Entry by Successful Speculators in Auctions with Resale*

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Abstract

We experimentally analyze the role of speculators, who have no use value for the objects on sale, in auctions. The environment is a uniform-price sealed-bid auction for 2 identical objects, followed by a free-form bargaining resale market. There is always one positive-value bidder, and either one to two speculators who may choose whether to enter the auction. We show that the bidder accommodates speculators by reducing demand in the auction and subsequently purchasing in the resale market, which encourages entry by speculators. The presence of multiple speculators induces each speculator to enter less often, but increases competition in the auction and the auction price. Speculators earn positive profits on average, except when multiple speculators enter the auction.

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1. Introduction

Many real-life auctions are characterized by the possibility of post-auction resale and the presence of speculators — participants who have no use value for the items on sale who participate with the intention of reselling to bidders with positive values. Prominent examples of auctions where speculators are known to exist include auctions for spectrum licenses, commodities, and tradable emissions permits.[1]

It may seem paradoxical that a speculator could win an auction — why would a bidder with a positive use value ever let a speculator win only to purchase from him after the auction? However, such behavior is not surprising in a multi-object auction: bidders with positive use values may prefer to let speculators acquire some of the items on sale, because accommodating speculators may allow them to reduce the auction price. Indeed, demand reduction behavior in multi-object auctions is observed even without resale or speculators (Kagel and Levin, 2001; Engelmann and Grimm, 2009). And the incentive to reduce demand is stronger when resale is allowed, because while the presence of a resale market encourages speculative behavior, it also provides a second opportunity for non-speculative bidders to purchase items lost in the auction (Pagnozzi, 2010).

Moreover, when bidders strategically reduce demand, additional speculators may be attracted to the auction by the possibility of positive profit.[2] In this case, however, competition between speculators reduces bidders' incentive to reduce demand, since this strategy may no longer result in a lower auction price.

These considerations raise a number of questions that we aim to explore using a combination of theoretical and experimental analysis. How do bidders react to the presence of speculators in auctions: do they recognize the incentive for strategic demand reduction, or do they compete aggressively against speculators? Can speculators obtain positive profit by participating in an auction? How do speculators decide whether to participate when it is costly to do so? Is a speculator's strategy affected by the potential presence of competing speculators? These questions have direct consequences for both the seller's revenue in the auction and the efficiency of the allocation.

To address these issues, we consider a simple environment consisting of a sealed-bid uniform-price auction with two identical items on sale followed by a resale market. There are two asymmetric players: a speculator with no use value for the items and a bidder who has a positive use value for both units. The speculator chooses whether to participate in the auction against the bidder or earn an outside option. This environment is then extended to two speculators who simultaneously choose whether to enter the auction.

Although there are multiple equilibria in this environment, we highlight that with one speculator in the auction there is an equilibrium in which both the speculator and bidder bid a positive

[1] See, for example, the discussion of the European Emission Trading Scheme in Mougeot *et al.* (2011).

[2] Xu, Levin, and Ye (2013) highlight that "resale naturally induces a speculative motivation for entry."

price only for a single item, so that each player wins one item at price zero. After the auction, the speculator resells to the bidder and obtains positive profit. Therefore, in this equilibrium the bidder reduces demand and accommodates the speculator. This equilibrium maximizes joint players' profit and we conjecture that it may be the focal point for actual behavior. By contrast, when there are multiple speculators in the auction, the bidder has a weaker incentive to reduce demand and competition is likely to reduce speculators' profit to zero.

Entry choices by speculators depend on their expectations about the outcome of the auction and the resale market. If a risk neutral speculator expects the bidder to accommodate him in the auction and allow him to earn more than the outside option, then he always enters when there is no other potential speculator. Multiple speculators, on the other hand, may not obtain positive profit by always entering the auction and may use mixed strategies to coordinate entry in a symmetric equilibrium.

Our empirical analysis is based on an economic experiment whose design mimics the theoretical environment.[3] In the post-auction resale market, the speculator(s) and bidder are allowed to make multiple offers and communicate through computerized chat to trade the items won by a speculator in the auction.[4] The baseline treatment consists of the bidder and a single speculator who are automatically entered into the auction. The remaining two treatments introduce entry choice by speculator(s) and vary the number of speculators.

We find strong evidence that bidders do accommodate speculators, even when multiple speculators are in the market. Bidders bid significantly less aggressively on the second unit than on the first. Conditional on a speculator entering the auction, approximately 85% of all auctions result in the resale market opening because a speculator wins at least 1 item, and speculators manage to resell 82% of the items that they acquire. In auctions with a single speculator, the most frequent outcome is the predicted split of the two items between the speculator and the bidder, but average auction prices are strictly positive. This indicates that players reduce demand in the auction to soften competition, but not enough to reduce the auction price to zero. Speculators obtain positive profits on average in all treatments, except when two speculators enter the auction, in which case competition results in negative profits for speculators and the lowest profits for the bidder. Speculators' profits are highest when only one of multiple potential speculators enters the auction, while the bidder's profits are highest when there is only one speculator who may enter.

Accommodating bidders and speculators' profits did encourage entry: in single speculator markets speculators entered in 79% of the auctions. In multiple speculator markets, each speculator entered less often than in single speculator markets, but the percentage of auctions with

[3] We use an experiment rather than field data for a number of reasons including the difficulty of measuring values and controlling for the entry choice of speculators. Moreover, there are very few field data on post-auction resale markets.

[4] The design of the resale market is a modified version of the free-form bargaining game used in Pagnozzi and Saral (2015, 2016), that allows to trade two units and the participation of up to three players. Murnighan and Roth (1977) also study a bargaining game with restricted communication between three players, where only a single trade is allowed.

at least one speculator was even higher (87%) and auctions with two speculators were most common (47%).

Summing up, our main result is that when resale is allowed after a multi-object auction, speculators manage to win against a standard bidder and then resell, thus earning positive profit. This induces speculators to participate to the auction. Competition among speculators, however, tends to induce too many speculators to participate in the auction, which erodes their profit.

The seller's revenue in the auction is higher when the bidder does not reduce demand and wins both units, especially when he competes with two speculators. The seller's revenue is also higher in markets with multiple speculators, even if only one of them enters the auction. Auction efficiency is relatively low due to demand reduction and while resale increases efficiency after the auction, it does not always ensure an efficient allocation of the items on sale.

Given the potential for losses and competition between speculators, we find a prominent role for risk preferences and selection with multiple speculators. Speculators with a higher risk tolerance are more likely to enter and bid more aggressively after previous losses, which significantly increases maximum bids in the current auction. More aggressive speculators leads to the highest speculator earnings in these markets, but also to the highest probability of losses.

Our paper contributes to the experimental literature on auctions with resale.[5] Experiments on single-object auctions with resale include Georganas (2011), Georganas and Kagel (2011), Lange *et al.* (2011), Saral (2012), and Chintamani and Kosmopoulou (2015), while Filiz-Ozbay *et al.* (2015) and Pagnozzi and Saral (2016) analyze multi-object auctions with resale. Throughout this literature, the focus is on the impact of resale on the strategies of bidders with positive use values for the items on sale. By contrast, we analyze entry and bidding strategies of speculators.

Most closely related to our paper is the examination of emission permits markets by Mougeot *et al.* (2011). The authors analyze the role of speculators in breaking collusion in sealed-bid and ascending multi-unit auctions and show that bidders are more likely to collude and accommodate speculators in an ascending rather than in a sealed-bid auction. While Mougeot *et al.* (2011) highlight differences in auction formats, we focus on the response of bidders and speculators to entry choices by speculators and to changes in the number of speculators.

The rest of the paper is organized as follows. Section 2 presents a theoretical analysis of the model that we refer to for our experiments. Section 3 discusses the experimental design, and Section 4 presents the results for entry, bidding and resale. Finally, Section 5 concludes. The Appendix contains proofs of the propositions, instructions and screenshots.

2. Theoretical Framework

Model Consider a (sealed-bid) uniform-price auction for 2 units of an identical good, with no reserve price. Each player submits 2 non-negative bids (possibly different), one for each unit

[5] See Kagel and Levin (2011) for a survey of the experimental literature on auctions.

on sale; the 2 highest bids are awarded the units, and the winner(s) pay a price equal to the 3^{rd}-highest bid for each unit. At the end of the auction, players observe the auction price but not their competitors' bids.

There is a bidder who is privately informed about his valuation $v_B \sim U[50; 100]$, which is the same for each unit on sale, and there are either 1 or 2 speculators who have valuation equal to zero for the units on sale, which is common knowledge. Hence, players know the efficient allocation of the units on sale before the auction.[6]

The bidder is always present in the auction, while speculators choose whether to enter the auction. Speculators have an outside option equal to $c > 0$, that they lose if they participate in the auction. The outside option may be interpreted as an alternative opportunity that a speculator misses in order to participate in an auction, or as a measure of bidding costs (for example, costs that have to be paid to convince investors of the opportunity to participate in an auction for speculative reasons, even if the objects on sale have no use value). All players are risk neutral.

A speculator who wins a unit in the auction can resell it to the bidder in a resale market. We assume that resale takes place through a generic (and un-modelled) bargaining mechanism between players. Let r be the actual resale price at which a speculator and the bidder trade as a result of post-auction bargaining with one-sided incomplete information, where the seller has value 0 and the buyer is privately informed about his value, which is uniformly distributed on $[50, 100]$.[7] To make the model interesting, we assume that the expected resale price is $\mathbb{E}[r] > c$, otherwise a speculator does not enter the auction even if he expects to win an object at price 0.

There is *demand reduction* if the bidder bids less than his valuation for the second unit and bids more for the first unit than for the second unit (see, e.g., Wilson, 1979, and Ausubel and Cramton, 1998), while there is *speculation* if a speculator bids a positive price for a unit.

Auction with 1 Speculator First suppose that only one speculator enters the auction, so that there are two players in total in the auction. We describe a possible equilibrium in which the speculator manages to obtain strictly positive profit, despite competing with a bidder who has a higher valuation.[8]

Proposition 1. *With one speculator, the auction has an equilibrium in which the bidder bids v_B for the first unit and 0 for the second unit and the speculator bids 50 for the first unit and 0 for the second unit.*

In this equilibrium, there is speculation by the speculator and demand reduction by the bidder. Hence, the bidder accommodates the speculator and the speculator only bids for one

[6] See Garratt and Tröger (2006) for a theoretical analysis of speculation in single-object auctions.

[7] See Ausubel *et al.* (2002), who show that with one-sided incomplete information and a "gap" between the seller's valuation and the support of the buyer's valuation, any bargaining procedure in which players sequentially exchange offers has essentially a unique sequential equilibrium, which is stationary and in which trade occurs in finite time. Our qualitative results are robust to many alternative models of the resale market.

[8] All proofs are in the Appendix.

unit, so that players win one unit each at price 0 and then trade at price r in the resale market (since the speculator does not learn any information about the bidder's valuation in the auction). Hence, the bidder obtains a total profit equal to $2v_B - r$, because he buys one unit at price 0 in the auction and one unit at price r in the resale market, and the speculator obtains a resale profit equal to r, because he buys one unit at price 0 in the auction and sells it at price r in the resale market. The seller's revenue in the auction is equal to 0.

In the proof of Proposition 1, we show that neither the bidder nor the speculator have an incentive to deviate from the equilibrium described because, in order to win more than one unit, a player has to increase the auction price so much that he reduces his profit.

Notice that there are many other equilibrium strategies that result in players winning one unit each at price zero.[9] There are also equilibria in which each player wins one unit at a strictly positive price, but in these equilibria both players obtain a strictly lower auction profit than in the equilibrium described in Proposition 1. Moreover, there are other equilibria in which a player wins both units (by bidding a high price that makes it unprofitable for the competitor to win a unit, exactly as in a single-object second-price auction), so that the other player obtains no profit in the auction. We focus on the equilibrium in which players win one unit each at price 0 because in this equilibrium the bidder allows the speculator to win a unit, and obtains the highest possible profit on the other unit in the auction.

Auction with 2 Speculators Even with 2 speculators in the auction there are multiple equilibria. However, in this case there is no scope for profitable demand reduction because, with 2 units on sale and 3 players, it is not possible for each player to win one unit in the auction. So competition between speculators tends to increase the auction price up to the expected resale price.

Proposition 2. *With two speculators, the auction has an equilibrium in which one speculator bids* 100 *for both units, the other speculator bids* $\mathbb{E}[r]$ *for both units, and the bidder bids* 0 *for both units.*

In this equilibrium, one speculator wins no unit while the other speculator wins both units at price $\mathbb{E}[r]$ and then resells them at price r to the bidder (since the speculator does not learn any information about the bidder's valuation in the auction). Hence, speculators obtain no profit from participating in the auction, regardless of whether they win the units or not. The bidder obtains a profit equal to $2(v_B - r)$ from buying the units in the resale market. The seller's revenue is higher than in the equilibrium described in Proposition 1 with only one speculator.

In the proof of Proposition 2, we show that the players who win no unit in the auction have no incentive to deviate from the equilibrium described because, in order to win a unit, they have to increase the auction price so much that they cannot obtain positive his profit.

[9] These equilibria are constructed by varying players' first-unit bid (compared to the strategies described in Proposition 1), but still ensuring that players have no incentive to deviate by winning two units in the auction.

Of course, there are many other equilibria with the same allocation as in the equilibrium described in Proposition 1 but a different auction price. There are also equilibria in which the bidder wins all the units in the auction and no speculator obtains positive profit. Because of the presence of multiple equilibria in our environment, both with one and with two speculators, players' actual bidding behavior is ultimately an empirical question, that we analyze in our experiments.

Entry by Speculators Suppose that a speculator expects to play the equilibrium described in Proposition 1 if he competes in the auction against the bidder, and that speculators obtain no profit if they both enter the auction. Therefore, when there is only one speculator, he enters the auction since he expects to obtain a profit $\mathbb{E}[r] > c$.

When there are two speculators who may enter the auction, a speculator who enters expects to obtain a profit equal to $\mathbb{E}[r]$ if the other speculator does not enter, and a profit equal to 0 if the other speculator also enters. While if a speculator does not enter the auction, he always obtains a profit equal to the outside option c. In other words, taking into account the anticipated outcome of the auction with 1 or 2 speculators, total speculator profits in the entry game between two speculators is

	Enter		Stay out	
Enter	0	0	$\mathbb{E}[r]$	c
Stay out	c	$\mathbb{E}[r]$	c	c

Therefore, the entry game has two pure-strategy asymmetric equilibria, in which one speculator enters and the other stays out. Moreover, there is a unique *symmetric* mixed-strategy equilibrium in which each speculator enters with probability $q^* \in (0,1)$ such that his expected payoff from entering the auction is equal to the outside option — i.e.,

$$(1-q^*)\,\mathbb{E}[r] = c \quad \Leftrightarrow \quad q^* \equiv 1 - \frac{c}{\mathbb{E}[r]}.$$

Speculators enter because of the possibility of winning the auction and reselling in case they compete only with the bidder in the auction, but they lose money if both speculators enter the auction since they lose the outside option, and competition among speculators drives their auction and resale profit to zero. In the mixed-strategy equilibrium, the probability that at least one speculator enters the auction is $\left(1 - \frac{c^2}{\mathbb{E}[r]^2}\right)$.

