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Efficiency in auctions with (failed) resale☆

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ABSTRACT

The possibility of resale affects efficiency in multi-object uniform-price auctions with asymmetric bidders. We theoretically show that when the exogenous probability of a resale market is sufficiently low, final efficiency is lower than in an auction without resale. Our experimental design consists of four treatments that vary the probability that bidders participate in a resale market. Resale always increases efficiency compared to the auction allocation, but it also induces demand reduction by high-value bidders, which reduces auction efficiency. Consistent with theory and in contrast to what is usually argued, the possibility of resale may reduce final efficiency and changes in the probability of resale have a non-monotonic effect on efficiency. We also analyze bargaining chat data to provide insights into the functioning of resale markets.

1. Introduction

Post-auction resale markets have been observed in many settings, including auctions for emissions permits, spectrum licenses, and timber sales.[1] Understanding the impact of post-auction resale markets is a crucial issue for market designers, as bidding behavior and auction outcomes can substantially change from what would be observed without 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, thus allowing 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 than the auction winner, because resale may fail for many different reasons. Bargaining disagreement, asymmetric information and transactions costs are all possible causes of resale failure. In

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[1] Haile (2001) provides an in-depth analysis of the consequences of post-auction resale markets using US Forest Service timber sales.

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addition to these market frictions, resale may also fail for exogenous reasons, like the imposition of new regulatory or legal constraints on post-auction trade.[2] Moreover, attempted transactions after the auction that require regulatory approval may fail to receive it.

There is substantial empirical evidence that bidders integrate the incentives created by post-auction resale into their bidding decisions when the auction is followed by a resale market whose presence is certain (e.g., Georganas, 2011; Lange et al., 2011; Saral, 2012). Pagnozzi and Saral (2017) 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.[3] Moreover, bidders with low values speculate by bidding aggressively if they have a chance to resell the objects acquired.

It remains an open question, 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. 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.[4] The strong bidder has a higher valuation and demands both units; the weak bidder has a lower valuation and demands only one unit.[5] Efficiency is measured both by the probability that the bidder with the highest valuation obtains the units, and by the valuations of the buyers of the units compared to the highest valuation.

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 failure allows us to directly analyze the effects of changes in this probability in our experiment.

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. On balance we show that, when the probability of resale failure is sufficiently high, final (post-resale) efficiency is actually lower than in an auction without resale,[6] and is increasing in the probability of resale failure. Moreover, changes in the probability of resale failure have a non-monotonic effect on final efficiency. Similarly, a lower probability of resale failure also has contrasting effects on revenue: it increases speculative bids of weak bidders, which tends to raise revenue, but it also makes strong bidders more likely to reduce demand. Therefore, 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.[7] 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%).[8] The baseline treatments of no resale and certain resale

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[2] 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 restrictions on resale, but may impose penalties for transactions taking place less than 5 years after the auction (see 47 C.F.R. section 1.2111 of the FCC). In procurement, restrictions to subcontracting are often imposed (see, e.g., Marion, 2007).

[3] 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).

[4] We focus on multi-unit auctions to investigate the effects of the presence of a resale market because it is more natural to expect bidders to trade in a resale market after a multi-unit auction than after a single-unit auction (see our discussion in Section 2).

[5] 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.

[6] 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.

[7] 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).

[8] In theory, the probability of 30% minimizes final efficiency (under reasonable assumptions); while the probability of 50% should result in the same final efficiency as an auction without resale.

are also analyzed in Pagnozzi and Saral (2017) 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. Pagnozzi and Saral (2017) show that the presence of a certain resale market significantly increases weak bidders' bids and reduces strong bidders' bids compared to the no resale treatment. Using the data from this paper as a baseline, we introduce resale market uncertainty and show that weak bidders continue to bid more aggressively than in the no resale treatment but, in contrast to theoretical predictions, the level of speculation does not depend on the probability of a resale market. 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 for the items. As the probability of resale failure increases, strong bidders with higher values are less likely to allow weak bidders to win, but still more likely than without resale. Intuitively, the presence of an uncertain resale market (rather than a certain one) reduces strong bidders' incentive to reduce demand 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 bargaining 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 probability of resale failure.

Consistent with the theoretical analysis, our main empirical 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 more likely to falsely state their values than weak bidders.

Our paper primarily contributes to the experimental literature on auctions with resale.[9] 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 (2017) 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 assume that a resale markets always exists, we consider the effects of an exogenous uncertainty of the resale market.

The rest of the paper is organized as follows. Section 2 presents a theoretical analysis of the model that we refer to for our experimental design. Section 3 discusses the design of our experiment, and Section 4 presents the experimental results. Specifically, Section 4.1 presents a summary of the experimental results, while Sections 4.2–4.5 analyze bidding behavior, efficiency and revenue, and the resale market. Finally, Section 5 concludes. The Appendix contains an additional proof and regression analysis. Instructions and screenshots from our experiment are available in the supplementary material.

2. Theoretical predictions

2.1. 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 (2017), 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 14): the 2 highest bids are awarded the units; and the winner(s) pay a price equal to the 3rd-highest bid for each unit won. We focus on 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 (for example, spectrum licenses). The qualitative results of the analysis, however, also hold for any mechanism designed to

[9] See Kagel and Levin (2016) for a survey of the experimental literature on auctions.

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.

We consider a multi-unit auction, rather than a single-unit one, since it is more natural to expect a resale market to operate after a multi-unit auction. As will become clear from our analysis, there is a compelling reason for a high-value bidder to reduce demand and let a low-value bidder win one unit in the auction, and then acquire it in a resale market: this strategy reduces competition in the auction, and with multiple units on sale, allows the high-value bidder to acquire some of the units at a lower price in the auction (also see, e.g., Pagnozzi, 2010). By contrast, this tradeoff between winning a larger number of units and reducing the auction price for some units by trading in the resale market is completely absent in single-unit auctions. In a second-price auction with one unit on sale, for example, there is always a 'natural' equilibrium in which the bidder with the highest value bids his valuation and acquires the unit, so that bidders never trade in the resale market, regardless of the distribution of bidders' valuations and the functioning of the 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. The distributions of bidders' valuations are common knowledge, and each bidder is privately informed about his own valuation. 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.[10] Therefore, bidder S submits two bids in the auction (which may be different) and bidder W submits one bid only. At the end of the auction, bidders observe the identity of the auction winner and the auction price.

Our assumption on bidders' valuations ensures that in our experiment, when they bid in the auction, bidders know whether they may have a chance to buy or sell if there is a resale market. This allows us to focus on the different bidding strategies of the two types of bidders and on how these strategies are affected by the possibility 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, he may have a chance to resell to bidder S in a resale market. A resale market exists with probability q (conditional on bidder W winning the auction). This probability may be interpreted as a reduced-form measure of trading frictions or the efficiency of the resale market. More literally, $(1-q)$ may be 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 (2017), we consider resale through a general bargaining procedure between bidders, rather than a new auction. 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). Notice that the presence of incomplete information does not preclude ex post efficient bargaining, since the supports of bidders' valuations do not overlap.

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 $\alpha \in (0, 1)$ of the gains from trade and W obtaining a share $(1-\alpha)$ of the gains from trade. Hence, for simplicity, the auction price does not affect bargaining in the resale market. This bargaining outcome arises, for example, when valuations are revealed after the auction and bidders trade at a resale price $(1-\alpha)v_S + \alpha v_W$. 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

[10] 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. Even if bidder W has positive valuations for both units and can win 2 units in the auction, it is an equilibrium for both bidders to reduce demand, bidding a positive price for one unit and 0 for the other, as in our model. The reason is that bidder S has an incentive to reduce demand only if he can win one unit in the auction at a low price (see Pagnozzi, 2010, for a detailed analysis of a similar environment).

