163	92	0.906	0.554	45	196	4	0.991	0.961	48
164	561	0.689	0.435	35	197	48	0.926	0.901	44
165	189	0.902	0.766	41	198	8	0.976	0.971	48
166	373	0.894	0.539	25	199	6	0.960	0.776	48
167	5	0.994	0.969	49					

Figure AIII1A: The distributions of Afriat's (1972) critical cost efficiency index (CCEI
in the three-person budget set experiment

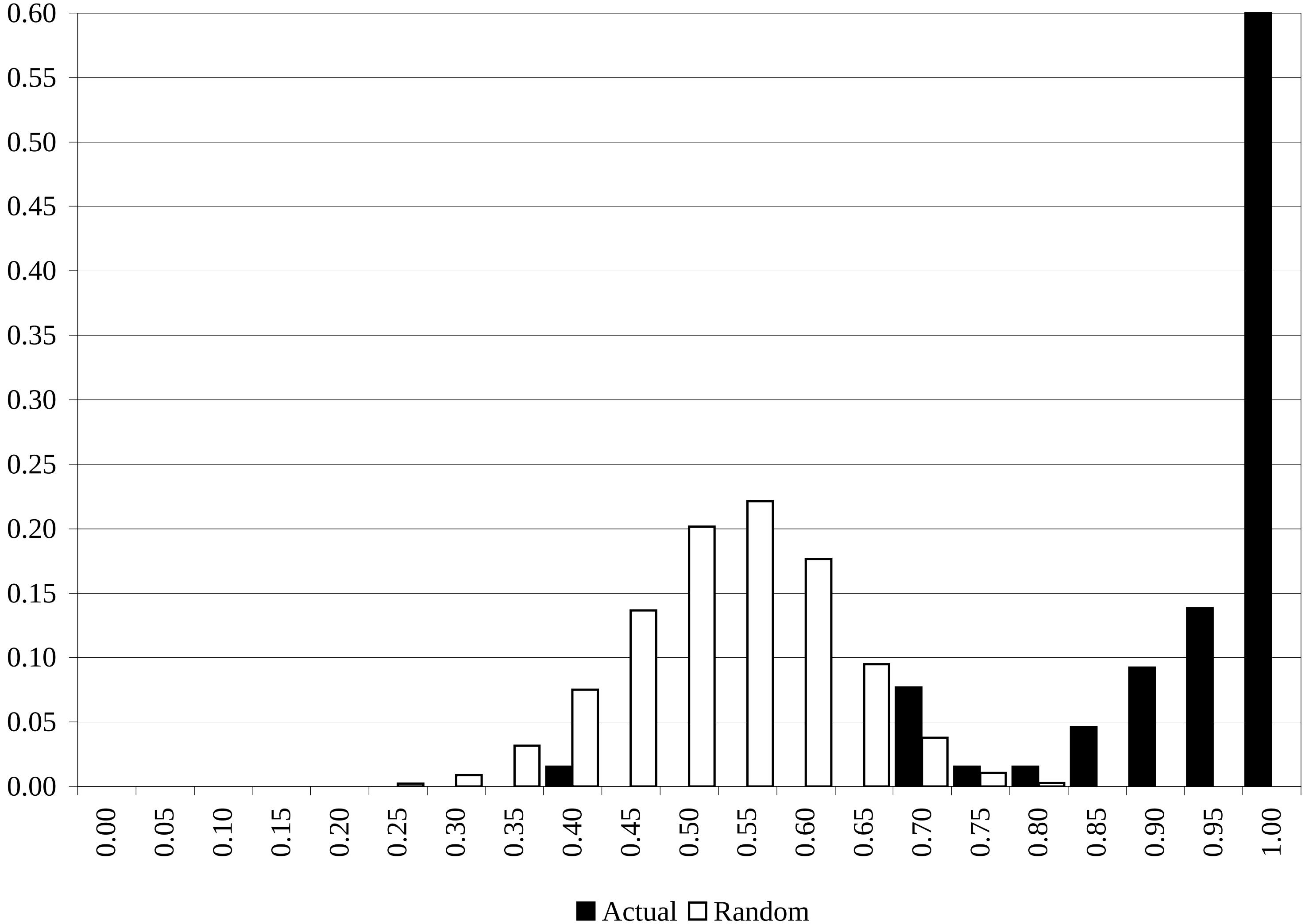


Figure AIII1B: The distributions of Varian (1991) index
in the two- and three-person budget set experiments

