Contests with Revisions*

Appendix - Online supplementary materials

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1 Appendix A - Proofs

1.1 Proposition 1 (All-Pay auction)

We characterize subgame perfect equilibria and thus start the analysis with round 2. As shown below, player A's round 2 best response correspondence is straightforward to characterize. Given player A's round 2 best response, round 1 shares important features with a complete information all-pay auction and asymmetric valuations. In particular, it follows from Baye et al. (1996) that in any equilibrium, the players must randomize. Baye et al.'s analysis and their Theorem 3 provide some background results.

In the proof, we assume that ties in expenditure are broken in favor of player A to avoid an open-set problem with player A's best response in round 2. It follows that if $x_B = x_{A2}$, player A wins the prize. Thus if round 2 is reached and $x_B < V$, player A's best response is $x^*_{A2} = x_B$, while if $x_B = V$, then player A's best response is the set $\{0, V\}$. In the former case, Player A wins the auction with certainty and earns a payoff of $V - x_B$ and in the latter, Player A's payoff is equal to $V - x_B = V - V = 0$ if $x^*_{A2} = V$ and to 0 as well if $x^*_{A2} = 0$. Thus, in any equilibrium, in the second round player A's payoff is $V - x_B$ if $x_B < V$ and 0 if $x_B = V$. Importantly for player B, in round 2 if $x_B < V$ player B's payoff is $-x_B$ and if $x_B = V$, then player B's payoff is $-V$ if $x^*_{A2} = V$ while it is equal to 0 if $x^*_{A2} = 0$.

In equilibrium in the first round, the players must randomize. We construct first round equilibrium distributions such that (a) both players randomize continuously on $[0, (1-\alpha)V]$ and player B may have (b) a mass point at zero and (c) a gap on $((1-\alpha)V, V)$ with a mass point at V. In the proof we assume that if $x_B = V$, then $x^*_{A2} = 0$ and player B wins with probability one, though netting a zero payoff. This generates equilibria in which player B has a mass point at V. We note that such equilibria do not arise if player B best responds to $x_B = V$ by setting $x^*_{A2} = V$.

Let $F_A(x_{A1})$ be player A's distribution and let $F_B(x_B)$ be player B's distribution. Also, define $S_B \subset [0, V]$ as the support of F_B. Using the above argument about round 2 expected payoffs, Player B's expected payoff from playing $x_B \in [0, V)$ is given by

$$\begin{aligned} Eu_B(x, F_A) &= (1-\alpha)[F_A(x)V - x] + \alpha(-x) \\ &= (1-\alpha)F_A(x)V - x. \end{aligned}$$

Since $Eu_B(x, F_A) = (1-\alpha)F_A(x)V - x \leq (1-\alpha)V - x$ and $Eu_B(x, F_A) \geq 0$ must hold (because player B can guarantee a payoff of zero by playing $x_B = 0$), it follows that player B's support does not contain expenditure levels in $((1-\alpha)V, V)$. Moreover, either player B has $x_B = V$ in his support or $(1-\alpha)V$ is the upper bound of his support. In the former case, it is clear that player B's equilibrium payoff must be zero since his payoff at $x_2 = V$ is zero. In the latter case, player B's payoff at $x_B = (1-\alpha)V$ is

$$Eu_B((1-\alpha)V, F_A) = (1-\alpha)[F_A((1-\alpha)V)V - (1-\alpha)V] + \alpha(-(1-\alpha)V)$$

which is less than zero if $F_A((1-\alpha)V) < 1$ and equal to zero is $F_A((1-\alpha)V) = 1$.

We thus seek to characterize equilibrium in which $(1-\alpha)V$ is the upper bound of player A's support and player B's equilibrium payoff is zero. Using the fact that player B's expected payoff is equal to zero at any $x \in S_B$, his expected payoff at $x = (1-\alpha)V$ satisfies:

$$\begin{aligned} U_B^* &= (1-\alpha)[V-(1-\alpha)V] + \alpha(-(1-\alpha)V) \\ &= 0. \end{aligned}$$

Therefore at any $x \in (0, (1-\alpha)V]$,

$$\begin{aligned} EU_B(x, F_A) = 0 &\iff (1-\alpha)[F_A(x)V - x] + \alpha(-x) = 0 \\ &\iff F_A(x) = \frac{x}{(1-\alpha)V}. \end{aligned}$$

Now let $h_B(V)$ denote the size of player B's mass point at $x_B = V$ and $h_B(0)$ the size of player B's mass point at $x_B = 0$. From the standpoint of round 1, player A's expected payoff when playing $x_{A1} = x$ is given by

$$\begin{aligned} EU_A(x, F_B) &= (1-\alpha)[F_B(x)V - x] + \alpha \int_{x_B \in S_2 \setminus \{V\}} (V - x_B) dF_B(x_B) + \alpha h_B(V) \times 0 \\ &= (1-\alpha)[F_B(x)V - x] + \alpha(V - E[x_B | x_B < V]) \end{aligned}$$

and at any point on the support, player A's expected payoff is constant and equal to some U_A^*:

$$(1-\alpha)[F_B(x)V - x] + \alpha(V - E[x_B | x_B < V]) = U_A^*.$$

In particular at $x = (1-\alpha)V$,

$$(1-\alpha)[(1-h_B(x))V - (1-\alpha)V] + \alpha(V - E[x_B | x_B < V]) = U_A^*$$

and at $x = 0$,

$$(1-\alpha)h_B(0)V + \alpha(V - E[x_B | x_B < V]) = U_A^*,$$

from which it follows that

$$h_B(0)V = (1-h_B(x))V - (1-\alpha)V \iff h_B(0) = \alpha - h_B(V)$$

Moreover, at x such that $0 < x < (1-\alpha)V$,

$$(1-\alpha)[F_B(x)V - x] + \alpha(V - E[x_B | x_B < V]) = U_A^*.$$

from which it follows that

$$(1-\alpha)[(1-h_B(x))V - (1-\alpha)V] = (1-\alpha)[F_B(x)V - x] \iff F_B(x) = \alpha - h_B(V) + \frac{x}{V}.$$

