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# WORKING PAPER NO. 432

## *Efficiency in Auctions with (Failed) Resale*

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# *Efficiency in Auctions with (Failed) Resale*

**Marco Pagnozzi** [*] **and Krista J. Saral**[**]

**Abstract**
We analyze how the possibility of resale affects efficiency in multi-object uniform-price auctions with asymmetric bidders using a combination of theory and experiments. Our experimental design consists of four treatments that vary the (exogenous) probability that bidders participate in a post-auction resale market, which is implemented as an unstructured bargaining game between bidders. In all treatments, the possibility of resale increases efficiency after the auction, but it also induces demand reduction by high-value bidders during the auction, which reduces auction efficiency. In contrast to what is usually argued, resale does not necessarily increase final efficiency. When there is a low probability of a resale market, final efficiency is actually lower than in an auction without resale. We also analyze the quantitative and qualitative bargaining chat data to provide additional behavioral insights into the functioning of resale markets.

**Keywords**: Efficiency, multi-object auctions, resale, asymmetric bidders, bargaining, economic experiments.

**JEL Classification**: D44, C90.

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## 1. Introduction

Understanding the impact of post-auction resale markets is a crucial issue for market designers. Auctions are frequently followed by the possibility of resale by winning bidders, which may dramatically alter the outcome from what would have been observed without resale. U.S. Treasury Bills, the Regional Greenhouse Gas Initiative program to sell CO2 allowances, and spectrum auctions all constitute important auction markets with active resale. From an efficiency perspective, resale markets are generally viewed positively because they offer a second chance for bidders with higher use values to purchase items that they were unable to obtain in the auction and allow agents to exploit gains from trade (e.g., Mankiw, 2007).

The presence of a resale market, however, does not ensure that a losing bidder will necessarily be able to acquire an object after the auction, even if he has a higher valuation for the object than the auction winner, because resale may fail. In fact, there are many reasons why resale may fail: bargaining disagreement, asymmetric information and transactions costs are possible causes of resale failure. In addition to market frictions, the imposition of new regulatory or legal constraints on post-auction trade may also impede resale.[1]

There is substantial empirical evidence that bidders integrate the incentives of a post-auction resale market into their bidding decisions when auctions are always followed by resale markets (e.g., Georganas (2011), Lange et al. (2011), and Saral (2012)). Pagnozzi and Saral (2016) show that resale after multi-object auctions tends to reduce auction efficiency, because it exacerbates bidders' incentive to reduce demand — i.e., to bid less than their valuations for marginal units, in order to reduce the auction price for inframarginal units.[2] Moreover, bidders with low values speculate by bidding aggressively if they have a chance to resell the objects acquired.

However, whether bidders will continue to respond to a post-auction resale market when its presence is uncertain (and they may not be able to trade after the auction) remains an open question. Therefore, when there is a risk of resale failure, the effects of a resale market on the seller's revenue and auction efficiency are unclear.

We theoretically and experimentally examine the effects of the possible, but uncertain, presence of a resale market on efficiency in multi-object auctions. We consider a simple theoretical model of a uniform-price auction with two identical units on sale and two asymmetric bidders, one strong and one weak, that may be followed by a resale market. The strong bidder has a higher valuation and demands both units; the weak bidder has a lower valuation and demands only one unit.[3]

[1] For example, resale was explicitly forbidden in the early U.S. spectrum auctions conducted by the FCC and in European countries. More recently, the FCC has relaxed strict restrictions on resale, but imposes penalties for any quick resale (less than 5 years). See 47 C.F.R. section 1.2111 of the FCC.

[2] For experimental evidence of demand reduction in auctions without resale see Kagel and Levin (2001, 2005), List and Lucking-Reiley (2000) and Engelmann and Grimm (2009). For theoretical analysis of demand reduction see, e.g., Wilson (1979), Ausubel and Cramton (1998) and Pagnozzi (2009, 2010).

[3] For example, in an auction for geographically differentiated mobile phone licenses, a strong bidder can be interpreted as an incumbent operator who aims at acquiring a nationwide license, while a weak bidder can be interpreted as a new and smaller entrant, possibly interested only in a local license, or even as a pure speculator.

The contribution of our paper is to introduce an exogenous probability of resale failure and to examine how changes in this probability affect bidding behavior, the auctioneer's revenue, and the efficiency of the allocation of the objects on sale. The exogenous probability of resale failure can be interpreted as a reduced-form representation of the efficiency of the resale market. More literally, it is a measure of exogenous trading frictions or transaction costs; or of the probability of an ex post ban of resale (due, for example, to new regulatory constraints). Of course, in reality resale may also fail for endogenous reasons, but introducing an exogenous probability of resale allows us to directly analyze the effects of changes in this probability in our experiments.

Our theoretical analysis demonstrates that a lower probability of resale failure (i.e., a more efficient resale market) leads to more speculation by weak bidders and more demand reduction by strong bidders. Hence, a more efficient resale market has two contrasting effects on allocative efficiency: it increases efficiency ex-post, once the auction is terminated, but it also induces a less efficient allocation of the objects on sale in the auction.[4] Similarly, a lower probability of resale failure also has contrasting effects on revenue: it increases speculative bids of weak bidders, which raises revenue, but it also makes strong bidders more likely to reduce demand. The net effect on efficiency and revenue is an empirical question as it is likely to depend on the specific characteristics of the resale market and the behavioral response of bidders to uncertainty.

Our empirical analysis is based on an economic experiment designed to identify how efficiency and revenue are impacted by an uncertain resale market. In our design, bidders participate in an ascending auction which is (possibly) followed by a realistic resale market where bidders have a chance to trade the objects acquired through an unstructured bargaining game. In the resale stage bidders are allowed to make multiple offers and communicate through computerized chat.[5] Our treatments vary the probability that a resale market exists, which we interpret as a measure of the uncertainty of resale. There are two baseline treatments: one where bidders always participate in a resale market when the auction allocation is inefficient; and one where they are never able to resell. In our primary treatments of interest we vary the commonly known probability of a resale stage between low (30%) and medium (50%). The baseline treatments of no resale and certain resale are also analyzed in Pagnozzi and Saral (2016) who show that bidders integrate the incentives of the resale market into their behavior. These treatments serve as benchmarks to determine how varying the uncertainty of resale affects behavior.

We find strong evidence that the presence of a resale market, even when uncertain, distorts the auction allocation because it induces high levels of demand reduction and speculation. Consistent with Pagnozzi and Saral (2016), we show that the presence of a certain resale market significantly increases weak bidders' bids and reduces strong bidders' bids compared to the no

[4] In single-object first-price auctions with asymmetric bidders, Hafalir and Krishna (2009) also show that resale may reduce efficiency, when resale may fail due to incomplete information.

[5] Feltovich and Swierzbinski (2011) use a similar approach with computerized chat in an unstructured bargaining game experiment studying the role of cheap talk. See Roth and Malouf (1979) and Roth and Murnighan (1982) for earlier examples of experiments with bargaining proposals accompanied by messaging. For a survey on the role of communication in experiments see Crawford (1998) and for a survey of bargaining experiments see Roth (1995).

resale treatment. With an uncertain resale market, weak bidders continue to bid more aggressively than in the no resale treatment but, in contrast to theoretical predictions, the level of speculation is similar across treatments. Strong bidders, on the other hand, are more sensitive to resale uncertainty. They bid lower whenever resale is possible, but the degree of demand reduction depends on the probability of resale failure and on their valuations. As the probability of resale failure increases, strong bidders with higher values are less likely to allow weak bidders to win, but still more than without resale. Intuitively, the presence of an uncertain resale market reduces strong bidders' strategic behavior because of the risk that they may not be able to acquire the objects after the auction. These bidding behaviors result in higher auction efficiency than in an auction with certain resale, but lower auction efficiency than in the no resale case.

The rate of endogenous failure to trade (due to disagreement) in the resale market is approximately the same across all treatments (20%). So differences in resale market efficiency are driven by differences in the exogenous rate of failure. Our main result is that changes in the efficiency of the resale market have a non-monotonic effect on final efficiency, and auctions followed by a highly uncertain resale market may actually perform worse than a randomly determined allocation.

We also find that resale reduces the seller's revenue, but only when there is a low probability of resale failure. However, allowing resale may increase revenue when strong bidders do not reduce demand, since weak bidders bid more aggressively with resale, thereby increasing the auction price.

Our experimental design also generates both quantitative and qualitative (chat) data on bargaining in the resale stage. Taking advantage of this additional data, we explore the causes of endogenous failure in resale markets and more generally investigate behaviors in bargaining games. We find that initial disagreement is more likely to lead to final disagreement in less uncertain resale markets, and that the auction price is an important focal point in more uncertain resale markets. Turning to the qualitative analysis, statements of offers and value dominate the bargaining conversation ($> 39\%$ of all chat), and value statements are frequently dishonest (54% of all value statements are false). Strong bidders are much more likely to falsely state their values than weak bidders.

Our paper primarily contributes to the experimental literature on auctions with resale.[6] 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). In these papers resale takes place either automatically, through another auction, or through a take-it-or-leave-it offer by the auction winner. Filiz-Ozbay *et al.* (2015) and Pagnozzi and Saral (2016) analyze multi-object auctions with resale, when a resale market always exists, and consider different resale mechanisms and auction formats. In contrast to all previous studies that examine certain resale markets, we consider the effects of resale market uncertainty.

The rest of the paper is organized as follows. Section 2 presents a theoretical analysis of

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

the model that we refer to for our experimental design. Section 3 discusses the design of our experiments, and Section 4 presents the experimental results. Specifically, Section 4.1 presents a summary of the experimental results, Sections 4.2 and 4.3 analyze bidding behavior by weak and strong bidders respectively, and Sections 4.4 and 4.5 discuss the resale market, efficiency and revenue. Finally, Section 5 concludes. The Appendix contains instructions and screenshots from our experiments.

## 2. Theoretical Predictions

**Model** We consider the simplest model that allows us to experimentally investigate the effects of the possible, but uncertain, presence of a resale market on bidding strategies and auction outcomes. Our theoretical analysis builds on the model in Pagnozzi and Saral (2016), who consider an auction that is always followed by a resale market.

*Auction.* There is a (sealed-bid) uniform-price auction for 2 units of an identical good, with no reserve price (we discuss the effect of a positive reserve price in footnote 10). Each player submits 2 non-negative bids, one for each unit; the 2 highest bids are awarded the units, and the winner(s) pay a price equal to the $3^{\text{rd}}$-highest bid for each unit won. We consider a uniform-price auction because it is the auction mechanism in which the incentive to reduce demand arises more clearly and because it is widely used to allocate multiple objects. The qualitative results of the analysis, however, also hold for any mechanism designed to allocate multiple units in which players face a trade-off between winning more units and paying lower prices. The auction may be followed by a resale market.

*Bidders and Valuations.* There are 2 risk-neutral asymmetric bidders. Bidders differ both in the number of units that they demand, and in their valuations for those units. Specifically, bidder $S$, the *strong* bidder, demands 2 units and has valuation $v_S \sim U[30; 50]$ for each unit on sale (i.e., he has flat demand); bidder $W$, the *weak* bidder, demands 1 unit only and has valuation $v_W \sim U[10; 30]$ for that unit. Bidders are privately informed about their (independent) valuations. Hence, bidder $S$ always has a higher valuation than bidder $W$, and bidders know the ex-post efficient allocation of the units on sale before the auction. For simplicity, we also assume that bidder $W$ cannot win more than 1 unit in the auction, even if resale is allowed.[7]

Our assumption on bidders' valuations ensures that in our experiments bidders know the role they will have in the resale market when they bid in the auction — i.e., whether they will have a chance to buy or sell in the resale market — allowing us to focus on the different bidding strategies of the two types of bidders and on how these strategies are affected by the possibility

[7] We chose to restrict bidder $W$ to single-unit demand to create a simple experimental environment where subject confusion is unlikely, thus eliminating potential confounding effects. This also facilitates the comparison between the weak bidders' behavior with and without resale.

Even if bidder $W$ can win 2 units when resale is allowed, it is an equilibrium for both bidders to reduce demand and bid for 1 unit only, as in our model. The reason is that, as it will become clear from the analysis, bidder $S$ has an incentive to reduce demand only if he can win one unit in the auction.

of resale. The assumption also implies that bidders know there are gains from trade in the resale market if $W$ wins a unit.

*Resale Market.* If bidder $W$ wins a unit in the auction and there is a resale market, he has a chance to resell the unit to bidder $S$. A resale market exists with probability $q$. This probability may be interpreted as a reduced-form measure of trading frictions or of the efficiency of the resale market. More literally, $(1-q)$ may be interpreted as the exogenous probability that bidders will not be allowed to trade after the auction even if they are willing to do so (e.g., because of legal or regulatory restrictions that forbid resale ex post). Hence, $q=0$ indicates an auction without resale and $q=1$ indicates an auction that is always followed by a resale market.

Following Pagnozzi and Saral (2016), we consider resale through a general bargaining procedure between bidders. We believe that this is a more realistic representation of many real-life situations in which bidders attempt to trade after an auction but do not follow a formal trading mechanism (e.g., because no bidder has the bargaining power to impose his preferred trading mechanism).

The actual gains from trade in the resale market are $v_S - v_W$, since $W$'s outside option when he trades in the resale market is equal to his valuation, while $S$'s outside option is zero. We assume that bargaining in the resale market results in $S$ obtaining a share $\alpha$ of the gains from trade and $W$ obtaining a share $(1-\alpha)$ of the gains from trade. This bargaining outcome follows from bidders trading at a resale price $(1-\alpha)\, v_S + \alpha v_W$, and it can be interpreted as a reduced-form representation of the final outcome of various different resale mechanisms in which both bidders expect to obtain some share of the gains from trade in the resale market, in case resale is possible. Our qualitative results are robust to many alternative models of the resale market.

*Bidding Strategies.* There is *demand reduction* if a bidder bids less than his valuation for a unit, while there is *speculation* if a bidder bids more than his valuation for a unit. In a uniform-price auction without resale, it is a weakly dominant strategy for a bidder to bid his valuation for the first unit. When resale may be possible, bidder $W$ may find it profitable to speculate and bid more than his valuation in the auction, if he expects to have a chance to resell the unit. Moreover, bidder $S$ may find it profitable to reduce demand and bid less than his valuation for the second unit in order to pay a lower price for the first unit. The logic is the same as the standard textbook logic for a monopsonist withholding demand: buying an additional unit increases the price paid for the first, inframarginal, units.

Because there are 2 units on sale and a total demand for 3 units, the auction outcome only depends on $W$'s bid for one unit, and on $S$'s bid for the second unit. The lower of these two bids will be the auction price and, depending on which bid is higher, either $S$ will win both units at a price equal to $W$'s bid, or the two bidders will win one unit each at a price equal to $S$'s bid.

**Equilibrium** To characterize equilibrium bidding strategies, suppose that bidder $S$ reduces demand and bids 0 for the second unit in the auction if $v_S \leq v^*$, and bids his valuation $v_S$ otherwise.

By assumption, if bidder $W$ wins a unit in the auction and there is a resale market, he obtains an actual surplus equal to $(1-\alpha)(v_S - v_W)$ in the resale market. Hence, bidder $W$ can obtain positive profit by outbidding bidder $S$ and winning a unit if and only if $v_S < v^*$ (because when $v_S > v^*$, in order to outbid bidder $S$, bidder $W$ has to pay an auction price equal to $v_S$). And since the resale market only exists with probability $q$, bidder $W$ bids

$$b_W \equiv v_W + \underbrace{q(1-\alpha)(\mathbb{E}[v_S \mid v_S < v^*] - v_W)}_{\text{expected resale profit}}$$

for a unit on sale in the auction.[8] This is the highest price that bidder $W$ is willing to pay for a unit. Therefore, in an auction without resale (i.e., when $q = 0$) bidder $W$ bids his valuation for a unit $v_W$, while if there is a chance of a resale market (i.e., when $q > 0$) bidder $W$ speculates because of the option to resell to bidder $S$ and bids higher than his valuation.

Given this strategy, bidder $S$ has a choice between two alternatives. First, bidder $S$ can outbid bidder $W$ and win 2 units in the auction at an expected price equal to $\mathbb{E}[b_W]$, thus obtaining an expected profit equal to

$$2(v_S - \mathbb{E}[b_W]). \tag{2.1}$$

Second, bidder $S$ can reduce demand and bid zero for the second unit in the auction (letting $W$ win the other unit),[9] thus winning one unit at price 0 in the auction and then possibly buying the second unit from bidder $W$ in resale market. In this case, $S$ obtains an expected total profit equal to

$$\underbrace{v_s - 0}_{\text{auction profit}} + \underbrace{q\alpha(v_S - \mathbb{E}[v_W])}_{\text{expected resale profit}}. \tag{2.2}$$

Comparing (2.1) and (2.2), when there is the possibility of a resale market bidder $S$ prefers to reduce demand in the auction rather than outbid bidder $W$ if and only if

$$(1+q\alpha)v_S - q\alpha\mathbb{E}[v_W] > 2\{v_S - \mathbb{E}[v_W] - q(1-\alpha)(\mathbb{E}[v_S \mid v_S < v^*] - \mathbb{E}[v_W])\}$$

$$\Leftrightarrow \quad v_S < v^* \equiv \frac{40 - 10q(1+\alpha)}{1-q}.$$

So it is indeed an equilibrium for bidder $S$ to reduce demand if and only if $v_S$ is lower than a threshold, as we have assumed.

[8] If $W$ wins a unit in the auction at price $p$, he obtains an expected profit equal to $(1-q)v_W + q[v_W + (1-\alpha)(\mathbb{E}[v_S | v_S < v^*] - v_W)] - p$; while if $W$ loses the auction, he obtains 0. So he bids a price such that his expected profit from winning is equal to zero.