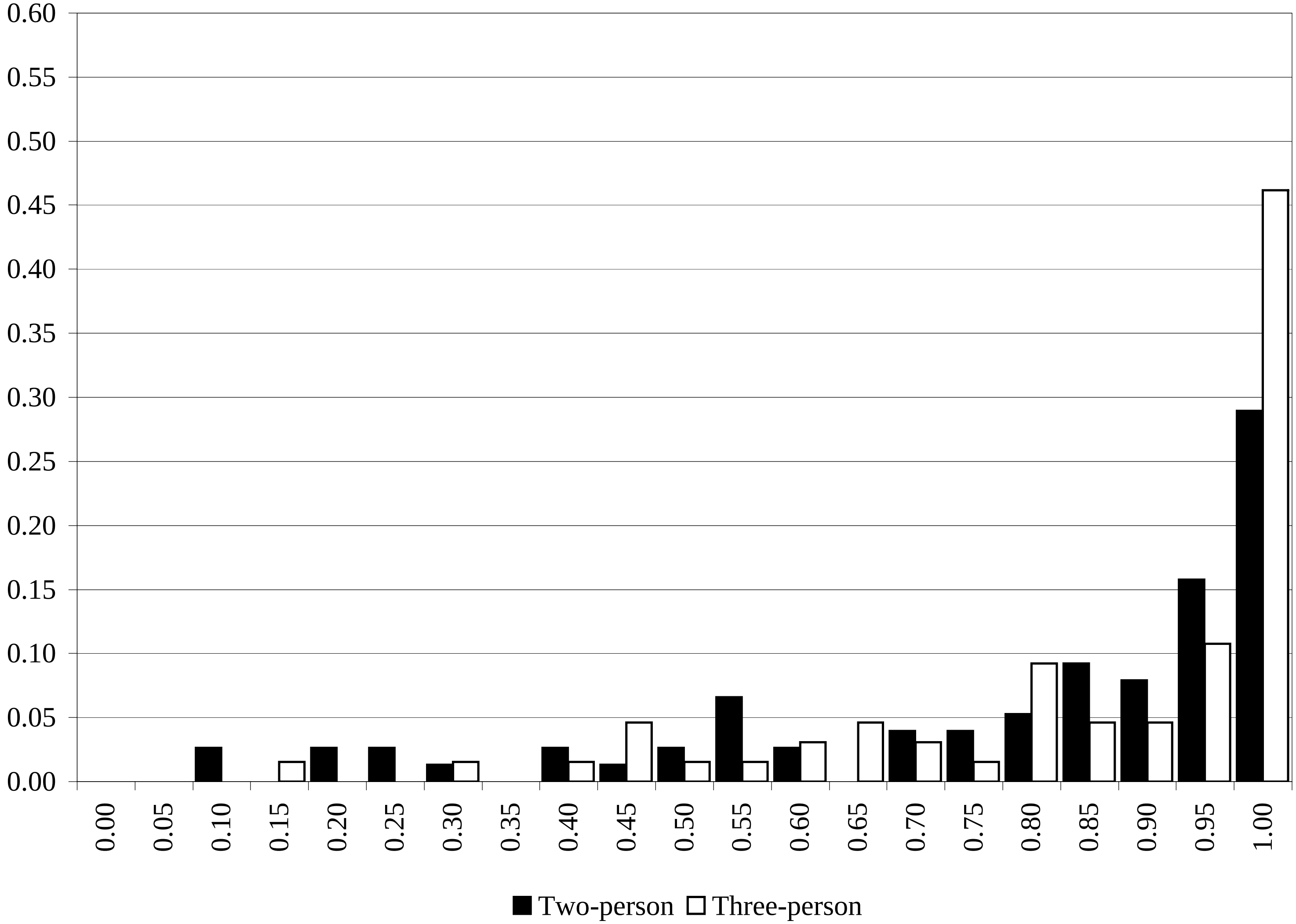


Figure AIII1C: The distributions of HM index
in the two- and three-person budget set experiments

