Liquidity Risk in Sequential Trading Networks

Online Appendix

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A Mixed and Non-Monotone Equilibria

Our theoretical analysis and experimental investigation focus on our model's symmetric, monotone, pure-strategy equilibrium. Our model admits many *mixed* and *non-monotone* equilibria as well. Below we briefly explain why other equilibria arise and how they can be constructed.

Given our baseline equilibrium characterization (Theorem 1), it is straightforward to construct other equilibria. Recall that Corollary 3 concluded that the equilibrium payoff of a trader with budget $w > w_r^*$ is

$$U_r(w) = F(w_r^*)^{N-1}(\nu_{r-1}^* - w_r^*),$$

which is a constant value independent of his bid (above w_r^*). Therefore, given others' strategies, a trader in row r is indifferent among all bids in the range of $b_r^*(w)$ above w_r^*. Conditional on having a sufficient budget, he can plan to randomize his bid in this range. Provided that

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across bidder types the randomization replicates the original equilibrium bid distribution, another equilibrium will obtain.

We can formalize this analysis further by defining a family of equilibria in *distributional strategies*. Following Milgrom and Weber (1985), a distributional strategy $\eta_{ri}(b, w)$ for bidder i in row r as a joint probability measure over bids and types. Let ν^*_{r-1} and $U_r(w)$ be defined as in Theorem 1 and define w^*_r as in Corollary 1. It is straightforward to verify that any family of $\eta_{ri}(w, b)$ satisfying the following conditions is an equilibrium of the trading game.

1. The support of $\eta_{ri}(w, b)$ is the set $\{(w, b)\colon 0 \leq b \leq w\} \subset [0, \bar{w}] \times [0, \bar{w}] = \mathcal{W} \times \mathcal{B}$.

2. The marginal cumulative distribution of $\eta_{ri}(w, b)$ on $\mathcal{W} = [0, \bar{w}]$ is $F(w)$.

3. The marginal cumulative distribution of $\eta_{ri}(w, b)$ on $\mathcal{B} = [0, \bar{w}]$ is

$$\sigma_{ri}(b) = \begin{cases} F(b) & b < w^*_r \\ F(w^*_r) + \left(\frac{U_r(w^*_r)}{\nu^*_{r-1} - b}\right)^{\frac{1}{N-1}} & b \in [w^*_r, \bar{b}_r) \\ 1 & \bar{b}_r \leq b \end{cases}$$

   where $\bar{b}_r = \nu^*_{r-1} - U(w^*_r)$.

4. For all $w < w^*_r$, the (conditional) cumulative distribution of b is

$$\sigma_{ri}(b|w) = \begin{cases} 0 & b < w \\ 1 & w \leq b \end{cases}.$$

Point 1 ensures that a trader bids less than his budget. Point 2 ensures the implied distribution of budgets aligns with our model's primitives. Point 3 describes the implied distribution of bids. This marginal distribution coincides with the budget distribution for bids below the critical value w^*_r. Finally, point 4 ensures that all agents with a low budget expend all of their funds, as implied by utility maximization.

B Trading Profits and Limited Liability

Per lab policy, our experimental protocol required subjects not to incur a loss. This limited liability requirement affected trader payoffs as follows. If a trader in row r paid b_r for the asset and resold it for b_{r-1}, his payoff was $\max\{b_{r-1} - b_r, 0\}$. In this appendix we outline the implications of this limited liability requirement. Specifically, we characterize the monotone equilibrium analogous to that reported in Theorem 1 for the case of no limited liability. To do so, we rely on the following lemma.

Lemma B.1. *Let $H_{r-1}(x)$ be the cumulative distribution function (c.d.f.) of the highest bid placed by a trader in row $r-1$. Suppose $H_{r-1}(x)$ is continuous, admits a density $h_{r-1}(x)$, and has support given by $[0, \bar{x}]$. For all $b \in [0, \bar{x}]$, let*

$$\begin{aligned} V_r(b) &= F(b)^{N-1} \int_0^{\bar{x}} \max\{x - b, 0\} h_{r-1}(x) dx \\ &= F(b)^{N-1} \int_b^{\bar{x}} (x - b) h_{r-1}(x) dx \end{aligned}$$

and assume that $V_r(b)$ is single-peaked. Let $\tilde{U}_r(w) = \max_{0 \le b \le w} V_r(b)$ and define $\tilde{b}_r(w)$ implicitly as the solution to

$$\begin{aligned} \tilde{U}_r(w) &= F(w)^{N-1} \int_0^{\bar{x}} \max\left\{x - \tilde{b}_r(w), 0\right\} h_{r-1}(x) dx. \\ &= F(w)^{N-1} \int_{\tilde{b}_r(w)}^{\bar{x}} \left(x - \tilde{b}_r(w)\right) h_{r-1}(x) dx. \end{aligned}$$

The function $\tilde{b}_r \colon [0, \bar{w}] \to [0, \bar{w}]$ defines a symmetric, monotone equilibrium of the first price auction among traders in row r given the limited liability constraint and the distribution of expected bids placed by traders in row $r-1$.