Of course, speculators have different incentives to enter if they expect to play a different equilibrium from the one described in Proposition 1 in the auction against the bidder. Specifically, if a speculator expects to win no unit against the bidder, then he never enters the auction. Similarly, if he expects to win but pay a strictly positive price, then he enters with a lower probability than q^* in a mixed-strategy equilibrium. By contrast, if he expects to win both units, then he enters with a higher probability.

Notice that by entering the auction a speculator gives up an outside option, which is certain,

for the possibility of obtaining positive profit in the auction, which is uncertain and depends on the behavior of his competitor(s) in the auction and in the resale market, and on the entry choice of the other speculator (when there are two speculators). Hence, for a risk-averse speculator entry is less attractive than for a risk-neutral speculator and, when there are two speculators, in a mixed-strategy equilibrium each speculator enters with a probability which is strictly lower than q^*.

Summing up, the theoretical predictions of our model are the followings.

Result 1. *When there is only one speculator in the auction, the bidder may reduce demand and allow the speculator to acquire one unit and obtain positive profit.*

Result 2. *When there are two speculators in the auction, they may not obtain positive profit.*

Result 3. *When there is only one speculator, he enters the auction if he expects the bidder to reduce demand. When there are two speculators, in a symmetric equilibrium each of them enters with a probability which is strictly positive, but lower than one.*

3. Experiment Design

The experiment design is based on the theoretical environment described above. In the baseline treatment, 1 speculator (S) and 1 bidder (B) participate in the auction and the remaining two treatments introduce entry choices for speculators and add an additional speculator.

In all treatments, each round had two identical items offered for sale via a sealed-bid uniform-price auction. Each auction always had 1 bidder, who randomly drew his private per-item valuation (identical for both items) from a uniform distribution on $[50, 100]$, and at least 1 speculator with no use value for the items. The distribution of the bidder's value and the fact that speculators had no use value were common knowledge. A subject's role as a bidder or speculator was randomly assigned at the start of the experiment, and stayed the same for the duration of the experiment.[10] In treatments where speculators had entry choice, they decided whether to enter the auction or earn the outside option of 10. With multiple speculators, entry decisions were simultaneous. If no speculator entered, the bidder automatically won both units at price zero.[11]

Auction participants placed one bid between 0 and 100 for each item,[12] and the two highest bids were each awarded one item at a price equal to the third-highest bid. Ties were broken randomly. After the auction, participants were informed of the number of items they won and the auction price. Bids were not publicly revealed. A participant who won an item in the auction earned the difference between his value and the auction price.

[10] To minimize labeling effects, the speculator was referred to as a "blue bidder" and the bidder was referred to as a "green bidder." The Appendix contains instructions for all treatments and sample screenshots.

[11] To lower the probability of boredom driving entry decisions, speculators who chose not to enter and bidders who won by default played an unpaid computerized version of tic-tac-toe against the computer.

[12] While we did not allow bidders to refrain from bidding, the instructions were clear that bidders could bid 0.

If a speculator won at least one unit, a resale market opened where the speculator could resell to the bidder through an unstructured bargaining game (as in Pagnozzi and Saral, 2016).[13] Both the speculator and bidder could make offers through a computerized offer board. Only one posted offer per participant was allowed at a time, but offers could always be changed prior to agreement. The resale stage terminated once a participant's offer was accepted by the counterpart. The speculator and bidder could also send each other messages and discuss offers through anonymous chat. When two speculators won one unit each, each speculator participated in a simultaneous and isolated bargaining game with the bidder and the two speculators could not communicate with each other.[14]

Participants could exit the resale market without trading at any point, and had up to 3 minutes to agree to an offer. If agreement was reached, the item was resold from the speculator to the bidder. If a single speculator won 2 items, he could sell each item at a separate price, or bundle them at a single price. For each item resold, the speculator earned the difference between the resale price and the auction price, and the bidder earned the difference between his value and the resale price. Resale earnings were in addition to the earnings from the auction.

The experimental treatments are summarized below.

1. **1 speculator (1S)**: one speculator competes in the auction against the bidder.
2. **1 speculator entry (1SE)**: one speculator chooses whether to participate in the auction against the bidder.
3. **2 speculators entry (2SE)**: two speculators choose whether to participate in the auction against the bidder.

Each session of a treatment had 15 auction/resale rounds and, on average, 20 subjects.[15] A subject was only allowed to participate in one session of one treatment. Table 3.1 shows the number of subjects who participated in each treatment. At the start of all sessions, we elicited risk preferences using a mechanism adapted from Eckel and Grossman (2008). Subjects were offered a choice between five binary 50/50 gambles with increasing expected value and risk, so that choosing a lower gamble indicates higher risk aversion. Subjects were then randomly assigned to roles and groups (of 2 or 3 subjects depending on the treatment) for the auction rounds. After each round, subjects were randomly rematched into new groups. To ensure the least amount of changes, we used the same value draws across treatments. Subjects were

[13] Previous experiments on auctions with resale assume a different structure for the resale market. Georganas (2011) use a secondary auction for the resale market; Georganas and Kagel (2011) and Filiz-Ozbay *et al.* (2012) utilize take-it-or-leave-it offers by the auction winner; Lange *et al.* (2011) and Saral (2012) assume automatic transfers to bidders with higher valuations.

[14] With two speculators, the bidder could make different offers in each resale market and could exit one market but remain active in the other.

[15] The minimum number of subjects in a session was 16 (1 session of 1SE) while the maximum was 21 (2 sessions of 2SE).

students at Florida State University recruited using ORSEE (Greiner, 2004). The experiment was programmed using Z-tree software (Fischbacher, 2007).

	1S	1SE	2SE
Bidder (B)	\$20.12	\$23.52	\$19.16
Speculator (S)	\$16.51	\$16.70	\$15.70
Number of Subjects	40	56	60

Table 3.1: Average experiment earnings.

Payoffs during the experiment were denominated in experimental currency units, ECUs, which transformed into US dollars at the rate of \$0.01 per ECU. Since subjects could make losses, a bidder had an initial endowment of 50 ECUs and a speculator of 400 ECUs to hopefully ensure that they did not have negative cumulative earnings at any point during the experiment. We employed standard rules for dealing with bankruptcy: subjects who went bankrupt a single time received a new endowment, while subjects who went bankrupt a second time were removed from the session and only received the participation fee. Two subjects assigned to the bidder role went bankrupt once (both in the first round of the 2SE treatment), and no subjects went bankrupt twice. Table 3.1 shows average earnings (including the \$10 participation fee and lottery earnings), by type and treatment.

4. Experiment Results

In this section, we describe the main experimental results in the order of the actual timing of decisions: (*i*) entry; (*ii*) bidding; (*iii*) resale. Section 4.1 presents summary statistics that provide a broad overview of the results. The remaining sections provide formal analysis of observed behavior: Section 4.2 considers entry decisions by speculators; Section 4.3 bidding behavior by speculators and bidders; Section 4.4 the resale market; Section 4.5 revenue, efficiency, and earnings.

4.1. Summary Statistics

Table 4.1 presents the frequency of entry by speculators and the resulting number of participants in the auction in treatments 1SE and 2SE. Entry choices in the 1SE treatment were lower than the risk neutral prediction of 100%, indicating either that speculators were risk averse or that they expected to earn less than the outside option in the auction.[16] In line with the theoretical predictions, speculators entered less frequently in the 2SE than 1SE treatment. The number of auction participants, n, could reach 2 in the 1SE treatment or 3 in the 2SE treatment. Despite each speculator entering less often in the 2SE treatment, there was a high percentage of auctions with at least 1 speculator (n=2, 3) because of the presence of multiple speculators who did not coordinate.

[16] The effects of risk preferences are discussed in Section 4.2.

% (*obs*)	S Enter	n=1	n=2	n=3
1SE	79.1 (332)	21.0 (88)	79.1 (332)	–
2SE	67.2 (403)	13.0 (39)	39.7 (119)	47.3 (142)

Table 4.1: Frequency of S entering and number of auction participants.

Table 4.2 provides average bids, conditional on a speculator entering, where bid 1 (2) denotes the maximum (minimum) bid placed. As bidding behavior may differ depending on the number of participants, we separately consider n=2 and n=3 in the 2SE treatment. Across all treatments, average first unit bids are much higher than second unit bids for both speculators and bidders, which supports the theoretical prediction of demand reduction by players. The average first unit bid is higher for speculators than for bidders, and reaches the highest level in the 1S treatment. The second unit bid is higher than zero for both types.

	S			B		
	bid 1	bid 2	bid 2 $\leq$ 10	bid 1	bid 2	bid 2 $\leq$ 10
1S	68.9	34.0	24.7%	57.2	28.7	45.3%
1SE	60.3	36.1	11.1%	57.8	27.4	35.5%
2SE n=2	63.3	41.0	23.5%	55.8	34.2	37.8%
2SE n=3	66.3	42.2	18.0%	60.6	35.1	29.6%

Table 4.2: Average bids and relative frequency of equilibrium play.

While average bids provide little support for the point predictions of the theory, to evaluate the frequency of observed behavior that weakly matches the theoretical equilibrium described in Proposition 1 we report the percentage of second unit bids that are less than or equal to 10 in the column *bid* 2 $\leq$ 10. The adherence to theory is highest in the 1S treatment for both speculators and bidders, and overall bidders were more likely than speculators to place a low second unit bid. In all cases, the frequency of equilibrium play for second unit bids falls below predicted levels.

Demand reduction by bidders could result in speculators acquiring units in the auction. Table 4.3 presents the relative and absolute frequency of speculators wining 0, 1, or 2 units, conditional on at least one speculator entering the auction. Since speculators can win all units in two ways, 2 indicates that a single speculator won both units, and $(1, 1)$ indicates that two speculators won one unit each in the 2SE treatment. In auctions with 1 speculator and 1 bidder, the most frequent outcome was that each player won 1 unit, consistent with the theoretical prediction. In the 2SE n=3 case, the most frequent outcome was that speculators won 2 units (57.1% of auctions), indicating that bidders accommodate speculators even when two speculators enter.

The last two columns of Table 4.3 present the frequency of the resale market opening, conditional on at least one speculator entering, and the resale success rate, defined as the ratio between the number of units resold and the number of units in the resale market. Most

	Units won by S				Resale	Resale
% (*obs*)	0	1	2	$(1,1)$	Market	Success
1S	16.3 (49)	57.7 (173)	26.0 (78)	–	83.7 (251)	.81
1SE	15.7 (52)	61.1 (203)	23.2 (77)	–	84.3 (280)	.85
2SE n=2	16.0 (19)	44.5 (53)	39.5 (47)	–	84.0 (100)	.86
2SE n=3	9.9 (14)	33.1 (47)	31.0 (44)	26.1 (37)	90.1 (128)	.74

Table 4.3: Frequency of units won by S; frequency of resale; resale success rate (units resold/units won by S).

treatments have similar frequencies of the resale market opening, except for auctions with two speculators where there was a resale market after 90% of auctions, despite the lowest resale success rate.

Table 4.4 summarizes average auction prices and final resale prices for auctions where at least one speculator entered.[17] Average auction prices were strictly positive, which is expected given the average bids in Table 4.2, and were highest in the 2SE treatment, especially with three participants. When the bidder reduced demand and won less than 2 units, auction prices were lower than when the bidder won both units. When there was a resale market because the bidder reduced demand, average resale prices were higher than auction prices.

	Auction Price			Resale Price
		B won < 2	B won 2	
1S	36.6	35.9	39.7	50.0
1SE	37.2	36.2	42.3	47.5
2SE n=2	40.9	39.4	49.0	54.5
2SE n=3	59.3	58.5	66.5	65.8

Table 4.4: Average auction and resale prices (per unit).

Table 4.5 summarizes total earnings, combining both auction and resale, conditional on at least one speculator entering.[18] A speculator could make positive earnings by purchasing a unit in the auction and reselling it at a higher price, but losses were possible if a speculator failed to resell.[19] When one speculator entered the auction he did make positive earnings on average, especially in the 2SE treatment. When 2 speculators entered they made losses on average, particularly when both units were won by a single speculator. Although average earnings were lower than the outside option of 10, speculators continued to enter. To provide a more

[17] We omit auctions where the bidder won at price 0 because no speculator entered.

[18] For earnings, we exclude auctions where no speculator entered (so that speculators earned the outside option and the bidder won at price 0). This happened 88 times (out of 420 auctions) in the 1SE treatment (21%), and 39 times (out of 261 auctions) in the 2SE treatment (13%).

[19] Speculators made losses in 18% of all auctions where they entered in the 1S treatment, 16% in the 1SE treatment, 14% in the 2SEn=2 treatment, and 22% in the 2SEn=3 treatment.

complete picture of earnings, we also report the standard deviation of earnings, the frequency of a speculator entering and earning more than the outside option, and data restricted to the last 5 periods of a session. All treatments have high earnings variability for speculators and the majority of auctions where a speculator entered resulted in earnings above the outside option, except when both speculators entered. Moreover, in the last 5 periods, speculators earned more than the outside option on average, except when both speculators entered, which suggests that learning plays an important role in this environment.[20]

Average bidders' earnings were highest with a single speculator and lowest when two speculators entered the auction. Similar to speculators, all treatments have high earnings variability and higher average earnings in the last 5 periods.

Earnings	S	S (last 5)	$S > 10$	$S > 10$ (last 5)	B	B (last 5)
1S	7.7 (42.0)	15.9 (40.2)	51.7%	52.0%	52.4 (45.5)	66.5 (46.9)
1SE	6.7 (33.9)	12.5 (32.2)	56.3%	64.7%	54.9 (37.7)	62.0 (36.4)
2SE	−2.4 (39.2)	7.3 (40.7)	32.3%	43.4%	31.9 (37.0)	41.9 (43.2)
2SE n=2	11.2 (45.8)	17.6 (47.5)	58.8%	67.3%	42.6 (43.5)	49.6 (48.4)
2SE n=3	−8.1 (34.6)	−2.6 (30.1)	21.1%	20.4%	23.0 (27.8)	27.0 (25.7)

Table 4.5: Average (standard deviation) earnings conditional on S entry; frequency of S earning more than 10. (last 5) indicates data were restricted to the last 5 rounds.

Table 4.6 shows the efficiency of the auction allocation and of the final allocation after the resale market. Auction efficiency is measured as the ratio between the sum of the use values of the winners of the two units in the auction and the highest use value; final efficiency is measured as the ratio between the sum of the use values of final holders of the units and the highest use value (so it is equal to 1 if a speculator resold the units or if the bidder won them in the auction, and it is less than 1 if a speculator failed to resell). For comparison, the efficiency of a random allocation is .5.

Efficiency	1S	1SE	2SE	2SE n=2	2SE n=3
auction	.45	.58	.41	.38	.26
final	.89	.93	.87	.91	.80

Table 4.6: Average efficiency.

The low efficiency of the auction allocation in all treatments indicates that units were frequently won by speculators. Auction efficiency is particularly low in 2SE n=3, and lower than a random allocation in all treatments except 1SE. Resale increases efficiency after the auction, but final efficiency is always lower than 1 because of resale failure: speculators failed to resell

[20] We investigate learning formally through regression analysis in subsequent sections.