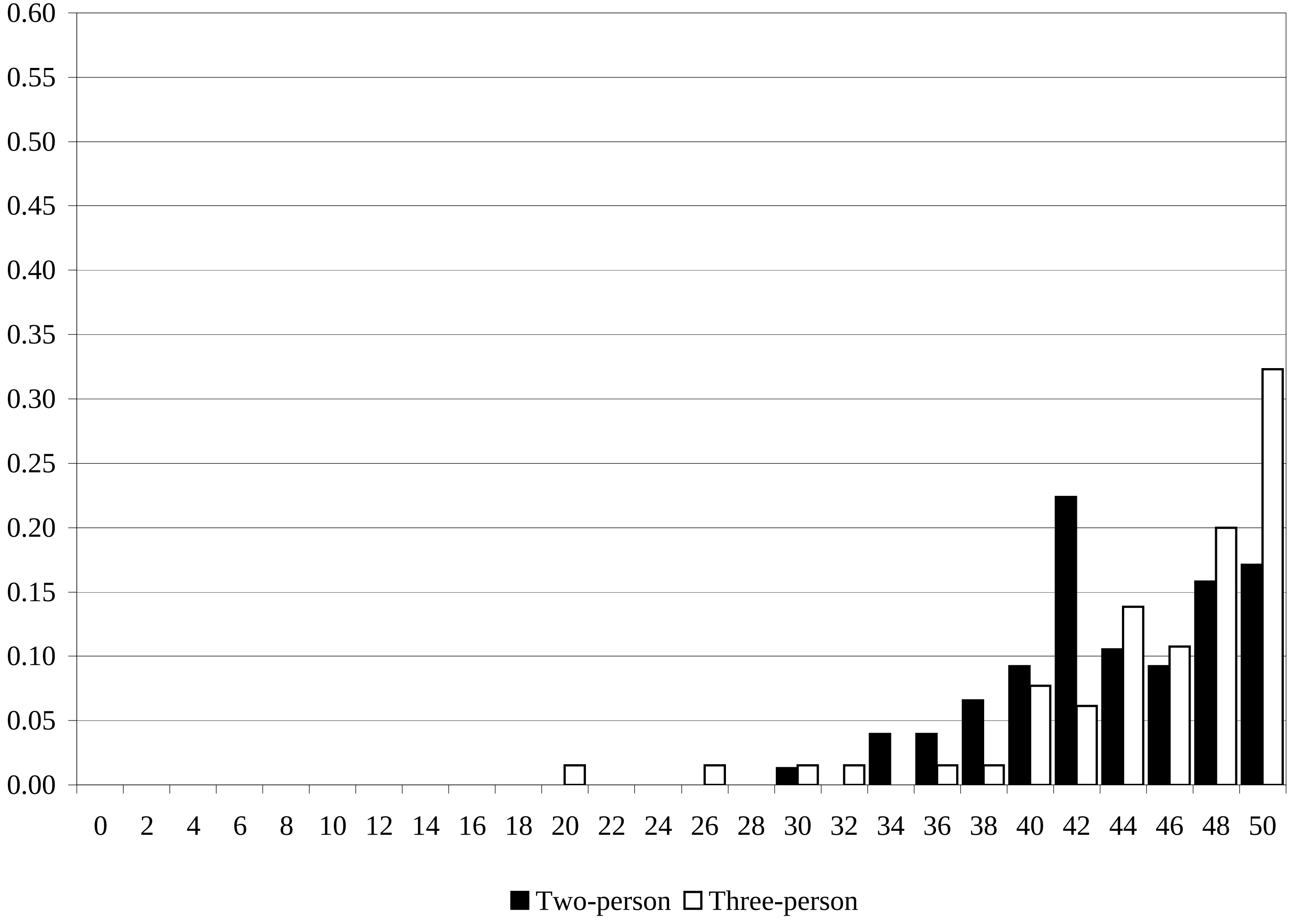