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—i.e., his lowest bid for a unit. The lower of these two bids is the auction price and, depending on which bid is higher, either S wins both units at a price equal to W's bid, or the two bidders win one unit each at a price equal to S's bid.

2.2. Equilibrium

We characterize an equilibrium where bidder S reduces demand and bids 0 for the second unit in the auction if $v_S \le v^*$, and bids his valuation v_S for the second unit 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

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

for a unit in the auction.[11] 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), thus winning one unit at price 0 in the auction and then possibly buying the second unit from bidder W in resale market.[12] 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), bidder S with valuation x prefers to reduce demand in the auction rather than outbid bidder W if and only if

$$(1+q\alpha)x - q\alpha\mathbb{E}[v_W] \ge 2\{x - \mathbb{E}[v_W] - q(1-\alpha)(\mathbb{E}[v_S \mid v_S < v^*] - \mathbb{E}[v_W])\}$$
$$\Leftrightarrow \quad x \le x^*(v^*) \equiv \frac{40 - 10q(1+\alpha) + q(1-\alpha)v^*}{1 - q\alpha}.$$

The threshold $x^*(v^*)$ is equal to v^* if and only if

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

So it is indeed an equilibrium strategy for bidder S to reduce demand if and only if his valuation is lower than a threshold, as we have assumed.[13]

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 $v_S < 2E[v_W] = 40$. 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

[11] 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.

[12] We show in the Appendix that reducing demand but bidding a strictly positive price for the second unit is never an optimal strategy.

[13] Of course, as in a single-unit second-price auction, there are also other equilibria which are arguably less reasonable, in which one bidder always wins by bidding a very high price (that he does not have to pay) and the other bidder bids a lower price, or even 0. However, it is straightforward to show that, when bidder W bids at least his willingness to pay for a unit taking into account his unconditional expected profit in the resale market, bidder S with value $v_S < v^*$ obtains a strictly higher profit in the equilibrium that we have characterized (where he reduces demand) than in any other equilibrium. And, of course, when bidder W wins a unit at price 0, he also obtains a strictly higher profit in the equilibrium that we have characterized than in any other equilibrium. In this sense, our equilibrium prediction of demand reduction by S is robust.

market.[14] 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 expected bid is decreasing in the probability of having this option.

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

$$q \geq q^*(\alpha) \equiv \frac{1}{4-\alpha},$$

where $q^*(\alpha) \in (0.25, 0.33)$. 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. A higher α 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, $\alpha = 1/2$, bidder S always reduces demand if $q \geq q^*(1/2) \simeq 0.29$. Moreover, $q \simeq 0.3$ is the lowest probability for which bidder S always reduces demand when no player obtains more than 3/4 of the resale surplus.[15]

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.

2.3. 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. If there is a resale market, bidders achieve an efficient final allocation by assumption. Therefore, 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 trade in case the auction allocation is inefficient.

When $q = 1$ the final allocation is always efficient, regardless of bidders' strategies during the auction. When $q = 0$, the final allocation is efficient with probability 1/2 (ex ante), since there is no resale market and half of bidder S's types reduce demand. When $q \geq q^*(\alpha)$, the final allocation is efficient with probability q, since bidder S always reduces demand and there is a resale market with probability q. When $q < q^*(\alpha)$, since bidder S reduces demand if and only if $v_S < v^*$, the final allocation is efficient with probability

$$Pr[v_S \geq v^*] + qPr[v_S < v^*] = \frac{1}{2} - q\left(1 - \frac{\alpha}{2}\right)$$

Hence (since $q^*(\alpha) \leq 1/3$): (i) final efficiency is lower than in an auction without resale if and only if $q < 1/2$; (ii) when $q < q^*(\alpha)$, final efficiency is decreasing in the probability of a resale market; and (iii) when $q > q^*(\alpha)$, final efficiency is increasing in the probability of a resale market. Fig. 2.1 represents final efficiency, measured as the probability of an efficient final allocation, as a function of q.[16]

The auction price is equal to 0 when bidder S reduces demand, and is positive and equal to b_W when bidder S does not reduce demand. 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. Hence: (i) when $q < q^*(\alpha)$, the expected seller's revenue is strictly positive; and (ii) when $q > q^*(\alpha)$, the seller's revenue is equal to zero.

Finally, notice that a risk averse (rather than risk neutral, as we have assumed) bidder S has a weaker incentive to reduce demand in the auction, since by reducing demand he trades off winning the auction with probability one against the uncertain possibility of acquiring a unit in the resale market. Hence, the presence of a risk-averse bidder S is likely to increase the probability that the bidder with the highest value wins the auction.

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

Result 1: W's bid. *Bidder W speculates when there is a positive probability of a resale market. 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/or a lower α make demand reduction by bidder S more likely. If q is sufficiently high, bidder S always reduces demand.*

Result 3: Auction efficiency. *A higher probability of a resale market reduces auction efficiency.*

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[14] 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.)

[15] In fact, when $\alpha \in [1/4, 3/4]$, $q^*(\alpha) \in [0.27, 0.31]$.

[16] Measuring efficiency as social surplus—i.e., the value of the final owner of the units—yields a similar representation. We consider both measures of efficiency when analyzing the experimental results in Section 4.

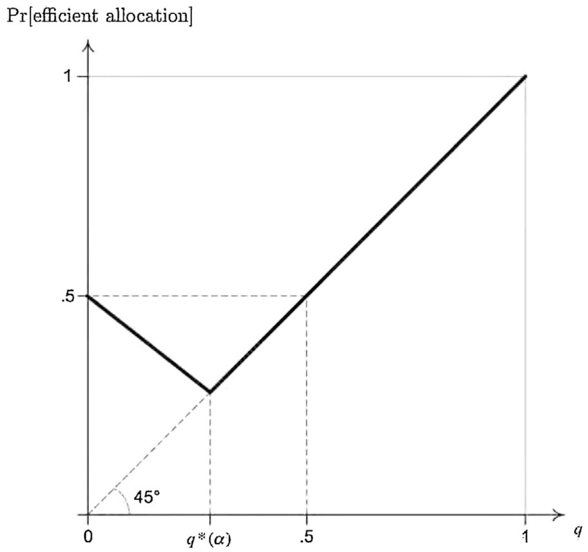

Fig. 2.1. Final efficiency.

Result 4: Final efficiency. *When the probability of a resale market is sufficiently low, final efficiency is lower than in an auction without resale and decreasing in the probability of a resale market. When the probability of a resale market is sufficiently high, final efficiency is higher than in an auction without resale and increasing in the probability of a resale market.*

Result 5: Revenue. *When the probability of a resale market is sufficiently low, the seller's revenue is positive. When the probability of a resale market is sufficiently high, the seller's revenue is lower than in an auction without resale and equal to zero.*

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 low ($q = .3$), to medium ($q = .5$), to certain resale ($q = 1$). These specific probabilities are chosen on the basis of our theoretical analysis to obtain a comprehensive picture of the effects of changes in the likelihood of resale: (i) when $q = .5$, final efficiency should be as in an auction without resale; when $q = q^*(\alpha) \simeq .3$ the auction allocation should always be inefficient and final efficiency should be minimized.