[9] Of course, reducing demand but bidding a strictly positive price is never an optimal strategy.

Bidder $S$'s incentive to reduce demand in the auction is lower when he has a relatively high valuation, because reducing demand and running the risk of not obtaining the second unit is more costly when that unit is more valuable. When resale is not allowed ($q = 0$), bidder $S$ reduces demand if and only if $v_S < 2\mathbb{E}[v_W] = 40$. A higher $q$ increases $v^*$, thus inducing bidder $S$ to reduce demand more often, because losing a unit in the auction is less costly when there is a high probability of a resale market.[10] In other words, bidder $S$ bids less aggressively in the auction when he may have an option to buy in the resale market, and his bid is lower the higher is the probability of having this option.

Bidder $S$ always reduces demand (regardless of his value) if $v^* \geq 50$ — i.e.,

$$q > q^* \equiv \frac{10}{40 - 10\alpha}.$$

In this case, the probability of a resale market is sufficiently high to induce bidder $S$ to always prefer to win one unit at price 0 in the auction and then attempt to buy the other unit from bidder $W$, rather than pay the price necessary to outbid bidder $W$ and win both units in the auction.[11] A higher $\alpha$ reduces $b_W$ and hence $v^*$, thus inducing bidder $S$ to reduce demand less often, because outbidding bidder $W$ to win the second unit is less costly when he bids less aggressively in the auction. With equal sharing of the resale surplus, $\alpha = \frac{1}{2}$, bidder $S$ always reduces demand if $q > q^* \simeq 0.29$.

Therefore, when $v_S < v^*$ there is demand reduction and bidders win one unit each in the auction at a price equal to 0 (which can also be interpreted as tacit collusion among bidders, intended to reduce the seller's revenue); when $v_S > v^*$ there is no demand reduction, bidder $S$ wins both units since $v_S > b_W$, and the auction price is equal to $b_W$.

**Revenue and Efficiency** Since bidder $S$ has a higher value than bidder $W$, demand reduction by bidder $S$ results in an inefficient allocation of the units on sale at the end of the auction, while the final allocation is inefficient if bidder $S$ does not win both units in the auction and there is no resale market.[12] Hence, an increase in $q$ has two contrasting effects on final efficiency: first, it reduces auction (interim) efficiency because it increases demand reduction by bidder $S$; second, it increases efficiency after the auction since it increases the probability that bidders will be able to trade in case the auction allocation is inefficient.

When $q = 1$ the final allocation is always efficient, regardless of bidders' strategies during

[10] Our qualitative results do not hinge on the absence of a reserve price, since bidder $S$ has an incentive to reduce demand even if he has to pay a strictly positive (but not too high) reserve price. Therefore, as in our model, if $q$ is sufficiently high: bidder $W$ is willing to pay the reserve price and resell to bidder $S$; bidder $S$ prefers to reduce demand and win 1 unit at the reserve price, rather than outbid bidder $W$ to win 2 units, if $v_S$ is sufficiently low. (The reserve price may be so high that it is unprofitable for bidder $W$ to win the auction, but sellers often lack the information and the commitment power to set high reserve prices.)

[11] If bidders are risk averse, the potential profits in the resale market become less attractive, due to the uncertainty of the resale market. Hence, bidders both speculate less and reduce demand less, thus reducing he probability that bidder $W$ wins a unit in the auction.

[12] By assumption, if there is a resale market bidders always trade and, hence, the final allocation is efficient.

the auction. When $q = 0$, the final allocation is efficient with probability $\frac{1}{2}$ (ex ante), since there is no resale market and half of bidder $S$ types reduce demand. When $q = q^*$, the final allocation is efficient with probability $q^* < \frac{1}{2}$, since bidder $S$ always reduces demand and there is a resale market with probability $q^*$. Hence, a relatively low probability of a resale market may reduce final efficiency compared to an auction without resale, depending on bidders' bargaining power in the resale market.

Finally, the seller's revenue is equal to 0 when bidder $S$ reduces demand, and is positive and increasing in $b_W$ when bidder $S$ does not reduce demand. Hence, an increase in $q$ also has two contrasting effects on the seller's revenue: first, it tends to reduce revenue because it increases demand reduction by bidder $S$; second, it tends to increase revenue because it increases bidder $W$'s bid (which represents the auction price when bidder $S$ does not reduce demand).

Therefore, the effects of a change in the probability of a resale market on final efficiency and the seller's revenue is ultimately an empirical question.

Summing up, the theoretical predictions of the model that we test using experimental methodology are the following.

**Result 1: W's Bid.** *Bidder $W$ bids $v_W$ without resale and bids above $v_W$ with resale. Bidder $W$'s bid is increasing in the probability of a resale market.*

**Result 2: S's Bid.** *Bidder $S$ reduces demand if and only if $v_S$ is sufficiently low. A higher probability of a resale market and a lower $\alpha$ make demand reduction by bidder $S$ more likely. If $q$ is sufficiently high, bidder $S$ always reduces demand.*

**Result 3: Efficiency.** *A higher probability of a resale market reduces auction efficiency. The effect of a higher probability of a resale market on final efficiency depends on the amount of demand reduction by bidder $S$.*

**Result 4: Revenue.** *The effect of a higher probability of a resale market on the seller's revenue depends on the amount of demand reduction by bidder $S$.*

## 3. Experimental Design

Our experiment is designed to test how an uncertain resale market impacts bidding behavior and consequently, auction and final outcomes. The design consists of four treatments that vary the probability that a resale market opens at the end of the auction, based on the theoretical environment described above. Our baseline treatment has no resale market ($q = 0$), and the remaining treatments implement positive probabilities of a resale market that vary from a low probability of resale ($q = .3$), to medium probability of resale ($q = .5$), to certain resale ($q = 1$).

In all treatments, each period began with an ascending clock uniform-price auction for two items of a hypothetical good.[13] Each auction always had 1 strong bidder and 1 weak bidder.

[13] We use ascending auctions (rather than sealed-bid ones) because they are widely used in the field and, based on previous experimental evidence, easier to understand for bidders.

The strong bidder was allowed to purchase up to 2 units of the hypothetical good, and randomly drew his private valuation for each unit from a uniform distribution on $[30, 50]$. The weak bidder could purchase 1 unit only, and randomly drew his private valuation from a uniform distribution on $[10, 30]$. A subject's role was randomly assigned at the start of the experiment, and stayed the same for the duration of the experiment.[14] During the auction, bidders were informed about the distribution of the competitor's valuation and the number of units demanded.

The auction used a bid clock that gradually increased from 0 in increments of 1, indicating the auction price for a unit. To bid in the auction, subjects chose to "drop out" when the clock reached a price at which they wanted to exit the auction. The auction ended as soon as one bidder dropped out, and the auction price paid for each unit was equal to the dropout bid. If neither subject dropped out, the auction ended when the bid clock hit the maximum possible value of the strong bidder, 50, and the units were awarded by random draw. If both subjects dropped out simultaneously, ties were again broken randomly. A bidder who won a unit earned the difference between his value and the price resulting from the auction.

In the no resale treatment, the auction determined the final outcome. In the uncertain resale treatments, if the weak bidder won a unit, whether or not a resale market would begin was determined by a random draw that was displayed to subjects using a computerized spin wheel with two color-coded pie sections that indicated "Resale" in the green section and "No Resale" in the red section. The size of the sections reflected the probability of resale (e.g. 30% of the pie was green, 70% of the pie was red when $q = .3$).[15] If the spin wheel landed on the "Resale" section, the resale market opened, otherwise the auction determined the final outcome. In the certain resale treatment, if the weak bidder won a unit, the resale market always opened. In the resale stage, participants knew the auction price and individual valuations remained private.

The resale market, if it did open, was an unstructured bargaining game (as in Pagnozzi and Saral, 2016) between the same auction bidders. Both the weak and strong players could simultaneously 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. Either role could accept the offer made by their counterpart and the resale stage terminated once an offer was accepted. Bidders could also send each other messages and discuss the offers through anonymous chat.[16] There was a time limit of 3 minutes to reach agreement.

In all resale treatments, participants could exit the resale market without trading at any point of their choosing. If a resale offer was agreed upon, the unit was transferred from the weak bidder (seller) to the strong bidder (buyer). The weak bidder earned the difference between the

[14] The strong bidder was referred to as a 2-unit bidder and the weak bidder as a 1-unit bidder to minimize labeling effects.

[15] Sample screenshots and instructions for all treatments are available in the appendix.

[16] Previous experiments on auctions with resale have almost always used automatic resale or take-it-or-leave-it formats for the resale market (see for example Saral, 2009; Georganas, 2011; Georganas and Kagel, 2011). The one exception is Pagnozzi and Saral (2016), from which the baseline treatments of this paper are drawn.

resale price and his value, and the strong bidder earned the difference between his value and the resale price. If resale failed, both bidders earned 0. Any resale earnings were in addition to the earnings from the auction. The experimental treatments are summarized below.[17]

1. **No Resale**: After the auction, there is no resale market.
2. **30% Resale:** If the weak bidder wins a unit in the auction, bidders participate in a resale market with 30% probability.
3. **50% Resale:** If the weak bidder wins a unit in the auction, bidders participate in a resale market with 50% probability.
4. **100% Resale:** If the weak bidder wins a unit in the auction, bidders always participate in a resale market.

We conducted 3 sessions for each treatment yielding a total of 12 sessions with 16 participants in each session. Each session had 30 auction/resale rounds, except when the time constraint of 2 hours required a reduction in the number of rounds. This happened in all three sessions of the 100% Resale treatment that had 20 rounds per session, and in one session in the 50% Resale treatment that had 28 rounds. After each round, subjects were randomly rematched. To ensure the least amount of changes, we used the same values and probability draws for failed resale in all sessions. Subjects were students at Florida State University recruited using ORSEE (Greiner, 2004).

The experiment was programmed using Z-tree software (Fischbacher, 2007). Prior to the beginning of the paid periods, all subjects were given instructions which included examples of bidding behavior and, when applicable, resale market outcomes. To ensure subjects' understanding, they were required to correctly complete a computerized quiz before continuing. Payoffs during the experiment were denominated in experimental currency units, ECUs, which transformed into US dollars at the rate of \$0.01 per ECU. Table 3.1 shows the average earnings (including the show-up fee) broken down by type and treatment.[18]

| | No Resale | 30% Resale | 50% Resale | 100% Resale |
|---|---|---|---|---|
| Weak Bidder Earnings | \$12.99 | \$14.46 | \$15.03 | \$14.67 |
| Strong Bidder Earnings | \$23.09 | \$22.82 | \$23.37 | \$20.43 |

Table 3.1: Average earnings.

[17] The No Resale and 100% Resale treatments are also analyzed in Pagnozzi and Saral (2016) as the No Resale and Bargain treatments.

[18] Note that these earnings are cumulative for the entire session and are not directly comparable to reported average period earnings in the results section because of varying periods between treatments.

## 4. Experimental Results

In this section, we describe the main results of our experiments. We begin with summary statistics that provide a broad overview of the results in Section 4.1. In the remaining sections we provide formal tests of the theoretical hypotheses: Sections 4.2 and 4.3 analyze the bidding behavior of weak and strong bidders, respectively, Sections 4.4 analyzes the resale market and Section 4.5 analyzes efficiency and revenue.

### 4.1. Summary Statistics

Table 4.1 presents the average per unit auction price (which is equivalent to half the auctioneer's revenue). The first column indicates the overall average price, which is decreasing in the probability of a resale market. Columns 2 and 3 divide the price by whether or not the weak bidder won a unit or the strong bidder won both. When the weak bidder won 1 unit, prices are much lower than when the strong bidder won both units, although they are above the predicted price of zero.

| | Auction Price | | | Efficiency | | |
|---|---|---|---|---|---|---|
| | | $W$ Wins | $W$ Loses | Auction | Final | Random |
| No Resale | 14.62 | 8.02 | 18.81 | .83 | .83 | .76 |
| 30% Resale | 11.24 | 6.61 | 20.01 | .70 | .76 | .76 |
| 50% Resale | 10.09 | 6.02 | 18.68 | .69 | .83 | .76 |
| 100% Resale | 8.47 | 5.25 | 17.22 | .66 | .95 | .76 |

Table 4.1: Average auction prices and efficiency.

The second part of Table 4.1 examines allocative efficiency depending on the probability of resale. Since the first unit was always awarded to the strong bidder, changes in efficiency depend on the allocation of the second unit. We consider two forms of efficiency: auction efficiency, defined as the ratio between the value of the auction winner and the value of the strong bidder, and final efficiency which takes into account transactions in the resale market and is measured as the ratio between the value of the final holder of the unit and the value of the strong bidder.

The highest efficiency in the auction stage was generated by the no resale treatment, indicating that strong bidders were winning both units in the auction most often in this treatment. Auction efficiency is decreasing in the probability of resale, as predicted. The low auction efficiency with a positive probability of resale is striking when compared to the random efficiency of 76% achieved if the auction winner was a randomly selected bidder. This indicates that strong bidders frequently allowed weak bidders to win, even though the resale market could fail to open.

In the 100% resale treatment, since bidders always participated in a resale market, final efficiency should rise and we do see efficiency reach 95%. However, full efficiency was not reached

since bidders failed to agree to trade in the resale market. In the uncertain (30% and 50%) resale treatments, although efficiency rises through resale, the exogenous probability of failure makes full efficiency impossible. Final efficiency is relatively low: the 50% resale treatment results in a final efficiency equivalent to the no resale case, and the 30% resale treatment does no better than a random allocation. Therefore, changes in the probability of resale have a non-monotonic effect on final efficiency.

Table 4.2 provides the relative and absolute frequency of resale and failed resale. Resale was only possible if the weak bidder won a unit because of demand reduction. The frequency of demand reduction is increasing in the probability of a resale market, and approximately 73% of auctions resulted in the weak bidder winning a unit when resale was certain. Notice that the theoretical predictions of demand reduction were based on risk neutral bidders, but one should expect risk averse strong bidders to be less willing to let a weak bidder win when the probability of failed resale is high, which is consistent with our empirical results.

| % | Resale Possible | Failed Resale | | |
|---|---|---|---|---|
| ($n$) | ($W$ Wins) | | Exogenous | Endogenous |
| No Resale | 38.9 | 100 | 100 | - |
| (720) | (280) | (280) | (280) | |
| 30% Resale | 65.4 | 80.7 | 74.7 | 5.9 |
| (720) | (471) | (380) | (352) | (28) |
| 50% Resale | 67.9 | 58.4 | 47.3 | 11.1 |
| (704) | (478) | (279) | (226) | (53) |
| 100% Resale | 73.1 | 20.5 | - | 20.5 |
| (480) | (351) | (72) | | (72) |

Table 4.2: Relative and absolute frequency of resale and failed resale.

Consider now resale failure when resale was possible. Resale could fail because of the exogenous probability given by the spin wheel, but it could also fail because of disagreement in the resale market (endogenous failure). The first column of the second part of Table 4.2 presents the overall relative frequency of failed resale. The failure rates are predictably decreasing in the exogenous probability of resale but, surprisingly, we still have high failure rates (20.5%) in the 100% resale treatment. The last two columns break down the failure rate into exogenous and endogenous rates of failure. Notably, the rate of endogenous failure decreases as resale becomes more uncertain.[19]

Table 4.3 presents summary information from the resale market, including the average first and last offers made by weak and strong players, and the final resale price when bidders agreed to trade. Average offers and resale prices were similar across treatments, making it less likely that the differences in the endogenous failure rates presented in Table 4.2 depended on price. In Section 4.4, we utilize both quantitative and qualitative analysis to determine what triggers

[19] The strength of this effect, however, depends on the reference group that the rate is calculated from. If the rate of endogenous failure is calculated out of auctions where the resale market opened (versus out of all auctions where $W$ won a unit, as in the table), the differences between treatments is smaller. In the 30% Resale treatment, endogenous failure occurs 23.5% of the time, in the 50% resale treatment, 21.0% of the time, and in the 100% treatment, 20.5% of the time.

endogenous resale failure.

| | First Offer | | Last Offer | | Resale Price | Resale Earnings | |
|---|---|---|---|---|---|---|---|
| | $W$ | $S$ | $W$ | $S$ | | $W$ | $S$ |
| 30% Resale | 33.54 | 18.65 | 28.72 | 24.58 | 26.15 | 6.59 | 12.44 |
| 50% Resale | 33.77 | 19.54 | 28.45 | 24.65 | 26.98 | 7.26 | 12.69 |
| 100% Resale | 33.86 | 20.61 | 29.22 | 25.36 | 27.45 | 8.36 | 12.44 |

Table 4.3: Average resale offers and price.

The last part of Table 4.3 examines resale market earnings (equal to the difference between the resale price and value for weak bidders, and between value and the resale price for strong bidders), which allows us to identify the surplus split (bargaining power) between types. It is evident that strong bidders dominated the surplus split in all resale treatments. Moreover, uncertainty strengthened the bargaining power of strong bidders as their share of the total resale surplus is approximately 65% in the uncertain resale treatments, and reduces to 60% in the certain resale treatment.

Table 4.4 examines total earnings across bidders and treatments. Earnings for weak bidders are predicted and observed to be much higher when the weak bidder was able to resell. Weak earnings are lowest under no resale and increasing in the probability of resale (even if resale failed) due to lower bids by strong bidders. In the 100% resale treatment, weak earnings when the weak bidder did not resell are close to the successful resale earnings. Earnings for strong bidders are highest when the strong bidder purchased the second unit in resale. For both types, total earnings across the resale treatments were relatively similar when resale was successful.

| | $W$ Wins | | | | $W$ Loses | |
|---|---|---|---|---|---|---|
| | No/Failed Resale | | Resale | | | |
| | $W$ | $S$ | $W$ | $S$ | $W$ | $S$ |
| No Resale | 12.75 | 29.71 | – | – | 0 | 44.33 |
| 30% Resale | 13.23 | 31.46 | 22.80 | 47.68 | 0 | 43.68 |
| 50% Resale | 14.87 | 32.66 | 21.69 | 47.07 | 0 | 44.27 |
| 100% Resale | 19.25 | 31.67 | 22.27 | 47.14 | 0 | 46.42 |

Table 4.4: Total earnings.