Proof. Suppose $V_r(\cdot)$ attaints its maximum at $\tilde{w}_r \in (0, \bar{x})$. Then,

$$\tilde{U}_r(w) = \begin{cases} F(w)^{N-1} \int_w^{\bar{x}} (x - w) h_{r-1}(x) dx & w < \tilde{w}_r \\ F(\tilde{w}_r)^{N-1} \int_{\tilde{w}_r}^{\bar{x}} (x - \tilde{w}_r) h_{r-1}(x) dx & w \ge \tilde{w}_r \end{cases}$$

Thus, for all $w < \tilde{w}_r$, $\tilde{b}_r(w) = w$. For all $w \ge \tilde{w}_r$, $\tilde{b}_r(w)$ is strictly increasing, less than w, and continuous.

To verify that $\tilde{b}_r(w)$ characterizes a symmetric equilibrium it is sufficient to confirm that when all traders in row r other than i bid according to that strategy, it is a best response for trader i to also bid according to this strategy. There are two cases.

1. Suppose trader i has a budget $w_i < \tilde{w}_r$. Given the strategy followed by other bidders, when i bids $b_i \leq w_i$, his expected payoff is $F(b_i)^{N-1} \int_{b_i}^{\bar{x}} (x - b_i) h_{r-1}(x) dx$. This expression is increasing in b_i. Hence $\tilde{b}_r(w_i) = w_i$ is the optimal bid.

2. Suppose trader i has a budget $w_i \geq \tilde{w}_r$. By the preceding case, it follows that all bids $b_i < \tilde{w}_r$ are dominated by the bid $\tilde{w}_r$. Of course, all bids exceeding $\tilde{b}_r(\bar{w})$, the maximum bid submitted by any competing bidder, are also dominated. If bidder i places a (feasible) bid of $b_i \in (\tilde{w}_r, \tilde{b}_r(\bar{w})]$, his expected payoff given the others' strategy is

$$\tilde{U}_r(\tilde{b}_r^{-1}(b_i)) = F(\tilde{b}_r^{-1}(b_i))^{N-1} \int_{b_i}^{\bar{x}} (x - b_i) h_{r-1}(x) dx.$$

   Given the definition of $\tilde{b}_r(\cdot)$, the preceding expression is a constant value equal to $F(\tilde{w}_r)^{N-1} \int_{\tilde{w}_r}^{\bar{x}} (x - \tilde{w}_r) h_{r-1}(x) dx$ for all $b_i \in (\tilde{w}_r, \tilde{b}_r(\bar{w})]$. Therefore, bidder i is indifferent among all bids in the range of $\tilde{b}_r(w)$ above $\tilde{w}_r$. Hence, $\tilde{b}_r(w_i)$ is a best response.

□

Remark B.1. Applying Lemma B.1 inductively on a row-by-row basis defines an equilibrium of the trading game as a whole.

We can employ Lemma B.1 and Remark B.1 to (numerically) compute the implied equilibrium strategy in our experimental parameterization. We illustrate the first two steps of this calculation below using notation parallel to that of Lemma B.1. There are three rows ($R = 3$) with three traders each ($N = 3$). Budgets are uniformly distributed on the unit interval, $F(w) = w$. (This is a convenient normalization.) We let $b_r^*(\cdot)$ denote the monotone equilibrium bidding strategy without limited liability (Theorem 1). We let $\tilde{b}_r(\cdot)$ denote the monotone equilibrium bidding strategy with limited liability.