For any $h_B(V) \in [0, \alpha]$, the following distributions form round 1 equilibrium behavior strategies in a subgame perfect equilibrium:

$$F_A(x) = \begin{cases} \frac{x}{(1-\alpha)V} & \text{if } x \in [0,(1-\alpha)V] \\ 1 & \text{if } x > (1-\alpha)V \end{cases}$$

and

$$F_B(x) = \begin{cases} \alpha - h_B(V) + \frac{x}{V} & \text{if } x \in [0,(1-\alpha)V] \\ 1 - h_B(V) & \text{if } x \in ((1-\alpha)V, V] \\ 1 & \text{if } x \geq V \end{cases}$$

Using $F_B(x)$, player A's equilibrium expected payoff is given by

$$\begin{aligned} U_A^* &= (1-\alpha)(\alpha - h_B(V))V + \alpha(V - E[x_B|x_B < V]) \\ &= \frac{\alpha V}{2}(3 - \alpha^2 - 2h_B(V)) > 0 \end{aligned}$$

while player B's expected payoff is equal to zero.

Expected expenditure levels are given by

$$E[x_{A1}] = \int_0^V x dF_A(x) dx = \frac{(1-\alpha)V}{2}$$

$$E[x_B] = \int_0^V x dF_B(x) dx = \frac{(1-\alpha)^2 V}{2} + h_B(V)V.$$

Player A's probability of winning in round 2, $Prob_{A2}$ is equal to $1 - h_B(V)$ and in round 1, it is given by

$$Prob_{A1} = \int_0^V F_B(x) F_A^{'}(x) dx = \frac{1 + \alpha - 2h_B(V)}{2}.$$

Figure A1 illustrates equilibrium distributions for the case of no mass point at V and for an example where player B has a mass point at V.

Pareto dominant equilibrium: Since U_A^* above is strictly decreasing in $h_B(V)$ and $U_B^* = 0$ in every equilibrium, the equilibrium in which $h_B(V) = 0$ Pareto dominates equilibria in which $h_B(V) > 0$. For the experimental hypotheses, we focus on that equilibrium. Setting $h_B(V) = 0$, we have

$$F_A(x) = \begin{cases} \frac{x}{(1-\alpha)V} & \text{if } x \in [0,(1-\alpha)V] \\ 1 & \text{if } x > (1-\alpha)V \end{cases}$$

and

$$F_B(x) = \begin{cases} \alpha + \frac{x}{V} & \text{if } x \in [0,(1-\alpha)V] \\ 1 & \text{if } x \geq (1-\alpha)V \end{cases}$$

with round 1 expenditure levels equal to

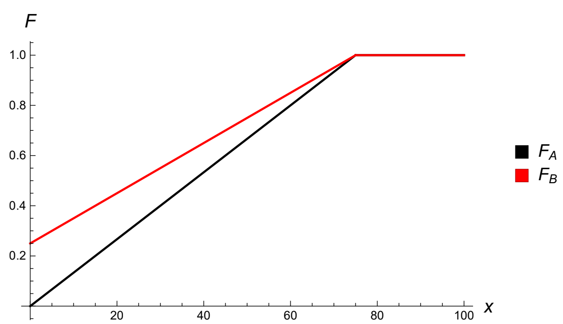
$$E[x_{A1}] = \frac{(1-\alpha)V}{2}$$

$$E[x_B] = \frac{(1-\alpha)^2 V}{2}.$$

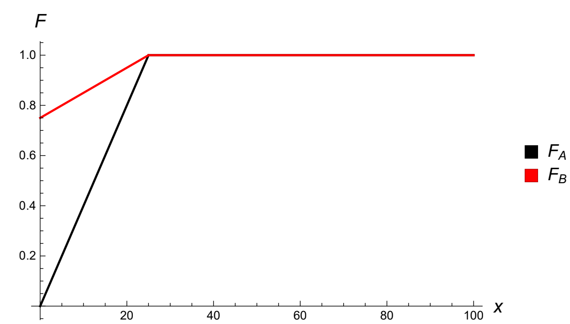
Since $\alpha < 1$, $E[x_{A1}] > E[x_B]$. Expected payoffs from the standpoint of round 1 are given by

$$U_A^* = \frac{\alpha V}{2}(3 - \alpha^2 - 2 \times 0) = \frac{\alpha V}{2}(3 - \alpha^2)$$
$$U_B^* = 0.$$

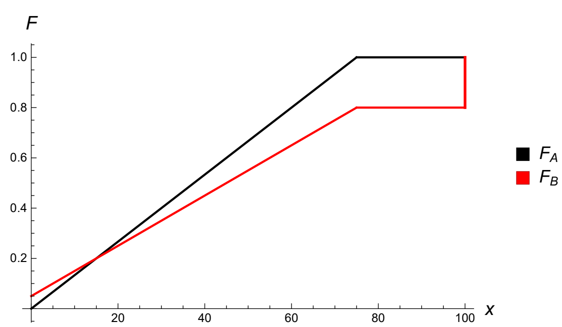
Figure A1: Round 1 equilibrium distribution in the all-pay auction for the Pareto dominant equilbrium ((a) and (b)) and for an inefficient equilibrium ((c) and (d)).