### 4.2. Weak Type Bidding

Weak bidders are predicted to bid up to their value in the no resale treatment, and to speculate and increase their bids by the expected resale surplus, which depends on the probability of resale, in the resale treatments. Hence, bids in the no resale treatment should be lower than in all resale treatments, and bids in the resale treatments should be increasing in the probability of resale.

Figure 4.1 provides scatterplots of the observed losing bids of weak bidders against values. The figures include a reference line for bids equal to value. In the no resale treatment, many

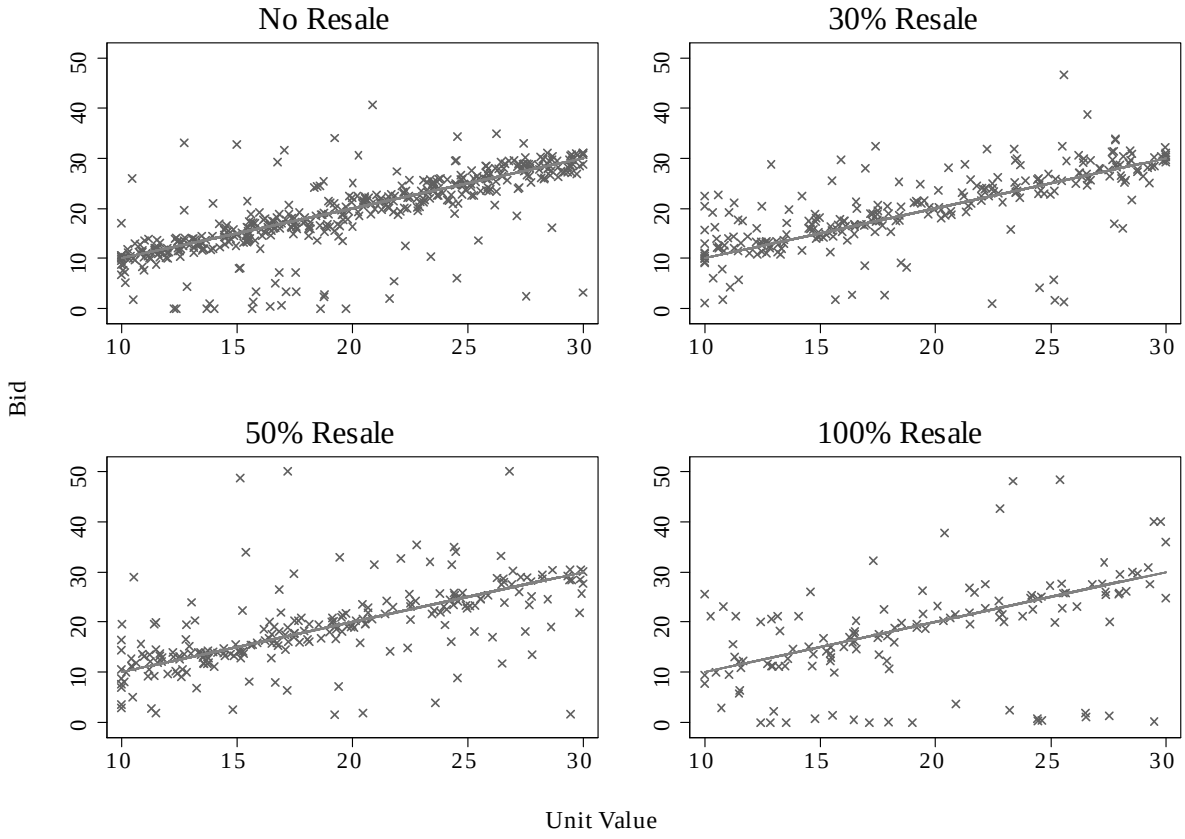


Figure 4.1: Observed (losing) bids versus unit values for weak bidders across all treatments.

bids equal value, as predicted. In the remaining treatments, we again see most bids clustered around value. However, since the graphs only display the observed losing bids, moving from the no resale to the 100% resale treatment we see a reduction in the number of observations. This indicates that weak bidders win more often when resale is more certain. In all graphs there are also bids above value, indicating that speculation does take place.

To formally examine bidding behavior, Table 4.5 reports marginal effects from panel tobit regressions on bids for weak types. We use a tobit model due to the large number of unobserved bids which are censored at the auction price whenever the weak bidder won a unit in the auction. The no resale treatment serves as the baseline treatment and the variables of interest include the value of the weak bidder, $v_w$, and treatment dummies. In the second specification we also include a dummy for losses and the variable Period, which tracks the round of play to test for learning effects.

The robust result across models is that bidding behavior is significantly more aggressive in the resale treatments than in the no resale treatment, confirming the first part of theoretical result 1. The magnitude of the coefficients is increasing in the probability of resale, but tests

| Weak Bid | (1) | (2) |
|---|---|---|
| $v_w$ | 0.662*** | 0.662*** |
| | (0.0260) | (0.0296) |
| 30% Resale (30R) | 2.646** | 2.606** |
| | (1.174) | (1.076) |
| 50% Resale (50R) | 3.135* | 3.211** |
| | (1.669) | (1.476) |
| 100% Resale (100R) | 4.284*** | 4.121*** |
| | (1.254) | (1.379) |
| 30R×$v_w$ | -0.0539 | -0.0532 |
| | (0.0450) | (0.0513) |
| 50R×$v_w$ | -0.103* | -0.109* |
| | (0.0591) | (0.0572) |
| 100R×$v_w$ | -0.155** | -0.155** |
| | (0.0665) | (0.0682) |
| Period | | -0.0234 |
| | | (0.0172) |
| $\text{Loss}_{t-1}$ | | -0.443 |
| | | (1.218) |
| Observations | 2,624 | 2,624 |

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

Table 4.5: Marginal effects from random effects panel tobit - Weak bidding.

between the resale treatment coefficients reveal no significant difference ($p \geq 0.218$) in either of the models, leading to a rejection of the second part of theoretical result 1.

**Empirical Result 1:** *Weak bidders bid more aggressively with resale than without, even when resale is uncertain.*

We also find a strong negative effect of value in the 100% resale treatment, indicating that bidders with higher values bid less aggressively when resale was certain. This effect also exists in the 50% treatment, but is statistically weaker. In model 2 we find no significant time effects or changes in bidding due to losses in the previous round.

### 4.3. Strong Type Bidding

Figure 4.2 provides scatterplots of the observed losing bids of strong bidders against values and includes a reference line for bids equal to value. In the no resale treatment, we see a greater number of zero bids for values below 40 than for values above 40. In all other resale treatments, we see a large number of zero bids, regardless of values.

To formally test for differences in treatments and to account for unobserved bids, Table 4.6 reports marginal effects from panel tobit regressions on bids for strong types. The first two specifications are run on all observations, while models 3 and 4 restrict the sample based on

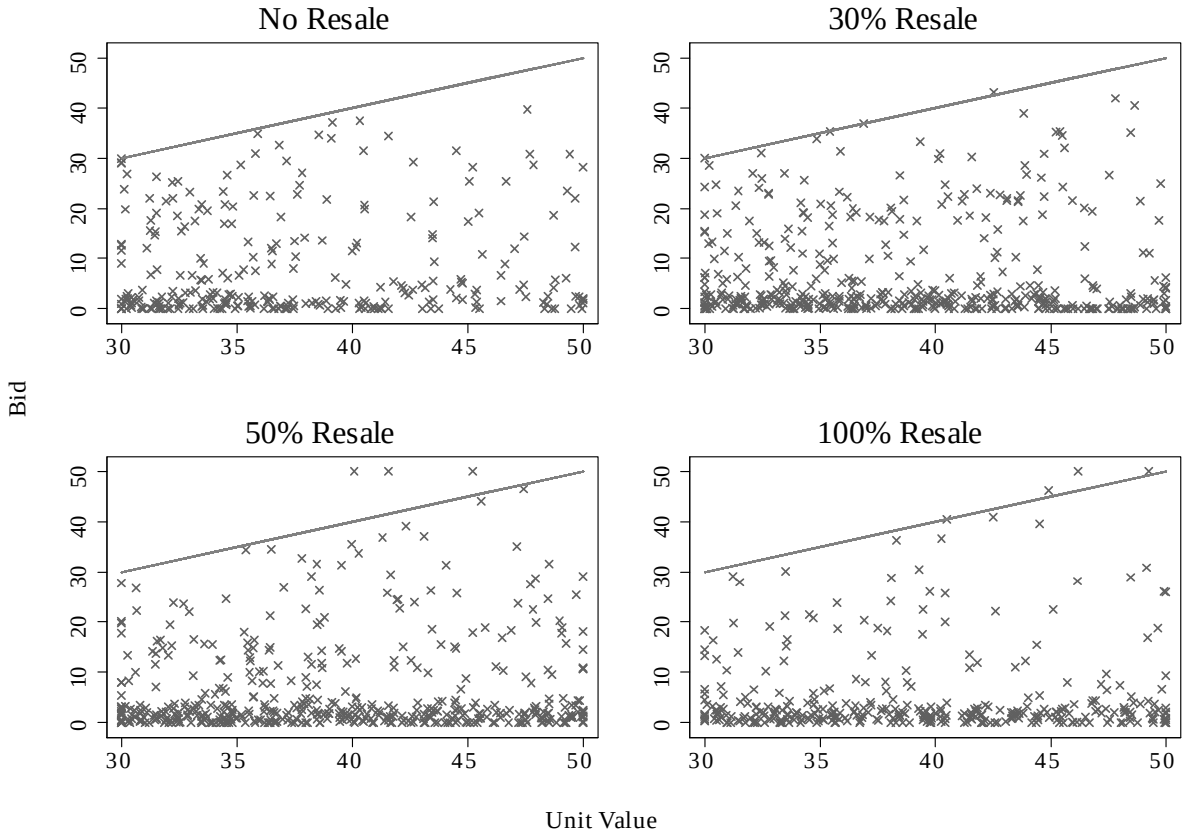


Figure 4.2: Observed (losing) bids versus unit values for strong bidders across all treatments.

strong bidders' values. We include the strong bidder's value, $v_s$, and treatment dummies in all models. In models 1 and 2, we also include an indicator variable, $I_{v_s>40}$, for when the strong bidder's value is above 40 to account for predicted theoretical differences in bidding behavior in the no resale treatment. We test for learning effects by including in models 2 through 4 the round variable, Period, and in models 3 and 4 the variable $\text{Win}_{t-1}$, that indicates if the bidder won 2 units in the last round.

The coefficients on the treatment variables in models 1 and 2 provide strong evidence that resale reduced strong type bids, even when the probability of resale was low. We also find a positive significant coefficient on the indicator variable for high values providing evidence of higher bids when strong bidders had higher values in the no resale treatment. Treatment interactions with this variable in model 2 suggest that bidding behavior when resale was more uncertain was closer to bidding behavior in the no resale treatment. As a robustness check of this result, model 3 restricts the regression to bids by strong bidders with values less than 40, and model 4 to bids by strong bidders with values greater than 40. Both models demonstrate that, with a positive probability of resale, strong bids are significantly lower than in the no

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Strong Bid | all $v_s$ | all $v_s$ | $v_s < 40$ | $v_s > 40$ |
| $v_s$ | 0.350*** | 0.332*** | 0.302*** | 0.141 |
| | (0.0738) | (0.0670) | (0.0613) | (0.0860) |
| 30% Resale (30R) | -3.829** | -3.073** | -2.600** | -5.896*** |
| | (1.568) | (1.345) | (1.275) | (2.167) |
| 50% Resale (50R) | -4.263** | -3.354** | -2.877** | -6.675*** |
| | (1.659) | (1.449) | (1.340) | (2.540) |
| 100% Resale (100R) | -5.524*** | -4.741*** | -3.975*** | -9.875*** |
| | (1.406) | (1.400) | (1.374) | (2.293) |
| $I_{v_s>40}$ | 7.182* | 9.633*** | | |
| | (4.044) | (3.601) | | |
| $I_{v_s>40} \times v_s$ | -0.182* | -0.177** | | |
| | (0.0986) | (0.0790) | | |
| 30R$\times I_{v_s>40}$ | | -2.107 | | |
| | | (1.332) | | |
| 50R$\times I_{v_s>40}$ | | -2.610* | | |
| | | (1.350) | | |
| 100R$\times I_{v_s>40}$ | | -4.408*** | | |
| | | (1.248) | | |
| Period | | -0.192*** | -0.171*** | -0.202*** |
| | | (0.0298) | (0.0163) | (0.0410) |
| $\text{Win}_{t-1}$ | | | 0.913** | 2.440*** |
| | | | (0.367) | (0.672) |
| Observations | 2,624 | 2,624 | 1,438 | 1,186 |

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

Table 4.6: Marginal effects from random effects panel tobit - Strong bidding.

resale treatment. For low values, we find no significant differences between the resale treatments ($p \geq 0.197$), but for higher values (model 4) we do find that bids are significantly lower in the 100% resale treatment ($p = 0.017$) than in the other resale treatments.[20] This supports the predictions of theoretical result 2.

**Empirical Result 2:** *Strong bidders bid lower with resale than without, even when resale is uncertain.*

**Empirical Result 3:** *Strong bidders with higher values bid higher when resale is more uncertain.*

In contrast to weak bidders, who displayed no learning effects, the significant negative impact of Period suggests that strong bids decrease over time. The positive and significant coefficient on $\text{Win}_{t-1}$ reveals a strong reinforcement learning effect from winning 2 units: strong bidders

[20] We have run alternative models that restrict the regression to only resale treatments (dropping the no resale treatment) as a robustness check of less demand reduction for higher values when resale is more uncertain. In these specifications, we continue to find evidence that when values are higher, bids are significantly lower in the 100% treatment than the 30% ($p = 0.006$) and 50% ($p = 0.047$) resale treatments.

who won 2 units in the previous round bid more aggressively in the current round, particularly when their value was higher.

### 4.4. Resale Market

The resale market was an unstructured bargaining game where, in addition to the ability to make alternating offers on a posted-offer board, subjects were allowed to freely communicate in an anonymous e-chat room.[21] We take advantage of this additional data and employ mixed methods, using both qualitative and quantitative approaches to examine resale market behaviors and outcomes.

To analyze chat in the bargaining game, we identified five major categories (nodes) of discussion: Value, Resale Earnings, Offers, Instruction, and Other that picked up the remainder of chat not directly related to the previous categories, but frequent enough to merit coding. The major categories were developed by grouping the minor categories that more precisely describe the content of a statement. All categories are listed in Table 4.7.

Two post-graduates independently coded the qualitative data into the identified categories. Table 4.7 reports the relative frequency of each category out of all bargaining groups.[22] The first column includes all chat groups across all treatments, and the subsequent columns provide the relative frequency by treatment. A statement was assigned to a category if both coders agreed to the categorization. Overall, there was a high level of agreement, which we measure using Cohen's kappa coefficient of inter-rater agreement. The most common form of communication was a statement of (non-binding) offer, followed closely by statements of value.[23]

Because statements of value were frequently used, we examine the honesty of subjects' value statements in Figure 4.3 which presents a density histogram of the difference between stated values and actual values. We break down the behavior by treatment and type, and include kernel density plots. Bars at 0 represent accurate statements of value and bars to right (left) of 0 represent overstatements (understatements) of value. False value statements are made by both types, but strong types appear to provide false lower values more frequently than weak types, who appear more honest, particularly in the 50% and 100% treatments.[24]

Although resale distorts the efficiency of the auction allocation, it can correct this allocative distortion when a weak bidder successfully resells to a strong one. In Table 4.8 we report marginal effects from probit regressions with agreement to a resale offer as the dependent variable, to examine how key variables influence the probability of resale. New variables are the difference

[21] Our only restriction on communication was that subjects do not identify themselves. We also asked that they refrain from the use of profanity.

[22] Examples of categories: Bargaining - stating that offer is too high/low, rejection of standing offer; General instructions - statements about partners, reference to conversion rate earnings; Game implications - reference to the spinner or other probabilities, 2 unit player claiming to help other person by dropping out early, 2 unit player makes more.

[23] Offers were only binding when submitted through the posted-offer mechanism.