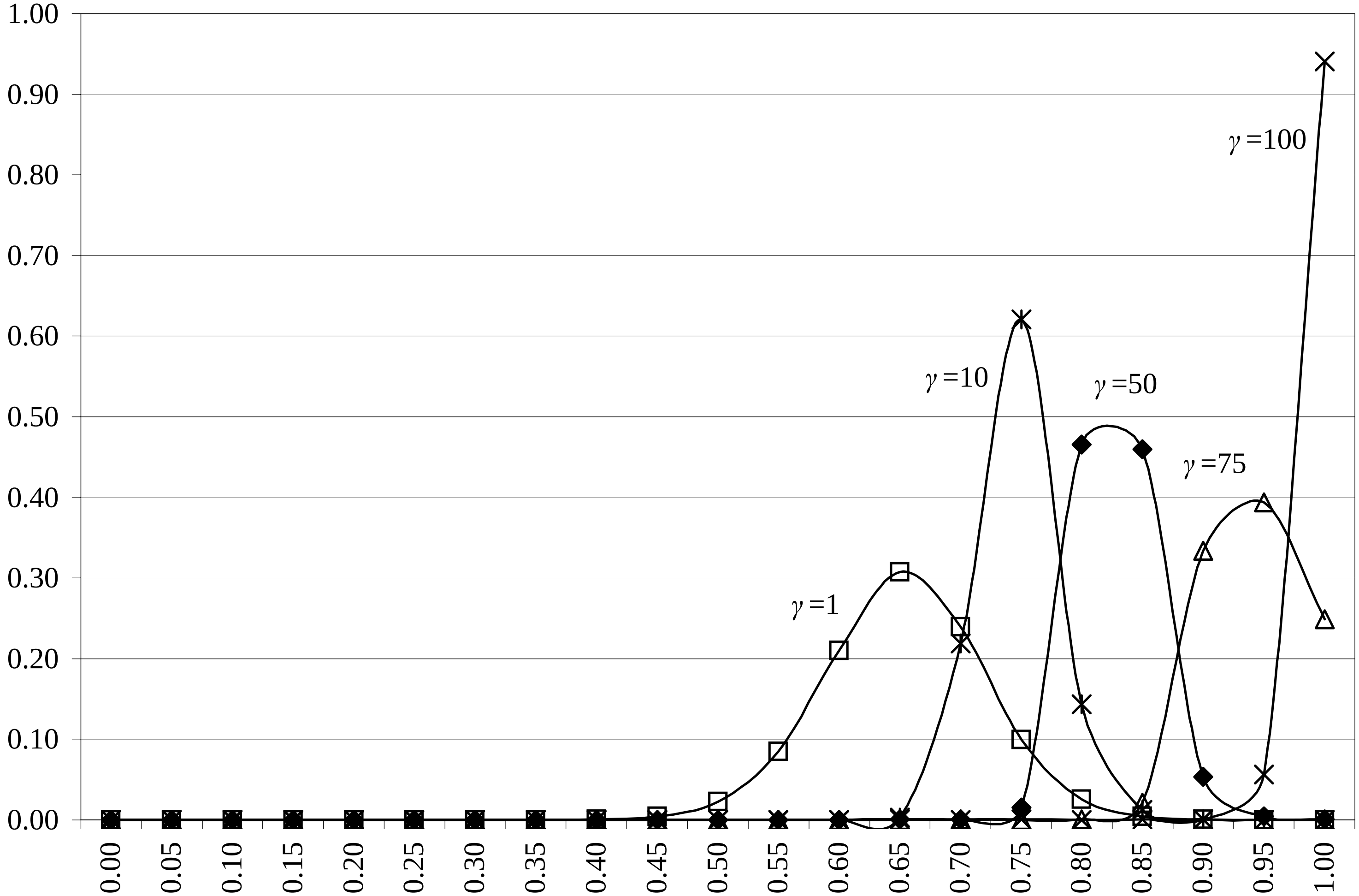