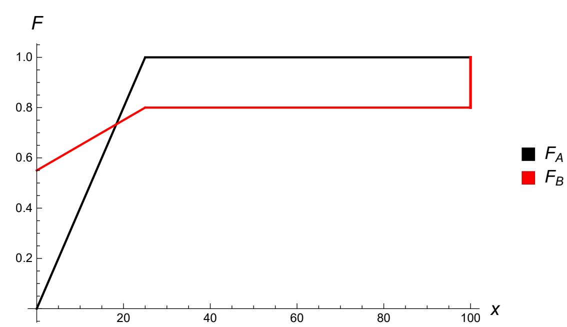
(a) $\alpha = 0.25$, no mass point at $x_B = V$



(b) $\alpha = 0.75$, no mass point at $x_B = V$



(c) $\alpha = 0.25$, mass point of 0.2 at $x_B = V$



(d) $\alpha = 0.75$, mass point of 0.2 at $x_B = V$

1.2 Proposition 2 (Lottery contest)

Let x_{A1} and x_B denote player A and player B's first round expenditure in the simultaneous moves game and x_{A2} denote player B's expenditure if the revision round – round 2 – is reached. Throughout, we assume $x_{At} \leq V$ and $x_B \leq V$, for $t \in \{1, 2\}$. If the game proceeds to round 2, Player A's expenditure is equal to his best response to x_B, which is given by the function

$$x'_{A2} = \sqrt{Vx_B} - x_B$$

for every $x_B \in (0, V]$. The best response to $x_B = 0$ is undefined since in this case, it is optimal for player A to set x_{A2} infinitesimally close to $x_B = 0$. However it is straightforward to rule out $x_B = 0$ in an equilibrium. Indeed, $x_B = 0$ can only be optimal if $x_{A1} = V$ or $x_{A2} = V$, which does not arise in equilibrium.

In round 1, in equilibrium Player B's expected payoff is given by

$$Eu_B(x_B, x_{A1}, x'_{A2}) = (1-\alpha)\frac{x_B V}{x_{A1} + x_B} + \alpha\frac{x_B V}{x'_{A2} + x_B} - x_B.$$

Substituting for x'_{A2}, the above can be simplified as

$$Eu_B(x_B, x_{A1}, x'_{A2}) = (1-\alpha)\frac{x_B V}{x_{A1} + x_B} + \alpha\sqrt{x_B V} - x_B.$$

Maximizing with respect to x_B, the FOC is

$$\frac{\partial Eu_B}{\partial x_B} = (1-\alpha)\frac{x_{A1} V}{(x_{A1} + x_B)^2} + \alpha\frac{\sqrt{V}}{2\sqrt{x_B}} - 1 = 0$$

and the SOC is satisfied

$$\frac{\partial^2 Eu_B}{\partial x_B^2} < 0$$

Now, in round 1, player A's expected payoff is

$$Eu_A(x_{A1}, x_B, x'_{A2}) = (1-\alpha)\left(\frac{x_{A1}}{x_{A1} + x_B}V - x_{A1}\right) + \alpha\left(\frac{x'_{A2}}{x'_{A2} + x_B}V - x'_{A2}\right)$$

Therefore player A's round 1 best response function is the same as his round 2 best response function:

$$x'_{A1} = \sqrt{x_B V} - x_B.$$

To solve for the equilibrium expenditure levels, we substitute for x'_{A1} into the FOC for player B and solve for x_B:

$$
\begin{aligned}
&(1-\alpha)\frac{x'_{A1}V}{(x'_{A1}+x_B)^2}+\alpha\frac{\sqrt{V}}{2\sqrt{x_B}}-1=0\\
\iff\ &(1-\alpha)\frac{(\sqrt{x_BV}-x_B)V}{(\sqrt{x_BV})^2}+\alpha\frac{\sqrt{V}}{2\sqrt{x_B}}-1=0\\
\iff\ &(1-\alpha)\frac{2(\sqrt{x_BV}-x_B)}{2x_B}+\alpha\frac{\sqrt{V}}{2\sqrt{x_B}}-1=0\\
\iff\ &2(1-\alpha)\sqrt{x_BV}-2(1-\alpha)x_B+\alpha\sqrt{x_BV}=2x_B\\
\iff\ &(2-\alpha)\sqrt{x_BV}=2(2-\alpha)x_B\\
\iff\ &\frac{\sqrt{V}}{2}=\sqrt{x_B}\\
\iff\ &\frac{V}{4}=x_B^*.
\end{aligned}
$$

and thus

$$
x_{A1}^*=x_{A2}^*=\sqrt{x_B^*V}-x_B^*=\frac{V}{4}.
$$

Expected payoffs are given by

$$
U_A^*=U_B^*=(1-\alpha)\frac{V/4}{V/4+V/4}V+\alpha\frac{V/4}{V/A+V/4}V-V/4=V/4.
$$

1.3 Revisions constrained to be upward only: $x_{A2}\geq x_{A1}$

Consider the game in which the type A player can only revise expenditure by increasing it, but not reducing it. In the lottery contest, equilibrium predictions remain the same and there is still nothing to gain from revising expenditure. More formally, if type A player can only revise expenditure upwards then it implies that given x_B, in round 2, a type A player chooses x_{A2} to solve

$$
\begin{gathered}
\text{Maximize } Eu_{A2}(x_{A2},x_B)\\
\text{subject to } x_{A2}\in[x_{A1},100]
\end{gathered}
$$

This is identical to the game in the paper except for the fact that the constraint in the paper is $x_{A2}\in[0,100]$. For a risk neutral player, the solution to the above problem is $x'_{A2}=\max\{x_{A1},R_A(x_B)\}$, where in the risk neutral case, $R_A(x_B)=10\sqrt{x_B}-x_B$. In round 1, the type A player's expected payoff is

$$
EU_A=(1-\alpha)\left[\frac{x_{A1}}{x_{A1}+x_B}100-x_{A1}\right]+\alpha\left[\frac{x'_{A2}}{x'_{A2}+x_B}100-x'_{A2}\right]
$$