[24] The strong histogram in the 100% treatment displays a bin beyond -20 (the difference between the minimum and maximum strong bidders' values) because four stated values by strong bidders were lower than 30.

| Category | % of All Chat | 30% Resale | 50% Resale | 100% Resale | $\kappa$ |
|---|---|---|---|---|---|
| **Value** | | | | | |
| Stating value | 39.82 | 25.45 | 37.50 | 45.09 | .83 |
| Asking for other's value | 20.36 | 18.18 | 14.29 | 25.45 | .88 |
| Other reference | 1.34 | 0 | 0.60 | 2.23 | .10 |
| **Resale Earnings** | | | | | |
| Fair earnings | 12.30 | 9.09 | 10.71 | 14.29 | .69 |
| Losses | 17.67 | 16.36 | 11.90 | 22.32 | .83 |
| Earnings from offer | 22.60 | 21.82 | 21.43 | 23.66 | .44 |
| Other reference | 0.89 | 0 | 0 | 1.79 | .50 |
| **Offers** | | | | | |
| Final offer/threat to exit | 10.96 | 12.73 | 10.71 | 10.71 | .74 |
| Asking for offer | 8.05 | 5.45 | 3.57 | 12.05 | .74 |
| Statement of offer | 42.51 | 34.55 | 52.98 | 36.61 | .79 |
| Bargaining | 30.43 | 32.73 | 32.14 | 28.57 | .41 |
| **Instruction** | | | | | |
| General instructions | 1.12 | 0 | 0.60 | 1.79 | .23 |
| How to bid | 1.34 | 0 | 1.79 | 1.34 | .47 |
| How to make decisions in resale | 1.12 | 0 | 0 | 2.23 | .48 |
| Game implications | 7.61 | 3.64 | 11.31 | 5.80 | .49 |
| Asking questions | 1.79 | 5.45 | 0.60 | 1.79 | .45 |
| **Other** | | | | | |
| Auction earnings /price | 0.22 | 1.82 | 0 | 0 | .14 |
| Reference to lying/honesty | 2.24 | 1.82 | 1.19 | 3.13 | .73 |
| Reference to earlier play | 2.46 | 0 | 1.79 | 3.57 | .45 |
| Verbal agreement to offer | 15.88 | 9.09 | 19.64 | 14.73 | .73 |
| Reference to time left | 2.01 | 3.64 | 1.19 | 2.23 | .69 |

Table 4.7: Percent of chat by category. Kappa coefficient of inter-rater agreement: .01-.20 slight, .21-.40 fair, .41-.60 moderate, .61-.80 substantial, >.80 almost perfect

between the initial offers of the resale participants, the difference between strong and weak values, the number of offers made by a bargaining pair, and five chat dummies which indicate whether a group had chat coded in the specified category.

Model 1 is the baseline test for treatment differences for all cases where the weak bidder won a unit (i.e., resale was possible). As expected, the probability of final agreement is significantly increasing in the exogenous probability of resale (coefficient test between 50% and 100%, $p < 0.001$). Models 2 through 5 restrict the data to observations where the resale market opened, which allows us to investigate the causes of endogenous failure of resale. In model 2, the basic treatment test, the average probability of agreement between resale treatments is not significantly different once we control for entry into the resale market (coefficient test; $p = 0.722$).

**Empirical Result 4:** *Differences in the probability of reselling the unit result from differences in the exogenous rate of resale failure. Once the resale market opens, the probability of resale is the same across treatments.*

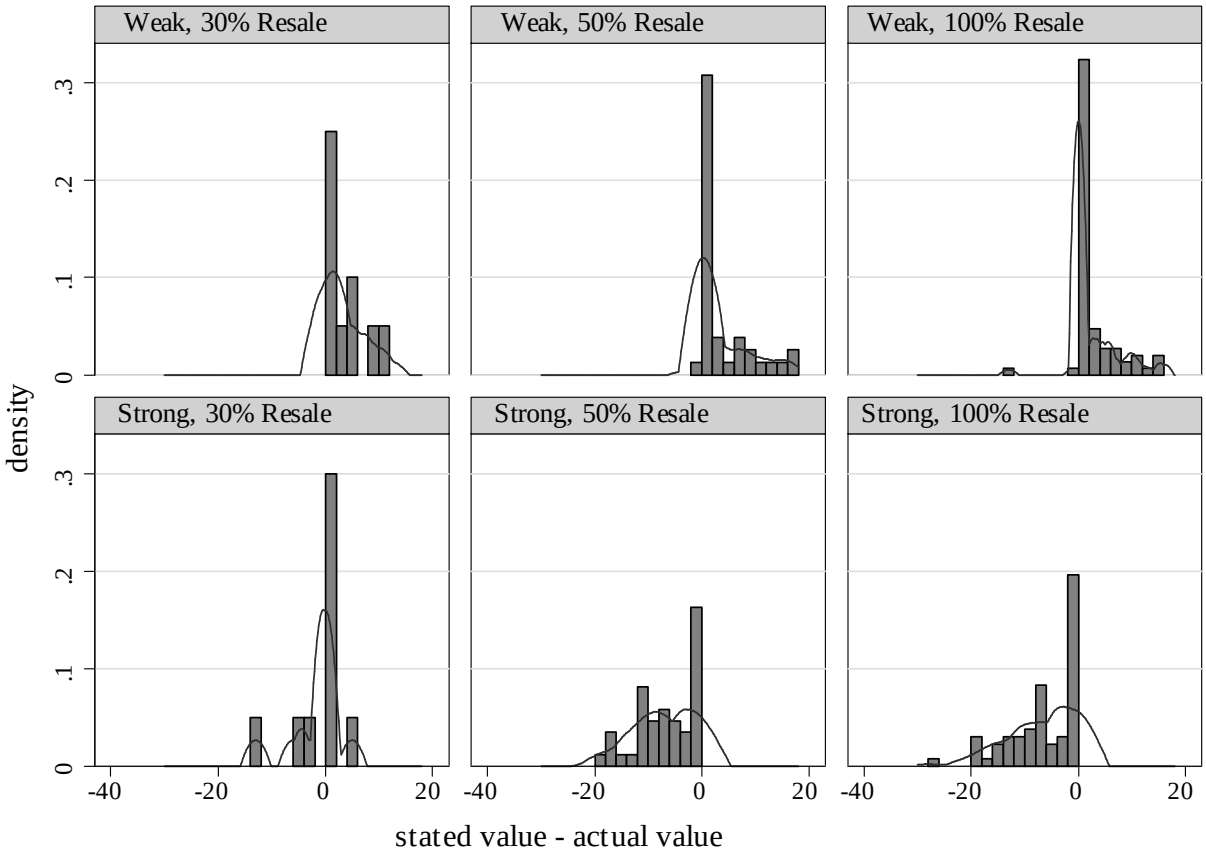


Figure 4.3: Histogram plots of value statements.

Models 3 to 5 examine each treatment individually. The only robust effect across treatments is the positive effect of the size of the gains from trade, $v_s - v_w$, on agreement. In the 30% treatment, higher auction prices significantly decrease the probability of reselling the unit, but auction price is insignificant in the other resale treatments. Initial disagreement in bargaining, which is measured by the difference in first offers, has no effect in the 30% resale treatment, but has a significant negative impact on final agreement in the 50% and 100% resale treatments. The size of the effect increases with the probability of resale, which suggests that more certain resale was correlated with stronger initial disagreement.

To examine the role of chat, we include the 5 major coded categories in the treatment models to uncover how qualitative differences in the bargaining discussion influenced the probability of resale. The types of conversation taking place have the most impact in the 30% treatment, where the discussion of resale earnings significantly increased the probability of reselling the unit, and discussion of the offer had a negative impact. The variable Other Chat, which includes discussion of the auction price, also significantly improves the probability of resale which is notable since

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Agreement | W Wins | | W Wins and Resale Market Opens | | |
| | | | 30% Resale | 50% Resale | 100% Resale |
| 50% Resale (50R) | 0.268*** | 0.0204 | | | |
| | (0.0428) | (0.0603) | | | |
| 100% Resale (100R) | 0.642*** | 0.0399 | | | |
| | (0.0117) | (0.0310) | | | |
| (First) Offer$_w$−Offer$_s$ | | | -0.00557 | -0.00961** | -0.0120*** |
| | | | (0.00752) | (0.00396) | (0.000545) |
| Auction Price | -0.00309* | -0.00208 | -0.00624*** | -0.00383 | 0.00284 |
| | (0.00188) | (0.00223) | (0.00185) | (0.00560) | (0.00176) |
| $v_s - v_w$ | 0.00980*** | 0.0138*** | 0.0121*** | 0.00812*** | 0.0150*** |
| | (0.00363) | (0.00200) | (0.00367) | (0.00196) | (0.00117) |
| # Offers Made | | | -0.0119 | -0.0134** | -0.00935* |
| | | | (0.0133) | (0.00595) | (0.00489) |
| Period | 0.0107*** | 0.00151 | 0.00422 | -0.00408** | 0.00809 |
| | (0.00262) | (0.00357) | (0.00655) | (0.00194) | (0.00501) |
| Value Chat | | | -0.0245 | 0.0814 | 0.0666** |
| | | | (0.231) | (0.0531) | (0.0284) |
| Resale Earnings Chat | | | 0.275*** | -0.0440 | 0.0281 |
| | | | (0.0197) | (0.0686) | (0.0586) |
| Offer Chat | | | -0.567*** | -0.0116 | -0.00666 |
| | | | (0.0275) | (0.0137) | (0.0383) |
| Instruction Chat | | | | 0.100* | -0.0446 |
| | | | | (0.0566) | (0.0424) |
| Other Chat | | | 0.236*** | 0.00943 | 0.0579 |
| | | | (0.0761) | (0.0263) | (0.0941) |
| Observations (Clusters) | 1,300 (9) | 722 (9) | 107 (3) | 215 (3) | 276 (3) |

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

Table 4.8: Marginal effects from probit regressions with agreement in the resale market as the dependent variable. Standard errors clustered at the session level.

the 30% treatment was the only treatment where the auction price had a significant effect.

Table 4.9 presents random effects regressions on the resale price, the other major outcome of interest in the resale market, with standard errors clustered at the session level. Model 1 analyzes treatment effects and shows no significant difference in the final resale price between treatments (coefficient test, $p = 0.500$). Resale prices, as one would predict, are significantly increasing in the values of the weak and strong bidders.

**Empirical Result 5:** *Final resale prices are not significantly different across treatments.*

Models 2 to 4 examine each treatment individually and consider the role of value statements. Despite the prevalence of false value statements, they only significantly affect the resale price in the 100% resale treatment, where strong types significantly lowered the resale price through

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Resale Price | | 30% Resale | 50% Resale | 100% Resale |
| 50% Resale (50R) | 0.335 | | | |
| | (1.817) | | | |
| 100% Resale (100R) | 1.371 | | | |
| | (1.307) | | | |
| Auction Price | 0.0180 | 0.146** | -0.0540** | 0.0553 |
| | (0.0227) | (0.0575) | (0.0258) | (0.0537) |
| $v_w$ | 0.293*** | -0.0585 | 0.346*** | 0.298*** |
| | (0.0450) | (0.0708) | (0.0802) | (0.0251) |
| $v_s$ | 0.141*** | 0.340*** | 0.187*** | 0.104** |
| | (0.0164) | (0.0268) | (0.0410) | (0.0498) |
| # Offers Made | -0.0275 | 0.241 | 0.567** | -0.487*** |
| | (0.141) | (0.340) | (0.237) | (0.188) |
| Period | 0.0211 | 0.284*** | 0.0438 | 0.0446 |
| | (0.0292) | (0.0370) | (0.0583) | (0.103) |
| Time of Agreement | | 0.0510* | -0.0270** | 0.0184 |
| | | (0.0264) | (0.0135) | (0.0119) |
| $W$ Value Statement Lie | | 1.482 | 1.739 | -1.112 |
| | | (2.113) | (1.223) | (0.999) |
| $W$ Value Statement Truth | | | 0.832 | -0.294 |
| | | | (1.824) | (0.929) |
| $S$ Value Statement Lie | | | 0.447 | -1.428** |
| | | | (1.847) | (0.671) |
| $S$ Value Statement Truth | | 0.753 | 1.073 | 1.668 |
| | | (2.416) | (2.474) | (2.169) |
| Resale Earnings Chat | | 9.299*** | 0.893 | 1.553 |
| | | (2.657) | (1.812) | (0.962) |
| Offer Chat | | -5.818 | 1.043 | -0.451*** |
| | | (3.626) | (1.156) | (0.134) |
| Instruction Chat | | | 1.202 | -1.107 |
| | | | (2.279) | (3.602) |
| Other Chat | | -4.567 | -2.293 | 0.959 |
| | | (6.320) | (1.615) | (0.772) |
| Constant | 14.69*** | 2.919 | 10.60*** | 17.70*** |
| | (1.905) | (5.202) | (2.871) | (2.392) |
| Observations (Clusters) | 569 (9) | 50 (3) | 105 (3) | 155 (3) |

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

Table 4.9: Random effects regressions with resale price as the dependent variable. Standard errors clustered at the session level.

false statements of value. Increases in the number of offers made helped raise prices in the 50% resale treatment, but in the 100% resale treatment this effect is reversed.

We also find two main effects of the major chat categories. In the 30% resale treatment, discussion of resale earnings significantly raised the resale price, while in the 100% resale treatment

discussion of the offer significantly lowered the resale price.

### 4.5. Efficiency and Revenue

Theoretical predictions for the effects of resale on efficiency and revenue are ambiguous, and depend on the amount of actual demand reduction and, for final efficiency, on bidders' ability to trade in the resale market.

To provide a visual overview of efficiency, Figure 4.4 plots the relative frequency of a strong bidder holding both units after the auction and after resale as a function of the bidder's value. The light gray bars represent the auction allocation, while the dark gray bars represent the final allocation after resale. Bars at 1 represent an efficient allocation, with the strong bidder holding both units. It is clear that the no resale treatment lead to the highest auction efficiency, and that higher values led to higher efficiency. In all resale treatments, auction efficiency is much lower due to demand reduction; even in the 30% resale treatment, despite the low probability of resale.

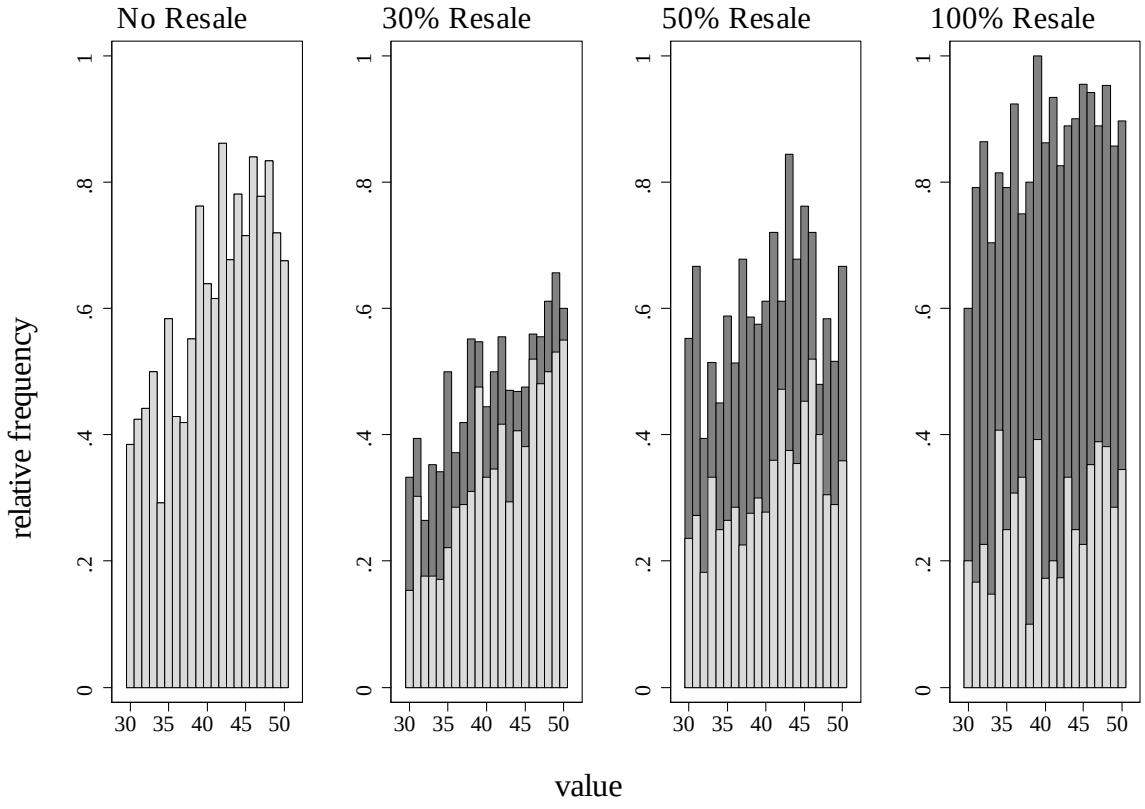


Figure 4.4: Relative frequency of $S$ holding both units after the auction (lighter gray) and after resale (dark grey) for unit value of $S$.

In the no resale treatment, the auction allocation represents the final allocation while in the resale treatments, the final allocation may change in the resale market. Given the probability of resale failure, final efficiency never reaches 1 in the resale treatments. Notably, despite the low likelihood of resale, in the 30% resale treatment bidders still choose to reduce demand, thus reducing final efficiency compared to the no resale treatment.

We formally analyze efficiency and auction prices in Table 4.10, using pooled OLS regressions with standard errors clustered at the session level. Model 1 examines auction efficiency, defined as the value of the winner of the second unit divided by the strong bidder's value. The negative significant coefficients on the three resale treatments supports theoretical result 3, indicating that resale results in significantly lower auction efficiency than the no resale treatment. Coefficient tests on the treatment dummies demonstrate a weakly significant difference for auction efficiency between the 50% and 100% resale treatments ($p = 0.070$). No other significant differences are found ($p > 0.348$).

| | (1) Auction Efficiency | (2) Final Efficiency | (3) Auction Price |
|---|---|---|---|
| Random Efficiency | 0.755*** | 0.261** | |
| | (0.137) | (0.114) | |
| Avg. Value $\left(\frac{v_w+v_s}{2}\right)$ | 0.00528*** | 0.00341* | 0.701*** |
| | (0.00175) | (0.00175) | (0.0781) |
| 30% Resale | -0.133** | -0.0708* | -3.343 |
| | (0.0447) | (0.0392) | (1.989) |
| 50% Resale | -0.144*** | -0.00447 | -4.315*** |
| | (0.0191) | (0.0231) | (1.246) |
| 100% Resale | -0.175*** | 0.123*** | -5.849*** |
| | (0.0248) | (0.0205) | (1.397) |
| Constant | 0.100 | 0.530*** | -6.402** |
| | (0.0974) | (0.110) | (2.842) |
| R-squared (Clusters) | 0.145 (15) | 0.087 (15) | 0.116 (15) |

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

Table 4.10: Pooled OLS regressions on outcome variables clustered at session level.