Figure AIII2: The distributions of Afriat's (1972) critical cost efficiency index (CCEI
of samples of 25,000 hypothetical subjects



Appendix IV

Two-person budget sets econometric analysis

ID	ρ	α	σ	g	sd(g)	r	sd(r)
1	-0.439	0.827	-0.695	2.970	0.332	0.305	0.150
3	-2.324	0.679	-0.301	1.253	0.089	0.699	0.085
5	0.658	0.576	-2.923	2.463	0.293	-1.923	0.230
6	-0.060	0.503	-0.943	1.012	0.020	0.057	0.020
7	0.543	0.706	-2.187	6.775	1.193	-1.187	0.167
8	0.942	0.532	-17.346	9.204	5.941	-16.346	3.734
9	0.493	0.748	-1.972	8.575	0.905	-0.972	0.110
10	-0.476	0.971	-0.678	10.749	0.974	0.322	0.066
11	0.144	0.927	-1.168	19.575	6.190	-0.168	0.290
12	0.823	0.639	-5.659	25.376	25.809	-4.659	1.452
13	-0.132	0.922	-0.883	8.912	0.792	0.117	0.092
14	0.615	0.771	-2.598	23.339	8.231	-1.598	0.204
15	0.334	0.699	-1.501	3.549	0.183	-0.501	0.057
18	-0.507	0.554	-0.664	1.153	0.043	0.336	0.036
21	-0.097	0.669	-0.912	1.897	0.167	0.088	0.100
23	0.497	0.746	-1.987	8.508	1.295	-0.987	0.129
28	0.315	0.893	-1.460	22.187	9.393	-0.460	0.278
29	0.260	0.922	-1.351	28.095	17.856	-0.351	0.443
30	0.428	0.657	-1.747	3.123	0.287	-0.747	0.096
32	-0.040	0.516	-0.962	1.064	0.012	0.038	0.010
34	0.291	0.532	-1.410	1.200	0.099	-0.410	0.077
36	-0.511	0.866	-0.662	3.430	0.270	0.338	0.067

ID	ρ	α	σ	g	sd(g)	r	sd(r)
37	-0.489	0.685	-0.672	1.686	0.099	0.328	0.071
38	0.219	0.787	-1.280	5.323	0.430	-0.280	0.084
39	0.583	0.649	-2.399	4.393	0.709	-1.399	0.152
40	-0.011	0.505	-0.989	1.020	0.014	0.011	0.012
41	0.577	0.812	-2.362	31.464	8.512	-1.362	0.151
43	-0.672	0.961	-0.598	6.814	1.120	0.402	0.134
45	-0.326	0.940	-0.754	7.924	1.046	0.246	0.133
46	-5.369	0.658	-0.157	1.108	0.031	0.843	0.040
49	0.027	0.530	-1.028	1.133	0.061	-0.028	0.059
50	0.337	0.579	-1.509	1.614	0.084	-0.509	0.064
51	0.702	0.580	-3.351	2.970	0.766	-2.351	0.373
52	0.114	0.767	-1.129	3.834	0.281	-0.129	0.059
54	0.992	0.504	-117.970	6.345	12.567	-116.970	36.202
55	-2.786	0.993	-0.264	3.678	0.178	0.736	0.057
56	-0.083	0.517	-0.924	1.065	0.045	0.076	0.043
59	0.674	0.522	-3.065	1.317	0.146	-2.065	0.235
61	-0.115	0.959	-0.897	16.978	1.654	0.103	0.126
64	-0.435	0.962	-0.697	9.446	1.965	0.303	0.182
66	0.329	0.581	-1.490	1.631	0.181	-0.490	0.123
69	0.231	0.638	-1.300	2.092	0.197	-0.300	0.108
70	-0.111	0.864	-0.900	5.277	0.448	0.100	0.104
72	0.170	0.670	-1.205	2.349	0.155	-0.205	0.073
73	-14.813	1.000	-0.063	9.980	0.708	0.937	0.055