If $x'_{A2}=x_{A1}$, then $x_{A1}>R_A(x_B)$ and EU_A can be increased by reducing x_{A1}. If $x'_{A2}=R_A(x_B)$, then either $x_{A1}<R_A(x_B)$ in which case EU_A can be increased by raising

x_{A1} (in this case, the term multiplied by α does not depend on x_{A1}), or $x_{A1} = R_A(x_B)$, in which case, raising x_{A1} results in

$$\frac{dEU_A}{dx_{A1}} = (1-\alpha)\left[\frac{x_{A1}}{(x_{A1}+x_B)^2}100 - 1\right] + \alpha\left[\frac{x_{A1}}{(x_{A1}+x_B)^2}100 - 1\right] = 0$$

when evaluated at $x_{A1} = R_A(x_B)$. Therefore, in equilibrium, $x_{A1} = x_{A2} = R_A(x_B)$. Thus, in a lottery contest, the subgame perfect Nash equilibrium in case where revision can be only made upwards is the same as in the case where x_{A2} is completely flexible.

In the all-pay auction, on the other hand, the restriction $x_{A2} \in [x_{A1}, 100]$ has significant implications. In the equilibrium characterized in the paper, whenever $x_{A1} > x_B$, the type A player's round 2 best response is to reduce expenditure. This adjustment is not possible if $x_{A2} \geq x_{A1}$ is required.

Below we construct equilibrium distributions for the type B player where the support of this player's distribution is $[0, (1-\alpha)100]$. In this equilibrium, the type B player's expected payoff is zero and the type A player's is maximized within the set of equilibrium payoffs. In such an equilibrium, the type A player's expected payoff in round 1 is given by:

$$EU_A(x, F_B) = (1-\alpha)\left[F_B(x)100 - x\right] + \alpha\left[100 - F_B(x)x - \int_x^{(1-\alpha)100} x_B f_B(x_B)\, dx_B\right]$$

The first term multiplied by $1-\alpha$ is the expected payoff if the game ends in round 1. For round 2, the terms multiplied by α include the prize minus (i) player A's expected expenditure in the event that player B's expenditure is such that $x > x_B$ and (ii) player A's expected expenditure if $x \leq x_B$, in which case player A can revise upward to $x_{A2} = x$. In case (i), player A's best response is x, unlike in the game in the paper. In equilibrium, the type A player earns a constant payoff U_A^* on the support of his equilibrium strategy. In particular, at $x = (1-\alpha)100$,

$$EU_A((1-\alpha)100, F_B) = (1-\alpha)\alpha 100 + \alpha^2 100 = \alpha 100$$

Differentiating the type A player's expected payoff at some x in the interior of the support, and setting equal to zero:

$$\frac{dEU_A}{dx} = (1-\alpha)f_B(x)100 - (1-\alpha) - \alpha\, F_B(x) = 0$$

The solution to the differential equation is

$$\widehat{F}_B(x) = k_1 \exp\left\{\left(\frac{\alpha x}{(1-\alpha)100}\right) - \frac{1-\alpha}{\alpha} + k_2\right\}$$

where k_1 and k_2 are constants. To solve for k_1 and k_2 we set up

$$\lim_{x \to 0} EU_A(x, F_B) = U_A^*$$

$$\Leftrightarrow (1-\alpha)\widehat{F}_B(0)100 + \alpha\left[100 - \int_0^{(1-\alpha)100} x_B \widehat{F}'_B(x)dx_B\right] = \alpha 100$$

and

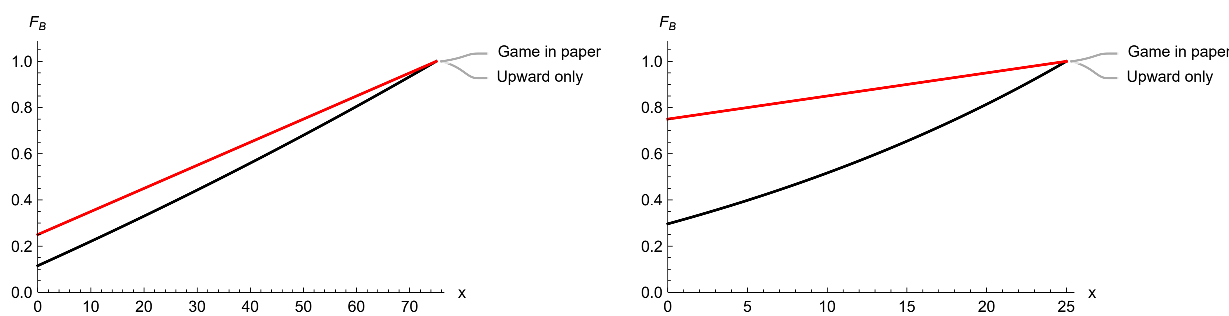
$$\widehat{F}_B\left((1-\alpha)100\right) = 1$$

Solving yields the following distributions for the type B player:

$$F_B(x) = \begin{cases} -3 + 3.12\exp(0.003x) & \text{if } \alpha = 0.25 \\ -0.33 + 0.63\exp(0.03x) & \text{if } \alpha = 0.75 \end{cases}$$

The distributions for the type A player are unchanged compared to the game with flexible expenditure analyzed in the paper. Qualitatively, the results are the same as for the game in the paper. Of course, the relative lack of flexibility implies that in this game, the type A player is worse off than in the comparable equilibrium of the game in the paper ($\alpha 100 < \alpha 50(3-\alpha^2)$). In particular, in the game where $x_{A2} \geq x_{A1}$, the type B player bids much more aggressively than in the game in the paper (otherwise the type A player would reduce expenditure in order to avoid "overexpending" in round 2 which occurs whenever $x_{A1} > x_B$ and the type A player is unable to reduce expenditure to just slightly outspend the type B player), with a much lower mass point at zero.