**Empirical Result 6:** *The possibility of resale results in lower auction efficiency, even when resale is uncertain.*

Model 2 uses final efficiency as the dependent variable, defined as the value of the final holder of the second unit divided by the strong bidder's value. The positive significant coefficient on 100% resale indicates that final efficiency increases when resale is certain. The coefficient for the 50% resale treatment is not significantly different from zero, and the coefficient on 30% resale is weakly significant and negative. We also find significant differences between the resale treatments ($p < 0.001$ for coefficient tests between the 30% or 50% and the 100% resale treatments; $p = 0.082$

between the 30% and 50% resale treatments). Thus, resale only improves the efficiency of the allocation when the resale market is relatively friction-free.

**Empirical Result 7:** *The possibility of resale improves final efficiency when resale is certain, but not necessarily when it is uncertain.*

Model 3 considers the auction price which is equivalent to the auctioneer's revenue for each unit sold. Compared to the no resale treatment, resale significantly lowers revenue in the 50% and 100% resale treatments, but not in the 30% resale treatment.

**Empirical Result 8:** *The possibility of resale reduces the seller's revenue when resale is relatively likely.*

## 5. Conclusion

Post-auction resale is commonly justified as a way to improve overall allocative efficiency, since it allows bidders to trade if gains from trade exist. However, this argument is based on the assumption that a resale market always takes place and bidders always manage to agree to trade. In reality, market frictions and regulatory restrictions may lead to resale failure.

We use a combination of theory and laboratory experiments to analyze the effects of an uncertain post-auction resale market in multi-objects auctions with asymmetric bidders. Our theoretical results demonstrate that, even when resale is uncertain, bidders engage in demand reduction and speculation, with the level of strategic behavior depending on the probability of the resale market. Even with a low probability of resale, however, strategic behavior continues to emerge, lowering revenue and auction efficiency, which may not be improved through resale.

Our experimental results suggest that resale does not necessarily increase efficiency — which conforms to our theoretical results, but stands in contrast to the usual arguments in favor of resale — nor does it always reduce the seller's revenue. Weak bidders speculate whenever resale is present and, despite predictions, speculative bids do not decrease when the probability of resale falls. Strong bidders, on the other hand, do respond to the likelihood of resale reducing demand significantly more when resale is more certain. This results in higher revenue when the likelihood of resale is low, and lower interim efficiency whenever resale is possible, regardless of its likelihood. Once bidders have entered the resale market, we find little difference between the rates of bargaining agreement depending on whether the resale market was more or less likely, so differences in final efficiency rates in our experiments are mostly influenced by exogenous factors.

These results are relevant for the design of auctions markets because they demonstrate how features of a post-auction resale market are likely to affect final efficiency and the auctioneer's revenue. In sum, our experimental results suggest that a relatively low probability of resale in multi-object auctions may actually be detrimental for final efficiency.

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# A. Appendix

## A.1. 30% and 50% Resale 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. If you have a question or problem please raise your hand and one of us will come to you. I also ask that you please turn off your cell phones.

General information: The purpose of this experiment is to study how people make decisions in a particular situation. You will receive $10 for showing up on time for the experiment. You will also make additional money during today's experiment. Upon completion of the experiment the amount that you make will be paid to you by check. Payments are confidential; no other participant will be told the amount you make. All amounts in this phase of the experiment are denominated in experimental currency units, ECUs. ECUs will transform into real dollars at the rate of $0.01 per ECU. These earnings are in addition to the show-up fee.

In this experiment, you will be a bidder in a series of auctions.

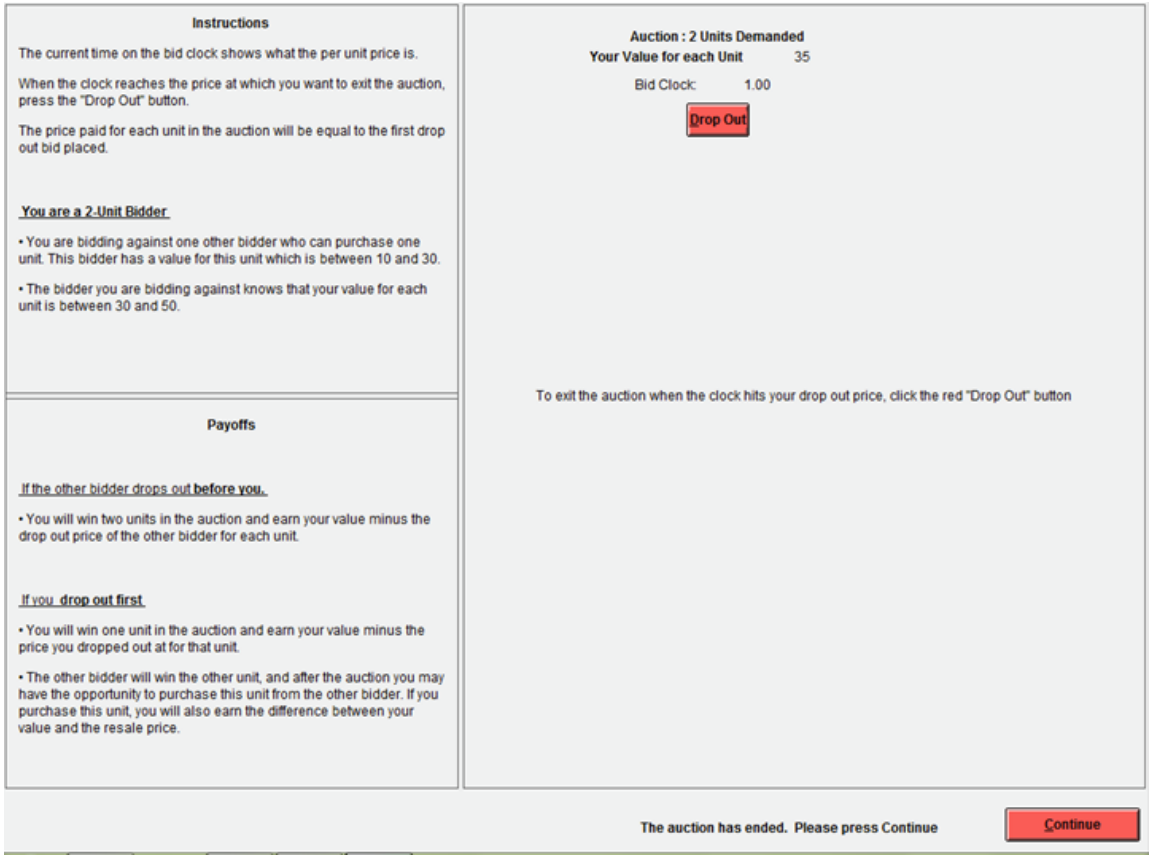
Please hit continue for general instructions. Please do not hit continue again until after I have finished with all instructions for this screen

In this experiment, we will create a market in which you will act as a bidder in a sequence of auctions. Each auction has two identical units of a hypothetical item for sale. You will be bidding in the auction against one other person. At the end of each auction there may be the possibility of the winner reselling the item to the other person. The person you are matched with to bid against will be randomly chosen at the start of each auction and will therefore be different across auctions. Each auction will always have two bidders: a 1-unit bidder and a 2-unit bidder. The 1-unit bidder can purchase only 1 unit of the item and will be assigned a single value for one (1) unit. The 2-unit bidder can purchase up to 2 units of the item and will be assigned a single value for each of the two (2) units. For both types of bidders, these values represent the value of the good to you - what we will pay you for any items purchased.

Please hit continue for information on roles, values, and resale. Again, please do not hit continue until I have finished with all instructions for this screen

You were randomly assigned a role of 1-unit bidder or 2-unit bidder, which is listed at the top of your screen. The possible values for the 2-unit bidder are the integers between 30 and 50, with all values being equally likely, and the possible values for the 1-unit bidder are the integers between 10 and 30, again all values are equally likely. If you are a 1-unit bidder, you will be bidding against a 2-unit bidder and vice versa. If the 1-unit bidder purchases a unit, they may have the opportunity to resell it to the 2-unit bidder. If the 2-unit bidder purchases a unit, they will not resell it because they have a higher value than the 1-unit bidder.

Please press continue again to work with the auction interface. What you should see is a flat example screen. Please do not hit continue until I have finished with all instructions for this screen.



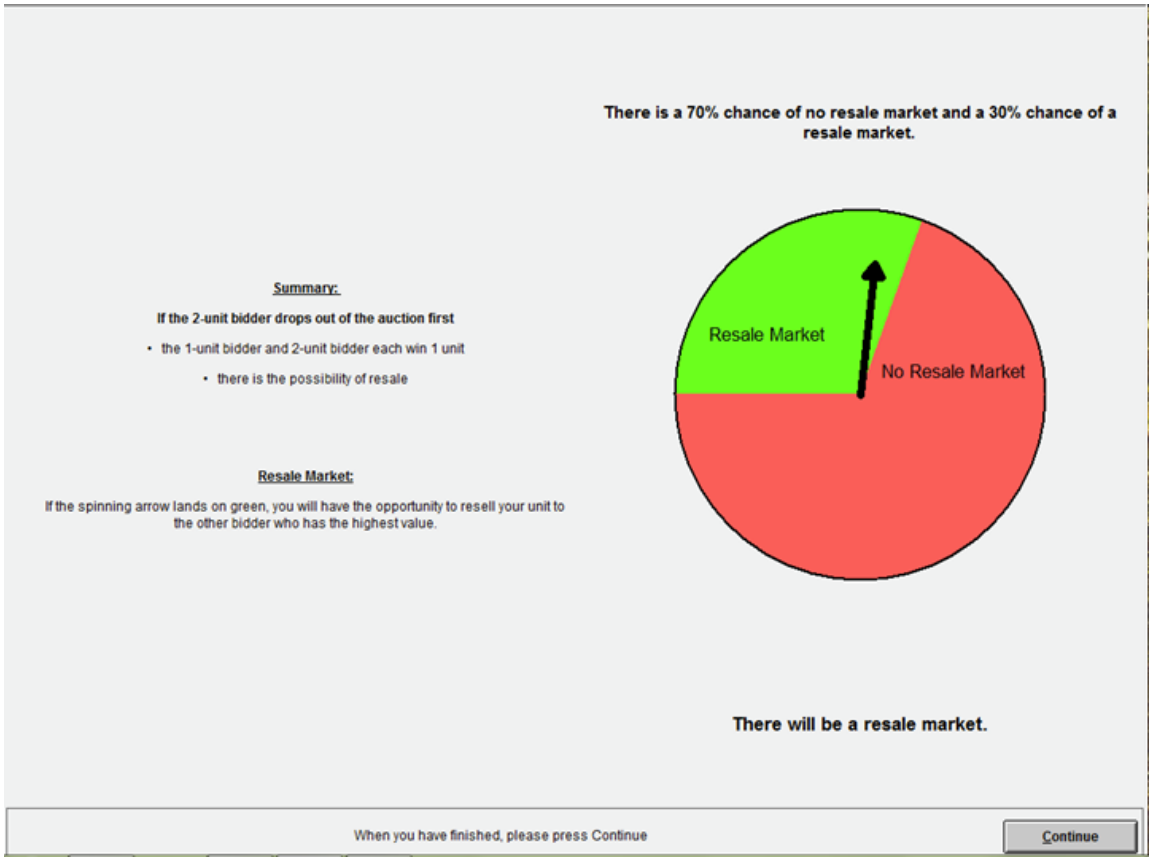

What you should see in front of you is a sample of the screen you will see for this auction. The left side of the screen contains boxes that have instructions and payoffs. On the right side of the screen you will see the primary auction interface. Beside the word "Auction" in the top line, you will see the number of units you can win (called "Units Demanded"). Below that you will see what your value is for a unit in ECUs for this auction (remember your value is what we will pay you for each unit won). Underneath your value, you will see a bid clock. This clock shows the current price in the auction and will steadily count up. The clock is not increasing now, because this is just an example screen. If this were the actual auction, the clock would be ticking up by 1 ECU per second. Both bidders begin the round "in" the auction. As the price increases on the bid clock, you can click on the "Drop Out" button to drop out of the auction at any point of your choosing. Note that drop out choices are irreversible so as soon as any bidder presses the drop out button, the auction will end and the time on the clock will be the auction price.

After the auction, there may be an opportunity for reselling the object.

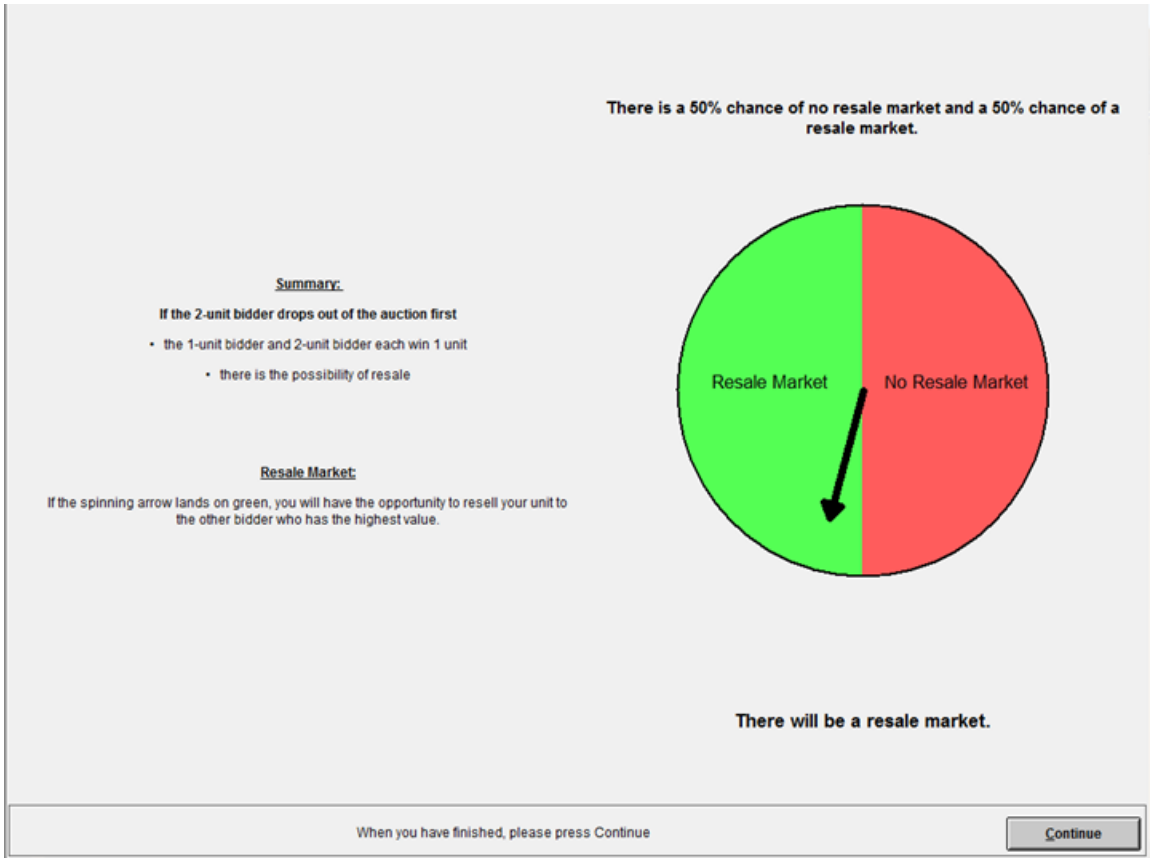
Payoffs: If the 1-unit bidder drops out first, the 2-unit bidder wins both units in the auction and there is no resale because the 2-unit bidder has the highest value. In this case, the 2-unit bidder will earn the difference between their value and the auction price, for each unit. The 1-unit bidder will earn zero.

If the 2-unit bidder drops out first, the 1-unit bidder wins one unit, and the 2-unit bidder also wins 1 unit. In this case, each bidder will earn the difference between their value and the auction price for the unit they won. In addition, because the 2-unit bidder has the highest value, the 1-unit bidder may have the opportunity to resell the unit they won in the auction to the 2-unit bidder.