19% of times in the 1S treatment, 15% in the 1SE treatment, and 25% in the 2SE treatment.

4.2. Entry

Table 4.7 examines speculators' entry decisions using probit regressions with the speculator choosing to enter the auction as the dependent variable (marginal effects reported). The first three models use data from both entry treatments 1SE and 2SE, with 1SE as the baseline, while the last model only uses 2SE data. In all models, we include lagged dummy variables to determine how the previous round of play influenced entry decisions: Win_{t-1}indicates whether the speculator won at least 1 unit in the previous round; Losses_{t-1} indicates whether the speculator made losses in the previous round; $\text{Earn}_{t-1}<10$ indicates whether the speculator earned less than the outside option in the previous round, and $(n=3)_{t-1}$ indicates whether the speculator competed with another speculator in the previous round. The variable Risk Measure (1-5) represents the gamble chosen in the Eckel-Grossman mechanism where lower numbers correspond to higher risk aversion, and Period tracks the round of play.

The negative coefficient on 2SE in models 1-3 provides robust evidence that the probability of an individual speculator entering in the 2SE treatment was significantly lower than in the 1SE treatment, which is consistent with Result 3.

Empirical Result 1: *A speculator is less likely to enter an auction when there may be another speculator.*

The strong negative effect of Period (in all models), Losses_{t-1} (in model 1) and $\text{Earn}_{t-1}<10$ (in models 2 and 3) indicates that speculators were less likely to enter in later periods, and after making losses or earning less than the outside option in the previous round. Winning at least 1 unit in the previous round had a strong positive effect on entry decisions. Including interactions with the risk measure and treatment in model 3, strong differences emerge for risk tolerant speculators in the 2SE treatment, who were more likely to enter despite earning less than 10 in the previous round.

Model 4 restricts the analysis to the 2SE treatment and shows that when a speculator was in an auction in the previous round with another speculator, risk tolerant speculators were more likely to enter than risk averse ones.

4.3. Bidding

4.3.1. Speculator

Figure 4.1 provides a jittered scatterplot of the two bids made by speculators across treatments, where bid 1 (or the first unit bid) is the highest and bid 2 (or the second unit bid) is the lowest bid. Treatment differences are most apparent in the 1SE treatment for bid 1, which appears lowest, and in the 2SE $n=3$ treatment for bid 2, which appears highest.

S Entry Choice	(1)	(2)	(3)	(4) 2SE only
2SE	-0.358**	-0.376**	-0.373**	
	(0.143)	(0.150)	(0.154)	
Risk Measure (1-5)	-0.0644	-0.0676	-0.0675	-0.00679
	(0.0409)	(0.0429)	(0.0468)	(0.0301)
2SE×Risk Measure	0.0819*	0.0858*	0.0634	
	(0.0466)	(0.0493)	(0.0516)	
Period	-0.0226***	-0.0233***	-0.0225***	-0.0265***
	(0.00361)	(0.00380)	(0.00374)	(0.00549)
Win_{t-1}	0.133***	0.0716**	0.0662*	0.0450
	(0.0386)	(0.0344)	(0.0345)	(0.0452)
$\text{Earn}_{t-1}<10$		-0.0856***	-0.171***	-0.0748*
		(0.0326)	(0.0604)	(0.0428)
$\text{Earn}_{t-1}<10\times$Risk Measure			-0.00524	
			(0.0226)	
$2\text{SE}\times\text{Earn}_{t-1}<10\times$Risk Measure			0.0540***	
			(0.0194)	
Losses_{t-1}	-0.192***			
	(0.0480)			
$(n{=}3)_{t-1}$				-0.0935
				(0.0743)
$(n{=}3)_{t-1}\times$Risk Measure				0.0637***
				(0.0208)
Observations	952	952	952	560

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.7: Marginal effects from population-averaged probit regressions with S choosing to enter as dependent variable.

Most first unit bids appear higher than 60, which is consistent with speculation. A number of second units bids are at zero and almost all second unit bids are strictly lower than first unit bids, a difference that is significant according to a one-sided sign test on session averages ($p = 0.004$). Comparing behavior between the 2SE n=2 and n=3 environments, both bid 1 and bid 2 are lower with two speculators in the auction.

Empirical Result 2: *Speculators bid positive prices for the first unit and strictly less for the second unit than for the first unit.*

To analyze treatment effects on bids, Table 4.8 reports results from random effects regressions with bid 1 (bid 2) as the dependent variable in models 1, 3, and 5 (models 2, 4, and 6). Standard errors are clustered at the individual level. The first two models are run on all data, with the 1S treatment as the baseline, while the last four models only consider the entry treatments, with

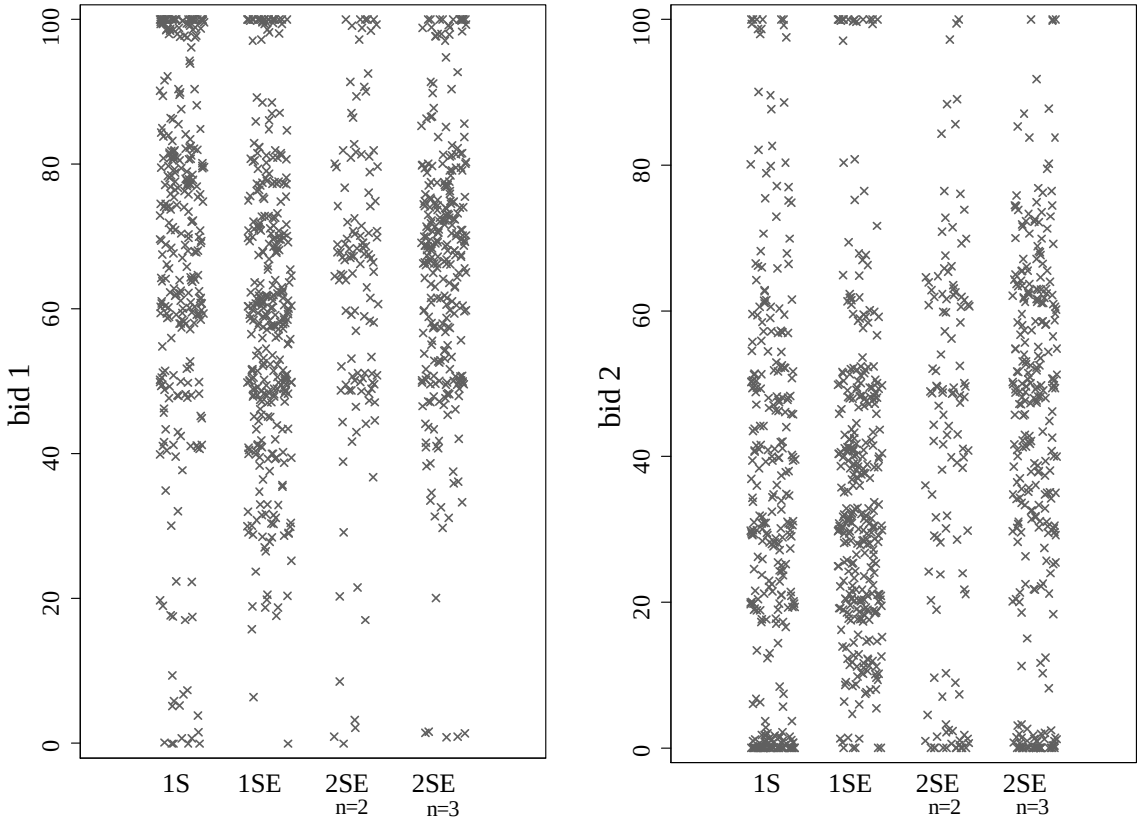

Figure 4.1: Scatterplot of S's bids for unit 1 and unit 2.

the 1SE treatment as the baseline. In all models we include treatment dummies and, for the 2SE treatment, we differentiate auctions with 2 or 3 participants.

For the first unit bid, the main treatment difference is in model 1, where bids are significantly lower in the 1SE treatment than in the 1S treatment. Coefficient tests also demonstrate treatment differences between the 1SE and 2SE n=3 treatments ($p = 0.028$), which is confirmed in model 3 using data restricted to the entry treatments. Model 5 examines first unit bids in the entry treatments by including additional controls and two dummy variables, 1 Unit Win_{t-1} and 2 Unit Win_{t-1}, which indicate whether the speculator won 1 or 2 units in the previous round, respectively. The main result is that winning one unit in the previous round (weakly) increases bids for the fist unit, while winning 2 units decreases them.

Models 2 and 4 show a weak treatment effect of slightly more aggressive bids for the second unit in the 2SE n=3 treatment. In model 6, the negative coefficient on period provides evidence that speculators bid less aggressively over time on the second unit. This indicates learning to reduce demand, even though the constant coefficient indicates that average bids are higher than zero.

	(1)	(2)	(3)	(4)	(5)	(6)
				1SE and 2SE only		
S Bid	bid 1	bid 2	bid 1	bid 2	bid 1	bid 2
1SE	-10.57**	1.504				
	(5.066)	(5.350)				
2SE n=2	-4.449	5.874	6.098	4.385	5.471	6.184
	(5.101)	(5.835)	(4.346)	(4.879)	(4.486)	(4.947)
2SE n=3	-2.927	9.014*	7.624**	7.479*	7.288*	7.073*
	(4.387)	(5.088)	(3.477)	(3.955)	(3.869)	(4.284)
Risk Measure (1-5)					0.852	0.674
					(1.251)	(1.592)
Period					-0.0534	-1.019***
					(0.233)	(0.270)
1 Unit Win$_{t-1}$					2.184*	0.464
					(1.291)	(1.403)
2 Units Win$_{t-1}$					-3.260**	1.470
					(1.421)	(1.737)
Losses$_{t-1}$					-3.418	-3.375
					(4.293)	(7.139)
Losses$_{t-1}$×Risk Measure					1.285	0.221
					(1.118)	(1.799)
Constant	68.86***	34.02***	58.31***	35.54***	56.93***	42.64***
	(4.054)	(4.418)	(3.043)	(3.035)	(4.340)	(5.245)
Observations	1,035	1,035	735	735	672	672
Number of Clusters	88	88	68	68	68	68

Robust standard errors in parentheses

***p<0.01, **p<0.05, *p<0.1

Table 4.8: Random effects regressions with S's bids as dependent variables.

4.3.2. Bidder

The bidder has a strong incentive to reduce demand and accommodate a single speculator in the auction, but this incentive is lower with two speculators. Figure 4.2 presents scatterplots of bidders' bids against values, where bid 1 (bid 2) is the highest (lowest) bid. All graphs include a regression plot (dashed line) and a reference plot for bids equal to value (solid line).

Many first unit bids fall slightly below value, but clustering towards value is apparent, particularly in the 1S treatment. The regression lines indicate that bids tend to be lower than value, and increasing in value. We run panel random regressions to test the hypothesis that first unit bids are equal to value. In all treatments, joints tests that the constant is 0 and the coefficient on value is 1 reject value bidding ($p < 0.001$).[21] For the second unit, almost all bids fall below value, and the regression line is further away from the value line, indicating stronger

[21] This includes breaking the 2SE treatment into separate regressions for the $n = 2$ and $n = 3$ cases. Regression results reported in table A.1 in the appendix.

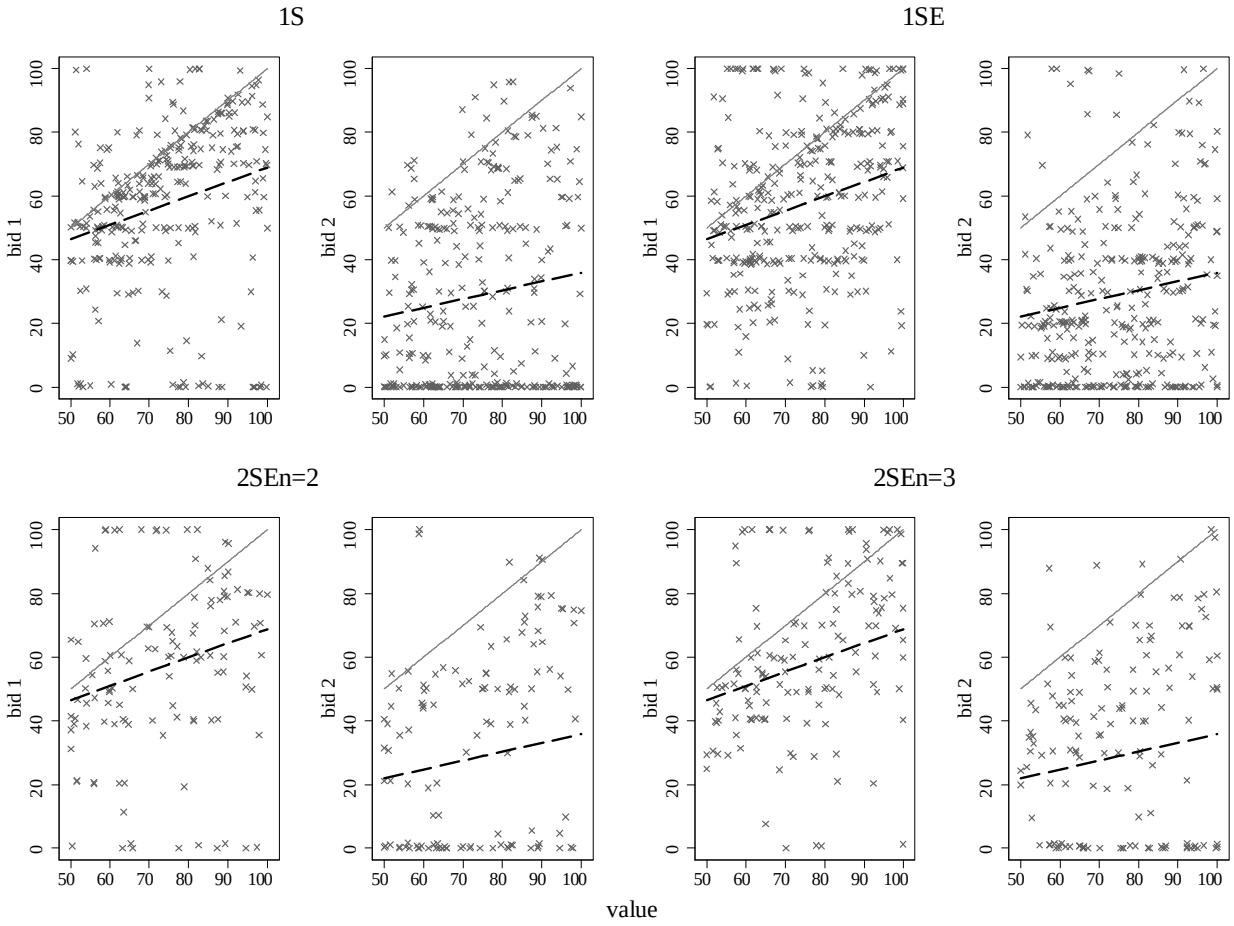

Figure 4.2: Scatterplot of B's bids for unit 1 and unit 2.

demand reduction on the second unit.