Figure A2: Type B player's equilibrium distributions: Compare: Game in paper (red) to game with $x_{A2} \geq x_{A1}$ ("Upward only", black)



(a) $\alpha = 0.25$ (b) $\alpha = 0.75$

As shown on the above graphs, the type B player submits higher expenditure levels than in the game in the paper. Thus, she wins more often than in the game in the paper, but she nonetheless nets a payoff of zero in expected terms.

2 Appendix B - Sample instructions

WELCOME

This is an experiment in the economics of strategic decision making. The instructions for the experiment are simple. If you follow them closely and make appropriate decisions, you can earn an appreciable amount of money. It is very important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

At the end of the experiment you will be paid privately and in cash. In order to keep your decisions private, please do not reveal your choices to any other participant. You may cease participation at any point; if you do, you will receive the $7 participation fee but will not receive any additional compensation.

THE EXPERIMENT

The experiment will proceed in five parts. Each part contains decision problems that require you to make a series of economic choices which determine your total earnings. The currency used in Parts 1 and 2 of the experiment is U.S. Dollars. The currency used in Parts 3-5 of the experiment is Francs. These Francs will be converted to U.S. Dollars at a rate of 15 Francs to 1 dollar.

INSTRUCTIONS FOR PARTS 1 - 2

In PARTS 1 and 2 of the experiment, you will be asked to make a series of choices in decision problems. How much you receive will depend partly on chance and partly on the choices you make. In each PART, you will see a table with 20 lines. You will state whether you prefer Option A or Option B in each line. You should think of each line as a separate decision you need to make. However, in each PART only one line will be the 'line that counts' and will be paid out. In particular, at the end of the experiment, the computer will randomly choose a line by throwing a 20-sided die. The number on the die indicates which line in that part will be paid out. For instance, if the number on the first roll of the die is 17, you will be paid for your choice in line 17 in PART 1. If the number on the second roll of the die is 8, you will be paid for your choice in line 8 in PART 2. Because each line is equally likely to be selected, and because you do not know which line will be selected when you make your choices, you should pay close attention to the choices you make in each line. Both PARTS have very different row payouts and probabilities. So you should think of each part as separate.

PART 1

For each line in the table, please state whether you prefer option A or option B. Notice that there are a total of 20 lines in the table - you should think of each line as a separate decision you need to make. Your earnings for the selected line depend on which option you chose: If you chose option B in that line, you will receive an amount of money specified by option B - between $0.25 and $5 - depending on the line. If you chose option A in that line, you will receive either $5 or $0. To determine your earnings in the case you chose option A the computer will draw a random number. To visualize how this is done, picture the computer randomly drawing a ball from a bag containing twenty balls. There are ten pink and ten green balls in the bag. This means that there is a 50% chance that the drawn ball is pink and a 50% chance that it is green. If the drawn ball is pink, you will receive $5 which corresponds to the payoffs in the column labelled pink. If the drawn ball is green, you will receive $0, which corresponds to the payoffs in the column labelled green. For instance, suppose the chosen line is 6 (see below). If you chose Option B, then you get $1.50 for sure. If you chose Option A, then there is a 50% chance you get $5 and

50% chance you get $0. While you have all the information in the table, you should input all your 20 decisions into the computer. The actual drawing of the ball and the throw of the 20-sided die by the monitor computer for this part of the experiment will be done at the end of the experiment. Use the following tables for your reference:

Decision Number	OPTION A		OPTION B	Choose A or B
	PINK	GREEN		
1	$5.00 with 50% chance	$0.00 with 50% chance	$0.25 for sure	
2	$5.00 with 50% chance	$0.00 with 50% chance	$0.50 for sure	
3	$5.00 with 50% chance	$0.00 with 50% chance	$0.75 for sure	
4	$5.00 with 50% chance	$0.00 with 50% chance	$1.00 for sure	
5	$5.00 with 50% chance	$0.00 with 50% chance	$1.25 for sure	
6	$5.00 with 50% chance	$0.00 with 50% chance	$1.50 for sure	
7	$5.00 with 50% chance	$0.00 with 50% chance	$1.75 for sure	
8	$5.00 with 50% chance	$0.00 with 50% chance	$2.00 for sure	
9	$5.00 with 50% chance	$0.00 with 50% chance	$2.25 for sure	
10	$5.00 with 50% chance	$0.00 with 50% chance	$2.50 for sure	
11	$5.00 with 50% chance	$0.00 with 50% chance	$2.75 for sure	
12	$5.00 with 50% chance	$0.00 with 50% chance	$3.00 for sure	
13	$5.00 with 50% chance	$0.00 with 50% chance	$3.25 for sure	
14	$5.00 with 50% chance	$0.00 with 50% chance	$3.50 for sure	
15	$5.00 with 50% chance	$0.00 with 50% chance	$3.75 for sure	
16	$5.00 with 50% chance	$0.00 with 50% chance	$4.00 for sure	
17	$5.00 with 50% chance	$0.00 with 50% chance	$4.25 for sure	
18	$5.00 with 50% chance	$0.00 with 50% chance	$4.50 for sure	
19	$5.00 with 50% chance	$0.00 with 50% chance	$4.75 for sure	
20	$5.00 with 50% chance	$0.00 with 50% chance	$5.00 for sure	

PART 2

For each line in the table, please state whether you prefer option A or option B. Notice that there are a total of 20 lines in the table - you should think of each line as a separate decision you need to make. Your earnings for the selected line depend on which option you chose: If you chose option B in that line, you will receive $0. If you chose option A in that line, you can receive either a loss between -$0.50 and -$10, depending on the line, or a gain of $5. To determine your earnings in the case you chose option A the computer will randomly draw a ball from a bag containing twenty balls. To visualize how this is done, picture the computer randomly drawing a ball from a bag containing twenty balls. There are ten pink and ten green balls in the bag. This means that there is a 50% chance that the drawn ball is pink and a 50% chance that it is green. If the drawn ball is pink, you will receive -$x (the exact amount depends on the line chosen in the column labelled pink). If the drawn ball is green, you will receive $5, which corresponds to the payoffs in the column labelled green.