Since the buyer pays a fixed value for the asset exceeding the maximum budget, no calculations are required to characterize bidding of row 1 traders when they face limited liability. The strategy from the baseline case applies:

$$\tilde{b}_1(w) = b_1^*(w) = \begin{cases} w & w < \frac{2}{3} \\ 1 - \frac{4}{27w^2} & \frac{2}{3} \leq w \end{cases}. \tag{B.1}$$

Given (B.1), the probability with which a trader in row places a bid less than x is given by the cumulative distribution function (c.d.f.)

$$\begin{cases} x & x \in \left[0, \frac{2}{3}\right] \\ \frac{2}{3}\sqrt{\frac{1}{3-3x}} & x \in \left(\frac{2}{3}, \frac{23}{27}\right] \end{cases}.$$

Thus, the c.d.f. of the highest bid submitted by a bidder in row 1 is

$$H_1(x) = \begin{cases} x^3 & x \in \left[0, \frac{2}{3}\right] \\ \frac{8}{27}\left[\frac{1}{3-3x}\right]^{3/2} & x \in \left(\frac{2}{3}, \frac{23}{27}\right] \end{cases}.$$

The associated probability density function (p.d.f.) is

$$h_1(x) = \begin{cases} 3x^2 & x \in \left[0, \frac{2}{3}\right] \\ \frac{4}{3}\left[\frac{1}{3-3x}\right]^{5/2} & x \in \left(\frac{2}{3}, \frac{23}{27}\right] \end{cases}.$$

Now, fix $b \in \left[0, \frac{23}{27}\right]$ and define the following expression:

$$\begin{aligned} V_2(b) &= F(b)^2 \int_0^{\frac{23}{27}} \max\{x-b, 0\} h_1(x)dx \\ &= F(b)^2 \int_b^{\frac{23}{27}} (x-b)h_1(x)dx \\ &= \begin{cases} b^2\left[\frac{19}{27} - b + \frac{b^4}{4}\right] & b \in \left[0, \frac{2}{3}\right] \\ b^2\left[\frac{5}{9} + \frac{16}{81\sqrt{3-3b}} - b\right] & b \in \left(\frac{2}{3}, \frac{23}{27}\right] \end{cases} \end{aligned} \tag{B.2}$$

We observe that $V_2(b)$ is strictly increasing for all $b < 0.5005$ and decreasing thereafter. We define $\tilde{w}_2 = 0.5005$. Let $\tilde{U}_2(w) = \max_{0 \le b \le w} V_2(b)$. Noting the parallel with (B.2), define $\tilde{b}_2(w)$ as the solution to

$$\tilde{U}_2(w) = F(w)^2 \int_{\tilde{b}_2(w)}^{\frac{23}{27}} (x - \tilde{b}_2(w))h_1(x)dx. \tag{B.3}$$

The function $\tilde{b}_2(w)$ is continuous has the following properties. For all $w < \tilde{w}_2$, $\tilde{b}_2(w) = w$. For all $w \ge \tilde{w}$, $\tilde{b}_2(w)$ is strictly increasing.

For $w < \tilde{w}_2^*$, $\tilde{b}_2(w) = w$. For $w > \tilde{w}_r^*$, there is no closed form solution for $\tilde{b}_2(w)$. However, we can solve (B.3) numerically on a grid of values for w. Using this numerical solution, or a high-order polynomial approximation, we can compute the distribution $H_2(x)$. Repeating the reasoning above, we can compute $\tilde{b}_3(w)$.

The strategies resulting from these calculations are illustrated in Figure 4.

C Experiment Instructions

This appendix presents sample instructions from the "3×3" experiment treatment. Instructions for the "1×3" and "2×3" treatments were similar.

Instructions

This is an experiment in decision-making. Your payoffs will depend partly on your decisions and on the decisions of the other participants and partly on chance. Funding for this experiment has been provided by the University of California and by public and private research foundations. Please pay careful attention to the instructions as a considerable amount of money is (potentially) at stake.

Your participation in the experiment and any information about your payment will be kept strictly confidential. Each participant will be assigned a participant ID number. This number will be used to record all data, and only the person(s) making payments (*not* the experimenters) will have both the list of participant ID numbers and names. Neither the experimenters nor the other participants will be able to link you to any of your decisions. Neither your name nor any other identifying information about you will be used in any final reports of the study.

The entire experiment should be complete within an hour and a half. Your earnings in the experiment will be $5 as a participation fee (simply for showing up on time) plus whatever you earn in the experiment proper. You will be paid privately according to your participant ID number as you leave the room at the end of the experiment. You are free to leave at any time, but if you leave before the experiment is over, you will only receive the $5 show-up fee. 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:

$$1 \text{ Token} = 1 \text{ Dollar}$$

The instructions will be read aloud by the experimenter, and you may also ask questions if anything is unclear. Once the experiment begins, we ask everyone to remain silent. In order to keep your decisions private, please do not reveal your choices to any other participant. If you have any questions, please raise your hand and an experimenter will approach your desk.

The experiment is divided into 50 independent and identical trading periods. In each period, you will be asked to submit a bid (a price at which you are willing to buy) for a single unit of an indivisible asset. Trades take place in an interconnected market represented by a six-person network. You will only be able to trade with participants to whom you are connected in this network.