Consistent with Result 1 and demand reduction, the majority of first unit bids are strictly higher than second unit bids, which is confirmed by a one-sided sign test on session averages for the two bids ($p = 0.004$). Compared to speculators, a larger number of second unit bids are at 0, which suggests that bidders were less aggressive.

Empirical Result 3: *In all treatments, bidders bid less than their value for the first unit, and bid strictly more for the first unit than for the second unit.*

To analyze treatment effects on bidders' bids, Table 4.9 presents results from random effects regressions with bid 1 and bid 2 as dependent variables. Standard errors clustered at the individual level. In addition to the variables used for speculators, we include the bidder's unit value and its interactions with treatment. The first four models are run on all treatments, with the 1S treatment as the baseline, and the last two models only consider the entry treatments, with the 1SE treatment as the baseline.

	(1)	(2)	(3)	(4)	(5)	(6)
					1SE and 2SE only	
B Bid	bid 1	bid 2	bid 1	bid 2	bid 1	bid 2
v_B	0.549***	0.379***	0.522***	0.290***	0.569***	0.443***
	(0.0567)	(0.0655)	(0.0953)	(0.107)	(0.0681)	(0.0768)
1SE	-0.525	-1.216	-9.186	-17.56*		
	(6.024)	(5.987)	(9.958)	(9.394)		
2SE n=2	-0.426	6.010	-10.29	-12.05	0.124	7.283
	(6.577)	(7.193)	(9.882)	(9.309)	(6.438)	(6.219)
2SE n=3	2.152	5.690	2.779	-9.110	2.665	6.863
	(5.835)	(6.511)	(10.91)	(13.16)	(5.632)	(5.393)
1SE×v_B			0.113	0.210		
			(0.134)	(0.151)		
2SE n=2×v_B			0.145	0.263*		
			(0.147)	(0.159)		
2SE n=3×v_B			-0.0180	0.186		
			(0.155)	(0.204)		
Risk Measure (1-5)			0.897	1.089		
			(1.711)	(1.521)		
Period			-0.569**	-0.847***		
			(0.235)	(0.250)		
1 Unit Win$_{t-1}$			1.930	1.983		
			(1.279)	(1.443)		
2 Units Win$_{t-1}$			-0.399	3.137**		
			(1.246)	(1.430)		
Constant	16.59***	0.679	21.23**	10.24	14.60**	-5.307
	(5.144)	(5.666)	(9.048)	(8.956)	(6.340)	(5.518)
Observations	893	893	828	828	593	593
Number of Clusters	68	68	68	68	48	48

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4.9: Random effects regressions with B's bids as dependent variables.

There are no significant treatment effects in models 1 or 2 (coefficient tests, $p > 0.198$), or in models 3 and 4 with additional controls (only the 1SE treatment is weakly significant), or in models 5 and 6 with data restricted to the entry treatments. The constant coefficient indicates that the average bid intercept is significantly different from zero for bid 1, but not for bid 2. The positive and significant coefficient on value indicates an increase in bids as value increases, although the magnitude of this effect is much lower for bid 2. All these results are consistent with demand reduction by the bidders, in all treatments. Models 3 and 4 show a significant negative effect of period on bids for both units, and model 4 shows that winning two units in the previous period leads to an increase in the second unit bid.

4.4. Resale

Table 4.10 examines the probability of a resale market opening using probit regressions, where the dependent variable is equal to 1 if at least one unit was won by a speculator in the auction. The first two models consider all auctions, including those in which no speculator entered, to examine the overall probability of resale. In model 3 we only consider auctions where at least one speculator entered to examine the frequency of resale after entry decisions, and we distinguish between n=2 and n=3 in the 2SE treatment. In all models, the 1S treatment serves as the baseline.

	(1)	(2)	(3)
Resale Market			S Entered
v_B	-0.00428***	-0.00430***	-0.00493***
	(0.000930)	(0.000930)	(0.000879)
1SE	-0.169***	-0.0344	0.0135
	(0.0522)	(0.0843)	(0.0472)
2SE	-0.0826	0.136	
	(0.0519)	(0.113)	
Period	-0.00675**	0.00534	0.00276
	(0.00306)	(0.00535)	(0.00268)
1SE×Period		-0.0130**	
		(0.00649)	
2SE×Period		-0.0209**	
		(0.00869)	
2SE n=2			0.000693
			(0.0578)
2SE n=3			0.0875*
			(0.0530)
Observations	1,020	1,020	893

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.10: Marginal effects from population-averaged probit regressions with the resale market opening as dependent variable.

The coefficient on 1SE in model 1 is negative and significant and a coefficient test shows significant differences between the 1SE and 2SE treatments ($p = 0.0471$), demonstrating that resale was less likely in the 1SE treatment. The negative and significant coefficient on v_B indicates that resale was less likely when the bidder had a higher value. There is also a significant negative time trend, which emerges in both entry treatments but is stronger in the 2SE treatment (see model 2). In the last model, there is no major treatment effects conditional on entry by a speculator.

Empirical Result 4: *Post-auction resale occurs less often when the bidder has a higher value*

and in markets with one speculator who has entry choice.

Table 4.11 analyzes the success of resale using probit regressions, where the dependent variable is equal to 1 if all units won by a speculator are resold to the bidder. We include variables which measure the difference between the bidder's value and the auction price, the difference between the speculator's and the bidder's last resale offers, period of play, and the number of offers made by players. Model 1 tests for treatment effects, with the 1S treatment as the baseline, while model 2 tests if the success of resale depends on the number of units won by speculators and number of speculators in the resale market.

	(1)	(2)
Resale Success		
v_B−Auction Price	0.00402***	0.00362***
	(0.000824)	(0.000715)
Last offer difference	-0.00599***	-0.00547***
	(0.00152)	(0.00143)
Period	0.00582	0.00463*
	(0.00361)	(0.00279)
# S offers	-0.00801	-0.000190
	(0.00743)	(0.00891)
# B offers	-0.0171*	-0.0225**
	(0.00929)	(0.00915)
1SE	-0.0407	
	(0.0455)	
2SE	0.0149	
	(0.0511)	
B 1 Unit Win_{t-1}	0.00349	
	(0.0262)	
B 2 Units Win_{t-1}	0.0147	
	(0.0306)	
S win 1		0.0999**
		(0.0490)
S win 2		0.0102
		(0.0499)
Observations	519	566

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.11: Marginal effects from population-averaged probit regressions with resale success as dependent variable.

The positive and significant effect of the difference between the bidder's value and the auction price suggests that, by bidding aggressively and increasing the auction price, speculators increase their probability of winning but also reduce their success rates in resale. Model 1 shows no treatment effect (coefficient tests, $p = 0.192$). Model 2 compares the baseline case where 2

speculators win one unit each with the cases where only one speculator wins one unit and where one speculator wins both units: the probability of successful resale is higher when there is only one speculator who wins a single unit (coefficient test, $p = 0.008$).

Empirical Result 5: *Resale is more likely to succeed if a single speculator won only one unit.*

The difference between success rates for markets with one speculator and two speculators is not surprising, since it is more difficult for the bidder to bargain with more speculators. It is somewhat surprising, however, that resale with a single speculator who won both units is also less likely to succeed, since the bidder could obtain zero earnings in this case. Moreover, speculators were allowed to bundle the units, which may make trading easier, or sell each unit separately at possibly different prices. In most cases where the speculator won both units, they chose to bundle the units (173 out of 246 resale markets), and failure was rarely the result of 1 unit selling without the other (8 out of 188 failure cases).

4.5. Prices, Efficiency, and Earnings

Table 4.12 presents pooled OLS regressions with standard errors clustered at the session level.

	(1) Auction Price	(2) Auction Efficiency	(3) Final Efficiency
v_B	0.179***	0.00530***	0.00497***
	(0.0406)	(0.000873)	(0.00120)
1SE	0.321	0.00685	0.0137
	(3.271)	(0.0173)	(0.0226)
2SE n=2	5.373	-0.0647*	0.0116
	(3.664)	(0.0326)	(0.0285)
2SE n=3	21.28***	-0.198**	-0.0869*
	(3.298)	(0.0647)	(0.0391)
Period	-0.668***	-0.00162*	0.00577*
	(0.179)	(0.000790)	(0.00247)
Constant	30.06***	0.0765	0.465***
	(5.366)	(0.0642)	(0.105)
Observations	893	893	893
R-squared	0.161	0.097	0.093

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.12: Pooled OLS regressions on outcome variables.

Model 1 examines auction prices. The average auction price is above zero, as indicated by the significant constant, and is increasing in the bidder's valuation. No significant differences are found between treatments with two participants ($p = 0.102$), but prices are significantly higher

in the 2SE n=3 treatment ($p < 0.001$). The negative significant coefficient on Period indicates that the auction price decreases over time.

Empirical Result 6: *Auction prices are higher when two speculators enter the auction.*

Models 2 and 3 examine auction and final efficiency. In all models, efficiency is positively correlated to the bidder's value, indicating that bidders with higher values tend to obtain the units more often in the auction and in the resale market. Model 2 shows that auction efficiency is lower in the 2SE treatment, especially when both speculators enter the auction. Treatment differences for final efficiency are reduced in model 3, indicating that resale corrects the lower auction efficiency observed in the 2SE treatment.

	(1)	(2)	(3)	(4)	(5)
Earnings	S	S	S	B	B
v_B		0.565***	0.570***		1.476***
		(0.0904)	(0.0906)		(0.0844)
1SE	-0.678	-1.105	9.314	2.645	1.461
	(3.415)	(3.477)	(7.483)	(4.133)	(3.903)
2SE n=2	1.679	2.104	28.42**	-12.16**	-11.05**
	(5.689)	(5.787)	(12.29)	(5.644)	(5.272)
2SE n=3	-14.13***	-15.44***	1.155	-26.63***	-29.87***
	(3.631)	(3.625)	(8.102)	(4.392)	(4.011)
Period	1.114***	0.912***	0.927***	1.582***	1.029***
	(0.274)	(0.268)	(0.265)	(0.316)	(0.304)
Risk Measure (1-5)	0.712	1.092	5.076**	-0.120	-0.644
	(0.898)	(0.939)	(1.974)	(1.069)	(0.983)
1SE×Risk Measure			-3.697		
			(2.362)		
2SE n=2×Risk Measure			-9.017***		
			(3.128)		
2SE n=3×Risk Measure			-5.628**		
			(2.300)		
Constant	-5.472	-46.29***	-57.96***	37.01***	-64.79***
	(4.812)	(9.209)	(10.93)	(5.764)	(6.767)
Observations	1,035	1,035	1,035	893	893
Number of Clusters	88	88	88	68	68

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.13: Random effects regressions with players' earnings in a round as dependent variables.

Table 4.13 examines total earnings, including both auction and resale earnings, for speculators (models 1-3) and the bidder (models 4 and 5), through random effects panel regressions with standard errors clustered at the individual level and the 1S treatment as the baseline.

Observations are restricted to rounds where a speculator entered.[22] In Model 1, speculators' earnings are lower when two speculators entered the auction. There are no other significant differences between treatments ($p = 0.643$). In Model 2, the bidder's value has a positive and significant effect on speculators' earnings.

Model 3 interacts speculators' risk preferences with treatments. The significant coefficient on the risk measure shows that risk tolerant speculators earned more in markets with a single speculator, while the coefficients on the interactions of the risk measure with the 2SE treatment shows that speculators earned less in markets with two speculators.

The last two models examine bidders' earnings. Basic treatment effects are tested in model 4 which shows that bidders are worse off in markets with two speculators, especially when both entered the auction ($p = 0.005$). The bidder's value in model 5 has a positive and significant effect on earnings, as expected. Across all models, earnings are increasing for both types over time, which corresponds to falling auction prices in Table 4.12.

Empirical Result 7: *Speculators' and the bidder's earnings are lowest when there are 2 speculators in the auction.*

5. Conclusion

We use a combination of theory and controlled laboratory experiments to analyze the effects of speculators in multi-object auctions, where the number of speculators and the entry choice of the speculator is varied. The environment is designed to measure the response of non-speculative bidders to the presence of speculators, and speculators' response to other speculators in the market.

Regardless of the number of speculators, bidders consistently reduce demand by bidding less aggressively on the second unit, allowing speculators to win at least one unit in the auction. In most cases, speculators make positive profit by reselling, which induces other speculators to enter the auction. In markets with multiple speculators, individual speculators enter less often, as predicted, but coordination failure led most auctions to have multiple speculators which almost always resulted in speculators' losses.

Speculators are much more responsive than bidders to treatment conditions. In markets with a single speculator, speculators did not always enter the auction and we find little evidence that this is due to risk preferences. In the treatment with multiple speculators, speculators with high levels of risk tolerance were more likely to enter, even after periods in which they made losses or both speculators entered. Since no effects on bidding were observed, the higher revenue in auctions with multiple speculators was only due to an increase in the number of participants.

Auction efficiency is often lower than in a random allocation. Resale may correct an inefficient auction allocation, but it never fully restores efficiency in our environment. The main reason for

[22] Specifically, we only include speculators who participated in the auction and bidders who did not win by default.

resale failure is an auction price too close to the bidder's value, which was most likely to occur when the bidder did not win any unit.

In sum, our results suggest that in multi-object auctions bidders will generally reduce demand whenever speculators are present. Therefore, a seller who aims to increase his revenue should attract multiple speculators, who are not likely to coordinate, by reducing their participation costs. However, more speculators also reduce the efficiency of the resale market and of the final allocation, suggesting a revenue/efficiency trade-off.

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A. Appendix

A.1. Proofs

Proof of Proposition 1. First notice that the first-unit bid (i.e., the highest bid by a player) does not affect the auction price, and that increasing the second-unit bid without changing the auction allocation only increases the auction price and reduces players' profit. Therefore, a player may only have an incentive to deviate from the equilibrium described if this allows him to win two units — i.e., the speculator may only have an incentive to deviate by bidding more than v_B for both units and the bidder may only have an incentive to deviate by bidding more than 50 for both units.

If the speculator bids any price higher than v_B for both units, he wins two units at per-unit price v_B but, because he cannot resell them at a price higher than the bidder's valuation, he obtains at most zero profit. If the bidder bids any price higher than 50 for both units, he wins two units at per-unit price 50 but obtains a profit that is lower than the equilibrium ones because

$$2v_B - r > 2\left(v_B - 50\right) \quad \Leftrightarrow \quad r < 100,$$

which is always true since the resale price cannot be higher than the highest possible bidder's valuation. Hence, neither the bidder nor the speculator have any incentive to deviate from the equilibrium described. ■

Proof of Proposition 2. We show that no player has an incentive to deviate from the strategies described. First, consider the speculator who bids 100 for both units and wins both units at price $\mathbb{E}[r]$ in the auction. By changing his strategy, he could only reduce the number of units he wins in the auction, without affecting the auction price.