Please press continue to learn more about the resale opportunity




30% Resale



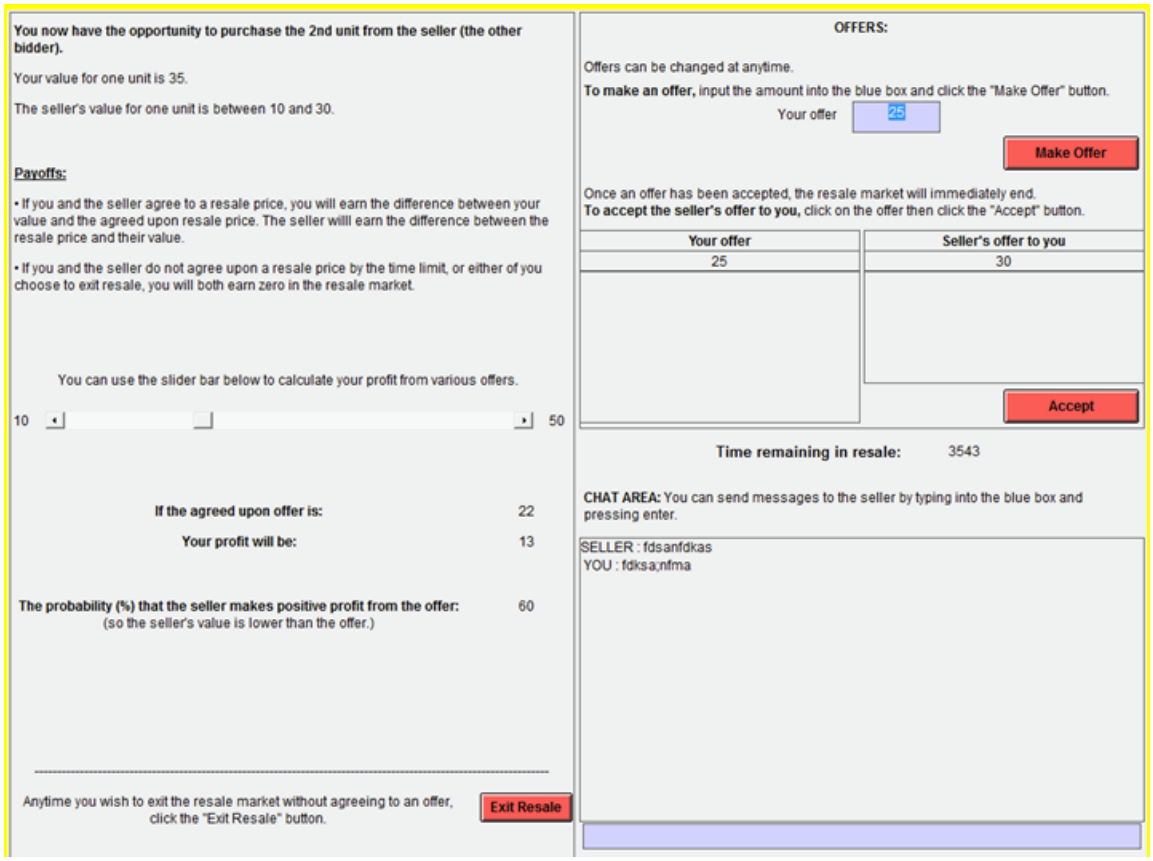

50% Resale

.

Resale Opportunity: If resale is possible because the 1-unit bidder won 1 unit, both bidders will enter into the stage you now see on your screen.

On the right side of the screen, you will see an active spin wheel. (wait for spinner to stop spinning before reading on) The spinner has now stopped. Recall, bidders will only enter this stage if the 2-unit bidder drops out of the auction first. In this case the 1-unit bidder and the 2-unit bidder each win 1 unit, and there is the possibility of resale. However, whether or not both bidders will enter the resale stage also depends on the outcome of a random draw played out by the spin wheel. Notice that the spin wheel has two colors. If the spinner lands on red, there will be no resale stage. If the spinner lands on green, there will be a resale stage. Notice also that the size of the green block is smaller than the red block. The size of these blocks translates into a 70% (50%) probability that no resale market will occur and a 30% (50%) probability that it will. The computer will randomly determine where the spinner lands. In this example, you will see that the spinner has landed on green, which means there will be a resale market.

Please press continue to work with the resale interface.




Resale: If resale is possible because the 1-unit bidder won 1 unit and the spinner landed on green in the previous stage, both bidders will enter the resale stage. What you should see in front of you now is a sample of the screen you will see in the resale stage.

If you were a 1-unit bidder in the auction, you will always be the seller in the resale stage. If you were a 2-unit bidder in the auction, you will always be the buyer in the resale stage. These roles are now defined by the bolded sentence at the top left of the screen. If you are the buyer, you have the opportunity to purchase the 2nd unit from the seller and if you are the seller, you have the opportunity to sell the unit you won in the auction to the buyer. Immediately below this, you will see a reminder of your value for the unit and the range of potential values for the other resale participant you are bargaining with. Your value and the other participant's value remain identical to the values you both had in the auction stage.

Immediately below this, still on the left side of the screen is the resale payoff information. For resale to occur, both the buyer and seller must agree to a resale offer. If they agree to a resale offer, the seller will earn the difference between the resale price and their value. The buyer will earn the difference between their value and the resale price. If no resale offer is agreed to, both the buyer and seller earn 0 in this stage. Any earnings from the resale stage are in addition to the earnings from the auction.

Resale offers are made at the top right of the screen. To make an offer, type in the price you would like to offer into the blue box and click "Make Offer." Once you make this offer, it will immediately appear in the box below under the label, "Your Offer." Any offers made by the other resale participant to you will also appear in this box on the right hand side.

Please input any offer amount into the blue box and press "Make Offer." You should see that your offer box has updated with the offer you input. You should also see the other participant's

offer to you once they have made their offer. Please now input another offer and click "Make Offer" to see that your offer has changed. To accept the offer of the other participant, click on their offer, which will highlight in blue and then click "Accept." You can only accept offers made by the other participant. Currently, the Accept button is disabled because this is an example screen, but when either the buyer or seller agree to an offer by pressing this button, the resale stage will immediately terminate. Prior to agreement, offers can be changed at anytime.

You have two tools to facilitate your resale decisions. The first is chat, located at the bottom right hand side of the screen. Messages can be sent to the other participant in this box. Please type a message now, for example, "hello" and press enter. You will see that your message has popped up and is identifiable by the label, "YOU." If your practice partner has also sent a message, that message should have popped-up in the box and is identifiable by their role of either BUYER or SELLER. Make sure that you hit enter after you have typed a message for it to be sent. We also ask that throughout the experiment you do not provide identifiable information about yourself to the other participant.

In addition to chat, you will also have access to the scrollbar seen on the left side of the screen. You can use the scrollbar to determine your payoff for a given offer. The minimum possible resale offer is 10, and the maximum is 50. You can choose any resale price between these two values by sliding the scrollbar, or clicking on the right and left arrows, which will increase and decrease the resale price. Please move the scrollbar now.

You should now see that information has appeared below the scrollbar, which will be automatically updated as you move the scrollbar. The resale offer is given directly below the scrollbar. Below the offer, you are given your resale profit for that given offer. Directly below your profit, you are given the probability that the other participant's resale profit will be positive for that particular offer.

If you would like to exit resale, there is a button at the bottom left of the screen that you can click to choose to exit the resale stage at any time. (Emphasize) You will have 180 seconds (3 minutes) to agree to an offer with the other participant. The time will be indicated in the middle of the right side of the screen, above chat. If an offer is not accepted either by you or the other participant before time expires, no resale will occur.

Please press Exit Resale to continue.

Please follow along with example 1, as we go through a sample auction. Please note that this example is for explanatory purposes only and is not intended to suggest how you should make decisions. If you are a 1-unit bidder, your value is 25 and if you are the 2-unit bidder, your value is 35

In this example, the 1-unit bidder will drop out first at a price of 20, so the 2-unit bidder (who doesn't drop out) will win both units in the auction.

We will now play this auction out. When you click continue, you will immediately be taken into the auction with the live bid clock. On the next screen, the 1-unit bidder should drop out when the auction price hits 20. The 2-unit bidder should not click the drop out button.

Please click continue to enter the practice auction.

You will now see the bid clock ticking up. The 1-unit bidder should press the drop out button once the bid clock has reached a price of 20. The 2-unit bidder should not click the drop out button.

(After 20 seconds and bidder has dropped out.)

If you dropped out at a price other than 20, the computer assumed the drop out price was 20 for example purposes. You should now see that the auction has ended because the drop-out button disappeared. You will also be told of the auction price.

Please click continue to be taken to the results summary.

You should now see the results screen for this practice auction. The 2-unit bidder won both units in the auction because the 1-unit bidder dropped out first. The 1-unit bidder did not win a unit. Since the 2-unit bidder won both units and has a higher value, there is no opportunity for resale.

Earnings for example 1: Notice that the auction price of the item is equal to the drop out price of 20 made by the 1-unit bidder. The 2-unit bidder won two units. For each unit, the 2-unit bidder's earnings are the difference between their value, 35, and the auction price, 20, so the 2-unit bidder earns 15 for each unit and the total payoff for both units won is 30. The 1-unit bidder earns zero because they did not win a unit.

Please click continue as we will now go through an example where the 2-unit bidder drops out first.

Recall, if you are a 1-unit bidder your value for this example is 25 and if you are a 2-unit bidder your value is 35.

In this example, the 2-unit bidder will drop out first at a price of 20, so the 1-unit bidder (who doesn't drop out) will win one unit in the auction and the 2-unit bidder will win the other unit.

We will now play this auction out. When you click continue, you will be immediately taken into the auction with the live bid clock. On the next screen, the 2-unit bidder should drop out when the auction price hits 20. The 1-unit bidder should not click the drop out button.

Please click continue to enter the next practice auction.

Remember, the 2-unit bidder should try to drop out at a price of 20. The 1-unit bidder should not click the drop out button.

(After 20 seconds and bidder has dropped out)

Again, if the 2-unit bidder dropped out at a price different from 20, the computer assumed a drop out of 20 for example purposes. The auction is now over, and since the 2-unit bidder dropped out first, the 2-unit bidder won one unit and the 1-unit bidder won one unit. Because the 2-unit bidder has the highest value, there may be a resale stage where the 1-unit bidder will have the opportunity to resell the item to the 2-unit bidder. You will now be taken to a screen which summarizes the auction outcome and plays the random spin wheel to determine if there will be a resale market in this round.

Please click continue to be taken to this screen

You should now see the screen with the spin wheel. On the left side of the screen you will see a summary of your earnings in the auction. Both bidders won a unit in the auction and paid a price equal to the 2-unit bidder's drop out price of 20. The 1-unit bidder earned the difference between their value, 25 and the price 20, for auction profit equal to 5. The 2-unit bidder earned the difference between their value 35 and the price paid in the auction, 20, for auction profit equal to 15.

Turning your attention to the spin wheel you will see that the computer generated a spin to determine if there would be a resale market or not. (stop reading until after spinner stops) You will notice that the spinner has landed on green and as a result there will be a resale market in this example. When you hit continue, you will be taken to the resale stage. Had the spinner landed on red, there would be no resale market and you would have been taken immediately to the results screen for this round. Your profit for this round would be equal to your auction profit listed at the top left of the screen.

This bottom left side of this screen will also remind you of your role in resale in the event that resale occurs. The 1-unit bidder is always the seller in the resale market, while the 2-unit

bidder is always the buyer.

Please click continue to be taken to resale stage.

Assume in the resale stage that both resale participants agree to a resale price of 32. To see how accepting an offer works, please input an offer of 32 and click "Make Offer." Once the other participant has input a price of 32, you will see that update as well. To agree to the offer made by the other participant, click on the offer given. You will know you have selected the offer once it highlights in blue. During the actual paid resale games, you do not have to both input the same offer for resale agreement; this is only for practice purposes. Please note that either role can accept and make offers, and it is only necessary for 1 offer to be made and accepted for resale to take place. After selecting the offer, click the "Accept" button. Once an accept decision is made, resale ends and you should be now taken to the results screen.

You should now see the results screen, which summarizes your auction profit at the top and your resale profit at the bottom.

The seller's resale profit is 7, which is the difference between the resale price, 32, and their value, 25. The buyer's resale profit is 3, which is the difference between their value, 35, and the resale price, 32. Total earnings are equal to auction profit plus resale profit.

Last informational points: Note that it is possible to lose money in the auction or in resale. The 2-unit bidder loses money if they purchase a unit at a price that is higher than their value. The 1-unit bidder loses money if they purchase a unit in the auction at a price higher than their value and resale does not occur, or if the resale price is lower than the auction price. You will all begin this phase of the experiment with a balance of 150 ECUs. 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.

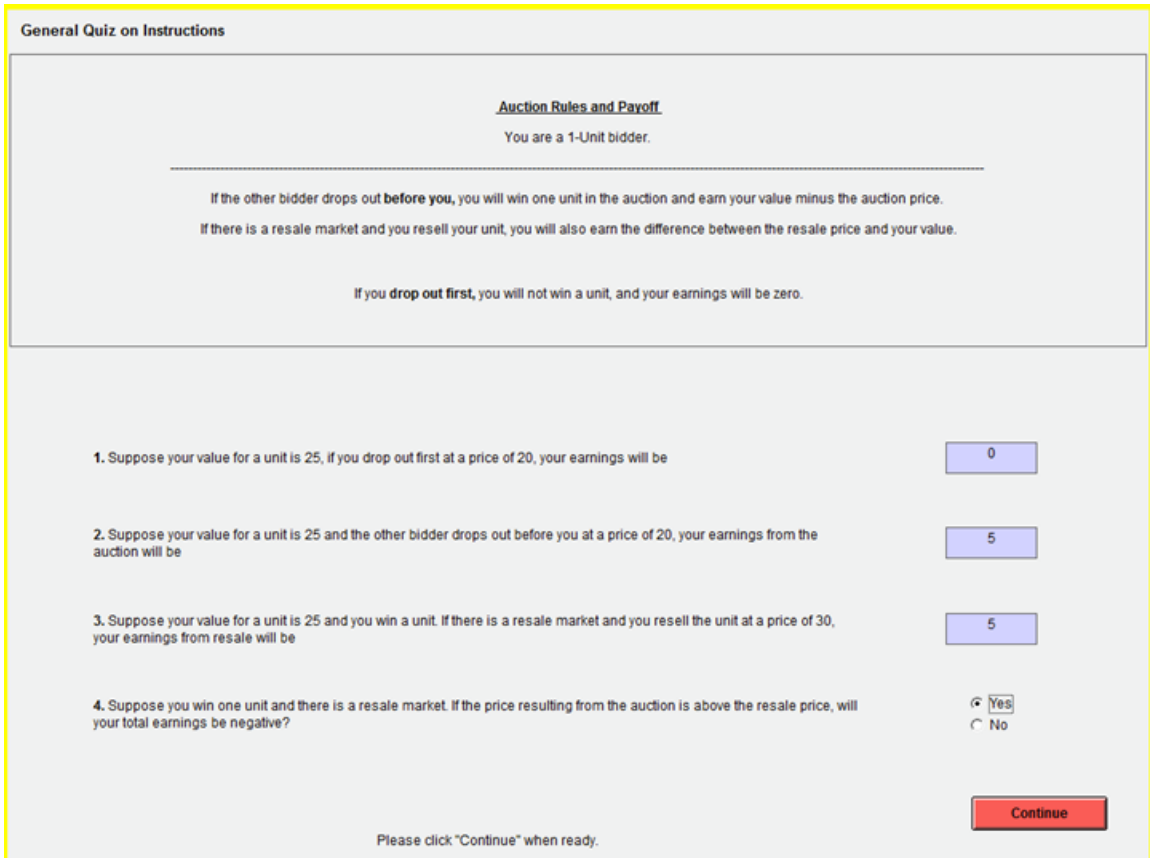
Ties: If both bidders dropped out at the exact same time, the computer will randomly select a winner to break the tie.

Random Groups: You will be randomly re-assigned to a new group each period. There will always be two people in your group, and the other bidder will be the opposite role.

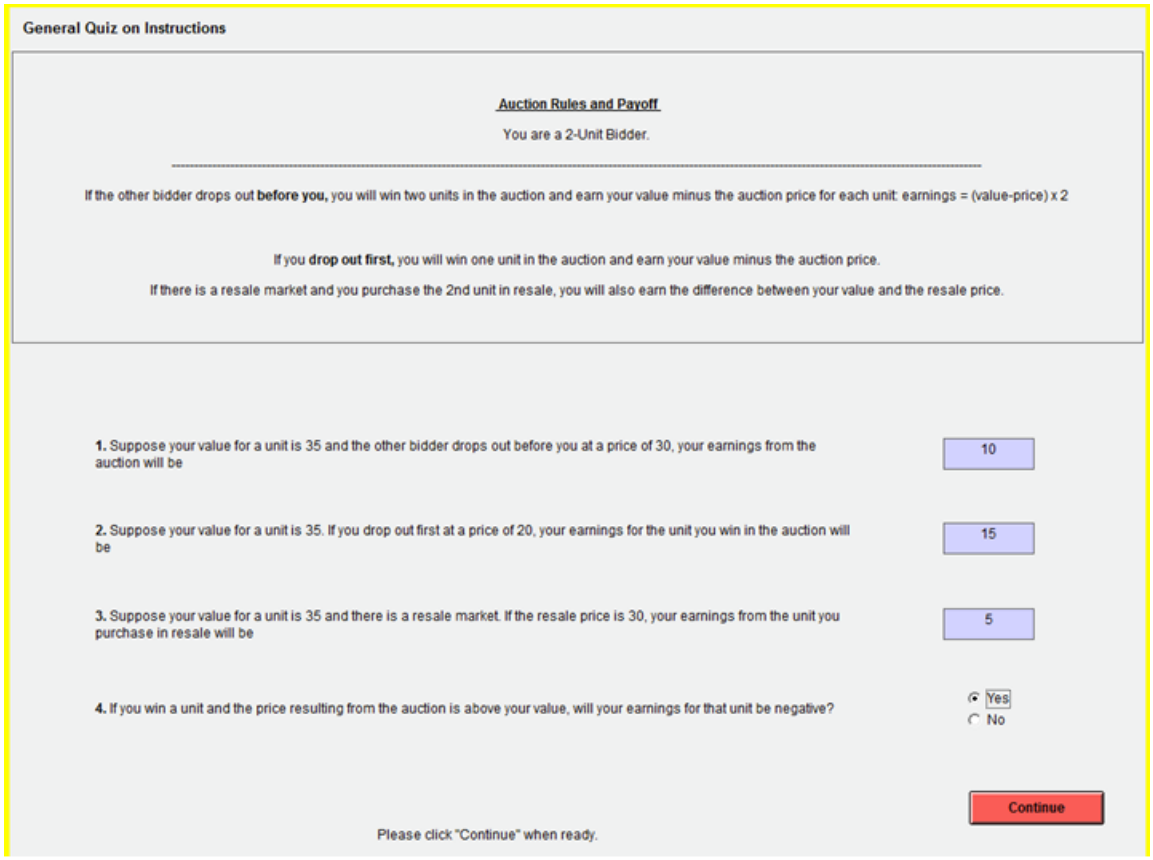
At some point, because of the software, we may have a group finish before another. This does not imply any advantage in payments and we ask that you please wait patiently for the others to finish.