For instance, suppose the chosen line is 6 (see below). If you chose Option B, then you get $0 for sure. If you chose Option A, then there is a 50% chance you lose $3 and 50% chance you get $5. While you have all the information in the table, you should input all your 20 decisions into the computer. The actual drawing of the ball and the throw of the 20-sided die by the monitor computer for this part of the experiment will be done at the end of the experiment. Use the following tables for reference:

Decision Number	OPTION A		Option B	Choose A or B
	PINK	GREEN		
1	-$0.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
2	-$1.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
3	-$1.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
4	-$2.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
5	-$2.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
6	-$3.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
7	-$3.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
8	-$4.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
9	-$4.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
10	-$5.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
11	-$5.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
12	-$6.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
13	-$6.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
14	-$7.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
15	-$7.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
16	-$8.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
17	-$8.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
18	-$9.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
19	-$9.50 with 50% chance	$5.00 with 50% chance	$0.00 for sure	
20	-$10.00 with 50% chance	$5.00 with 50% chance	$0.00 for sure	

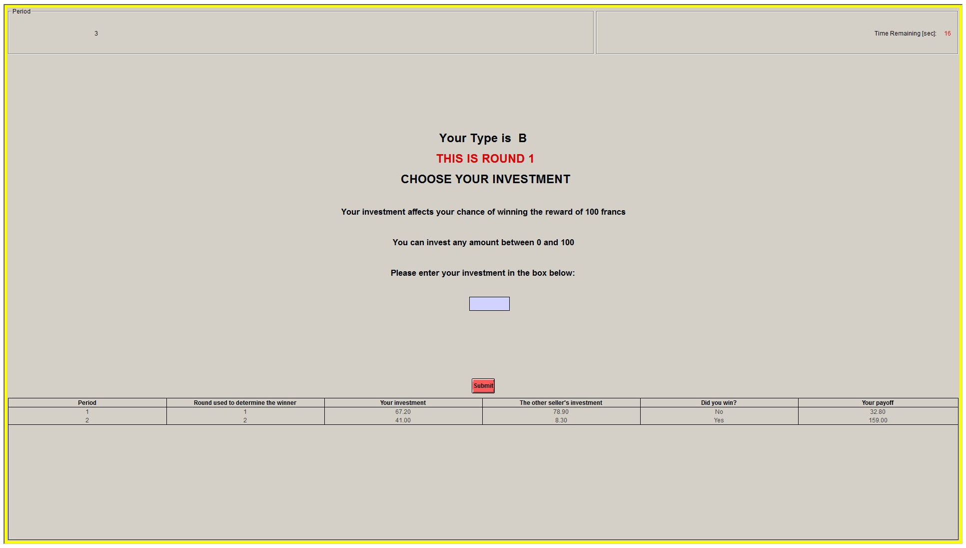
INSTRUCTIONS FOR PART 3
YOUR DECISION

This part of the experiment consists of 20 decision-making periods. How much you receive will depend partly on the choices you make and partly on the choices made by the other participants in the room.

The 16 participants in today's experiment will be randomly re-matched every period into 8 groups with 2 participants in each group. Therefore, the specific person who is the other participant in your group will change randomly after each period. The group assignment is anonymous, so you will not be told which of the participants in this room are assigned to your group.

Each period you and the other participant in your group will simultaneously make investment decisions. You will be given an initial endowment of 100 francs that you may use to make an investment. Your investment in each period cannot exceed 100 francs (any number, including 2 decimal points). The more you invest, the more likely you are to win a particular period. This will be explained in more detail later. The participant who wins receives the reward of 100 francs.

Your total earnings depend on whether or not you receive the reward and on how many francs you spent on investment. An example of your decision screen is shown below in Figure 1:



THE TWO ROUNDS

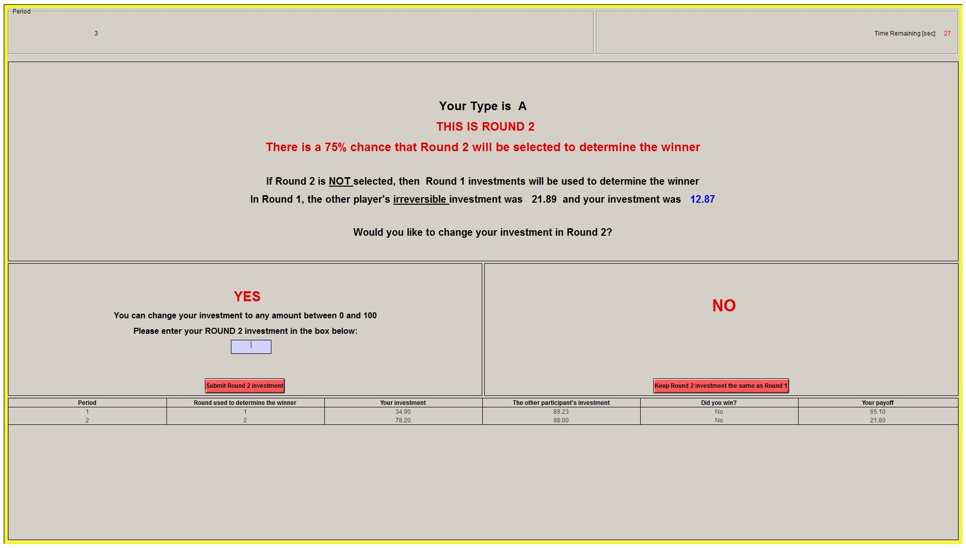
In every period, there will be two rounds of decision-making. Regardless of your type, you and the other participant must submit an investment decision in Round 1. If your type is B, this choice is irreversible and thus cannot be changed. After submitting your Round 1 investment,