Second, consider the speculator who bids $\mathbb{E}[r]$ for both units and wins no unit in the auction. In order to win a unit, he has to outbid the other speculator and raise the auction price up to 100. This would result in negative profit since he cannot resell a unit at a price that is higher than the highest possible bidder's valuation. Third, consider the bidder who wins no unit in the auction and acquires them in the resale market at price r. In order to win a unit in the auction, he has to outbid the speculators and raise the auction price up to 100. Since this is higher than r, by winning two units the bidder reduces his profit. ■

A.2. Additional Regressions

B Bid	(1) 1S bid 1	(2) 1SE bid 1	(3) 2SE n=2 bid 1	(4) 2SE n=3 bid 1	(5) 2SE n=3 bid 2
v_B	0.509***	0.570***	0.660***	0.485***	0.408**
	(0.103)	(0.0870)	(0.104)	(0.139)	(0.180)
Constant	19.54***	14.53**	8.187	23.82**	3.931
	(6.802)	(7.375)	(7.064)	(10.04)	(12.17)
Observations	300	332	119	142	142
Number of Clusters	20	28	20	20	20

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

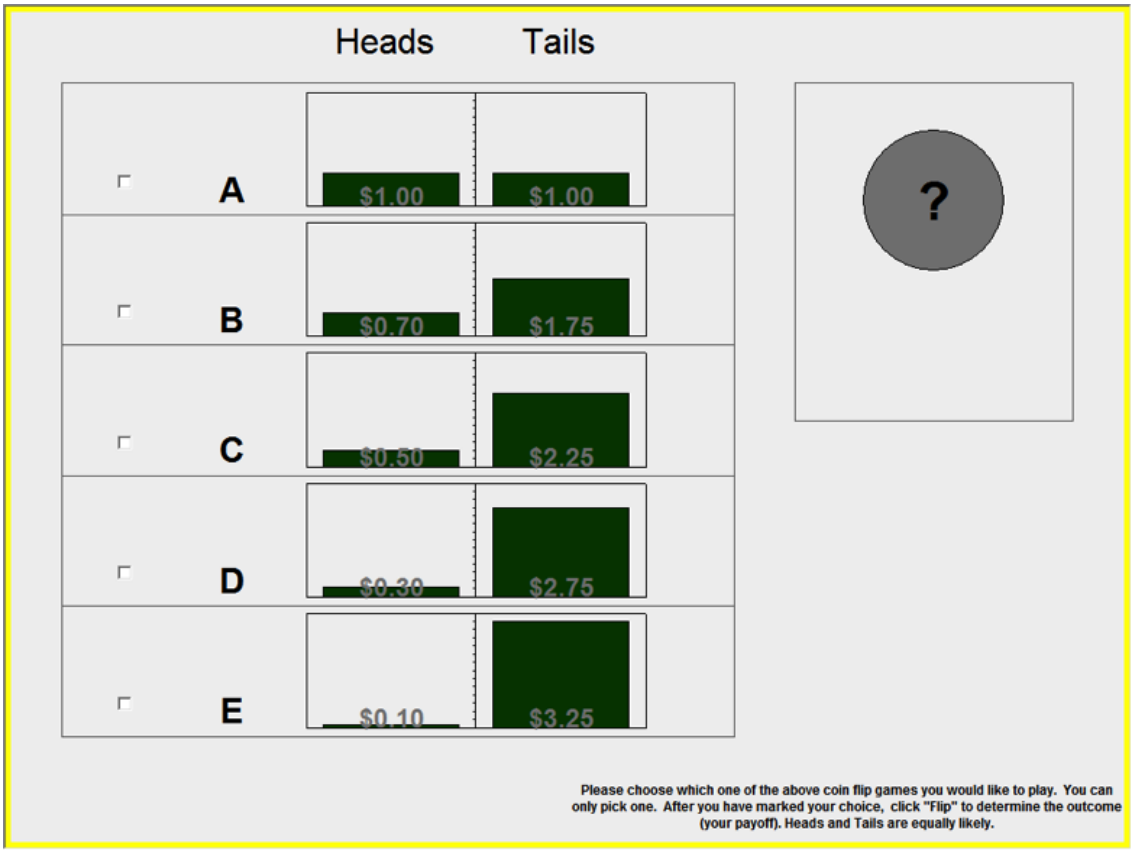
Table A.1: Random effects regressions with bidder's bid for either unit 1 (the highest bid) or unit 2 as dependent variable.

A.3. 1S Instructions

Thank you for participating in today's experiment. I will read through a script to explain to you the nature of today's experiment as well as how to work the computer interface you will be using. I will be using this script to make sure that all sessions of this experiment receive the same information, but please feel free to ask questions as they arise. We ask that everyone please refrain from talking or looking at the monitors of other subjects during the experiment.

The purpose of this experiment is to study how people make decisions in a particular situation. You will receive 10 dollars for showing up for the experiment. You will also make additional money during today's experiment. Payments will be in cash at the end of the experiment and are confidential.

You can now follow along with the instructions on your screen. In the first stage of this experiment, we will ask you to play a lottery of your choice. Please press continue to enter in to this game.



What you should see is a series of 5 lotteries labeled A through E. On the right there is a virtual coin, which has two sides, heads and tails, and will be used to determine the payoff outcome. Please choose one of the lotteries you would like to play and then "Flip" the coin. Depending on which side the coin lands on, you will earn the amount corresponding to the heads or tails column. Both heads and tails are equally likely. Once you have confirmed your choice, the game will play out and your resulting payoff will be shown at the bottom of the screen.

Please make your decision now, and hit continue once you have finished.

Stage 2: In this next stage, you will be a bidder in a series of auctions. You may have some experience bidding in auctions or you may have seen various types of auctions on television.

Please do not assume this auction is like those and please pay particular attention to the rules of this auction as it is in your financial interest to do so. All amounts in this phase of the experiment are in experimental currency units, ECUs. At the end of the experiment, each ECU you earn will convert into dollars at a rate of 1 ECU = \$0.01.

Basics: To make these instructions as simple as possible, we will first discuss the basic details and then we will add in other elements.

Rounds: You will participate in a series of rounds. Each round will consist of you participating in an auction, which may then be followed by a post-auction resale market.

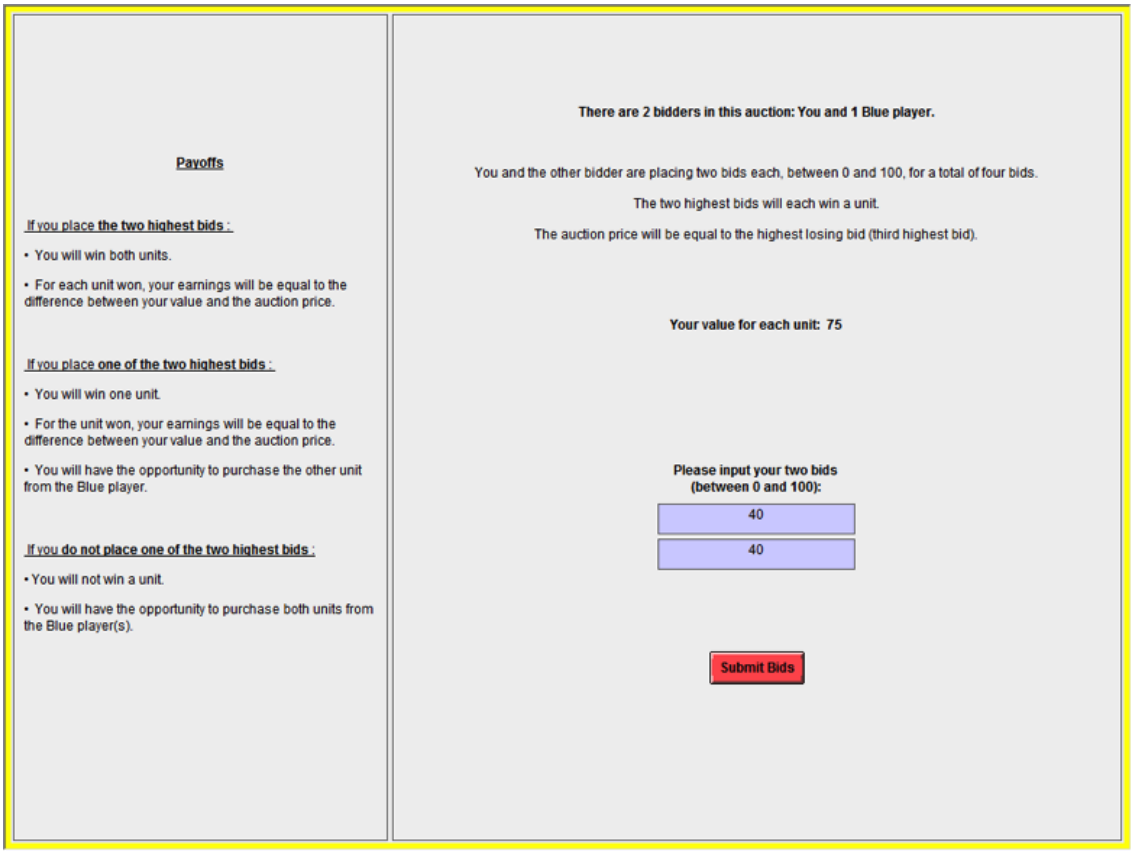
Player Types: You have been assigned a player type: blue or green player. You will maintain this type throughout the experiment.

Groups: In each round, you will be randomly matched into a group consisting of 1 green player and 1 blue player. The two players in the group will be bidding against each other.

Auction: Each auction has 2 hypothetical items for sale, which we call units. Both units will be auctioned off together. Green players will be given a unit value in each round that is drawn randomly from the numbers between 50 and 100, with each number equally likely. What this value represents is the amount paid to green players if they win a unit in the auction. Blue players will have no unit value.

Resale Market: After the auction, if a blue player wins a unit in the auction, they will have the opportunity to resell any units won to the green player.

Auction and Resale Payoffs: Green players make money by buying units in the auction or in resale. Blue players make money by selling units won in the auction to green players.



In the auction you can make two bids - one bid for each unit on sale. To place bids, type the bid amounts in the blue boxes located in the middle of the screen and press the "Submit Bids"

button. If your bids are higher than the bids submitted by the other player from your group, you will win both units. If you place one of the two highest bids in your group, you will win one unit. If you do not place the two highest bids, you will not win any units.

The auction price that winners must pay for each unit is set by the third highest bid and is the same for both units.

Please turn now to the auction example in the handout you were given to see how this works

	Bid 1	Bid 2
Blue Player	55	60
Green Player (value 75)	70	0

In this example both the blue player and green player place two bids, as seen in the first table, for a total of 4 bids. Please note that these bids are for example purposes only and are not suggestive of how you should make decisions. The computer will rank all bids made from highest to lowest, and assign outcomes. It doesn't matter which order the bids were submitted and any ties in bids will be broken randomly by the computer. You can see how this works in the second table. All bids have been ranked from highest to lowest.

Rank	Bid	Player who made bid	Result
1	70	Green	Highest bid – win unit 1
2	60	Blue	2nd highest bid – win unit 2
3	55	Blue	3rd highest bid – sets the auction price (55) for units 1 & 2
4	0	Green	

The green player made the highest bid of 70, and so wins 1 unit. The blue player placed the second highest bid of 60, and wins the second unit. The auction price is set by the third highest bid, which in this example is 55. The price is the same for both units, so in this example, the green player and the blue player will each pay a price of 55 for the unit they won.

Auction payoffs can be seen in the third table. The only type of player who can make money during the auction is the green player. If the green player wins a unit, they will earn the difference between their unit value and the auction price. Blue players will pay the price for any unit won, but cannot make money in the auction because they do not have a value.

Player	Units Won	Auction Price	Auction Payoffs
Green	1	55	Value – Price Paid = 75-55 = 20 ECUs
Blue	1	55	Price Paid 55

Assuming the green player's value is 75 and that the price resulting from the auction is 55, the green player who won a unit would earn 20 ECUs in the auction. The blue player will pay a price of 55, and if they fail to resell the unit, the must still pay the auction price resulting in a loss of -55 for the round.

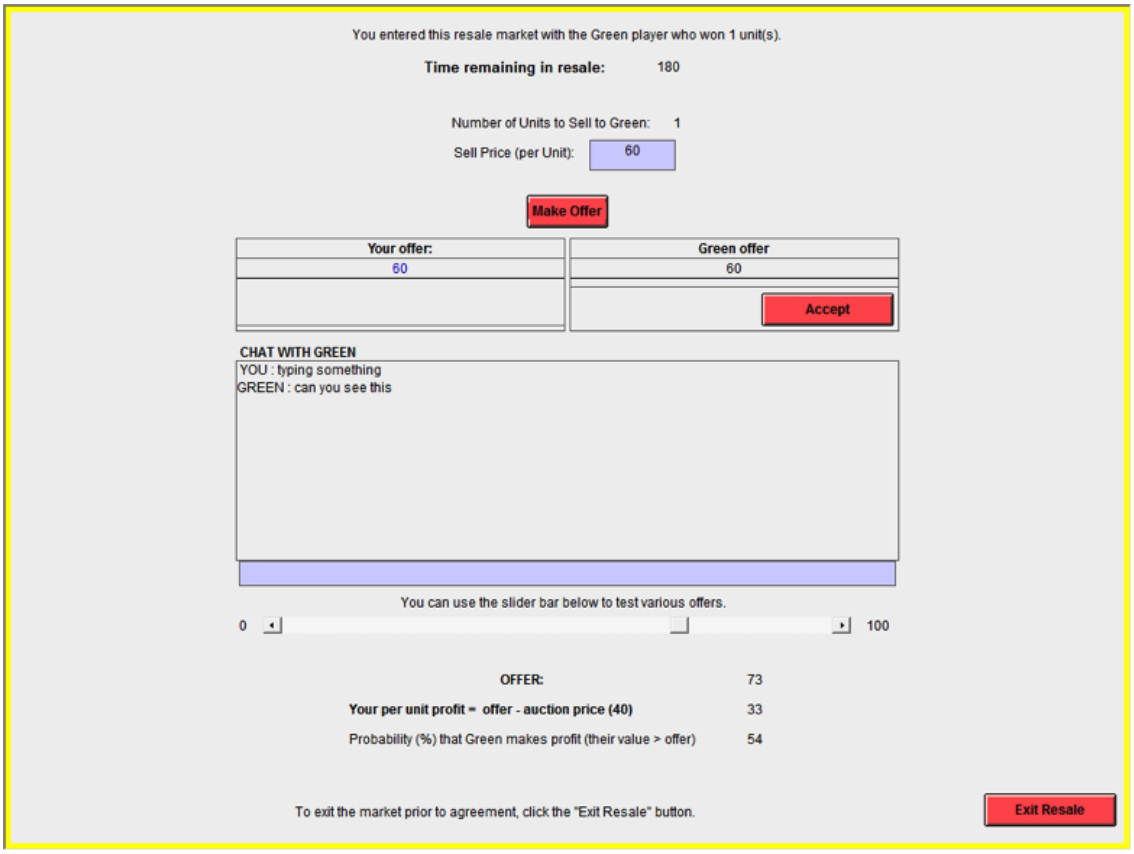
Since it is possible to lose money, you will all begin this phase of the experiment with a balance of ECUs: 400 for blue players and 50 for green players. This balance will increase as you make profits and decrease when you make losses. Should you lose enough money that this balance becomes negative; you will be reset with your initial balance once, and continue