Appendix V

Three-person budget sets econometric analysis

The solution to the subutility $w_s(\pi_A, \pi_B)$ maximization problem is given by

$$\pi_A(p_o, m_o) = \left[\frac{g'}{(p_B/p_A)^{r'} + g'}\right]\frac{m_o}{p_A}$$

where $r' = -\rho'/(1-\rho')$, $g' = [\alpha'/(1-\alpha')]^{1/(1-\rho')}$ and $m_o = p_o\pi_o$ is the total expenditure on tokens given to *others*. The solution to the macro utility $v_s(\pi_s, w_s(\pi_o))$ maximization problem is then given by

$$\pi_s(p, m) = \left[\frac{g}{q^r + g}\right]\frac{m}{p_s}$$

where $r = -\rho/(1-\rho)$, $g = [\alpha/(1-\alpha)]^{1/(1-\rho)}$ and q is a *weighted relative price of giving* defined by

$$q = \frac{(p_A/p_s) + (p_B/p_s)\left[(\alpha'/(1-\alpha'))(p_B/p_A)\right]^{1/(\rho'-1)}}{\left[\alpha' + (1-\alpha')\left[(\alpha'/(1-\alpha'))(p_B/p_A)\right]^{\rho'/(\rho'-1)}\right]^{1/\rho'}}.$$

This generates the following individual-level two-stage econometric specification for each subject n:

$$\frac{\pi^t_{A,n}}{m^t_{O,n}/p^t_{A,n}} = \frac{g'_n}{\left(p^t_{B,n}/p^t_{A,n}\right)^{r'_n} + g'_n} + \epsilon'^t_n \tag{1}$$

and

$$\frac{\pi^t_{s,n}}{m^t_n/p^t_s} = \frac{g_n}{(q^t_n)^{r_n} + g_n} + \epsilon^t_n \tag{2}$$

where ϵ^t_n and ϵ'^t_n are assumed to be distributed normally with mean zero and variance σ^2_n and σ'^2_n respectively. Note that the demands (1) and (2) are estimated as budget shares, which are bounded between zero and one, with an *i.i.d.* error term. Using nonlinear tobit maximum likelihood estimation, we first generate estimates of $\hat{g}'_n$ and $\hat{r}'_n$ using (1) and use this to infer the values of the underlying subutility parameters, $\hat{\alpha}'_n$ and $\hat{\rho}'_n$, and the elasticity of social substitution $\hat{\sigma}'_n$. Then, the estimated parameters for the subutility function are employed in estimating the parameters $\hat{g}_n$ and $\hat{r}_n$ using (2), which are then used to infer the values of the parameters of the macro utility function $\hat{\alpha}_n$ and $\hat{\rho}_n$ and the elasticity of altruistic substitution $\hat{\sigma}_n$. Table AV1 presents the results of the estimations $\hat{a}_n$, $\hat{\rho}_n$, $\hat{\sigma}_n$, $\hat{a}'_n$, $\hat{\rho}'_n$ and $\hat{\sigma}'_n$ for the 29 subjects (44.6 percent) for whom we need to recover the underlying distributional preferences by estimating the CES model.

[Table AV1 here]

Table AV1. Results of individual-level three-person CES demand function estimation
(macro utility function)