The experiment starts by having the computer randomly assign each participant to one of three rows: top, middle or bottom. You have an equal probability of being assigned to each row and your row assignment will remain unchanged throughout the experiment. Before the start of each period, you will be randomly assigned to one of the positions in one of the networks. The positions are labeled with the letters A through I. The top row consists of positions (A, B, C), the middle row consists of positions (D, E, F), and the bottom row consists of positions (G, H, I).

Each period starts by having the computer randomly form nine-person networks by selecting one participant of type-A, one of type-B, one of type-C, and so on. If you were initially designated a top row player, you will be assigned to a top row position in one of the networks, and similarly if you are a middle or bottom row player. Your type (A, B, C, D, E, F, G, H, I) will be displayed in the top right hand corner of the program dialog window (see attachment 1).

The networks formed in each period depend solely upon chance and are independent of the networks formed in any of the other periods. That is, in any network each top-row participant is equally likely to be chosen as type-A, type-B, or type-C participant for that network, and similarly with middle-row and bottom-row participants. Note again that your row assignment will remain unchanged throughout the experiment but your type and network may change from period to period. The other participants in your network may also change from period to period. In each period, your network depends solely on chance.

The network is displayed in the large window that appears in the center of the program dialog window (see attachment 1). A line segment between any two types indicates that they are connected and, hence, are allowed to trade. The arrowhead points from the seller to the buyer. In the network used in this experiment, each of the types in the middle row (D, E, F) can trade with all the types in the top and bottom rows, whereas the types in the top row (A, B, C) and the bottom row (G, H, I) can only trade with the types in the middle row (D, E, F).

The asset is initially held by a computer-generated seller. The computer-generated seller is always willing to sell only one unit of the asset for a price of zero tokens. In addition, there is a computer-generated buyer who is always willing to buy one unit of the asset at a price of 100 tokens. The computer-generated seller can only sell the unit to the types in the top row (A, B, C). The computer-generated buyer can only buy the unit from the types in the bottom row (G, H, I). Note that the computer-generated seller and buyer do not appear in the network displayed in the program dialog window (see attachment 1).

A trading period

Next, we will describe in detail the process that will be repeated in all 50 trading periods and the user interface that you will use to make your decisions. Each period starts by having the computer randomly form six-person networks by selecting one participant of each type (A, B, C, D, E, F, G, H, I). At the start of each period, each participant receives an endowment of tokens. Each trading period starts by having the computer randomly select the endowments from the set of numbers (including decimals) between 0 and 100. That is, the endowment of type-A is equally likely to be any number between 0 and 100, the endowment of type-B is equally likely to be any number between 0 and 100, and so on. The endowments selected in each trading period are independent of each other and of the endowments selected for any of the other trading periods. Note that other participants may have a different endowment than you.

You will be informed only of your endowment. You will use the tokens in your endowment to pay for the asset when you buy. In addition, you will receive others tokens in exchange for the asset when you sell. All trades must move the asset "downward":

- The types in the top row can only buy from the computer-generated seller and can only sell to the middle row. For example, type A can buy from the computer generated seller and can sell to types D, E or F.
- The types in the middle row can only buy from the top row and sell to the bottom row. For example, type D can buy from types A, B or C and sell to types G, H or I.
- The types in the bottom row can only buy from the middle row and sell to the computer-generated buyer. For example, type G can buy from types D, E or F and sell to the computer-generated buyer.

In each period, you will be asked to submit a single bid to the sellers to whom you are connected by the network, indicating the price at which you are willing to buy one unit of the asset. The bid of each participant cannot exceed her or his endowment. When you are ready to make your decision, use the mouse to position the cursor in the Bid Input field on the right of the dialog window (see attachment 1) and use the keyboard to enter the number (including decimals) of tokens between 0 and your endowment that you wish to bid. Once you have entered the bid, confirm your decisions by clicking the Submit button. Once you have clicked the Submit button, your decisions cannot be revised.

Trades are executed sequentially. First, trades between the computer-generated seller and the buyers in the top row take place, followed by trades between the seller in the top row and the buyers in the middle row, followed by trades between the seller in the middle row and the buyers in the bottom row, and finally trades between the seller in the bottom row and the computer-generated buyer. At each stage, the asset is transferred from the seller to the buyer with the highest bid. If two buyers tie for the highest bid, the asset will be assigned to one of the buyers at random. The buyer pays the seller the number of tokens equal to her or his bid.