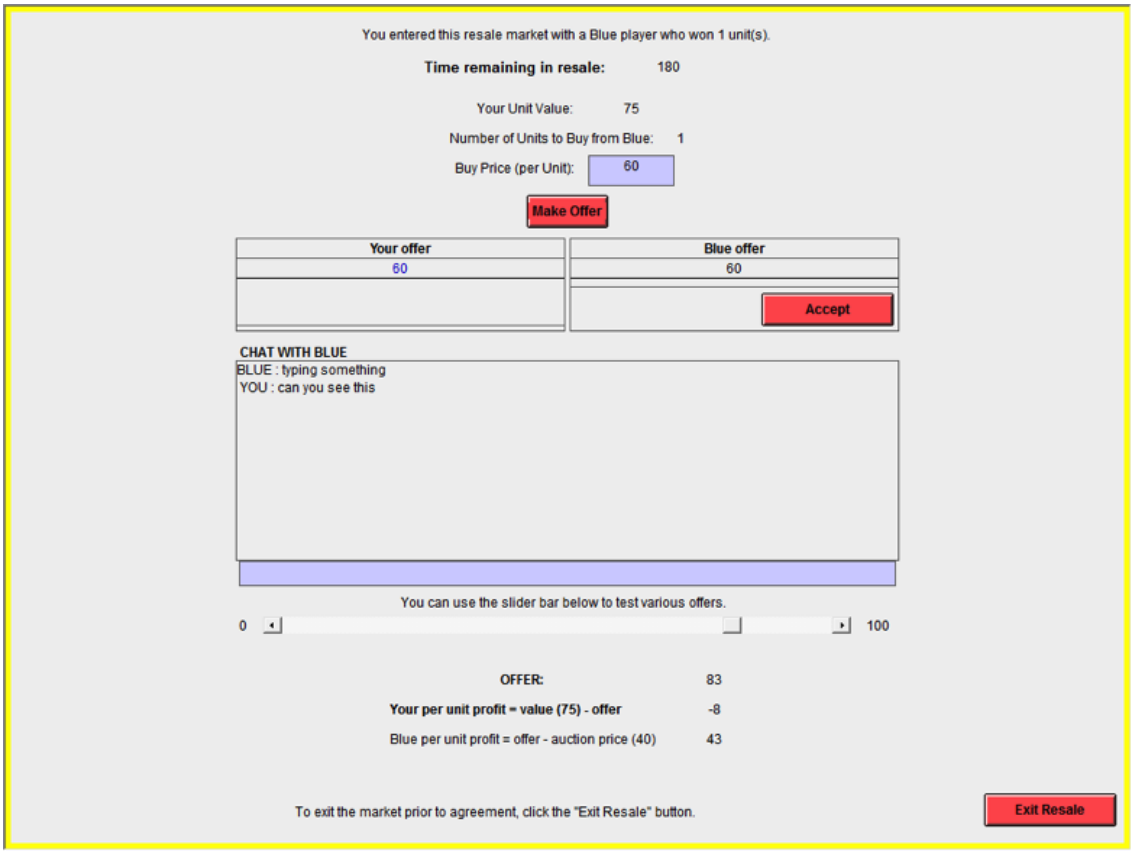
participating. If you go bankrupt a second time, you will be removed from the experiment and paid your show-up fee only.

During the auction, you will have a reminder of the payoff rules which you can see on the left side of the auction screen. A few final details before we continue: All bids must be between 0 and 100, which is the maximum possible value of the green player. At the top of the auction screen, you will find reminder information about how many bidders are in the auction – which is 2. Any ties in bids will be broken randomly by the computer.

We will now work through a new example using the computer where you input bids. Please input two bids, both equal to 40, into the blue boxes and press Submit Bids. Please note that bids do not have to be equal, this is only for example purposes. When the auction ends, you will be redirected to a results screen similar to the one that you see now. The blue and green player tied for the two highest bids and so the computer randomly split the units between these two players. The blue player won 1 unit and the green player won 1 unit. They both paid the auction price of 40 for their unit.

Because the blue player won a unit, there will be a resale market where the blue player can resell the unit won to the green player. The green player earned the difference between their value, 75, and the auction price, 40, for auction earnings of 35 for the unit won. Please press continue to enter the resale market





The green player's value will be identical to the value held during the auction stage. If you are a green player, you will see a reminder of this at the top of the market.

For resale to occur, both the blue player and the green player must agree to a resale offer. If they agree to a resale offer, the unit will be traded and the green player will earn the difference between their value and the resale price. The blue player will earn the difference between the resale price and the price they paid in the auction. If no resale offer is agreed to, no units will be traded.

Resale offers are made in the blue box at the top of the screen. Directly above this box, you will see a reminder of the units for sale in this market, which in this case is 1 unit.

You have two tools to facilitate your resale decisions. The first is chat. Messages can be sent to the other participant in this box. Please type a message now in the long blue space below the large box where the chat is displayed, for example, "hello" and press enter. Make sure that you hit enter after you have typed a message for it to be sent. Check that everyone was able to send a message. We also ask that throughout the experiment you do not provide identifiable information about yourself to the other participants.

In addition to chat, you will also have access to the scrollbar seen at the bottom of the screen. You can use the scrollbar to determine your payoff for a given offer. This will always be your per unit profit, even if you are selling 2 units. Please move the scrollbar now. You will see your profit for a given offer. You are also given information about the other's payoff below your profit. For green players, it will be Blue's profit and for Blue players, you will be told the probability that a given offer would lead to positive profits for the green player.

If you would like to exit resale at any time before agreement, there will be an exit button at the bottom of the market which you can click. (Emphasize) You will have 180 seconds (or

3 minutes) to agree to an offer with the other participant. The time will be indicated at the top of the screen Currently it is paused at 180 seconds for example purposes, but during the experiment this clock will actively click down.

The resale market will end automatically when time expires, or when one of the participants chooses to exit, or when an offer is agreed to. Once resale ends, you will be automatically redirected to the next screen. Let's now practice making an offer. Everyone please input an offer of 60 into the blue box. Of course, if this were the actual experiment, you do not both have to type in the same offer, and this is only for example purposes. Once you have typed in the offer, you will see the box underneath update with your offer if you have done this correctly. You should also see the other player's offer update.

To accept the offer of the other participant, click on their offer, which will highlight in Blue and then click "Accept." Once all units have been agreed to, the resale stage will immediately terminate. Prior to agreement, offers can be changed at any time. Please accept the offer available to you to continue.

What you will now see is the typical screen at the end of the round that displays all results. At the top will be a recap of the auction. Green players won 1 unit and earned 35 for that unit in the auction. The blue player won the other unit and paid a price of 40. Below this will be the resale results. In resale, Green purchased 1 unit from the blue player, for a resale price of 60. Green earns the difference between their value in this practice round, 75, and the resale price, 60, for the unit purchased. Total earnings for green in resale are 15. Green's total earnings for the round are equal to the auction earnings plus resale earnings, 50. Blue earned the resale price of 60, less the price paid in the auction, 40, for total earnings of 20.

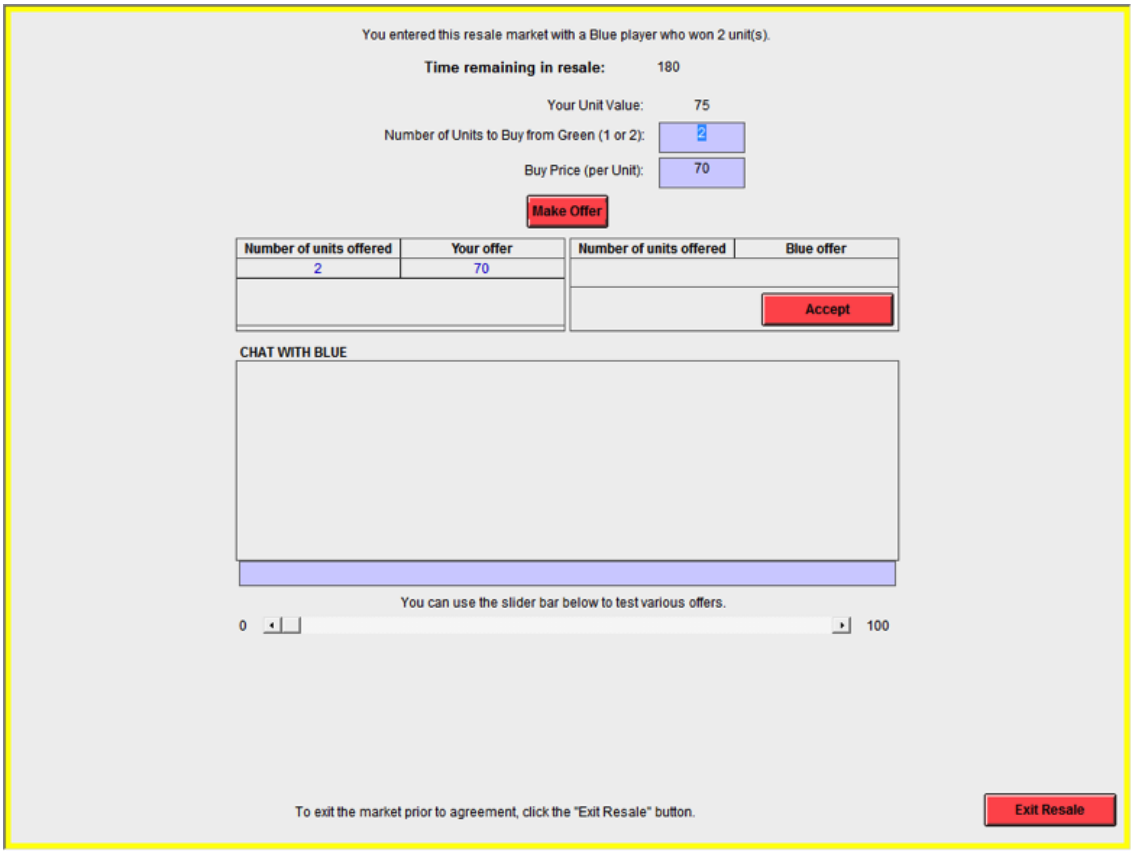
Please press continue. We will go through one more example that will demonstrate other scenarios you may encounter.

If you are a green bidder, please place two 0 bids. Blue players can also bid 0, but for this example, if you are a blue player please place two bids of 30. Please submit your bids.You will now see that you have been directed to a tic-tac-toe board rather than the auction results.

Because of group matching design we use, it may be the case that some groups are waiting on others to finish making decisions. During this downtime, all members of your group will be directed to a tic-tac-toe board similar to this to wait until the round can continue. There are no earnings for tic-tac-toe.

Please press continue.

You will see the summary screen of the auction here. The blue player placed the two highest bids and won both units at a price of 0, which was the third highest bid of the group. The last line of this screen for both players will indicate the number of units available for trade – which in this example will be 2. Please press continue to enter into the resale market for this example.



The screen for resale is now slightly different from the last example. Notice that in addition to the offer price, you must now also input the number of units to trade: 1 or 2. Below the units input, you will again be asked to submit an offer. The offer will always be per unit, but both units can be traded together. For example, please now input 2 and an offer of 70, then click "MAKE OFFER". If this offer was accepted by the other participant, the total resale price would be 140. It is also possible to sell one unit at a time by inputting 1 unit instead of 2.

In all resale stages, you will have the option to exit before a trade is made. Please press the EXIT RESALE button to leave the resale market.

You can now see the standard results screen for this example –notice there are no resale earnings, because no units were traded in resale. Please press continue.

We are about to begin the actual auctions that you will be paid for. Are there any questions ? You will now begin the paid rounds. You are participating at your own pace. Please follow the on screen instructions. Please also make sure that when a continue button is available, you click it whenever you are ready so the experiment can continue.

A.4. 1SE Instructions

Thank you for participating in today's experiment. I will read through a script to explain to you the nature of today's experiment as well as how to work the computer interface you will be using. I will be using this script to make sure that all sessions of this experiment receive the same information, but please feel free to ask questions as they arise. We ask that everyone please refrain from talking or looking at the monitors of other subjects during the experiment.

The purpose of this experiment is to study how people make decisions in a particular situation. You will receive 10 dollars for showing up for the experiment. You will also make additional money during today's experiment. Payments will be in cash at the end of the experiment and are confidential. You can now follow along with the instructions on your screen.

In the first stage of this experiment, we will ask you to play a lottery of your choice. Please press continue to enter in to this game.

(see lottery screenshot in 1S instructions)

What you should see is a series of 5 lotteries labeled A through E. On the right there is a virtual coin, which has two sides, heads and tails, and will be used to determine the payoff outcome. Please choose one of the lotteries you would like to play and then "Flip" the coin. Depending on which side the coin lands on, you will earn the amount corresponding to the heads or tails column. Both heads and tails are equally likely. Once you have confirmed your choice, the game will play out and your resulting payoff will be shown at the bottom of the screen.

Please make your decision now, and hit continue once you have finished.

Stage 2: In this next stage, you will be a bidder in a series of auctions. You may have some experience bidding in auctions or you may have seen various types of auctions on television. Please do not assume this auction is like those and please pay particular attention to the rules of this auction as it is in your financial interest to do so. All amounts in this phase of the experiment are in experimental currency units, ECUs. At the end of the experiment, each ECU you earn will convert into dollars at a rate of 1 ECU = \$0.01.

Please hit continue

Basics: To make these instructions as simple as possible, we will first discuss the basic details and then we will add in other elements.

Rounds: You will participate in a series of rounds. Each round will consist of some of you making a choice to enter into an auction, which may then be followed by a post-auction resale market.

Player Types: You have been assigned a player type: blue or green player. You will maintain this type throughout the experiment.

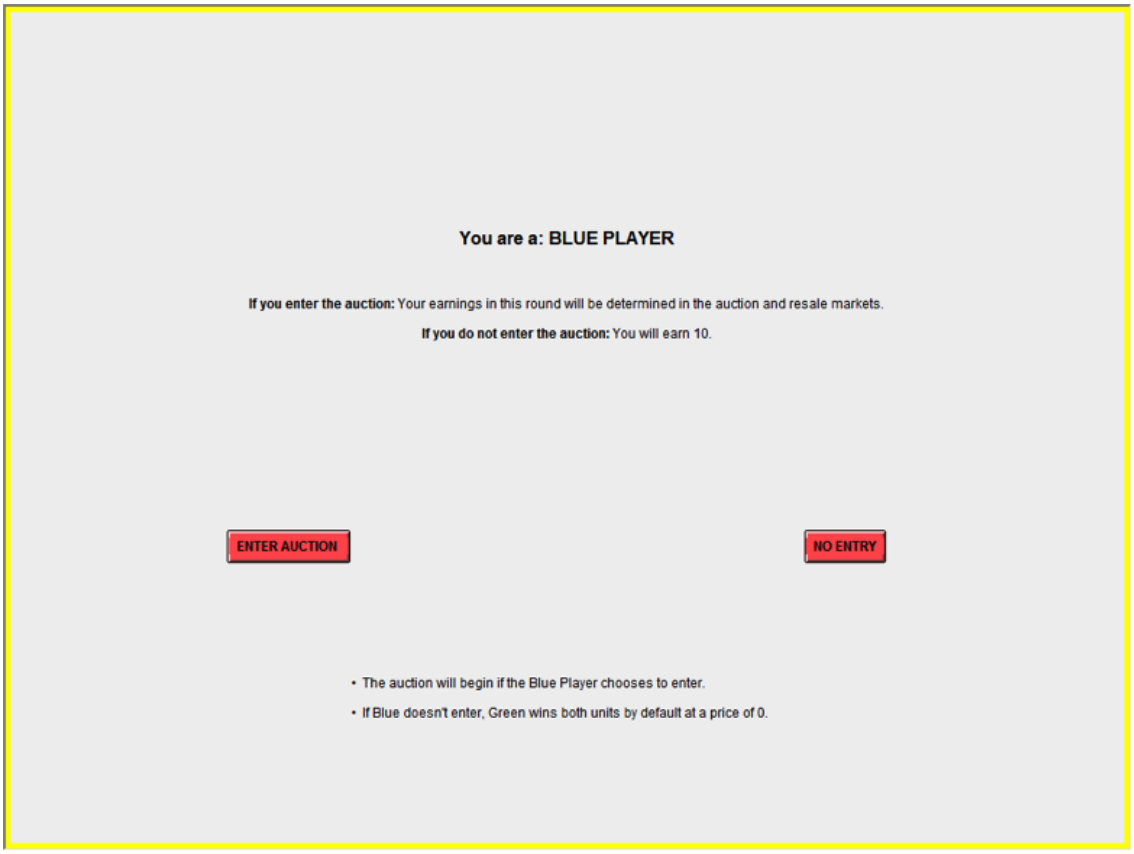
Entry & Groups: In each round, you will be randomly matched into a group consisting of 1 green player and 1 blue player. The blue player in your group will choose whether or not to enter into the auction with the green player who was automatically entered, and all entrants into the auction will be bidding against each other.