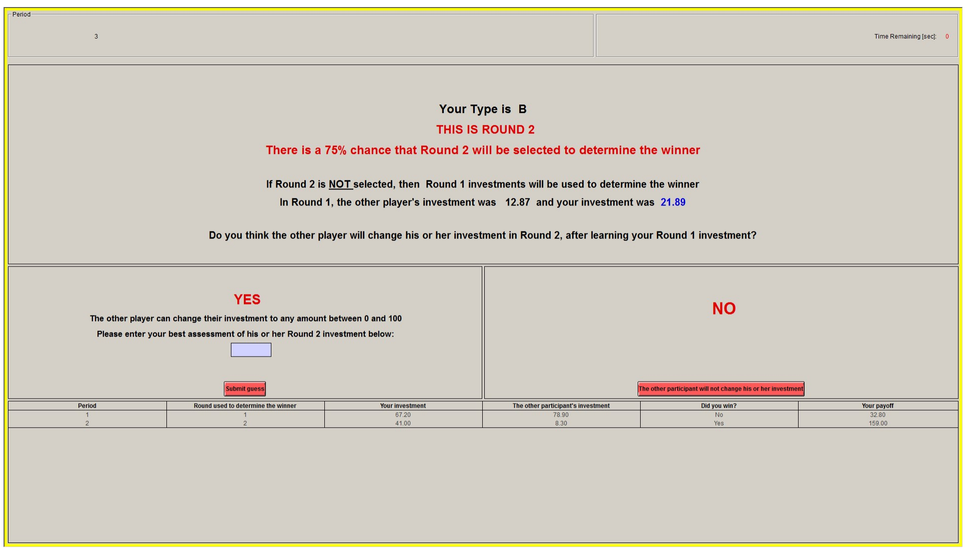
- if your type is A, you will learn the other participant's Round 1 investment and you will be asked whether you wish to change your investment. We refer to this as Type A's Round 2 investment. You are not required to change your investment in which case your Round 2 investment is equal to your Round 1 investment.
- if your type is B you will be asked to submit a guess regarding the other participant's decision to change his or her investment in Round 2. Please submit your best guess. Note that your guess has absolutely no impact on how the payoffs are determined.

To determine the payoffs, the computer will first select which investments are used to determine the winner. If your Type is B, your Round 1 investment will be used for sure. If your Type is A, then there is a 25% chance that your Round 1 investment will be used and a 75% chance that your Round 2 investment will be used. In other words, with a 25% chance, the computer determines the winner using Type A's Round 1 investment and Type B's Round 1 investment; and with a 75% chance, the computer determines the winner using Type A's Round 2 investment and Type B's Round 1 investment.

Note that your player type - Type A or Type B - is randomly determined every period. Your type in a particular period is not determined by your investment decisions in previous periods or by your type in previous periods. That is, in each period, you are equally likely to be the Type A or the Type B participant in your group.

An example of the decision screen for Type A in Round 2 is shown in Figure 2. Figure 3 shows the corresponding decision screen for Type B in Round 2.





[*all-pay SESSIONS*]

DETERMINING THE WINNER

If your investment is higher than the other participant's then you win the reward. So, if you invest X francs while the other participant invests Y francs, where X > Y then the computer will choose you as the winner for the period. For instance, if your investment is 20 francs and the other participant's investment is 10 francs, then you win. If instead X = Y, then the computer will randomly determine the winner so that in this case, both you and the other participant are equally likely to win.

[*LOTTERY SESSIONS*]

CHANCE OF WINNING

You can never guarantee a win. However, the greater your investment is relative to the other participant's investment, the greater is your probability of winning. That is, the more you invest, the more likely you are to win. The more the other participant in your group invests, the less likely you are to win. Specifically, your chance of winning is given by the following expression.

$$\text{Your change of winning} = \frac{\text{Your investment}}{\text{Your investment} + \text{The Other Participant's Investment}}$$

Think of it in the following way. For each Franc you invest, you receive lottery tickets. For example, if you invest 10 Francs and the other participant invests 20 Francs, you will receive 10 lottery tickets and the other participant receives 20 lottery tickets. At the end of each period the computer randomly draws one ticket among all the tickets purchased by you and the other participant in your group. The owner of the drawn ticket wins in that period. In the example above, your chance of winning is $0.33 = 10/(10+20)$ and the other participant's chance of winning is $0.67 = 20/(10+20)$. Note that your chance of winning is proportional to the amount of lottery tickets you purchased.