After everyone has submitted a bid, you will observe the bids of all other participants, the actual prices at which the asset was traded and the sequence of trades. This information is displayed in the large window that appears in the center of the dialog window (see attachment 2). Endowments (E) are colored red, bids (B) are colored blue, and the actual prices (P) at which the asset was traded are colored green. For reference, the price at which the computer-generated seller is willing to sell the asset is indicated by CA. The bid of the computer generated buyer is indicated by CB.

To move on to the next trading period, press the OK button on the bottom right hand corner of the program dialog window (see attachment 2). Note that after one minute the program will move automatically to the next period, but you will always be able to review the results of this period later in the experiment by selecting this period and clicking on the View Results button on the top right hand corner of the program dialog window (see attachment 2). Prior to each period, the computer will randomly form new groups of participants in networks. The process will be repeated until all the 50 independent and identical trading periods are completed. Throughout the experiment please pay careful attention to the messages window at the bottom of the program dialog window (see attachment 1). At the end of the last trading period, you will be informed the experiment has ended.

Payoffs

Your trading profit in each period can be summarized by the formula:

$$\text{trading profit} = \text{(sales revenue) - (cost)}.$$

The sales revenue is the actual price you received if you sold the asset and zero otherwise. The cost is the bid price you paid if you bought the asset and zero otherwise. Your total earnings in each trading period are equal to your trading profits, positive or negative. Your final payoff in the experiment is determined as follows. At the end of the experiment, the computer will randomly select one period in which to execute the trades "for real".

- If you did not trade the asset in the period that is selected to be executed, you will receive 10 tokens to keep.

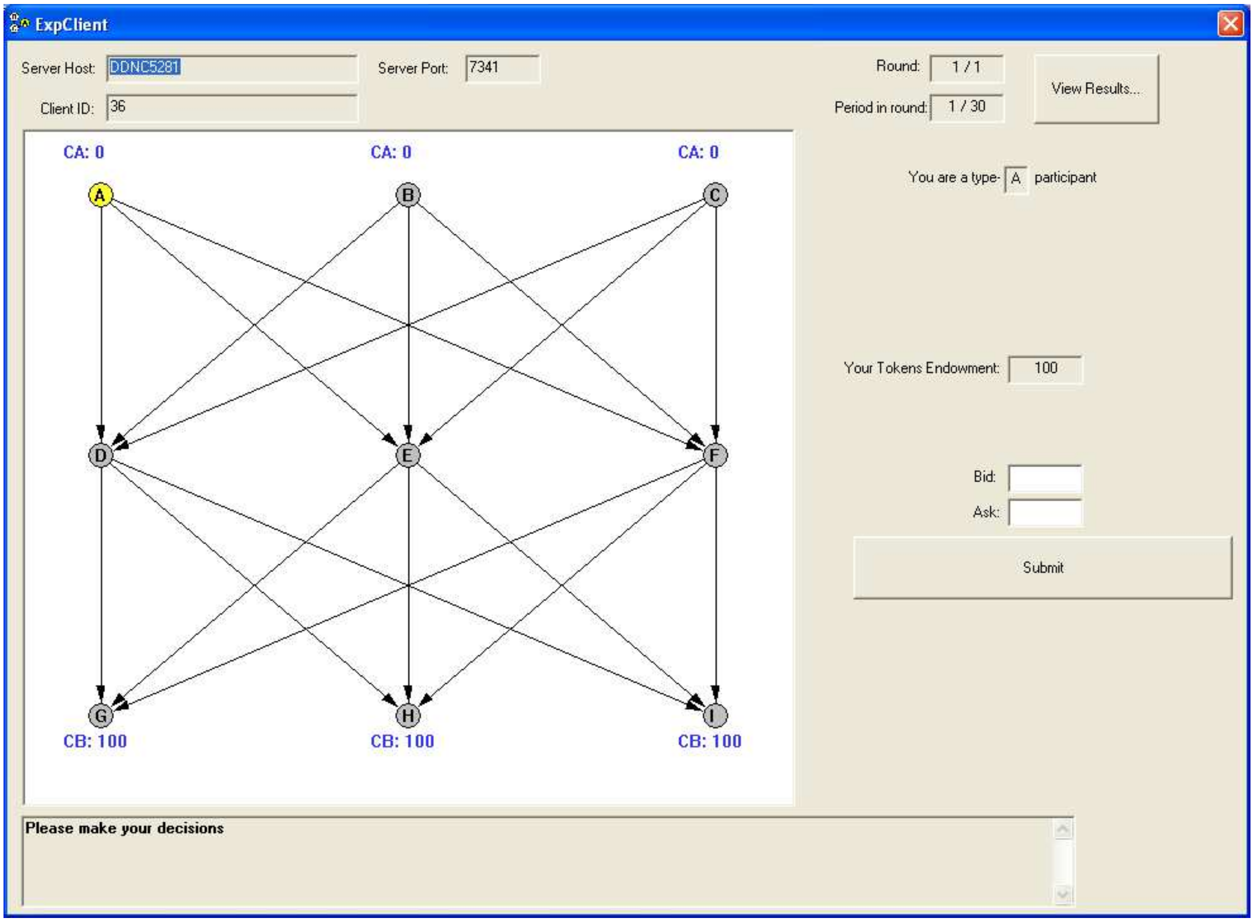
- If you traded the asset in the period that is selected to be executed and your trading profit is *positive* in that period, you will receive your trading profit *plus* 10 tokens to keep.