Auction: Each auction has 2 hypothetical items for sale, which we call units. Both units will be auctioned off together. Green players will be given a unit value in each round that is drawn randomly from the numbers between 50 and 100, with each number equally likely. What this value represents is the amount paid to green players if they win a unit in the auction. Blue players will have no unit value.

Resale Market: After the auction, if a blue player wins a unit in the auction, they will have the opportunity to resell any units won to the green player.

Auction and Resale Payoffs: Green players make money by buying units in the auction or in resale. Blue players make money by selling units won in the auction to green players.

Please press continue as we will now go through a series of examples to explain the details



At the start of each round, the blue player will be asked if they want to enter into the auction. Depending on your type, blue or green, this is a sample of the screen you will see. If you are a blue player and you enter the auction, your earnings will be determined in the auction and resale markets. If however, you choose not to enter the auction, you will earn 10 ECUs for the round. This will be the final payment for the round if you are a blue player. If you are a green player you are automatically entered into the auction in each round.

For the auction to begin, the blue player must choose to enter. If the blue player does not enter into the auction, the units will be awarded by default to the green player at a price of zero (with no auction taking place since there is only 1 bidder).

If you are a blue player, Please hit "ENTER AUCTION" to learn how the auction works. If you are a green player please hit "Continue" – during the paid rounds you will not have this button, but will be automatically directed forward once the decision by the blue player in your group has been made.

(see auction screenshot in 1S instructions)

In the auction you can make two bids - one bid for each unit on sale. To place bids, type the bid amounts in the blue boxes located in the middle of the screen and press the "Submit Bids" button. If your bids are higher than the bids submitted by the other player from your group, you will win both units. If you place one of the two highest bids in your group, you will win one unit. If you do not place the two highest bids, you will not win any units. The auction price that winners must pay for each unit is set by the third highest bid and is the same for both units.

In this example, assume there are two bidders in the auction because the blue player entered. Each bidder places two bids, as seen in the first table, for a total of 4 bids. Please note that these

bids are for example purposes only and are not suggestive of how you should make decisions.

Please turn now to the auction example in the handout you were given to see how this works

	Bid 1	Bid 2
Blue Player	55	60
Green Player (value 75)	70	0

In this example both the blue player and green player place two bids, as seen in the first table, for a total of 4 bids. Please note that these bids are for example purposes only and are not suggestive of how you should make decisions. The computer will rank all bids made from highest to lowest, and assign outcomes. It doesn't matter which order the bids were submitted and any ties in bids will be broken randomly by the computer. You can see how this works in the second table. All bids have been ranked from highest to lowest.

Rank	Bid	Player who made bid	Result
1	70	Green	Highest bid – win unit 1
2	60	Blue	2nd highest bid – win unit 2
3	55	Blue	3rd highest bid – sets the auction price (55) for units 1 & 2
4	0	Green	

The green player made the highest bid of 70, and so wins 1 unit. The blue player placed the second highest bid of 60, and wins the second unit. The auction price is set by the third highest bid, which in this example is 55. The price is the same for both units, so in this example, the green player and the blue player will each pay a price of 55 for the unit they won.

Auction payoffs can be seen in the third table. The only type of player who can make money during the auction is the green player. If the green player wins a unit, they will earn the difference between their unit value and the auction price. Blue players will pay the price for any unit won, but cannot make money in the auction because they do not have a value.

Player	Units Won	Auction Price	Auction Payoffs
Green	1	55	Value – Price Paid = 75-55 = 20 ECUs
Blue	1	55	Price Paid 55

Assuming the green player's value is 75 and that the price resulting from the auction is 55, the green player who won a unit would earn 20 ECUs in the auction. The blue player will pay a price of 55, and if they fail to resell the unit, the must still pay the auction price resulting in a loss of -55 for the round.

Since it is possible to lose money, you will all begin this phase of the experiment with a balance of ECUs: 400 for blue players and 50 for green players. This balance will increase as you make profits and decrease when you make losses. Should you lose enough money that this balance becomes negative; you will be reset with your initial balance once, and continue participating. If you go bankrupt a second time, you will be removed from the experiment and paid your show-up fee only.

Please now turn again to the auction screen on your computer. During the auction, you will have a reminder of the payoff rules which you can see on the left side of the auction screen.

A few final details before we continue: All bids must be between 0 and 100, which is the maximum possible value of the green player. At the top of the auction screen, you will find reminder information about how many bidders are in the auction – which is 2. Any ties in bids will be broken randomly by the computer.

We will now work through a new example using the computer where you input bids. Please input two bids, both equal to 40, into the blue boxes and press Submit Bids. Please note that bids do not have to be equal, this is only for example purposes. When the auction ends, you will be redirected to a results screen similar to the one that you see now. The blue and green player tied for the two highest bids and so the computer randomly split the units between these two players. The blue player won 1 unit and the green player won 1 unit. They both paid the auction price of 40 for their unit.

Because the blue player won a unit, there will be a resale market where the blue player can resell the unit won to the green player. The green player earned the difference between their value, 75, and the auction price, 40, for auction earnings of 35 for the unit won.

Please press continue to enter the resale market

(see resale screenshots in 1S instructions)

The green player's value will be identical to the value held during the auction stage. If you are a green player, you will see a reminder of this at the top of the market.

For resale to occur, both the blue player and the green player must agree to a resale offer. If they agree to a resale offer, the unit will be traded and the green player will earn the difference between their value and the resale price. The blue player will earn the difference between the resale price and the price they paid in the auction. If no resale offer is agreed to, no units will be traded.

Resale offers are made in the blue box at the top of the screen. Directly above this box, you will see a reminder of the units for sale in this market, which in this case is 1 unit.

You have two tools to facilitate your resale decisions. The first is chat. Messages can be sent to the other participant in this box. Please type a message now in the long blue space below the large box where the chat is displayed, for example, "hello" and press enter. Make sure that you hit enter after you have typed a message for it to be sent. Check that everyone was able to send a message. We also ask that throughout the experiment you do not provide identifiable information about yourself to the other participants.

In addition to chat, you will also have access to the scrollbar seen at the bottom of the screen. You can use the scrollbar to determine your payoff for a given offer. This will always be your per unit profit, even if you are selling 2 units. Please move the scrollbar now. You will see your profit for a given offer. You are also given information about the other's payoff below your profit. For green players, it will be Blue's profit and for Blue players, you will be told the probability that a given offer would lead to positive profits for the green player.

If you would like to exit resale at any time before agreement, there will be an exit button at the bottom of the market which you can click. (Emphasize) You will have 180 seconds (or 3 minutes) to agree to an offer with the other participant. The time will be indicated at the top of the screen Currently it is paused at 180 seconds for example purposes, but during the experiment this clock will actively click down.

The resale market will end automatically when time expires, or when one of the participants chooses to exit, or when an offer is agreed to. Once resale ends, you will be automatically redirected to the next screen.

Let's now practice making an offer. Everyone please input an offer of 60 into the blue box. Of course, if this were the actual experiment, you do not both have to type in the same offer,

and this is only for example purposes. Once you have typed in the offer, you will see the box underneath update with your offer if you have done this correctly. You should also see the other player's offer update.

To accept the offer of the other participant, click on their offer, which will highlight in Blue and then click "Accept." Once all units have been agreed to, the resale stage will immediately terminate. Prior to agreement, offers can be changed at anytime.

Please accept the offer available to you to continue.

What you will now see is the typical screen at the end of the round that displays all results. At the top will be a recap of the auction. Green players won 1 unit and earned 35 for that unit in the auction. The blue player won the other unit and paid a price of 40. Below this will be the resale results. In resale, Green purchased 1 unit from the blue player, for a resale price of 60. Green earns the difference between their value in this practice round, 75, and the resale price, 60, for the unit purchased. Total earnings for green in resale are 15. Green's total earnings for the round are equal to the auction earnings plus resale earnings, 50. Blue earned the resale price of 60, less the price paid in the auction, 40, for total earnings of 20.

Please press continue. We will go through one more example that will demonstrate other scenarios you may encounter.

You should see the same entry screen that starts a round. If you are a blue player, please now choose ENTER AUCTION. If you are a green player, press continue.

If you are a green bidder, please place two 0 bids. Even though you do not have choice about whether or not to enter the auction, you can still choose to bid 0 on each item. Blue players can also bid 0, but for this example, if you are a blue player please place two bids of 30. Please submit your bids.

You will now see that you have been directed to a tic-tac-toe board rather than the auction results.

Because of group matching design we use, it may be the case that some groups are waiting on others to finish making decisions. During this downtime, all members of your group will be directed to a tic-tac-toe board similar to this to wait until the round can continue. There are no earnings for tic-tac-toe. Please press continue

You will see the summary screen of the auction here. The blue player placed the two highest bids and won both units at a price of 0, which was the third highest bid of the group. The last line of this screen for both players will indicate the number of units available for trade – which in this example will be 2.

Please press continue to enter into the resale market for this example.

(see resale screenshot in 1S instructions)

The screen for resale is now slightly different from the last example. Notice that in addition to the offer price, you must now also input the number of units to trade: 1 or 2. Below the units input, you will again be asked to submit an offer. The offer will always be per unit, but both units can be traded together. For example, please now input 2 and an offer of 70, then click "MAKE OFFER". If this offer was accepted by the other participant, the total resale price would be 140. It is also possible to sell one unit at a time by inputting 1 unit instead of 2.

In all resale stages, you will have the option to exit before a trade is made. Please press the EXIT RESALE button to leave the resale market.

You can now see the standard results screen for this example –notice there are no resale earnings, because no units were traded in resale. Please press continue.

We are about to begin the actual auctions that you will be paid for. Are there any questions? You will now begin the paid rounds. You are participating at your own pace. Please follow the

on screen instructions. Please also make sure that when a continue button is available, you click it whenever you are ready so the experiment can continue.

A.5. 2SE Instructions

The purpose of this experiment is to study how people make decisions in a particular situation. You will receive 10 dollars for showing up for the experiment. You will also make additional money during today's experiment. Payments will be in cash at the end of the experiment and are confidential.

You can now follow along with the instructions on your screen.

In the first stage of this experiment, we will ask you to play a lottery of your choice. Please press continue to enter in to this game.

After they have clicked through and landed on lottery screen

(see lottery screenshot in 1S instructions)

What you should see is a series of 5 lotteries labeled A through E. On the right there is a virtual coin, which has two sides, heads and tails, and will be used to determine the payoff outcome. Please choose one of the lotteries you would like to play and then "Flip" the coin. Depending on which side the coin lands on, you will earn the amount corresponding to the heads or tails column. Both heads and tails are equally likely. Once you have confirmed your choice, the game will play out and your resulting payoff will be shown at the bottom of the screen.

Please make your decision now, and hit continue once you have finished.

Stage 2: In this next stage, you will be a bidder in a series of auctions. You may have some experience bidding in auctions or you may have seen various types of auctions on television. Please do not assume this auction is like those and please pay particular attention to the rules of this auction as it is in your financial interest to do so. All amounts in this phase of the experiment are in experimental currency units, ECUs. At the end of the experiment, each ECU you earn will convert into dollars at a rate of 1 ECU = \$0.01.

Please hit continue

Basics: To make these instructions as simple as possible, we will first discuss the basic details and then we will add in other elements.

Rounds: You will participate in a series of rounds. Each round will consist of some of you making a choice to enter into an auction, which may then be followed by a post-auction resale market.

Player Types: You have been assigned a player type: blue or green player. You will maintain this type throughout the experiment.

Entry & Groups: In each round, you will be randomly matched into a group consisting of 1 green player and 2 blue players. Both blue players in the group will choose whether or not to enter into the auction with the green player who was automatically entered, and all entrants into the auction will be bidding against each other.

Auction: Each auction has 2 hypothetical items for sale, which we call units. Both units will be auctioned off together. Green players will be given a unit value in each round that is drawn randomly from the numbers between 50 and 100, with each number equally likely. What this value represents is the amount paid to green players if they win a unit in the auction. Blue players will have no unit value.

Resale Market: After the auction, if a blue player wins a unit in the auction, they will have the opportunity to resell any units won to the green player.

Auction and Resale Payoffs: Green players make money by buying units in the auction or in resale. Blue players make money by selling units won in the auction to green players.

Please press continue as we will now go through a series of examples to explain the details

(see entry screenshot 1SE instructions)

At the start of each round, the blue players will be asked if they want to enter into the auction. Depending on your type, blue or green, this is a sample of the screen you will see. If you are a blue player and you enter the auction, your earnings will be determined in the auction and resale markets. If however, you choose not to enter the auction, you will earn 10 ECUs for the round. This will be the final payment for the round if you are a blue player. If you are a green player you are automatically entered into the auction in each round.

For the auction to begin, at least one blue player from the group must choose to enter. If no blue player enters into the auction, the units will be awarded by default to the green player at a price of zero (with no auction taking place since there is only 1 bidder).

If you are a blue player, Please hit "ENTER AUCTION" to learn how the auction works. If you are a green player please hit "Continue" – during the paid rounds you will not have this button, but will be automatically directed forward once all decisions by blue players in your group have been made.

(see auction screenshot in 1S treatment)

In the auction you can make two bids - one bid for each unit on sale. To place bids, type the bid amounts in the blue boxes located in the middle of the screen and press the "Submit Bids" button. If your bids are higher than all other bids submitted by players from your group who are also participating in the auction, you will win both units. If you place one of the two highest bids in your group, you will win one unit. If you do not place the two highest bids, you will not win any units.

The auction price that winners must pay for each unit is set by the third highest bid and is the same for both units.