Please press Continue.

We are now about to take a short quiz to ensure you understand the instructions. When you have finished the quiz, please press continue again to check your answers. If you have an incorrect answer for one of the questions, the correct answer will be given to you in a pop-up. Please correct your incorrect answer and hit continue again until all questions have been answered correctly. Once everyone has completed this quiz, the experiment will continue.




1 Unit Bidder Quiz - Resale Treatments




2 Unit Bidder Quiz - Resale Treatments

Are there any questions? We are about to begin the actual auctions that you will be paid for. Before each auction round, you will see this pause screen which will inform you of your value for the next round.

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.2. 100% Resale 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. If you have a question or problem please raise your hand and one of us will come to you. I also ask that you please turn off your cell phones.

General information: The purpose of this experiment is to study how people make decisions in a particular situation. You will receive $10 for showing up on time for the experiment. You will also make additional money during today's experiment. Upon completion of the experiment the amount that you make will be paid to you by check. Payments are confidential; no other

participant will be told the amount you make. All amounts in this phase of the experiment are denominated in experimental currency units, ECUs. ECUs will transform into real dollars at the rate of $0.01 per ECU. These earnings are in addition to the show-up fee.

In this experiment, you will be a bidder in a series of auctions. Please hit continue for general instructions. Please do not hit continue again until after I have finished with all instructions for this screen

In this experiment, we will create a market in which you will act as a bidder in a sequence of auctions. Each auction has two identical units of a hypothetical item for sale. You will be bidding in the auction against one other person. At the end of each auction there will be the possibility of the winner reselling the item to the other person. The person you are matched with to bid against will be randomly chosen at the start of each auction and will therefore be different across auctions. Each auction will always have two bidders: a 1-unit bidder and a 2-unit bidder. The 1-unit bidder can purchase only 1 unit of the item and will be assigned a single value for one (1) unit. The 2-unit bidder can purchase up to 2 units of the item and will be assigned a single value for each of the two (2) units. For both types of bidders, these values represent the value of the good to you - what we will pay you for any items purchased.

Please hit continue for information on roles, values, and resale. Again, please do not hit continue until I have finished with all instructions for this screen

You were randomly assigned a role of 1-unit bidder or 2-unit bidder, which is listed at the top of your screen. The possible values for the 2-unit bidder are the integers between 30 and 50, with all values being equally likely, and the possible values for the 1-unit bidder are the integers between 10 and 30, again all values are equally likely. If you are a 1-unit bidder, you will be bidding against a 2-unit bidder and vice versa. If the 1-unit bidder purchases a unit, they will have the opportunity to resell it to the 2-unit bidder. If the 2-unit bidder purchases a unit, they will not resell it because they have a higher value than the 1-unit bidder.

Please press continue again to work with the auction interface. What you should see is a flat example screen. Please do not hit continue until I have finished with all instructions for this screen

What you should see in front of you is a sample of the screen you will see for this auction. The left side of the screen contains boxes that have instructions and payoffs. On the right side of the screen you will see the primary auction interface. Beside the word "Auction" in the top line, you will see the number of units you can win (called "Units Demanded"). Below that you will see what your value is for a unit in ECUs for this auction (remember your value is what we will pay you for each unit won). Underneath your value, you will see a bid clock. This clock shows the current price in the auction and will steadily count up. The clock is not increasing now, because this is just an example screen. If this were the actual auction, the clock would be ticking up by 1 ECU per second. Both bidders begin the round "in" the auction. As the price increases on the bid clock, you can click on the "Drop Out" button to drop out of the auction at any point of your choosing. Note that drop out choices are irreversible so as soon as any bidder presses the drop out button, the auction will end and the time on the clock will be the auction price.

After the auction, there may be an opportunity for reselling the object.

Payoffs: If the 1-unit bidder drops out first, the 2-unit bidder wins both units in the auction and there is no resale because the 2-unit bidder has the highest value. In this case, the 2-unit bidder will earn the difference between their value and the auction price, for each unit. The 1-unit bidder will earn zero.

If the 2-unit bidder drops out first, the 1-unit bidder wins one unit, and the 2-unit bidder

also wins 1 unit. In this case, each bidder will earn the difference between their value and the auction price for the unit they won. In addition, because the 2-unit bidder has the highest value, the 1-unit bidder will have the opportunity to resell the unit they won in the auction to the 2-unit bidder.

Please press continue again to work with the resale interface.

Resale: If resale is possible because the 1-unit bidder won 1 unit, both bidders automatically enter the resale stage. What you should see in front of you is a sample of the screen you will see in resale.

If you were a 1-unit bidder in the auction, you will always be the seller in the resale stage. If you were a 2-unit bidder in the auction, you will always be the buyer in the resale stage. These roles are now defined by the bolded sentence at the top left of the screen. If you are the buyer, you have the opportunity to purchase the 2nd unit from the seller and if you are the seller, you have the opportunity to sell the unit you won in the auction to the buyer. Immediately below this, you will see a reminder of your value for the unit and the range of potential values for the other resale participant you are bargaining with. Your value and the other participant's value remain identical to the values you both had in the auction stage.

Immediately below this, still on the left side of the screen is the resale payoff information. For resale to occur, both the buyer and seller must agree to a resale offer. If they agree to a resale offer, the seller will earn the difference between the resale price and their value. The buyer will earn the difference between their value and the resale price. If no resale offer is agreed to, both the buyer and seller earn 0 in this stage. Any earnings from the resale stage are in addition to the earnings from the auction.

Resale offers are made at the top right of the screen. To make an offer, type in the price you would like to offer into the blue box and click "Make Offer." Once you make this offer, it will immediately appear in the box below under the label, "Your Offer." Any offers made by the other resale participant to you will also appear in this box on the right hand side.

Please input any offer amount into the blue box and press "Make Offer." You should see that your offer box has updated with the offer you input. You should also see the other participant's offer to you once they have made their offer. Please now input another offer and click "Make Offer" to see that your offer has changed. To accept the offer of the other participant, click on their offer, which will highlight in blue and then click "Accept." You can only accept offers made by the other participant. Currently, the Accept button is disabled because this is an example screen, but when either the buyer or seller agree to an offer by pressing this button, the resale stage will immediately terminate. Prior to agreement, offers can be changed at anytime.

You have two tools to facilitate your resale decisions. The first is chat, located at the bottom right hand side of the screen. Messages can be sent to the other participant in this box. Please type a message now, for example, "hello" and press enter. You will see that your message has popped up and is identifiable by the label, "YOU." If your practice partner has also sent a message, that message should have popped-up in the box and is identifiable by their role of either BUYER or SELLER. Make sure that you hit enter after you have typed a message for it to be sent. We also ask that throughout the experiment you do not provide identifiable information about yourself to the other participant.

In addition to chat, you will also have access to the scrollbar seen on the left side of the screen. You can use the scrollbar to determine your payoff for a given offer. The minimum possible resale offer is 10, and the maximum is 50. You can choose any resale price between these two values by sliding the scrollbar, or clicking on the right and left arrows, which will increase and decrease the resale price. Please move the scrollbar now.

You should now see that information has appeared below the scrollbar, which will be automatically updated as you move the scrollbar. The resale offer is given directly below the scrollbar. Below the offer, you are given your resale profit for that given offer. Directly below your profit, you are given the probability that the other participant's resale profit will be positive for that particular offer.

If you would like to exit resale, there is a button at the bottom left of the screen that you can click to choose to exit the resale stage at any time. (Emphasize) You will have 180 seconds (3 minutes) to agree to an offer with the other participant. The time will be indicated in the middle of the right side of the screen, above chat. If an offer is not accepted either by you or the other participant before time expires, no resale will occur.

Please press Exit Resale to continue.

Please follow along with example 1, as we go through a sample auction. Please note that this example is for explanatory purposes only and is not intended to suggest how you should make decisions. If you are a 1-unit bidder, your value is 25 and if you are the 2-unit bidder, your value is 35

In this example, the 1-unit bidder will drop out first at a price of 20, so the 2-unit bidder (who doesn't drop out) will win both units in the auction.

We will now play this auction out. When you click continue, you will immediately be taken into the auction with the live bid clock. On the next screen, the 1-unit bidder should drop out when the auction price hits 20. The 2-unit bidder should not click the drop out button.

Please click continue to enter the practice auction.

You will now see the bid clock ticking up. The 1-unit bidder should press the drop out button once the bid clock has reached a price of 20. The 2-unit bidder should not click the drop out button.

(After 20 seconds and bidder has dropped out.)

If you dropped out at a price other than 20, the computer assumed the drop out price was 20 for example purposes. You should now see that the auction has ended because the drop-out button disappeared. You will also be told of the auction price.

Please click continue to be taken to the results summary.

You should now see the results screen for this practice auction. The 2-unit bidder won both units in the auction because the 1-unit bidder dropped out first. The 1-unit bidder did not win a unit. Since the 2-unit bidder won both units and has a higher value, there is no resale.

Earnings for example 1: Notice that the auction price of the item is equal to the drop out price of 20 made by the 1-unit bidder. The 2-unit bidder won two units. For each unit, the 2-unit bidder's earnings are the difference between their value, 35, and the auction price, 20, so the 2-unit bidder earns 15 for each unit and the total payoff for both units won is 30. The 1-unit bidder earns zero because they did not win a unit.

Please click continue as we will now go through an example where the 2-unit bidder drops out first.

EXAMPLE 2

Recall, if you are a 1-unit bidder your value for this example is 25 and if you are a 2-unit bidder your value is 35.

In this example, the 2-unit bidder will drop out first at a price of 20, so the 1-unit bidder (who doesn't drop out) will win one unit in the auction and the 2-unit bidder will win the other unit.

We will now play this auction out. When you click continue, you will be immediately taken into the auction with the live bid clock. On the next screen, the 2-unit bidder should drop out

when the auction price hits 20. The 1-unit bidder should not click the drop out button.

Please click continue to enter the next practice auction.

Remember, the 2 –unit bidder should try to drop out at a price of 20. The 1-unit bidder should not click the drop out button.

(After 20 seconds and bidder has dropped out)

Again, if the 2-unit bidder dropped out at a price different from 20, the computer assumed a drop out of 20 for example purposes. The auction is now over, and since the 2-unit bidder dropped out first, the 2-unit bidder won one unit and the 1-unit bidder won one unit. Because the 2-unit bidder has the highest value, there will be a resale stage where the 1-unit bidder will have the opportunity to resell the item to the 2-unit bidder, but first you will be taken to an auction summary screen.

Please click continue to be taken to the pre-resale auction results summary.

Both bidders won a unit in the auction and paid a price equal to the 2-unit bidder's drop out price of 20. The 1-unit bidder earned the difference between their value, 25 and the price 20, for auction profit equal to 5. The 2-unit bidder earned the difference between their value 35 and the price paid in the auction, 20, for auction profit equal to 15.

This pre-resale results screen will also remind you of your role in resale. The 1-unit bidder is always the seller in the resale market, while the 2-unit bidder is always the buyer.

Please click continue to be taken to resale stage.

Assume in the resale stage that both resale participants agree to a resale price of 32. To see how accepting an offer works, please input an offer of 32 and click "Make Offer." Once the other participant has input a price of 32, you will see that update as well. To agree to the offer made by the other participant, click on the offer given. You will know you have selected the offer once it highlights in blue. During the actual paid resale games, you do not have to both input the same offer for resale agreement; this is only for practice purposes. Please note that either role can accept and make offers, and it is only necessary for 1 offer to be made and accepted for resale to take place. After selecting the offer, click the "Accept" button. Once an accept decision is made, resale ends and you should be now taken to the results screen.

You should now see the results screen which summarizes your auction profit at the top and your resale profit at the bottom.

The seller's resale profit is 7, which is the difference between the resale price, 32, and their value, 25. The buyer's resale profit is 3, which is the difference between their value, 35, and the resale price, 32. Total earnings are equal to auction profit plus resale profit.

Last informational points: Note that it is possible to lose money in the auction or in resale. The 2-unit bidder loses money if they purchase a unit at a price that is higher than their value. The 1-unit bidder loses money if they purchase a unit in the auction but the resale price is lower than the auction price. You will all begin this phase of the experiment with a balance of 150 ECUs. 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.

Ties: If both bidders dropped out at the exact same time, the computer will randomly select a winner to break the tie.

Random Groups: You will be randomly re-assigned to a new group each period. There will always be two people in your group, and the other bidder will be the opposite role.

At some point, because of the software, we may have a group finish before another. This does not imply any advantage in payments and we ask that you please wait patiently for the

others to finish.

Please press Continue.

We are now about to take a short quiz to ensure you understand the instructions. When you have finished the quiz, please press continue again to check your answers. If you have an incorrect answer for one of the questions, the correct answer will be given to you in a pop-up. Please correct your incorrect answer and hit continue again until all questions have been answered correctly. Once everyone has completed this quiz, the experiment will continue. (Same quiz as previous instructions)

Are there any questions? We are about to begin the actual auctions that you will be paid for. Before each auction round, you will see this pause screen which will inform you of your value for the next round.

### A.3. No Resale

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. If you have a question or problem please raise your hand and one of us will come to you. I also ask that you please turn off your cell phones. Please wait until instructed to click the "Continue" button.

General information: The purpose of this experiment is to study how people make decisions in a particular situation. You will receive $10 for showing up on time for the experiment. In addition, you will make money during today's experiment. Upon completion of the experiment the amount that you make will be paid to you by check. Payments are confidential; no other participant will be told the amount you make. All amounts in this phase of the experiment are denominated in experimental currency units, ECUs. ECUs will transform into real dollars at the rate of $0.01 per ECU. These earnings are in addition to the $10 show-up fee.

Details of phase 1 (Auction): In this experiment, you will be a bidder in a series of auctions.

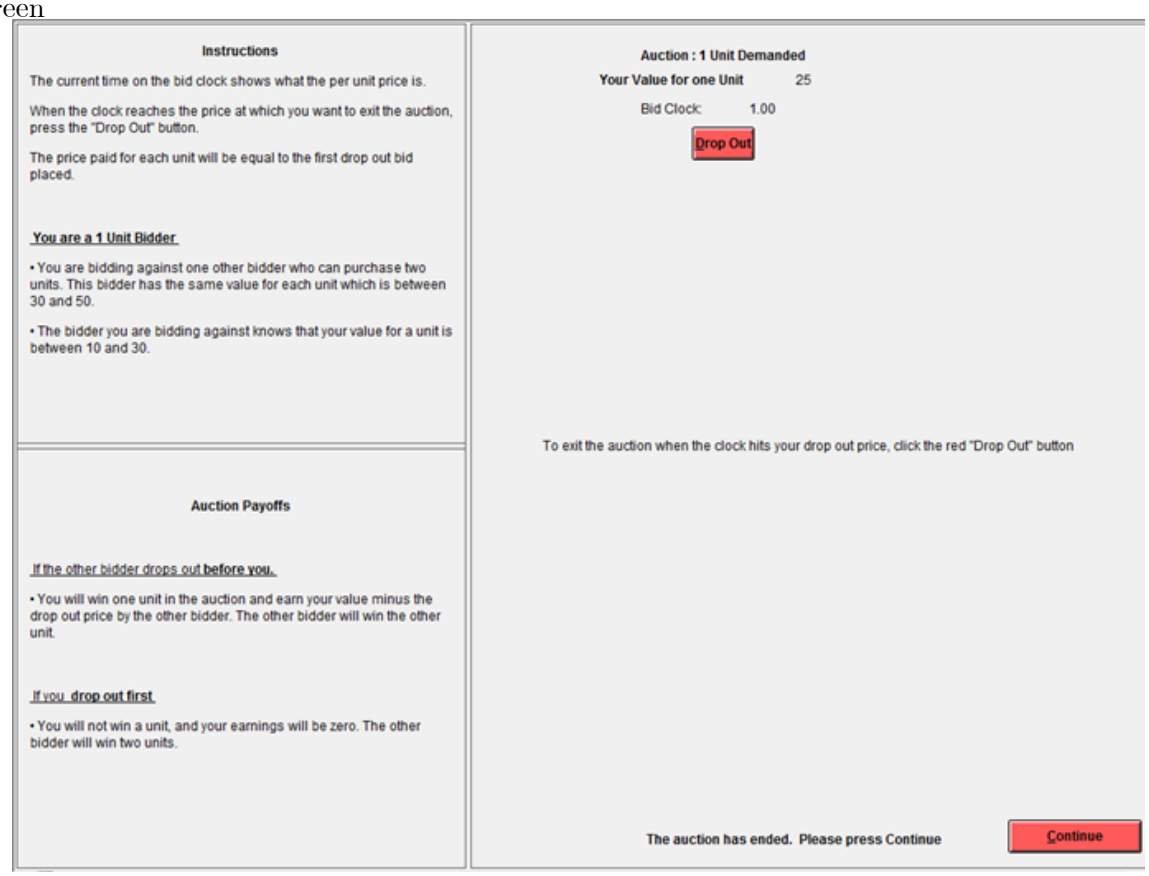
Please hit continue for general instructions. Please do not hit continue again until after I have finished with all instructions for this screen

In this experiment, we will create a market in which you will act as a bidder in a sequence of auctions. Each auction has two identical units of a hypothetical item for sale. You will be bidding in the auction against one other person. The person you are matched with to bid against will be randomly chosen at the start of each auction and will therefore be different across auctions. Each auction will always have two bidders: a 1-unit bidder and a 2-unit bidder. The 1-unit bidder can purchase only 1 unit of the item and will be assigned a single value for one (1) unit. The 2-unit bidder can purchase up to 2 units of the item and will be assigned a single value for each of the two (2) units. For both types of bidders, these values represent the value of the good to you - what we will pay you for any items purchased.