- If you traded the asset in the period that is selected to be executed and your trading profit is *negative* in that period, you will receive 10 tokens to keep.

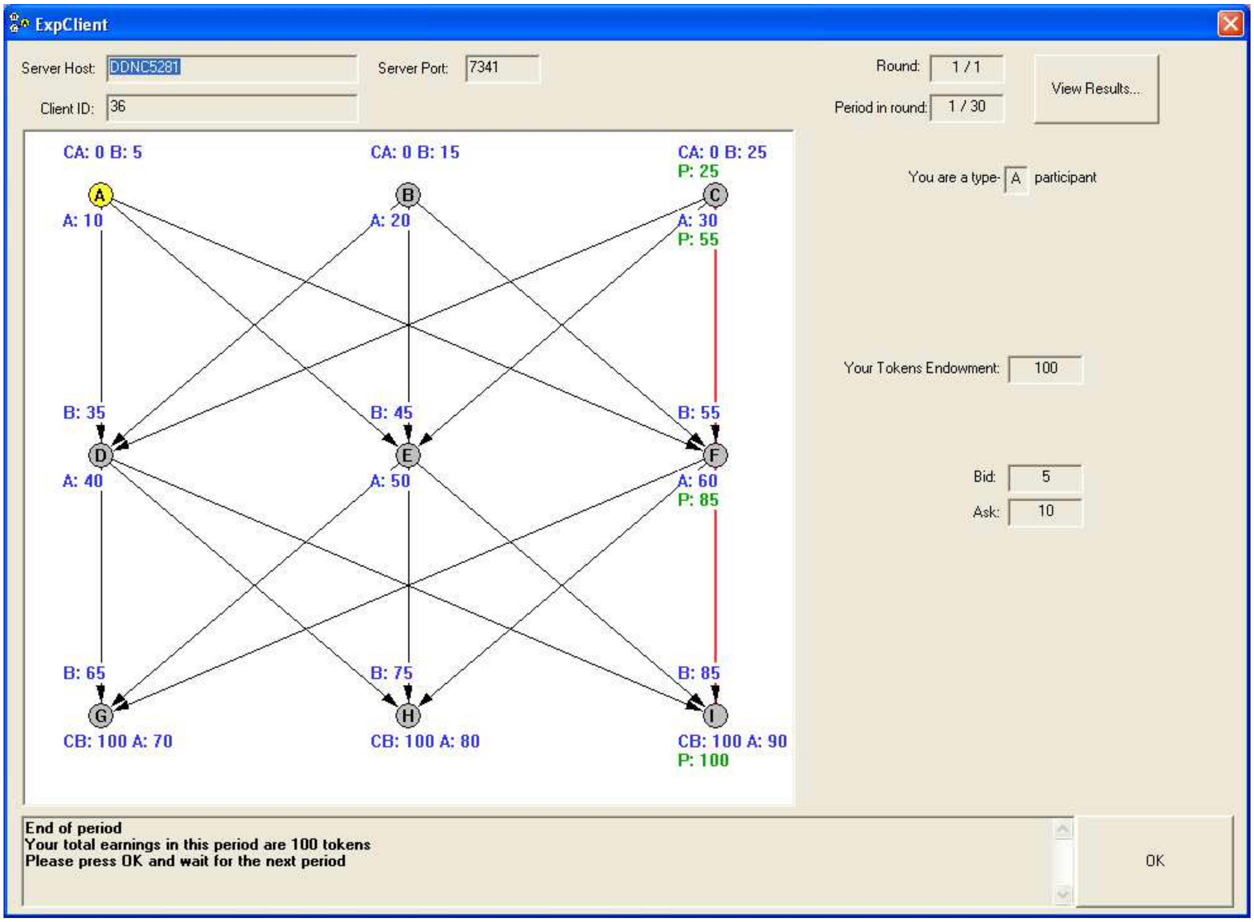
At the end of the experiment, the tokens will be converted into money. Each token will be worth $1. You will receive your payment as you leave the experiment.