In all treatments, each period began with an ascending clock uniform-price auction for two units of a hypothetical good, with one strong bidder and one weak bidder. The strong bidder was allowed to purchase up to 2 units of the 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].[17] A subject's role was randomly assigned at the start of the experiment, and stayed the same for the duration of the experiment. During the auction, bidders were informed about the distribution of the competitor's valuation and the number of units demanded.[18]

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, bidders 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 for each unit was equal to the dropout price. If the weak bidder dropped out first, the strong bidder won two units; if the strong bidder dropped out first, the strong and weak bidder won one unit each. If neither bidder dropped out, the auction ended at the maximum possible value of the strong bidder, 50, and the units were awarded by random draw. If both bidders dropped out simultaneously, ties were again broken randomly. A bidder who won a unit earned the difference between his value and the auction price.

[17] We use ascending auctions (rather than sealed-bid) because they are widely used in the field and, based on previous experimental evidence, easier to understand for bidders. Since the weak bidder only bids for a single unit, the ascending auction is strategically equivalent to the uniform-price auction that we analyzed in our theoretical model: in both environments, each bidder simply decides the highest price that he is willing to bid for one unit (without obtaining any relevant information about his opponent's behavior).

[18] The wording used on the auction screen for the weak bidder was "You are bidding against one other bidder who can purchase two units. This bidder has the same value for each unit which is between 30 and 50. The bidder you are bidding against knows that your value for a unit is between 10 and 30." The wording for the strong bidder was "You are bidding against one other bidder who can purchase one unit. This bidder has a value for this unit which is between 10 and 30. The bidder you are bidding against knows that your value for each unit is between 30 and 50." The strong bidder was referred to as a 2-unit bidder and the weak bidder as a 1-unit bidder to minimize labeling effects.

Table 3.1
Average earnings.

	No resale	30% resale	50% resale	100% resale
Weak bidders' earnings	$12.99	$14.46	$15.03	$14.67
Strong bidders' earnings	$23.09	$22.82	$23.37	$20.43

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 $q = .3$).[19] 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, the resale market always opened when the weak bidder won a unit. In the resale stage, participants knew the auction price and individual valuations remained private.

The resale market was an unstructured bargaining game (as in Pagnozzi and Saral, 2017) between the same two auction bidders. Both players could simultaneously make offers through a computerized offer board. Only one posted offer per player was allowed at a time, but offers could always be changed prior to agreement. Either player could accept the offer of the counterpart and the resale stage terminated once an offer was accepted. Players could also send each other messages and discuss the offers through anonymous chat.[20] There was a time limit of 3 minutes to reach agreement.

In all resale treatments, players 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 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 from the resale market. Any resale earnings were in addition to the earnings from the auction. The experimental treatments are summarized below.[21]

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—a between subjects design. 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 of the 50% Resale treatment that had 28 rounds. After each round, subjects were randomly rematched. To ensure the least amount of changes, bidders' valuations and the random draws used to determine if the resale market opened were identical across treatments.[22] 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.[23]

4. Experimental results

In this section, we describe the main results of our experiment. We begin with summary statistics that provide a broad overview of the results in Section 4.1. In the subsequent 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, while Section 4.4 analyzes efficiency and revenue. We conclude with an analysis of the resale market in Section 4.5.

[19] See the supplementary material for sample screenshots and instructions for all treatments.

[20] 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, 2012; Georganas, 2011; Georganas and Kagel, 2011). The one exception is Pagnozzi and Saral (2017), from which the baseline treatments of this paper are drawn.

[21] The No Resale and 100% Resale treatments are also analyzed in Pagnozzi and Saral (2017) as the No Resale and Bargain treatments.

[22] The random draws for resale were different across periods within an experimental session, but identical across sessions. Of course, whether a random draw fell into the range that induced the resale market to open depended on the treatment q. For bidders' valuations, each of the three sessions of a treatment used different random draws.

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

Table 4.1
Average theoretical and observed auction prices.

	Auction price			
	Theory	Observed	Observed W wins	Observed W loses
No resale	10.43	14.62	8.02	18.81
30% resale	0	11.24	6.61	20.01
50% resale	0	10.09	6.02	18.68
100% resale	0	8.47	5.25	17.22

Table 4.2
Average theoretical and observed efficiency.

	Efficiency				% Efficient			
	Auction		Final		Auction		Final	
	Theory	Observed	Theory	Observed	Theory	Observed	Theory	Observed
No resale	.789	.829	.789	.829	50.8	61.4	50.8	61.4
30% resale	.515	.697	.660	.759	0	34.7	30.0	47.4
50% resale	.516	.687	.758	.825	0	32.7	50.0	60.7
100% resale	.517	.655	1	.953	0	27.1	100	85.2

4.1. Summary statistics

Table 4.1 presents the theoretical (assuming $\alpha \leq 2/3$) and observed average per unit auction price (which is equivalent to half the auctioneer's revenue). The observed average auction price is lower with a positive probability of a resale market than without a resale market, which is qualitatively consistent with theoretical result 5, even though point predictions are not satisfied. Columns 3 and 4 separate the observed results by whether or not the weak bidder won a unit: prices are much lower when the weak bidder won a unit, than when the strong bidder won both units.

The first part of Table 4.2 reports a measure of theoretical and observed allocative efficiency by treatment. Since the first unit was always awarded to the strong bidder, changes in efficiency depend on the allocation of the second unit. Efficiency is defined as social surplus, with auction efficiency measured by the ratio between the value of the auction winner and the value of the strong bidder. Final efficiency takes into account transactions in the resale market and is measured by the ratio between the value of the final holder of the unit and the value of the strong bidder.

The highest auction efficiency arises in 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, which is consistent with theoretical result 3, although the point theoretical predictions are lower. The low auction efficiency with a positive probability of resale is striking when compared to the random efficiency achieved if the second unit is randomly allocated among bidders, which is.75 in all treatments.[24] 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 could fail to agree to trade. 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 almost equivalent to the no resale case, and the 30% resale treatment results in a final efficiency lower than the no resale case and does no better than a random allocation. This is consistent with theoretical result 4.

The second part of Table 4.2 examines the relative frequency of efficient outcomes, which is the measure of efficiency used in Section 2. Mirroring the results of the efficiency measure, the percentage of efficient auction outcomes is decreasing 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 a resale market is low, which is consistent with our empirical results. Turning to final efficiency, the relative frequency of efficient outcomes after the resale market also supports the qualitative predictions of theory—changes in the probability of resale have a non-monotonic effect on final efficiency.

To provide a visual overview of auction and final efficiency, Fig. 4.1 plots the percentage of efficient outcomes after the auction and after resale, as a function of the strong bidder's value. The light gray bars represent the auction allocation, while the dark gray bars represent the final allocation after resale. It is clear that the no resale treatment leads to the highest auction efficiency, and that higher values led to higher efficiency. In all other treatments (as compared to the no resale treatment),

[24] Measuring efficiency as the ratio between the valuation of the unit holder and the valuation of the strong bidder, with a random allocation expected efficiency is $(1/2\mathbb{E}[v_S]+1/2\mathbb{E}[v_W])/\mathbb{E}[v_S]=3/4$.