ID	ρ	α	σ	g	sd(g)	r	sd(r)
136	0.097	0.405	0.093	0.652	0.053	-0.107	0.086
148	-2.336	0.999	0.116	7.734	1.877	0.700	0.195
151	0.375	0.472	0.198	0.837	0.133	-0.600	0.195
152	0.576	0.537	0.173	1.420	0.255	-1.360	0.238
156	0.676	0.423	0.243	0.385	0.120	-2.082	0.465
157	0.174	0.525	0.113	1.130	0.109	-0.210	0.094
159	0.205	0.875	0.069	11.565	2.186	-0.258	0.207
161	-0.338	0.914	0.088	5.871	1.145	0.253	0.159
163	0.795	0.500	0.299	1.004	0.473	-3.877	0.915
165	0.395	0.553	0.178	1.425	0.244	-0.652	0.174
166	-0.461	0.602	0.173	1.328	0.194	0.316	0.139
170	0.534	0.384	0.173	0.362	0.090	-1.146	0.289
172	0.349	0.504	0.132	1.026	0.140	-0.537	0.153
173	-0.425	0.519	0.135	1.055	0.127	0.298	0.109
174	0.594	0.580	0.150	2.221	0.333	-1.463	0.228
175	0.133	0.403	0.125	0.637	0.066	-0.153	0.110
176	0.990	0.688	0.135	7.9E+33	8.0E+34	-97.474	48.066
177	-0.698	0.678	0.097	1.551	0.153	0.411	0.100
179	-20.243	1.000	0.132	6.362	1.514	0.953	0.202
183	0.312	0.462	0.129	0.800	0.093	-0.454	0.144
185	-0.282	0.335	0.161	0.586	0.085	0.220	0.168
186	0.304	0.861	0.049	13.723	2.085	-0.437	0.177
187	0.114	0.770	0.113	3.917	0.708	-0.129	0.186
191	-0.295	0.553	0.143	1.179	0.131	0.228	0.116
192	0.642	0.636	0.159	4.772	1.235	-1.793	0.374
193	0.481	0.408	0.208	0.488	0.126	-0.925	0.288
194	0.646	0.381	0.300	0.253	0.124	-1.823	0.540
197	-0.914	0.607	0.082	1.255	0.099	0.478	0.073
198	0.581	0.742	0.076	12.463	2.889	-1.387	0.231

(sub utility function)

ID	ρ'	α'	σ'	g'	sd(g')	r'	sd(r')
136	0.121	0.531	0.134	1.153	0.095	-0.137	0.102
148	0.544	0.514	0.224	1.127	0.209	-1.195	0.319
151	0.655	0.537	0.255	1.532	0.315	-1.899	0.461
152	0.247	0.476	0.407	0.880	0.285	-0.328	0.435
156	0.562	0.497	0.241	0.975	0.171	-1.281	0.295
157	-0.079	0.503	0.118	1.012	0.070	0.074	0.082
159	0.400	0.426	0.320	0.610	0.187	-0.666	0.418
161	-10.891	0.607	0.136	1.037	0.095	0.916	0.145
163	0.889	0.442	0.397	0.123	0.299	-8.043	7.124
165	0.427	0.518	0.241	1.134	0.195	-0.746	0.274
166	-0.055	0.462	0.174	0.866	0.089	0.053	0.146
170	0.341	0.510	0.121	1.060	0.084	-0.516	0.101
172	0.626	0.504	0.117	1.049	0.093	-1.671	0.179
173	-0.269	0.563	0.198	1.220	0.146	0.212	0.125
174	0.636	0.470	0.194	0.719	0.134	-1.746	0.312
175	0.173	0.485	0.110	0.930	0.060	-0.210	0.080
176	0.926	0.453	0.309	0.079	0.737	-12.580	37.706
177	-9.359	0.612	0.031	1.045	0.020	0.903	0.036
179	-5.123	0.521	0.050	1.014	0.039	0.837	0.058
183	0.341	0.521	0.123	1.137	0.087	-0.517	0.110
185	0.099	0.496	0.206	0.982	0.118	-0.110	0.149
186	0.247	0.564	0.234	1.411	0.331	-0.328	0.329
187	0.452	0.503	0.165	1.026	0.119	-0.825	0.152
191	-1.714	0.522	0.071	1.033	0.045	0.632	0.060
192	0.421	0.415	0.263	0.552	0.190	-0.728	0.487
193	-0.364	0.434	0.220	0.823	0.112	0.267	0.200
194	0.646	0.497	0.273	0.963	0.208	-1.822	0.427
197	-2.390	0.593	0.068	1.117	0.048	0.705	0.062
198	0.978	0.502	0.019	1.452	0.153	-44.151	8.534

Appandix VI

The number of decisions corresponding to each subset of the step-shaped constraint aggregated to the subject level