If there are no further questions, you are ready to start. An instructor will approach your desk and activate your program.

Attachment 1



Attachment 2



D A Parametric Bidding Model

In this appendix we provide a complementary analysis of traders' bidding strategies. Our aim is to provide a parametric analysis augmenting our non-parametric results reported in the main text. Specifically, we focus on and estimate the empirical bidding model

$$\mathrm{BID}_{it} = \min\Big\{\mathrm{BUDGET}_{it}, \beta_0 + \beta_1 \mathrm{BUDGET}_{it} + \beta_2 \mathrm{BUDGET}_{it}^2 + \varepsilon_{it}\Big\} \qquad \text{(D.1)}$$

where $\varepsilon_{it} \overset{\text{iid}}{\sim} N(0, \sigma^2)$ is the error term.

The model defined in (D.1) draws directly on our theoretical model and anticipates the binding nature of budget constraints. In (D.1), BID_{it} is the observed bid of subject i in auction t, BUDGET_{it} is his private endowment, and ε_{it} is an idiosyncratic error term. Of course, $\{\beta.\}$ are parameters. We include a higher order term in (D.1) to capture the anticipated non-linearity in bidding strategies, as suggested by Corollary 1.

We estimate model (D.1) using the method of maximum likelihood and we report the results in Table 1. We estimate (D.1) separately for each network, but we pool over sessions. All parameters are statistically distinct from zero at conventional significance levels. (We omit the customary asterisks for clarity.) The estimate of the parameter corresponding to the model's non-linear term, $\hat{\beta}_2$, is consistently negative across networks and rows suggesting that the anticipated concavity of the monotone equilibrium bidding strategy is observed in the data.

To gauge the qualitative implications of the specified model, in Figure 5 we plot the implied bidding strategies along with 95% confidence bounds. This figure's most striking conclusion is the uniform ordering of bidding strategies across rows. This ordering is consistent with both Corollary 1 and Prediction 1. In both the 2×3 and the 3×3 networks, traders in rows closer to the final buyer bid uniformly more aggressively on average. The 95% confidence intervals for the bidding strategy of row 2 and row 3 traders in the 3×3 network overlap only at $w \approx 50$ and $w \approx 100$. Around these values of realized endowments, the parameter estimates are based on fewer observations owing to censoring by the endowment level and the upper bound on the endowment distribution. The observed ordering of strategies is robust to alternative model specifications. For example, the same uniform order of confidence bounds is observed under a linear specification of (D.1), i.e. where β_2 is constrained to zero. We note that the resulting estimates closely correspond to the estimates presented in our main analysis. Estimated confidence bounds are also of a similar magnitude.

The estimates reported in Table 1, and which inform Figure D.1, are based on a pooled sample across all sessions. To gauge our specification's robustness, in Table 2 we estimate model D.1 incorporating subject-level fixed effects. Comparing Tables 1 and 2, we observe considerable consistency in both the signs and magnitudes of estimated values. (Statistical significance is also maintained.)

Table 1: Maximum likelihood estimates of model (D.1).

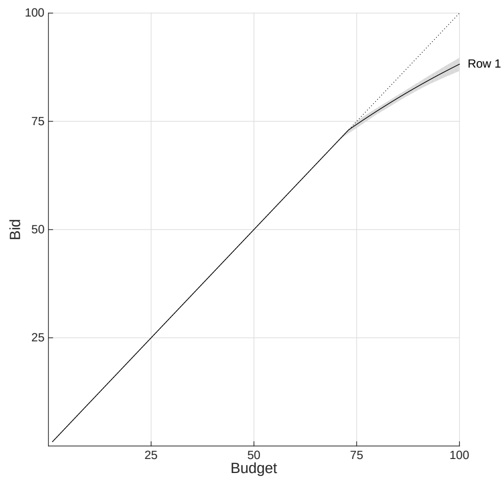
Network	1×3	2×3		3×3		
Row	1	1	2	1	2	3
(Constant) $\hat{\beta}_0$	7.3119	11.4470	15.3368	7.5791	6.0228	6.8215
	(1.0893)	(1.0893)	(1.4554)	(1.2809)	(0.9923)	(1.2877)
(Linear) $\hat{\beta}_1$	1.1463	1.2374	0.9953	1.3367	1.1536	1.0948
	(0.0440)	(0.0584)	(0.0564)	(0.0516)	(0.0415)	(0.0525)
(Quadratic) $\hat{\beta}_2$	-0.0034	-0.0052	-0.0052	-0.0059	-0.0052	-0.0051
	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0004)	(0.0005)
$\hat{\sigma}$	9.0099	12.1743	14.0793	10.2166	9.5672	12.1402
	(0.3088)	(0.3980)	(0.3528)	(0.3577)	(0.2480)	(0.3308)
Obs.	1500	1800	1800	1500	1500	1500

Bootstrap standard errors in parenthesis. All values are statistically different from zero at the 5% level.