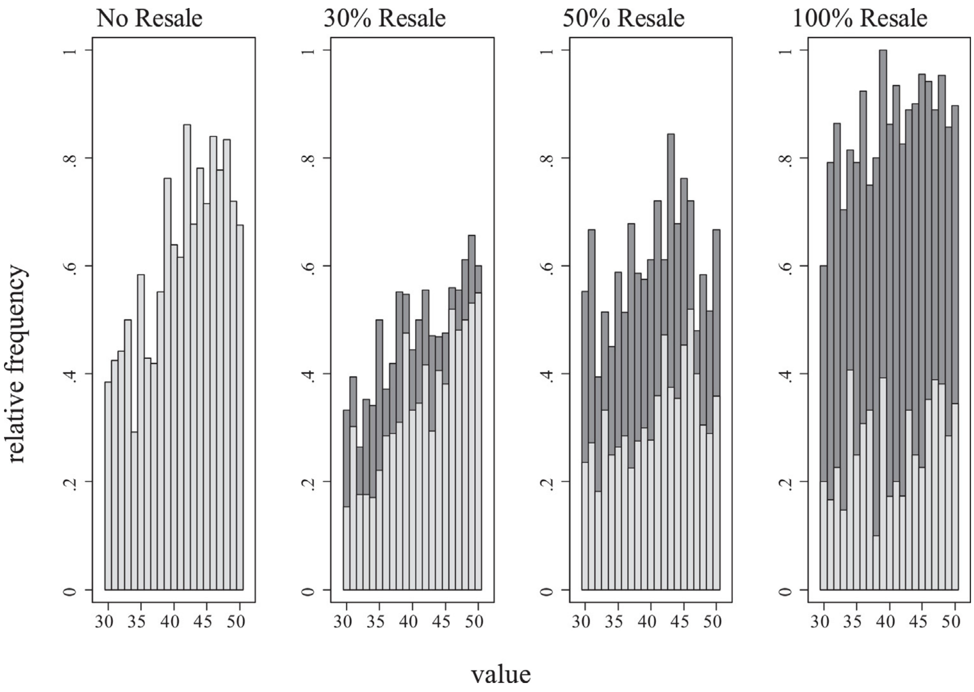

Fig. 4.1. Relative frequency of *S* holding both units after the auction (lighter gray) and after resale (dark grey) for unit value of *S*.

Table 4.3
Relative and absolute frequency of failed resale.

%	Failed resale		
	Total	Exogenous	Endogenous
No resale	100(280 out of 280)	100(280 out of 280)	–
30% resale	80.7(380 out of 471)	74.7(352 out of 471)	23.5(28 out of 119)
50% resale	58.4(279 out of 478)	47.3(226 out of 478)	21.0(53 out of 252)
100% resale	20.5 (72 out of 351)	–	20.5(72 out of 351)

Table 4.4
Average resale offers, prices and earnings.

	First offer		Last offer		Resale price	Resale earnings		Observed α
	W	*S*	*W*	*S*		*W*	*S*	
30% resale	33.54	18.65	28.72	24.58	26.15	6.59	12.44	.76
50% resale	33.77	19.54	28.45	24.65	26.98	7.26	12.69	.65
100% resale	33.86	20.61	29.22	25.36	27.45	8.36	12.44	.61

auction efficiency is much lower due to demand reduction by the strong bidder; even when there is a low probability of resale. While in the no resale treatment the auction allocation represents the final allocation, in the resale treatments the final allocation may change in the resale market. Notably, the fact that strong bidders reduce demand even in the 30% resale treatment, despite the low likelihood of resale, reduced final efficiency compared to the no resale treatment. Qualitatively, Fig. 4.1 is consistent with Fig. 2.1 in the theoretical analysis.

Table 4.3 provides the relative and absolute frequency of failed resale, once resale was possible—i.e., when the auction allocation was inefficient because the weak bidder won a unit. Resale failed with exogenous probability $1 - q$, but it could also endogenously fail because of disagreement among bidders. The first column of Table 4.3 reports the overall frequency of failed resale, which is decreasing in the exogenous probability of a resale market, but remains high even in the 100% resale treatment. The other two columns separately report the exogenous failure rate (out of all auctions where the weak bidder won a unit) and the endogenous failure rate (out of auctions where the resale market actually opened). In Section 4.5, we utilize both quantitative and qualitative analysis to determine what factors trigger endogenous resale failure.

Table 4.4 presents summary information from the resale market. Average first and last offers made by weak and strong bidders and final resale prices when bidders agreed to trade were similar across treatments. The second part of Table 4.4 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) and the average observed value of α (defined as the ratio between the strong

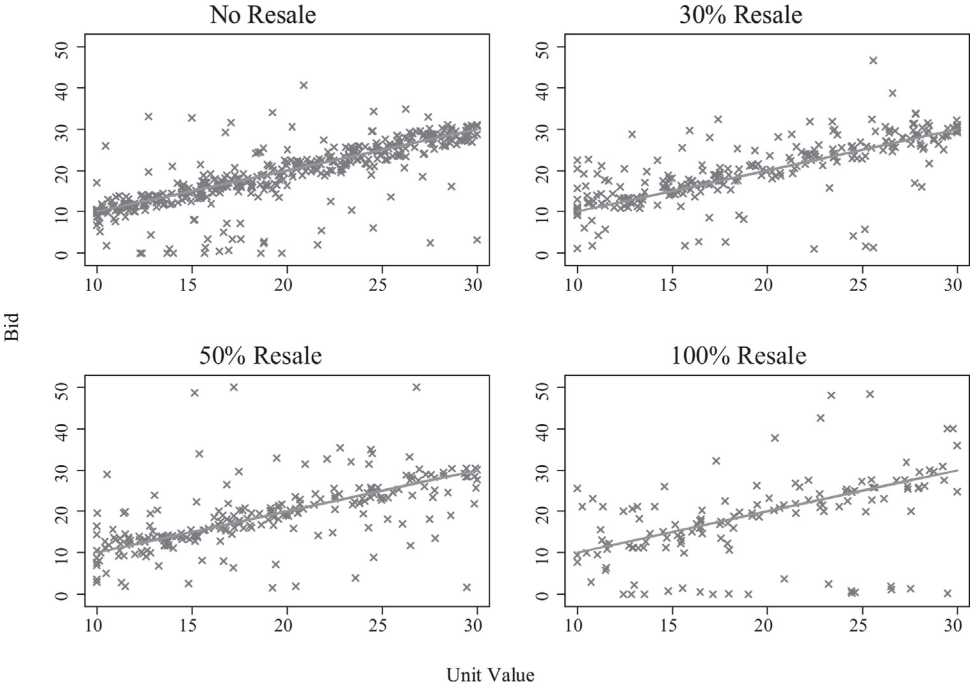

Fig. 4.2. Observed (losing) bids versus unit values for weak bidders across all treatments.

bidder's resale earnings and the total resale surplus $v_S - v_W$). Strong bidders dominated the surplus split in all resale treatments and uncertainty strengthened their bargaining power.

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.

Fig. 4.2 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 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 less uncertain. 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 lagged 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, providing support for the first part of theoretical result 1. However, while the magnitude of the coefficients is increasing in the probability of resale, post-estimation Wald tests for equality between the coefficients of the resale treatments reveal no significant difference ($p \geq 0.247$) in either of the models.[25] Hence, the data provide no evidence for the second part of theoretical result 1.

Empirical result 1: *Weak bidders bid more aggressively with resale than without, regardless of the probability of a resale market.*

[25] The reported p-values for all post-estimation Wald tests on weak bidding coefficients are from one-sided Chi-Squared tests.