Please turn now to the auction example in the handout you were given to see how this works

In this example, assume there are three bidders in the auction because both blue players entered. Each bidder places two bids, as seen in the first table, for a total of 6 bids. Please note that these bids are for example purposes only and are not suggestive of how you should make decisions.

	Bid 1	Bid 2
Blue Player 1	55	50
Blue Player 2	50	60
Green Player (value 75)	70	0

The computer will rank all bids made from highest to lowest, and assign outcomes. It doesn't matter which order the bids were submitted and any ties in bids will be broken randomly by the computer. You can see how this works in theond table. All bids have been ranked from highest to lowest.

Rank	Bid	Player who made bid	Result
1	70	Green	Highest bid – win unit 1
2	60	Blue 2	2nd highest bid – win unit 2
3	55	Blue 1	3rd highest bid – sets the auction price (55) for units 1 & 2
4	50	Blue 2	
5	50	Blue 1	
6	0	Green	

The green player made the highest bid of 70, and so wins 1 unit. Blue Player 2 placed the second highest bid of 60, and wins the second unit. Blue Player 1 does not win a unit because he did not place either of the two highest bids.

The auction price is set by the third highest bid, which in this example is 55. The price is the same for both units, so in this example, the green player and blue player 2 will each pay a price of 55 for the unit they won. Auction payoffs can be seen in the third table. The only type of player who can make money during the auction is the green player. If the green player wins a unit, they will earn the difference between their unit value and the price resulting from the auction. Blue players will pay the price for any unit won, but cannot make money in the auction because they do not have a value.

Player	Units Won	Auction Price	Auction Payoffs
Green	1	55	Value – Price Paid = 75-55 = 20 ECUs
Blue 2	1	55	Price Paid 55

Assuming the green player's value is 75 and that the price resulting from the auction is 55, the green player who won a unit would earn 20 ECUs in the auction. The blue player will pay a price of 55, and if they fail to resell the unit, the must still pay the auction price resulting in a loss of -55 for the round.

Since it is possible to lose money, you will all begin this phase of the experiment with a balance of ECUs: 400 for blue players and 50 for green players. This balance will increase as you make profits and decrease when you make losses. Should you lose enough money that this balance becomes negative; you will be reset with your initial balance once, and continue participating. If you go bankrupt a second time, you will be removed from the experiment and paid your show-up fee only.

Please now turn again to the auction screen on your computer.

During the auction, you will have a reminder of the payoff rules which you can see on the left side of the auction screen.

A few final details before we continue: All bids must be between 0 and 100, which is the maximum possible value of the green player. At the top of the auction screen, you will find information about how many players entered into the auction. In this example, there are three bidders in the auction.

If 1 blue player had chosen to enter, rather than both blue players, then there will be a total of 4 bids placed. In both cases, the bidding rules and pricing rules stay the same: The two highest bids will each win a unit and the auction price will be equal to the third highest bid.

We will now work through a new example using the computer where you input bids.

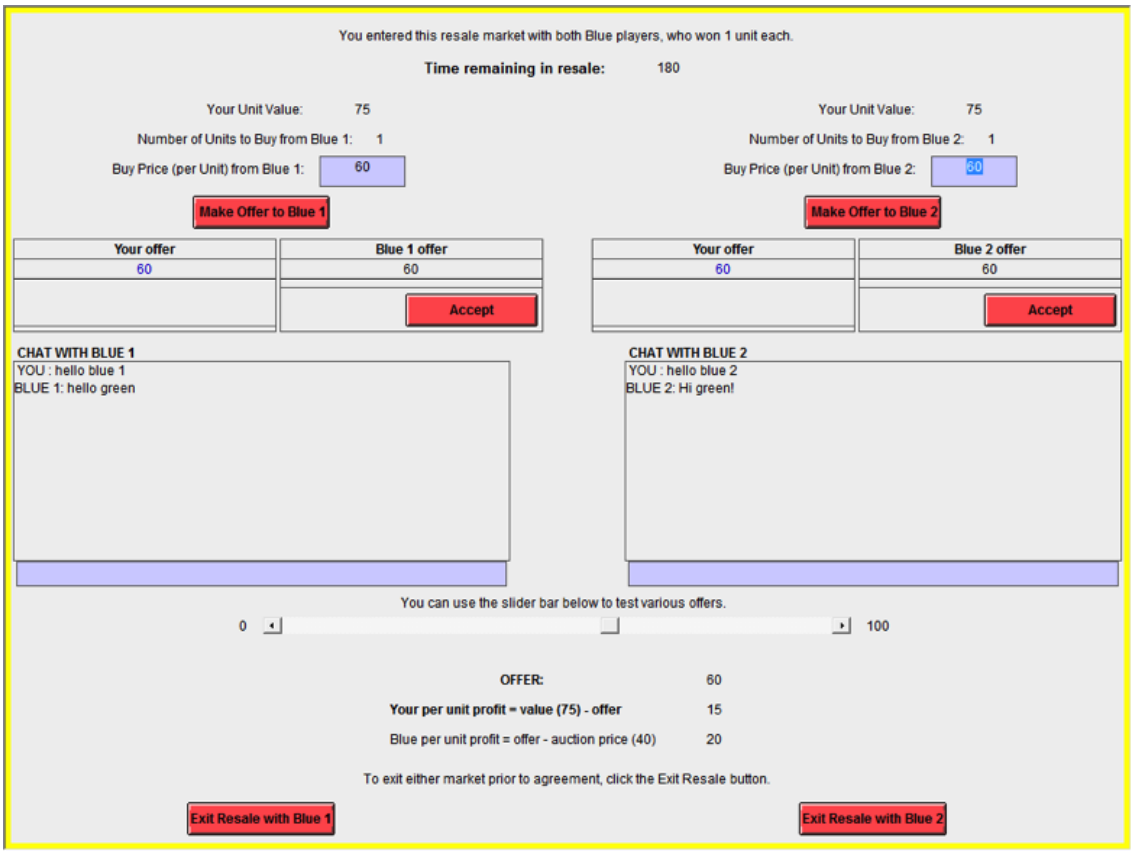
If you are a green player, please input two bids, both equal to 40. If you are a blue player, please input two bids equal to 50 into the blue boxes and press Submit Bids. Please note that bids do not have to be equal, this is only for example purposes.

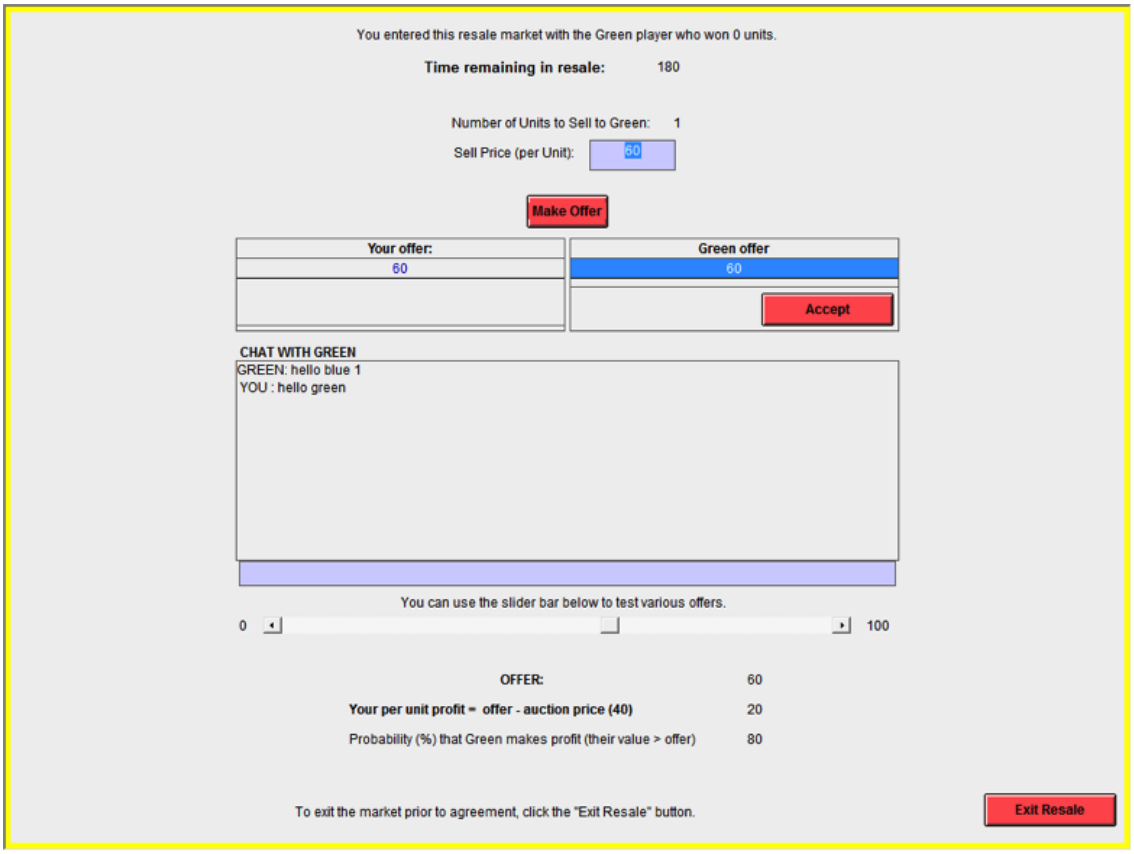
When the auction ends, you will be redirected to a results screen similar to the one that you see now. The two blue players tied for the two highest bids and so the computer randomly split the units between these two players. Each blue player won 1 unit and paid the auction price of 40 for their unit.

The green player won zero units, because neither of their bids were one of the two highest.

Because the blue players won a unit, there will be a resale market where the blue player can resell the unit won to the green player. In the resale market, the green player can purchase up to two units, one from each blue player.

Please press continue to enter the resale market





The green player's value will be identical to the value held during the auction stage. If you are a green player, you will see a reminder of this at the top of each market. In this example, there are two markets open for green players – one on the left, which is the market with blue player 1 and one on the right, which is the market with blue player 2. You can buy 1 unit from each blue player. In each market, you are only interacting with that specific blue player, and the other blue player will not be aware of these exchanges. Blue players will only have one market open as they only interact with the green player.

For resale to occur, both the blue player and the green player must agree to a resale offer. If they agree to a resale offer, the unit will be traded and the green player will earn the difference between their value and the resale price. The blue player will earn the difference between the resale price and the price they paid in the auction. If no resale offer is agreed to, no units will be traded.

Resale offers are made in the blue box (or boxes if you are a green player) at the top of the screen. Directly above this box, you will see a reminder of the units for sale in each market, which in this case is 1 unit.

You have two tools to facilitate your resale decisions. The first is chat. Messages can be sent to the other participant in this box. Please type a message now in the long blue space below the large box where the chat is displayed, for example, "hello" and press enter. Make sure that you hit enter after you have typed a message for it to be sent. Check that everyone was able to send a message. If you are a green player, please input a message in each box to each of the blue players you are in the market with. Any message sent to Blue 1 will not be sent to Blue 2 and vice versa. We also ask that throughout the experiment you do not provide identifiable information about yourself to the other participants.

In addition to chat, you will also have access to the scrollbar seen at the bottom of the screen. You can use the scrollbar to determine your payoff for a given offer. This will always be your per unit profit, even if you are selling 2 units. Please move the scrollbar now. You will see your profit for a given offer. You are also given information about the other's payoff below your profit. For green players, it will be Blue's profit and for Blue players, you will be told the probability that a given offer would lead to positive profits for the green player.

If you would like to exit resale at any time before agreement, there will be an exit button at the bottom of the market which you can click. (Emphasize) You will have 180 seconds (or 3 minutes) to agree to an offer with the other participants. The time will be indicated at the top of the screen Currently it is paused at 180 seconds for example purposes, but during the experiment this clock will actively click down.

The resale market will end automatically when time expires, or when one of the participants chooses to exit, or when an offer is agreed to. Once resale ends, you will be automatically redirected to the next screen. If two markets are open for the green player, you will be automatically redirected when both markets close.

Let's now practice making an offer. Everyone please input an offer of 60 into the blue box. If you are a green player, please make this offer to both blue players. Of course, if this were the actual experiment, you do not both have to type in the same offer, and this is only for example purposes. Once you have typed in the offer, you will see the box underneath update with your offer if you have done this correctly. You should also see the other player's offer update.

To accept the offer of the other participant, click on their offer, which will highlight in Blue and then click "Accept." Once all units have been agreed to, the resale stage will immediately terminate. Prior to agreement, offers can be changed at anytime.

Please accept the offer available to you to continue. If you are a green player, please accept both offers to continue.

What you will now see is the typical screen at the end of the round that displays all results. At the top will be a recap of the auction. Green players didn't win a unit and so earned 0. Blue players each won 1 unit and paid a price of 40. Below this will be the resale results. In resale, Green purchased 2 units from each of the Blue players, for a resale price of 60. Green earns the difference between their value in this practice round, 75, and the resale price, 60, for each unit purchased. Green's total earnings are therefore 30 (or 15 for each unit). Blue earned the resale price of 60, less the price paid in the auction, 40, for total earnings of 20.

Please press continue. We will go through one more example that will demonstrate other scenarios you may encounter.

You should see the same entry screen that starts a round. If you are a blue player, please now choose ENTER AUCTION. If you are a green player, press continue.

Assume in this example that only 1 blue player in the group entered into the auction. The other blue player in the group opted for NO ENTRY. You can see at the top of the auction screen that there are only 2 bidders in the auction.

If you are a green bidder, please place two 0 bids. Even though you do not have choice about whether or not to enter the auction, you can still choose to bid 0 on each item. Blue players can also bid 0, but for this example, if you are a blue player please place two bids of 30. Please submit your bids.

You will now see that you have been directed to a tic-tac-toe board rather than the auction results.

Because of group matching design we use, it may be the case that some groups are waiting on others to finish making decisions. During this downtime, all members of your group will be

directed to a tic-tac-toe board similar to this to wait until the round can continue. There are no earnings for tic-tac-toe.

Please press continue. You will see the summary screen of the auction here. The blue player placed the two highest bids and won both units at a price of 0, which was the third highest bid of the group. The last line of this screen for both players will indicate the number of units available for trade – which in this example will be 2.

Please press continue to enter into the resale market for this example.

(see resale screenshot in 1S instructions)

The screen for resale is now slightly different from the last example as the market has changed. In this example, the Green player is only in the market with the one blue player who won both units and so there is now only one market open instead of two. Notice that in addition to the offer price, you must now also input the number of units to trade: 1 or 2. Below the units input, you will again be asked to submit an offer. The offer will always be per unit, but both units can be traded together. For example, please now input 2 and an offer of 70, then click "MAKE OFFER". If this offer was accepted by the other participant, the total resale price would be 140. It is also possible to sell one unit at a time by inputting 1 unit instead of 2.

In all resale stages, you will have the option to exit before a trade is made. Please press the EXIT RESALE button to leave the resale market.

You can now see the standard results screen for this example –notice there are no resale earnings, because no units were traded in resale. Please press continue.

Are there any questions? We are about to begin the actual auctions that you will be paid for. You will now begin the paid rounds. You are participating at your own pace. Please follow the on screen instructions. Please also make sure that when a continue button is available, you click it whenever you are ready so the experiment can continue.