YOUR PAYOFF

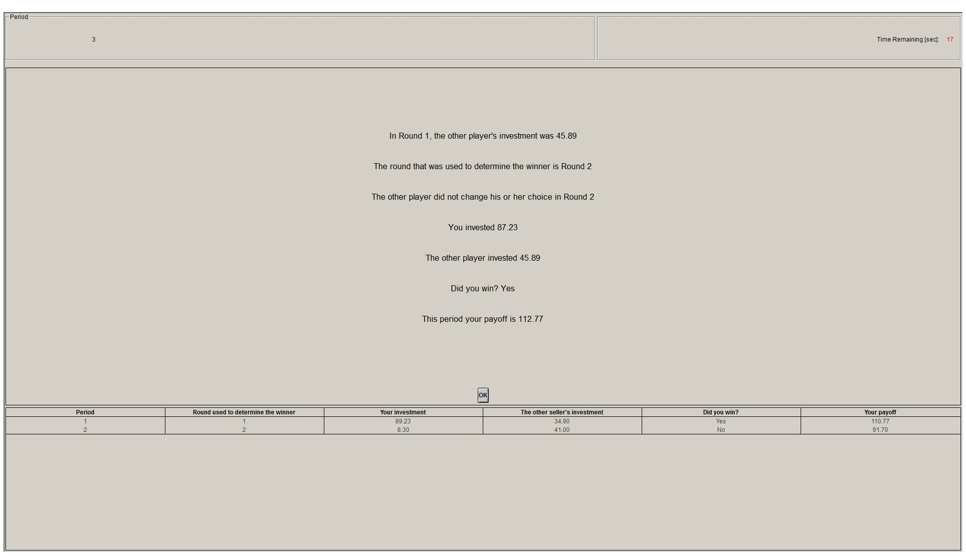
In every period, your payoff for the period depends on how many Francs you invest and whether or not you win in that period.

Your Payoff if you win= 100+100 - your investment
Your payoff if you lose= 100+0 - your investment

END OF THE PERIOD

After both participants make their decisions in Round 1 and Round 2, the computer will make a random draw to select which investments are used to determine the winner. You will then observe the outcome of the period - your investment, the other participant's investment, the round used to determine the winner, whether or not you won as well as your payoff for this period, as shown in Figure 4.

Importantly, note that you will be randomly re-matched with a different participant at the start of the next period.



At the end of the experiment the computer will roll a 20 sided die to randomly select 1 out of 20 periods from Part 3 for actual payment. Your earnings will be converted to a U.S. dollar payment, as shown on the last page of your personal record sheet.

Are there any questions?

INSTRUCTIONS FOR PART 4

This part of the experiment also consists of 20 decision-making periods where you will be randomly re-matched with another participant in every period. Your player type - Type A or Type B - will also be randomly determined at the beginning of each period, as in Part 3. All other rules for Part 4 are the same as the rules for Part 3.

The only difference in this part of the experiment is that the probability that the computer chooses Round 1 investments to determine the winner is now 75%. To summarize, with a 75% chance, the computer determines the winner using Type A's Round 1 investment and Type B's Round 1 investment; and with a 25% chance, the computer determines the winner using Type A's Round 2 investment and Type B's Round 1 investment.

At the end of the experiment, the computer will roll a 20 sided die to randomly select 1 out of 20 periods from Part 4 for actual payment. Your earnings will be converted to a U.S. dollar payment, as shown on the last page of your personal record sheet.

INSTRUCTIONS FOR PART 5

The last part of the experiment consists of only 1 decision-making period. The rules for PART 5 are the same as the rules for PARTS 3 and 4. At the beginning of the period, you will be randomly matched with another participant. You will be given an initial endowment of 100 Francs. You will use this endowment to make an investment in order to be a winner. For each Franc you investment you will receive one lottery ticket. At the end of the single period the computer draws randomly one ticket among all the tickets purchased by you and the other participant in your group. The owner of the drawn ticket becomes a winner. Thus, your chance of becoming a winner is given by the number of Francs you invest divided by the total number of Francs in your group investment.

The only difference is that in PART 5 the winner does not receive the reward. Therefore, the reward is worth 0 Francs to you and the other participant in your group. After all participants have made their decisions, your earnings in Francs are calculated:

Your Payoff if you win= 100+0 - your investment
Your payoff if you lose= 100+0 - your investment

After all participants have made their decisions, your payoff will be displayed on the outcome screen. Your earnings will be converted to a U.S. dollar payment, as shown on the last page of your personal earnings sheet.

END OF THE EXPERIMENT

After Part 5 has ended, we will ask you to answer a short questionnaire. The computer will make the draws for each part when everyone has finished their questionnaire. The last screen will contain your earnings from each part of the experiment. Please write these in the earnings sheet, and the experimenter will come to your station to pay you in cash privately. We urge you to exit quietly and not discuss the experiment with others.

3 Appendix C - Expenditure choices near zero

Table C1: Distribution of subjects within frequency categories of expenditure choices between 0 and 5.

	Frequency of expenditure choices between 0 and 5				
All-Pay auction	**0-25%**	**25-50%**	**50-75%**	**75-100%**	**Total**
$\alpha = 0.25$	37	16	6	5	64
$\alpha = 0.75$	25	18	12	9	64
Lottery	**0-25%**	**25=50%**	**50-75%**	**75-100%**	**Total**
$\alpha = 0.25$	49	4	8	3	64
$\alpha = 0.75$	46	5	7	6	64

Table C2: Probit regressions with subject random effects, session dummies and standard errors clustered at the session level. Average partial effects are reported. The dependent variable is equal to 1 if the subject's expenditure was between 0 and 5 in period t and equal to 0 otherwise.

	Dependent variable = 1 if expenditure is between 0 and 5; = 0 otherwise	Dependent variable = 1 if expenditure is between 0 and 5; = 0 otherwise
1/Period	-0.192*** (0.03)	-0.122** (0.04)
Alpha dummy	0.145*** (0.02)	0.238*** (0.03)
Lottery dummy (= 1 if lottery)	-0.0208 (0.10)	0.0126 (0.10)
Type B dummy (= 1 if Type B)	0.0602*** (0.01)	0.200*** (0.03)
Type B x 1/Period		-0.143*** (0.05)
Type B x Alpha		-0.178*** (0.04)
Type B x Lottery		-0.0621*** (0.02)
Observations	5120	5120