Table 4.5
Marginal effects from random effects panel tobit – weak bidder's bid.

W's bid	(1)	(2)
v_w	0.662***	0.662***
	(0.029)	(0.027)
30% resale (30R)	2.646**	2.606**
	(1.202)	(1.205)
50% resale (50R)	3.135**	3.211***
	(1.228)	(1.153)
100% resale (100R)	4.284***	4.121***
	(1.433)	(1.364)
30R $\times v_w$	−0.054	−0.053
	(0.057)	(0.059)
50R $\times v_w$	−0.103**	−0.109**
	(0.048)	(0.048)
100R $\times v_w$	−0.155**	−0.155**
	(0.065)	(0.061)
Period		−0.023
		(0.020)
Loss_{t-1}		−0.443
		(1.176)
Observations	2624	2624

Bootstrapped standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

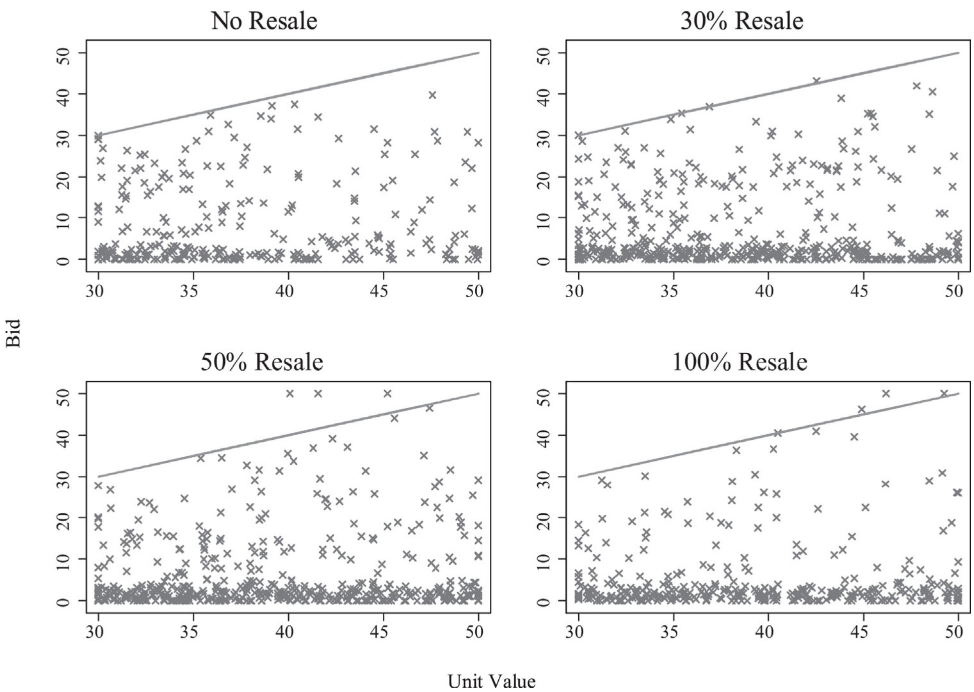

Fig. 4.3. Observed (losing) bids versus unit values for strong bidders across all treatments.

Bids are increasing in the value of the weak bidder, but the interaction of value with the 50% and 100% resale treatments show a modest reduction of this effect when resale is more likely. In model 2 we find no significant time effect or change in bidding due to losses in the previous round.

4.3. Strong type bidding

Fig. 4.3 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 more zero bids than in the no resale treatment, regardless of values. The relative frequency of observed bids below 10 is .67, .74, .76, and .83 for the no resale, 30%, 50%, and 100% resale treatments, respectively.

Table 4.6
Marginal effects from random effects panel tobit – strong bidder's bid.

S's bid	(1) all v_s	(2) all v_s	(3) $v_s < 40$	(4) $v_s > 40$
v_s	0.350***	0.332***	0.302***	0.141**
	(0.059)	(0.068)	(0.060)	(0.070)
30% resale (30R)	−3.829***	−3.073**	−2.600**	−5.896***
	(1.303)	(1.381)	(1.247)	(2.032)
50% resale (50R)	−4.263***	−3.354**	−2.877**	−6.675***
	(1.383)	(1.637)	(1.143)	(2.179)
100% resale (100R)	−5.524***	−4.741***	−3.975***	−9.875***
	(1.440)	(1.409)	(1.369)	(2.146)
$I_{v_s>40}$	7.182*	9.633**		
	(3.959)	(4.226)		
$I_{v_s>40} \times v_s$	−0.182*	−0.177*		
	(0.096)	(0.094)		
30R×$I_{v_s>40}$		−2.107		
		(1.724)		
50R×$I_{v_s>40}$		−2.610*		
		(1.506)		
100R×$I_{v_s>40}$		−4.408***		
		(1.457)		
Period		−0.192***	−0.171***	−0.202***
		(0.025)	(0.023)	(0.033)
Win$_{t-1}$			0.913**	2.440***
			(0.405)	(0.623)
Observations	2624	2624	1438	1186

Bootstrapped standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

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 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. We test for learning effects by including in models 2 through 4 the round variable, Period, and in models 3 and 4 the variable 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. The positive significant coefficient on the indicator variable for high values provides 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 resale treatment. For low values in model 3, coefficient tests of equality between the resale treatments find no significant differences ($p \geq 0.279$); while for higher values in model 4, coefficient tests of equality show that bids are significantly lower in the 100% resale treatment than in the other resale treatments (30%, $p = 0.022$; 50%, $p = 0.080$).[26] This supports the predictions of theoretical result 2.

Empirical result 2: *Strong bidders bid lower with resale than without, regardless of the probability of resale. For strong bidders with higher values, bids are lowest with a certain resale market.*

In contrast to weak bidders, who displayed no learning effects, the significant negative coefficient on Period in models 2–4 suggests that strong bids decrease over time. The positive and significant coefficient on Win$_{t-1}$ reveals a reinforcement learning effect: strong bidders who won 2 units in the previous round bid more aggressively in the current round, particularly when their value was higher than 40.

4.4. *Efficiency and revenue*

We formally analyze efficiency in Table 4.7, using pooled OLS regressions with standard errors clustered at the session level. Models 1–3 examine auction efficiency, defined as the value of the winner of the second unit divided by the strong bidder's value.

[26] The reported p-values for all Wald tests on strong bidding coefficients are from one-sided Chi-Squared tests. In alternative regressions restricted to the resale treatments (dropping the no resale treatment, using the 30% treatment as the baseline) we still find evidence that, for higher values, bids are significantly lower in the 100% treatment than the 30% treatment ($p = 0.006$) and 50% treatment ($p = 0.047$).

Table 4.7
Pooled OLS regressions on efficiency, clustered at session level.