<u>Lexself</u>

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
81	0	0	50	0	0	0	0	0	0	0	-
82	0	0	50	0	0	0	0	0	1	0	-
83	0	0	50	0	0	0	0	0	0	0	-
86	0	0	50	0	0	0	0	0	2	0	-
87	0	7	43	0	0	0	0	0	0	0	-
88	0	2	46	1	0	0	0	0	0	1	1.6
90	0	0	50	0	0	0	0	0	1	0	-
94	0	0	50	0	0	0	0	0	1	0	-
96	0	0	50	0	0	0	0	0	1	0	-
97	0	0	50	0	0	0	0	0	0	0	-
99	0	0	50	0	0	0	0	0	1	0	-
104	0	8	42	0	0	0	0	0	1	0	-
107	0	11	39	0	0	0	0	0	0	0	-
108	0	0	50	0	0	0	0	0	1	0	-
110	0	1	49	0	0	0	0	0	0	0	-
112	0	3	46	1	0	0	0	0	1	0	-
115	0	9	41	0	0	0	0	0	0	0	-
118	0	0	50	0	0	0	0	0	0	0	-
119	0	7	37	4	0	0	0	0	0	2	1.2
120	3	3	44	0	0	0	0	0	0	0	-
122	0	0	50	0	0	0	0	0	0	0	-
123	0	0	50	0	0	0	0	0	1	0	-
124	0	5	38	5	0	0	0	0	1	2	1.0
128	0	0	50	0	0	0	0	0	1	0	-
130	0	0	50	0	0	0	0	0	0	0	-
131	1	1	48	0	0	0	0	0	1	0	-
Mean	0.3	3.2	45.6	0.7	0.0	0.0	0.0	0.0	0.5	0.3	1.1

Table AVI1 (cont.)

Social welfare

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
80	0	0	45	0	0	0	5	0	1	0	-
101	0	0	44	0	0	0	6	0	0	0	-
105	0	0	45	0	0	0	5	0	0	0	-
106	0	0	48	0	0	0	2	0	1	0	-
121	0	0	45	0	0	0	5	0	0	0	-
132	0	3	36	0	0	1	10	0	0	0	-
134	0	3	43	1	0	0	3	0	1	0	-
Mean	0.0	0.9	43.7	0.1	0.0	0.1	5.1	0.0	0.4	0.0	-

Difference aversion

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
85	0	1	2	34	1	11	1	0	18	0	-
98	0	0	8	18	0	15	5	1	13	3	6.6
102	0	3	8	12	4	15	2	0	21	6	4.7
109	0	0	2	23	6	16	2	0	42	1	1.2
Mean	0.0	1.0	5.0	21.8	2.8	14.3	2.5	0.3	23.5	2.5	4.2

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
100	0	1	20	14	1	8	1	0	1	5	4.1
103	0	1	4	41	2	0	0	0	2	2	2.9
111	0	6	12	25	4	2	0	0	2	1	1.6
114	0	1	9	38	1	0	0	0	1	1	1.5
133	0	2	30	4	9	4	1	0	2	0	-
Mean	0.0	2.2	15.0	24.4	3.4	2.8	0.4	0.0	1.6	1.8	2.5

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
127	0	4	15	21	0	5	2	1	4	2	1.2

Table AVI1 (cont.)

Selfish

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
77	0	43	6	0	0	0	0	0	0	1	1.1
79	0	50	0	0	0	0	0	0	0	0	-
84	12	3	30	3	0	2	0	0	1	0	-
91	4	30	16	0	0	0	0	0	0	0	-
95	31	8	11	0	0	0	0	0	0	0	-
113	0	44	5	0	0	0	0	0	0	1	2.7
129	0	45	3	0	0	0	0	0	0	2	1.5
Mean	6.7	31.9	10.1	0.4	0.0	0.3	0.0	0.0	0.1	0.6	1.8

Competitive

ID	π^c	Π^1	π^s	Π^2	π^d	Π^3	π^o	Π^4	π^e	Obs.	Dist.
78	50	0	0	0	0	0	0	0	0	0	-
125	48	0	2	0	0	0	0	0	0	0	-
126	48	2	0	0	0	0	0	0	0	0	-
Mean	48.7	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-