Please hit continue for information on roles and values. Again, please do not hit continue until I have finished with all instructions for this screen

You were randomly assigned a role, which is listed at the top of your screen. You are either a 1-unit bidder or a 2-unit bidder. The possible values for the 2-unit bidder are the integers between 30 and 50, with all values being equally likely, and the possible values for the 1-unit bidder are the integers between 10 and 30, again all values are equally likely. If you are a 1-unit bidder, you will be bidding against a 2-unit bidder and vice versa.

Please press continue again to work with the auction interface. What you should see is a flat example screen. Please do not hit continue until I have finished with all instructions for this screen




What you should see in front of you is a sample of the screen you will see for this auction. The left side of the screen contains boxes that have instructions and auction payoffs. On the right side of the screen you will see the primary auction interface. Beside the word "Auction" in the top line, you will see the number of units you can win (called "Units Demanded"). Below that you will see what your value is for a unit in ECUs for this auction (remember your value is what we will pay you for each unit won). Underneath your value, you will see a bid clock. This clock shows the current price in the auction and will steadily count up. The clock is not increasing now, because this is just an example screen. If this were the actual auction, the clock would be ticking up by 1 ECU per second. Both bidders begin the round "in" the auction. As the price increases on the bid clock, you can click on the "Drop Out" button to drop out of the auction at any point of your choosing. Note that drop out choices are irreversible so as soon as you press the drop out button, you will exit the auction and the time on the clock is auction price. The auction will end as soon as one bidder has dropped out. After the auction concludes, you will be taken to another screen which will inform you of the auction results.

Earnings: After the auction, your earnings will be determined by how many units you won, which depends on whether or not you dropped out first.

If the 1-unit bidder drops out first, the 2-unit bidder wins both units and the 1-unit bidder does not win a unit. If the 2-unit bidder drops out first, the 1-unit bidder wins one unit, and the 2-unit bidder also wins 1 unit.

Your payoff for each unit won is the difference between your value and the auction price. If

you do not win a unit, your earnings will be zero.

Note that it is possible to lose money in this auction if the price resulting from the auction is more than your value. You will all begin this phase of the experiment with a balance of 150 ECUs. 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. Two-time bankrupt bidders will be replaced with robot bidders.

Ties: If both bidders dropped out at the exact same time, the computer will randomly select a winner to break the tie.

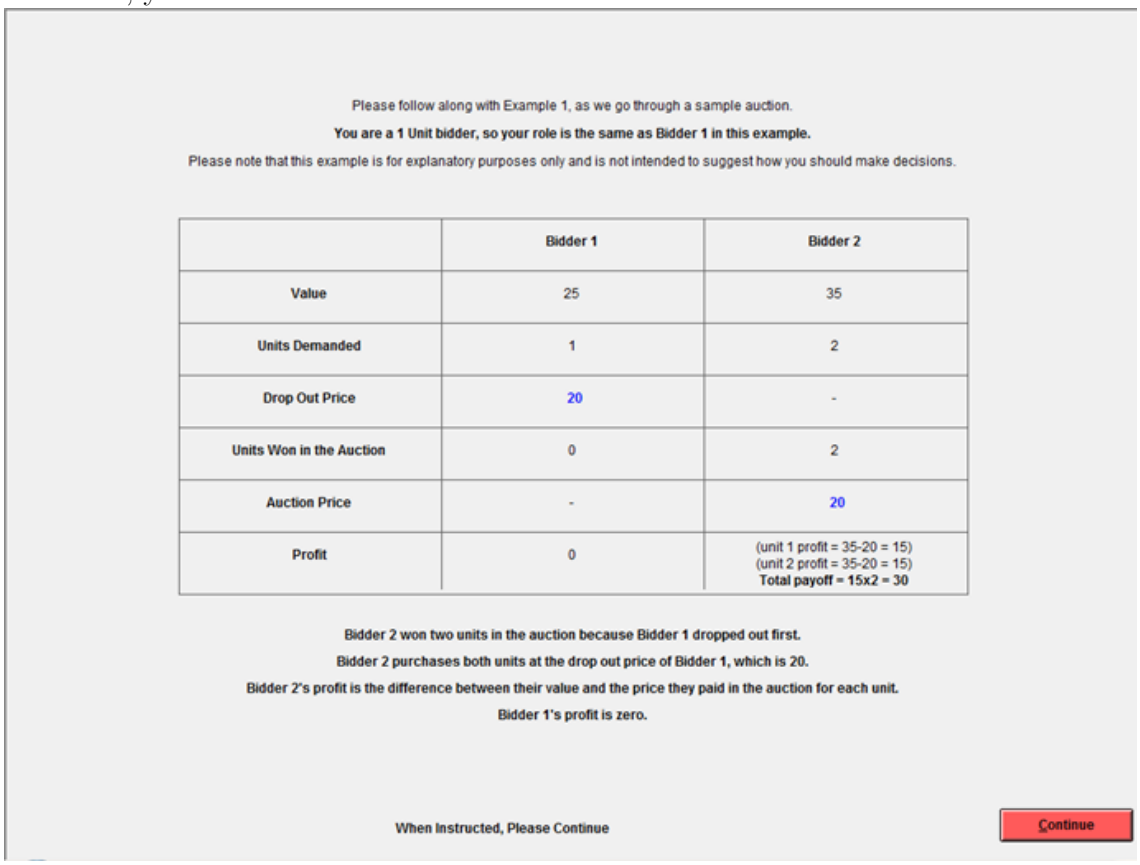
Random Groups: You will be randomly re-assigned to a new group each period. There will always be two people in your group, and the other bidder will be the opposite role.

At some point, because of the software, we may have a group finish before another. This does not imply any advantage in payments and we ask that you please wait patiently for the others to finish.

Please click continue to go through an example outcome.

EXAMPLE 1

In this example, if you are a 1 unit bidder, your role is the same as Bidder 1. If you are a 2-unit bidder, your role is the same as Bidder 2.



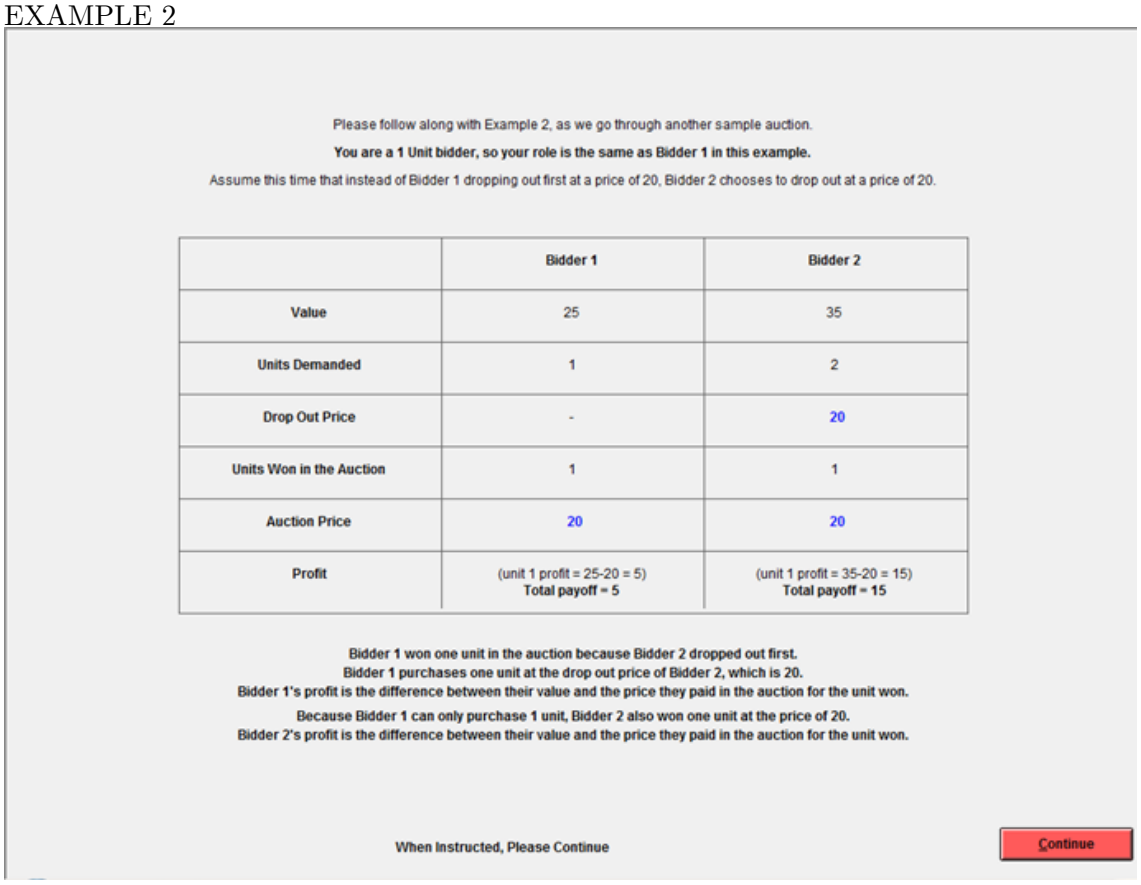

The following table contains a set of sample values and a drop out price that could occur in an auction round. Row 1 shows you the values each bidder has. The second row in the table lists the number of units each type of bidder can purchase. The third row lists the drop out price. Notice that Bidder 1 dropped out first at a price of 20, so Bidder 2 (who didn't drop out)

wins both units in the auction. The fourth row indicates the number of units each bidder won the auction. Bidder 2 won two units in the auction and Bidder 1 did not win a unit. Notice that the auction price of the item is equal to the drop out price made by Bidder 1. You can see this in row 5. The last row indicates the profit each bidder would have made. Bidder 1 would earn zero because he did not win a unit. Bidder 2 won two units. For each unit, Bidder 2's earnings are the difference between his value, 35, and the price paid in the auction, 20, so he earns 15 for each unit and his total payoff for both units is equal to 30.

Please note that these examples are for explanatory purposes only and are not intended to be suggested bids.

Please click continue as we will now go through an example outcome where Bidder 2 drops out first.

EXAMPLE 2

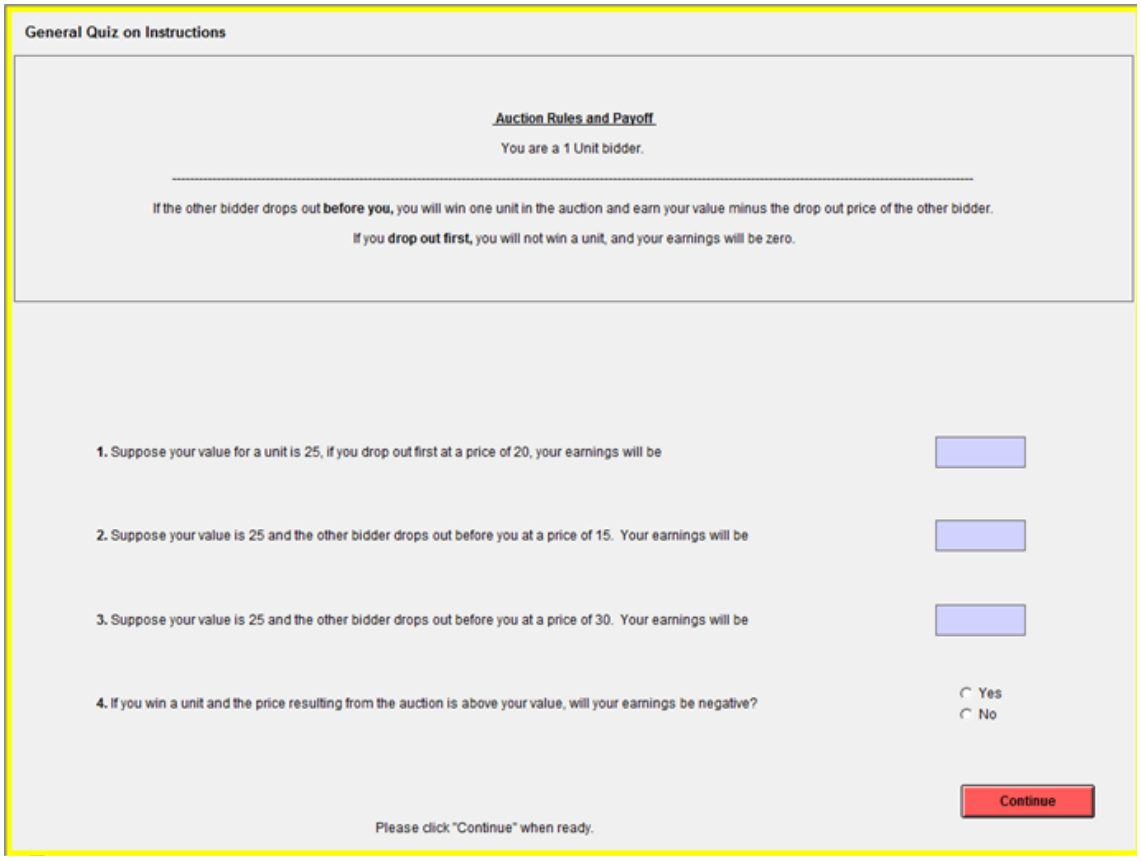



Assume this time that Bidder 2 drops out first at a price of 20, instead of Bidder 1. Because Bidder 2 dropped out first, Bidder 1 won 1 unit in the auction. Bidder 1 purchases one unit at the drop out price of Bidder 2, which is 20. Bidder 1's earnings are the difference between his value, 25, and the price paid in the auction, 20. So his total payoff is equal to 5. Because Bidder 1 can only purchase 1 unit, Bidder 2 won the remaining unit at the price he dropped out at, 20. Bidder 2's earnings are the difference between his value, 35, and the price paid in the auction, 20. So his total payoff is equal to 15.

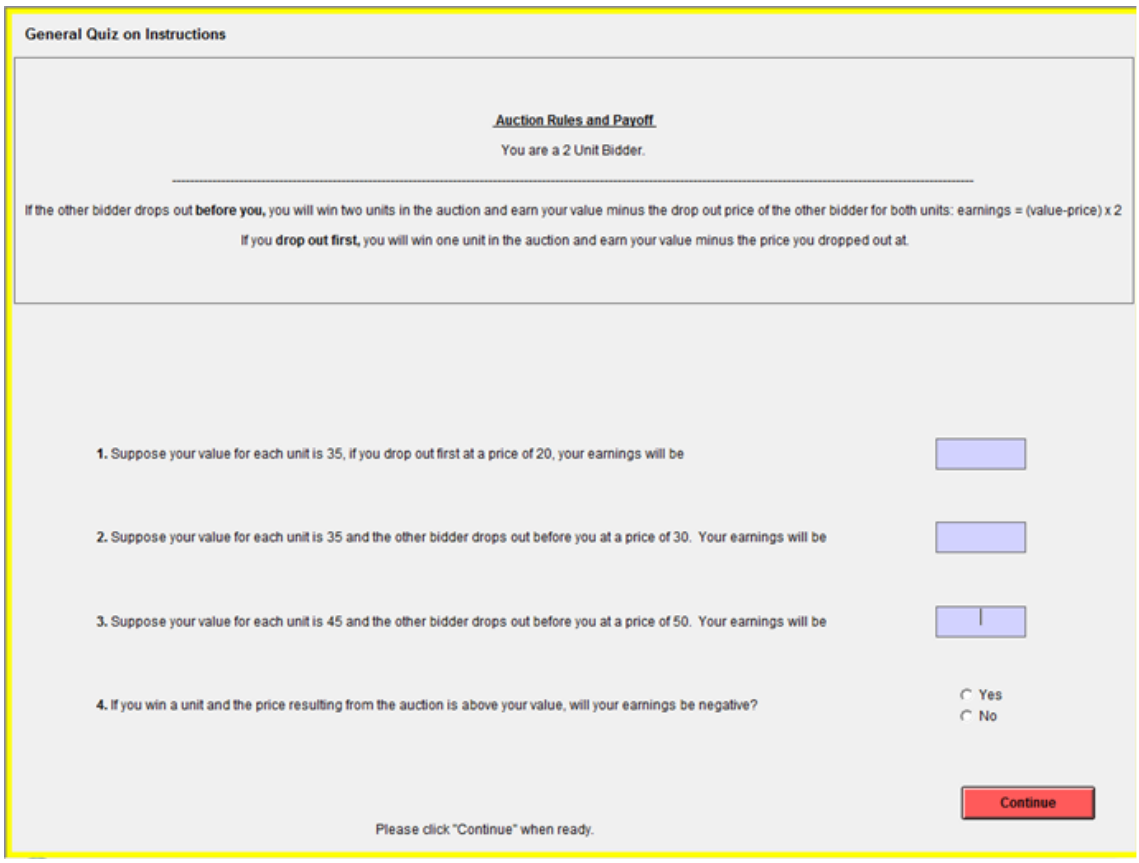
Please press Continue.

We are now about to take a short quiz to ensure you understand the instructions. When you have finished the quiz, please press continue again to check your answers. If you have an incorrect answer for one of the questions, the correct answer will be given to you in a pop-

up. Please correct your incorrect answer and hit continue again until all questions have been answered correctly. Once everyone has completed this quiz, the experiment will continue.




1 Unit Bidder Quiz - No Resale Treatment




2 Unit Bidder Quiz - No Resale Treatment

To familiarize yourself with the computer interface, you will now begin a practice round against a robot bidder. You will not be paid for this round. Please press "Continue" to enter into a practice auction with the robot bidder. Remember, to drop out of the auction, click the "drop out" button. When the auction has ended a continue button will appear at the bottom of the screen. When the auction has ended, either because you dropped out first, or the robot bidder dropped out first, please hit this continue button to move onto the practice round results.

(After practice)

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

Are there any questions? We are about to begin the actual auctions that you will be paid for. Before each auction round, you will see this pause screen which will inform you of your value for the next round.