Efficiency	(1) Auction	(2) Auction	(3) Auction	(4) Final	(5) Final
30% resale	−0.132**	−0.132**	−0.102*	−0.071*	−0.071*
	(0.047)	(0.047)	(0.054)	(0.040)	(0.040)
50% resale	−0.143***	−0.144***	−0.103***	−0.004	−0.004
	(0.021)	(0.021)	(0.029)	(0.024)	(0.024)
100% resale	−0.174***	−0.191***	−0.106***	0.123***	0.123***
	(0.026)	(0.026)	(0.030)	(0.021)	(0.020)
Period		−0.003***	−0.001		−0.000
		(0.001)	(0.002)		(0.001)
30R × Period			−0.002		
			(0.002)		
50R × Period			−0.003		
			(0.002)		
100R × Period			−0.007***		
			(0.002)		
Constant	0.830***	0.884***	0.853***	0.830***	0.831***
	(0.021)	(0.021)	(0.024)	(0.021)	(0.020)
Observations	2624	2624	2624	2624	2624
R-squared	0.064	0.075	0.079	0.071	0.071

Robust standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

The negative significant coefficients on the three resale treatments support theoretical result 3: resale results in significantly lower auction efficiency than the no resale treatment. Tests for equality of coefficients between the resale treatment dummies demonstrate a weakly significant difference for auction efficiency between the 50% and 100% resale treatments ($p = 0.076$), but no other significant differences are found ($p > 0.370$).[27] Models 2 and 3 include the variable Period to test for time effects, and show that auction efficiency is declining over time in the 100% resale treatment.

Empirical result 3: *Resale reduces auction efficiency, regardless of the probability of a resale market.*

To formally examine whether observed auction efficiency corresponds to the specific theoretical predictions, we examine pooled OLS models (reported in Table A.1 in the Appendix) for each treatment using auction efficiency as the dependent variable, the equilibrium prediction as the independent variable, and no intercept term. In the resale treatments, we find no support for the exact theoretical predictions as the coefficients on predicted efficiency are significantly different from 1 ($p \leq 0.034$). By contrast, we do not reject the theoretical point predictions in the no resale treatment, as the coefficient on predicted efficiency is not significantly different from 1 ($p = 0.348$).

Models 4 and 5 use 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. Consistent with our theoretical analysis, the coefficient of the 50% resale treatment dummy is not significantly different from zero and the coefficient of the 30% resale treatment dummy is negative and weakly significant. The only treatment that results in higher efficiency than the no resale baseline is the 100% resale treatment, which has a positive and significant coefficient. We find significant differences between the resale treatments ($p < 0.001$ for coefficient tests of equality between the 30% or 50% and the 100% resale treatments; and $p = 0.086$ for coefficient tests of equality between the 30% and 50% resale treatments). This provides evidence of a non-monotonic effect of changes in the probability of resale on final efficiency, which is consistent with theoretical result 4.

Empirical result 4: *Final efficiency is higher when a resale market exists with certainty than when there is no resale; but there is no evidence of higher final efficiency with an uncertain resale market.*

To compare predicted final efficiency with the observed one, we examine pooled OLS models (reported in Table A.2 in the Appendix) for each treatment using final efficiency as the dependent variable, the equilibrium prediction as the independent variable, and no intercept term. Similar to the results for auction efficiency, only the no resale treatment results in a coefficient on predicted final efficiency that is not significantly different from 1 ($p = 0.348$). In all other treatments, the coefficient on predicted efficiency is significantly different from 1 ($p = 0.092$ for 30% resale, $p = 0.030$ for 50% resale, and $p = 0.006$ for 100% resale). So, while we observe consistency with the qualitative theoretical predictions on final efficiency, specific point predictions are weak.

In Table 4.8, we examine revenue using pooled OLS regression with the auction price as the dependent variable. Standard errors are clustered at the session level. Compared to the no resale treatment, resale significantly lowers revenue in the 50% and 100% resale treatments, but not in the 30% resale treatment, which is qualitatively consistent with theoretical result 5.

[27] The reported p-values for all post-estimation Wald tests on efficiency coefficients are from one-sided F tests.

Table 4.8
Pooled OLS regressions on revenue, clustered at session level.

Auction price	(1)	(2)
v_w	0.418***	0.415***
	(0.0594)	(0.0581)
v_s	0.269***	0.290***
	(0.0401)	(0.0419)
30% resale	−3.371	−3.371
	(1.943)	(1.951)
50% resale	−4.528***	−4.610***
	(1.231)	(1.244)
100% resale	−6.057***	−7.335***
	(1.334)	(1.323)
Period		−0.257***
		(0.0445)
Constant	−4.482	−1.291
	(2.674)	(2.722)
Observations	2624	2624
R-squared	0.121	0.159

Robust standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

Coefficient tests of equality between the resale treatments show no significant difference in model 1 ($p \leq 0.564$). However, once we control for time effects in model 2 with the inclusion of Period (which is negative and significant), we do observe marginally significant differences between the 30% and 100% resale treatments (coefficient test of equality, $p = 0.068$) and between the 50% and 100% resale treatments (coefficient test of equality, $p = 0.083$).[28]

Empirical result 5: *The possibility of resale reduces the seller's revenue when the probability of a resale market is sufficiently high.*

4.5. 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.[29] 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. There were a total of 22 categories (including "no category" where statements that could not be assigned into the other 21 categories were placed). All categories are listed in Table 4.9.

Two post-graduates (coders) independently coded the qualitative data into the identified categories.[30] Table 4.9 reports the relative frequency of each category out of all bargaining groups. 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.[31] The most common form of communication was a statement of (non-binding) offer,[32] followed closely by statements of value.

We examine the honesty of subjects' statements of value in Fig. 4.4, which presents a density histogram of the difference between stated 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.[33]

[28] The reported *p*-values for all post-estimation Wald tests on revenue coefficients are from one-sided F tests.
[29] Our only restriction on communication was that subjects do not identify themselves. We also asked that they refrain from the use of profanity.
[30] Coders were provided with the raw data of all chat box entries typed by bidders, a list of categories along with a number that identified them, and example statements for coding (e.g. "I would be negative" was suggested to be coded as 5 and 6, which are references to losses in earnings and to earnings from the offer, respectively).
[31] A single statement could be assigned multiple categories. Each statement was analyzed to determine if both coders agreed to a category. Cohen's kappa coefficient of inter-rater agreement is a commonly used measure which calculates the expected rate of agreement between two coders (see Cohen, 1960).
[32] Offers were only binding when submitted through the posted-offer mechanism.
[33] 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.

Table 4.9
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.

Category	% of all chat	30% resale	50% resale	100% resale	κ
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

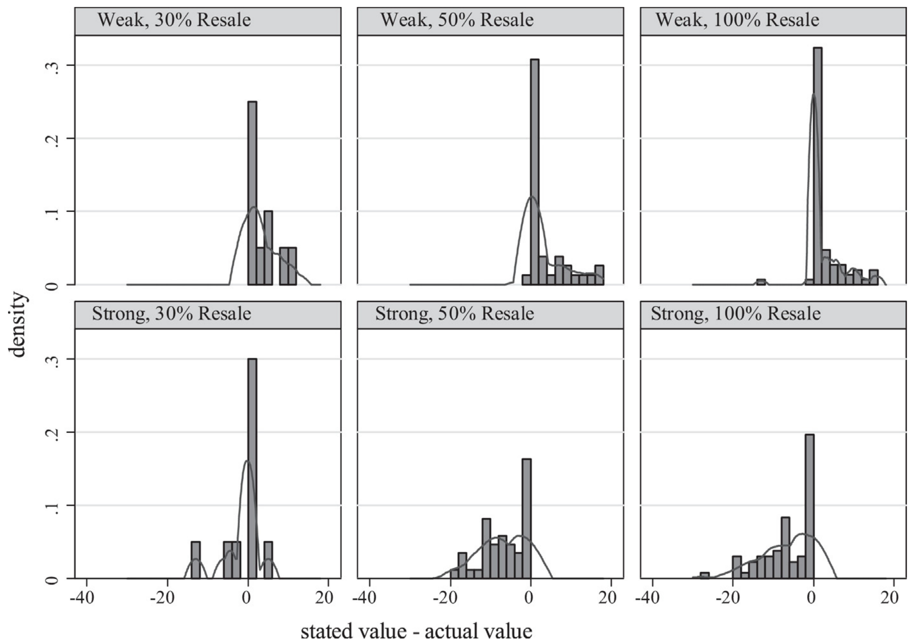

Fig. 4.4. Histogram plots of value statements.