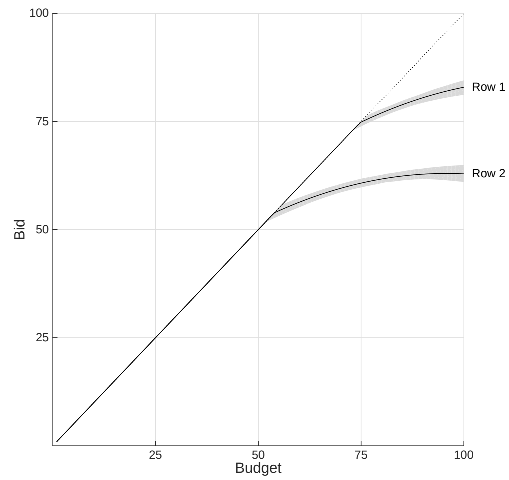
Table 2: Maximum likelihood estimates of model (D.1) with subject fixed effects.

Network	1×3	2×3		3×3		
Row	1	1	2	1	2	3
(Constant) $\hat{\beta}_0$	7.7607	11.9562	15.2937	7.4558	5.9040	6.8678
	(1.1613)	(1.4742)	(1.3924)	(1.2127)	(0.9886)	(1.2498)
(Linear) $\hat{\beta}_1$	1.1611	1.2265	0.9963	1.3420	1.1559	1.0933
	(0.0445)	(0.0570)	(0.0554)	(0.0491)	(0.0415)	(0.0519)
(Quadratic) $\hat{\beta}_2$	-0.0036	-0.0052	-0.0052	-0.0060	-0.0053	-0.0051
	(0.004)	(0.0005)	(0.0005)	(0.0005)	(0.0004)	(0.0005)
$\hat{\sigma}$	8.9894	12.0568	13.6932	9.8447	9.2718	11.8818
	(0.3318)	(0.3913)	(0.3565)	(0.3690)	(0.2357)	(0.3224)
Obs.	1500	1800	1800	1500	1500	1500

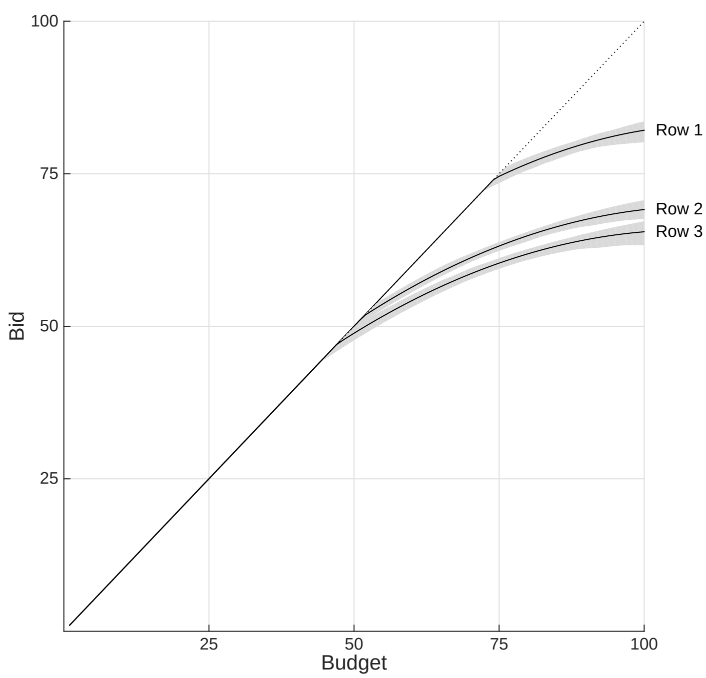
Bootstrap standard errors in parenthesis. All values are statistically different from zero at the 5% level.



(a) Estimated bidding strategy in the 1×3 network.



(b) Estimated bidding strategy in the 2×3 network.



(c) Estimated bidding strategy in the 3×3 network.

Figure D.1: Estimated monotone bidding strategies (95% confidence bounds).

References

Milgrom, P. R. and Weber, R. J. (1985). Distributional strategies for games with incomplete information. *Mathematics of Operations Research*, 10(4):619–632.