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 4.10 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 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.

Table 4.10
Marginal effects from probit regressions with agreement in the resale market as the dependent variable. Standard errors clustered at the session level.

	(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***	0.020			
	(0.043)	(0.060)			
100% resale (100R)	0.642***	0.040			
	(0.012)	(0.031)			
(First) Offer$_w$−Offer$_s$			−0.006	−0.010**	−0.012***
			(0.008)	(0.004)	(0.001)
Auction price	−0.003*	−0.002	−0.006***	−0.004	0.003
	(0.002)	(0.002)	(0.002)	(0.006)	(0.002)
$v_s - v_w$	0.010***	0.014***	0.012***	0.008***	0.015***
	(0.004)	(0.002)	(0.004)	(0.002)	(0.001)
# Offers made			−0.012	−0.013**	−0.009*
			(0.013)	(0.006)	(0.005)
Period	0.011***	0.002	0.004	−0.004**	0.008
	(0.003)	(0.004)	(0.007)	(0.002)	(0.005)
Value chat			−0.025	0.081	0.067**
			(0.231)	(0.053)	(0.028)
Resale earnings chat			0.275***	−0.044	0.028
			(0.020)	(0.069)	(0.059)
Offer chat			−0.567***	−0.012	−0.007
			(0.028)	(0.014)	(0.038)
Instruction chat				0.100*	−0.045
				(0.057)	(0.042)
Other chat			0.236***	0.009	0.058
			(0.076)	(0.026)	(0.094)
Observations (clusters)	1300 (9)	722 (9)	107 (3)	215 (3)	276 (3)

Robust standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

Model 1 is the baseline test for treatment differences for all auctions where the weak bidder won a unit. As expected, the probability of final agreement is significantly increasing in the exogenous probability of resale (coefficient test of equality between 50% and 100% resale treatments, $p < 0.001$).[34] Models 2 through 5 restrict the data to observations where the resale market opened, which allows us to investigate the causes of endogenous resale failure. 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 of equality, $p = 0.722$).

Empirical result 6: *Differences in the probability of reselling the unit result from differences in the exogenous probability of a resale market. Once the resale market opens, the probability of resale is the same across treatments.*

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% resale treatment, higher auction prices significantly decrease the probability of reselling the unit, but auction price is insignificant in the other 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 less uncertain resale markets resulted in more initial disagreement.

To examine the role of chat, we consider the 5 major coded categories to uncover how qualitative differences in the bargaining discussion influenced the probability of resale.[35] The types of conversation have the most impact in the 30% resale 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 the 30% resale treatment was the only treatment where the auction price had a significant effect.

Table 4.11 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 of equality, $p = 0.500$).[36]

[34] The reported p-values for all post-estimation Wald tests on the probability of agreement coefficients are from one-sided Chi-Squared tests.
[35] In Model 3, the variable Instruction Chat is excluded. This was a single coded observation that predicted success in the probit model perfectly and so was dropped.
[36] The reported p-values for all post-estimation Wald tests on the resale price coefficients are from one-sided Chi-Squared tests.

Table 4.11
Random effects regressions with resale price as the dependent variable. Standard errors clustered at the session level.

Resale price	(1)	(2) 30% resale	(3) 50% resale	(4) 100% resale
50% resale (50R)	0.335			
	(1.817)			
100% resale (100R)	1.371			
	(1.307)			
Auction price	0.018	0.146**	−0.054**	0.055
	(0.023)	(0.058)	(0.026)	(0.054)
v_w	0.293***	−0.059	0.346***	0.298***
	(0.045)	(0.071)	(0.080)	(0.025)
v_s	0.141***	0.340***	0.187***	0.104**
	(0.016)	(0.027)	(0.041)	(0.050)
# Offers made	−0.027	0.241	0.567**	−0.487***
	(0.141)	(0.340)	(0.237)	(0.188)
Period	0.021	0.284***	0.044	0.045
	(0.029)	(0.037)	(0.058)	(0.103)
Time of agreement		0.051*	−0.027**	0.018
		(0.026)	(0.013)	(0.012)
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	14.693***	2.919	10.598***	17.703***
	(1.905)	(5.202)	(2.871)	(2.392)
Observations (clusters)	569 (9)	50 (3)	105 (3)	155 (3)

Robust standard errors in parentheses.
***$p < 0.01$. **$p < 0.05$. *$p < 0.1$.

Empirical result 7: *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 false statements of value. Increases in the number of offers made raised 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.

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 manage to agree to trade. In reality, market frictions and regulatory restrictions may lead to resale failure.

We use a combination of theory and a laboratory experiment to analyze the effects of an uncertain post-auction resale market in multi-object 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. Weak bidders speculate whenever resale is present and, despite predictions, we find no evidence that speculative bids 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 and they have higher values. 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.

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.

Appendix A.

A.1. Additional proof

We show that bidder S never reduces demand by bidding a strictly positive price when bidder W adopts the bidding strategy $b_W(\cdot)$ — i.e., bidder S prefers either to always win both units, or to reduce demand and win one unit at price zero. The argument relies on the linearity of bidder W's bidding function.

Let the lowest possible bid by bidder W be $\underline{b_W} \equiv b_W(10)$ and let the highest possible bid by bidder W be $\overline{b_W} \equiv b_W(30)$. First, because the auction price does not affect the outcome of bargaining in the resale market by assumption, bidding a price that is positive but lower than $\underline{b_W}$ always yields a lower profit for bidder S than bidding zero. The reason is that bidding a positive price for a unit that bidder S does not win in the auction only results in player S paying a higher price for the unit acquired in the auction.

Suppose that bidder S bids a price p such that $\underline{b_W} < p < \overline{b_W}$. When p is lower than bidder W's bid, bidder S wins one unit at price p and then attempts to acquire the other unit in the resale market. When p is higher than bidder W's bid, bidder S wins both units at a price equal to bidder W's bid. Hence, bidder S obtains an expected profit equal to

$$\begin{aligned}&Pr[b_W > p][(1+q\alpha)v_s - q\alpha\mathbb{E}[v_W|b_W > p] - p] + Pr[b_W < p]\cdot 2(v_S - \mathbb{E}[b_W|b_W < p])\\&= 2v_S - p - Pr[b_W > p][(1-q\alpha)v_s + q\alpha\mathbb{E}[v_W|b_W > p]] - Pr[b_W < p]\underline{b_W}.\end{aligned} \tag{A.1}$$

Recall that when bidder S always wins 2 units in the auction (by bidding more than $\overline{b_W}$), he obtains an expected profit equal to

$$2v_S - 2\mathbb{E}[b_W], \tag{A.2}$$

while when bidder S bids zero for the second unit, he obtains an expected profit equal to

$$(1+q\alpha)v_s - q\alpha\mathbb{E}[v_W]. \tag{A.3}$$

Moreover, (A.3) is higher than (A.2) if and only if

$$\overline{b_W} + \underline{b_W} > (1-q\alpha)v_s + q\alpha\mathbb{E}[v_W]. \tag{A.4}$$

First, we show that if (A.3) is higher than (A.2), then (A.3) is also higher than (A.1). In fact, the difference between (A.3) and (A.1) is

$$p + Pr[b_W < p]\underline{b_W} + Pr[b_W > p]q\alpha\mathbb{E}[v_W|b_W > p] - Pr[b_W < p](1-q\alpha)v_s - q\alpha\mathbb{E}[v_W].$$

Using (A.4), the previous expression is higher than

$$\begin{aligned}&p + Pr[b_W < p]\underline{b_W} + Pr[b_W > p]q\alpha\mathbb{E}[v_W|b_W > p] - Pr[b_W < p](\overline{b_W} + \underline{b_W} - q\alpha\mathbb{E}[v_W]) - q\alpha\mathbb{E}[v_W]\\&\quad = p - Pr[b_W < p]\overline{b_W} + Pr[b_W > p]q\alpha(\underbrace{\mathbb{E}[v_W|b_W > p] - \mathbb{E}[v_W]}_{>0}),\end{aligned}$$

which is positive because

$$p - Pr[b_W < p]\overline{b_W} = p - \frac{p - \underline{b_W}}{\overline{b_W} - \underline{b_W}}\overline{b_W} = \frac{\underline{b_W}(\overline{b_W} - p)}{\overline{b_W} - \underline{b_W}} > 0.$$

Therefore, if $v_S < v^*$, then bidder S prefers to reduce demand and bid 0, thus earning (A.3), rather than bid a positive price.

Second, we show that if (A.2) is higher than (A.3), then (A.2) is also higher than (A.1). In fact, the difference between (A.2) and (A.1) is

$$p + Pr[b_W > p][(1-q\alpha)v_s + q\alpha\mathbb{E}[v_W|b_W > p]] - Pr[b_W > p]\underline{b_W} - \overline{b_W}.$$

Using the reverse of (A.4), the previous expression is higher than

$$p + Pr[b_W > p](\overline{b_W} + \underline{b_W}) - Pr[b_W > p]\underline{b_W} - \overline{b_W} = p - Pr[b_W < p]\overline{b_W},$$

which is positive (as we have shown above). Therefore, if $v_S > v^*$, then bidder S prefers to win both units in the auction for sure, thus earning (A.2), rather than bid a price lower than $\overline{b_W}$.

Table A.1
Pooled OLS regressions on auction efficiency, standard errors clustered at session level.

Auction efficiency	(1) No resale	(2) 30%	(3) 50%	(4) 100%
Theoretical auction efficiency	0.974***	1.262***	1.241***	1.203***
	(0.025)	(0.050)	(0.010)	(0.029)
Observations	720	720	704	480
R-squared	0.869	0.847	0.848	0.869

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table A.2
Pooled OLS regressions on final efficiency, standard errors clustered at session level.

Final efficiency	(1) No resale	(2) 30%	(3) 50%	(4) 100%
Theoretical final efficiency	0.974***	1.127***	1.079***	0.953***
	(0.025)	(0.041)	(0.014)	(0.004)
Observations	720	720	704	480
R-squared	0.869	0.888	0.915	0.981

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

A.2. Supplemental regressions

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jebo.2017.11.017.

References

Ausubel, L., Cramton, P., 1998. Demand Reductions and Inefficiency in Multi-Unit Auctions. University of Maryland, Mimeo.
Chintamani, J., Kosmopoulou, G., 2015. Auctions with resale opportunities: an experimental study. Econ. Inq. 53, 624–639.
Cohen, J., 1960. A coefficient of agreement for nominal scales. Educ. Psychol. Meas. 20 (1), 37–46.
Crawford, V., 1998. A survey of experiments on communication via cheap talk. J. Econ. Theory 78 (2), 286–298.
Engelmann, D., Grimm, V., 2009. Bidding behavior in multi-unit auctions – an experimental investigation. Econ. J. 119, 855–882.
Feltovich, N., Swierzbinski, J., 2011. The role of strategic uncertainty in games: an experimental study of cheap talk and unstructured bargaining in the Nash demand game. Eur. Econ. Rev. 55 (4), 554–574.
Filiz-Ozbay, E., Lopez-Vargas, K., Ozbay, E., 2015. Multi-object auctions with resale: theory and experiment. Games Econ. Behav. 89, 1–16.
Fischbacher, U., 2007. Z-Tree: Zurich toolbox for readymade economic experiments. Exp. Econ. 10 (2), 171–178.
Georganas, S., 2011. English auctions with resale: an experimental study. Games Econ. Behav. 73 (1), 147–166.
Georganas, S., Kagel, J., 2011. Asymmetric auctions with resale: an experimental study. J. Econ. Theory 146, 359–371.
Greiner, B., 2004. The Online Recruitment System ORSEE 2.0 – A Guide for the Organization of Experiments in Economics. University of Cologne, Working Paper No. 10.
Hafalir, I., Krishna, V., 2009. Revenue and efficiency effects of resale in first-price auctions. J. Math. Econ. 45 (9), 589–602.
Haile, P., 2001. Auctions with resale markets: an application to U.S. Forest Service Timber Sales. Am. Econ. Rev. 91 (3), 399–427.
Kagel, J., Levin, D., 2001. Behavior in multi-unit demand auctions: experiments with uniform price and dynamic Vickrey auctions. Econometrica 69, 413–454.
Kagel, J., Levin, D., 2005. Multi-unit demand auctions with synergies: behavior in sealed-bid versus ascending-bid uniform-price auctions. Games Econ. Behav. 53, 170–207.
Kagel, J., Levin, D., 2016. Auctions: a survey of experimental research. In: The Handbook of Experimental Economics. Princeton University Press, Princeton.
Lange, A., List, J., Price, M., 2011. Auctions with resale when private values are uncertain: theory and empirical evidence. Int. J. Ind. Organ. 29, 54–64.
List, J., Lucking-Reiley, D., 2000. Demand reduction in multi-unit auctions: evidence from a sportscard field experiment. Am. Econ. Rev. 90 (4), 961–972.
Mankiw, G., 2007. Principles of Microeconomics. Thoms South-Western.
Marion, J., 2007. Are bid preferences benign? The effect of small business subsidies in highway procurement auctions. J. Public Econ. 91, 1591–1624.
Pagnozzi, M., 2009. Resale and bundling in auctions. Int. J. Ind. Organ. 27 (6), 667–678.
Pagnozzi, M., 2010. Are speculators unwelcome in multi-object auctions? Am. Econ. J.: Microecon. 2 (2), 97–131.
Pagnozzi, M., Saral, K.J., 2017. Demand reduction in multi-object auctions with resale: an experimental analysis. Econ. J. 127, 2702–2729.
Roth, A., Malouf, M., 1979. Game-theoretic models and the role of information in bargaining. Psychol. Rev. 86 (6), 574–594.
Roth, A., Murnighan, J., 1982. The role of information in bargaining: an experimental study. Econometrica 50 (5), 1123–1142.
Roth, A., 1995. Bargaining experiments. In: Roth, A., Kagel, J. (Eds.), Handbook of Experimental Economics.
Saral, K.J., 2012. Speculation and demand reduction in English clock auctions with resale. J. Econ. Behav. Organ. 84 (1), 416–431.
Wilson, R., 1979. Auctions of shares. Q. J. Econ. 94, 675–689.