Asymmetric Auctions with Resale: An Experimental Study*

Sotiris Georganas and John Kagel

The Ohio State University

January 30, 2009

Abstract

We present results from an experiment based on Hafalir and Krishna's (2008) model of auctions with resale. As predicted weak bidders bid more with resale than without and resale raises average auction prices. When the equilibrium calls for weak types to bid higher than their values with resale they do so, but not nearly as much as the theory predicts. When the equilibrium calls for weak bidders to bid their value with resale, outcomes are much closer to the risk neutral Nash model's predictions.

JEL classification: D44, C90

*Research has been partially supported by a grant number ITR-0427770 and SES-0451981 from the National Science Foundation. We thank Isa Hafalir and Vijay Krishna for helpful comments. Any opinions, findings and conclusions or recommendations in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

1 Introduction

Auctions with resale have been the subject of considerable theoretical interest lately. Haile (2000, 2001, 2003) studies auctions where bidders have noisy signals about their values, as well as potential new buyers arriving after the initial auction, to motivate interest in the subject. Garratt and Troeger's (2006) research is motivated by the role of speculators, bidders with zero value for the item, who buy with a view to resell and who compete with bidders who buy for own use. Hafalir and Krishna (2008) study auctions where bidders have asymmetric valuations, a feature that is present to some degree or other in a number of auctions, so that a lower value bidder may obtain the item but can profitably resell it to a higher value bidder.

The present paper experimentally investigates the effect of resale in asymmetric auctions following the Hafalir and Krishna (2008) model. In their model a weak and a strong bidder first compete for the item in a first-price private value auction. The winner of the item then has the opportunity to sell it to the other bidder using a take it or leave it price. Key comparative static predictions of the model are that the weak player bids more than without resale in order to win the item and resell it, to the point that weak bidders may even bid more their value for the item. The strong player responds by bidding more aggressively for a wide range of private values. The net result is that resale raises auction prices, benefiting the seller, and efficiency improves compared to the no resale case[1].

Our experiment looks at two main treatments: In the first treatment the risk neutral Nash equilibrium (RNNE) calls for weak bidders to consistently bid above their private values when resale opportunities are present, winning half the auctions and making small positive average profits. Results show that weak bidders do, indeed, consistently bid above their private values, but not by nearly as much as the RNNE requires. The net result is that there is not nearly as much resale as predicted, with weak bidders consistently losing money conditional on winning the item in the auction, which drives biding down even

[1]Improved efficiency is not a general result. In the Hafalir and Krishna framework, if we assume uniform distributions of the values for both types, resale improves efficiency only if the ratio between the maximum values of the two types is greater than 2 (for details see Hafalir and Krishna 2009). This is true in all treatments we run.

further. We explore the reasons for the negative average profits which have partly to do with the knife edge nature of the equilibrium outcome, so that it is easily upset by loss aversion on the part of weak bidders and/or bidding above the RNNE by strong bidders (a not uncommon occurrence).

The second treatment is designed so that weak players bid their value in equilibrium so that there is no opportunity for losses or loss aversion to impact outcomes. We explore this treatment first in auctions with only resale opportunities present and then using a dual market procedure whereby subjects first bid in an auction without resale opportunities and then bid again, with exactly the same private values, in an auction with resale. In both cases weak bidders consistently make positive profits conditional on winning the item and bid higher than absent resale opportunities and nearly equal to their values throughout. Auction prices are significantly higher with resale opportunities than without, and the distribution of bids becomes more symmetric than absent resale opportunities, although not completely symmetric as the theory predicts.

To our knowledge there exist only two other experimental studies of auctions with resale: Georganas (2003) looks at symmetric English auctions where resale opportunities arise out of small deviations from equilibrium bidding that become magnified once resale opportunities are present. Lange, List and Price (2004) study symmetric first price auctions where opportunities for resale result from bidder uncertainty regarding the value of the item. Results from neither of these studies is directly applicable to our environment. More relevant is the growing literature on asymmetric private value auctions, in particular the Guth, Ivanova-Stenzel, and Wolfstetter (2005) experiment which employs supports similar to ours.

The outline of the paper is as follows: The next section outlines the theoretical implications of auctions with resale following the Hafalir and Krishna (2008) model as it relates to our parameterization. Section 3 outlines our experimental design and procedures. Section 4 reports our results. Section 5 summarizes our results and conclusions.

2 Theoretical Implications

In auctions with resale, bidders first compete in a first-price sealed bid auction to buy the item. Following the auction, the winner has an opportunity to sell the item at a take it or leave it price to the losing bidder, absent any information about the losing player's bid. There is one weak and one strong bidder in each play of the game with a single item for sale. The strong bidders value for the item is based on an iid from a uniform distribution with support $[0, a_s]$ where $a_s = 100$ in both treatments. Private values for weak bidders are iid from a uniform distribution with support $[0, a_w]$ where a_w is 10 in one treatment and 34 in the other. We will refer to the case where $a_w = 10$ as W10 and when $a_w = 34$ as W34.

The risk neutral Nash equilibrium (RNNE) bid function for bidder i in auctions with resale is (see Hafalir and Krishna, 2008)

$$b_i = v_i \frac{(a_s + a_w)}{4a_i}$$

Absent resale bidders employ the following bid functions (see Plum, 1992)

$$b_s = v_i / (1 + \sqrt{1 + \gamma v_i^2})$$
$$b_w = v_i / (1 + \sqrt{1 - \gamma v_i^2})$$

$$\text{with } \gamma = 1/a_w^2 - 1/a_s^2$$

The equilibrium bid functions with and without resale are shown in Figure 1. Note that without resale weak bidders never bid above their value for the item and strong bidders never bid above the upper bound of the weak bidders support (a_w). Further, absent resale, for any given valuation weak bidders bid higher than strong bidders, which generates inefficient allocations. With resale, weak bidders increase their bids for all valuations compared to the no resale case, even bidding above their value for the W10 case. In contrast, strong bidders reduce their bids somewhat relative to the no resale case for lower valuations, but increase their bids for higher valuations.

With resale, the bid distribution for the weak and strong types is the same. Note, this does not mean that the bid functions for the two types are the same as the supports for

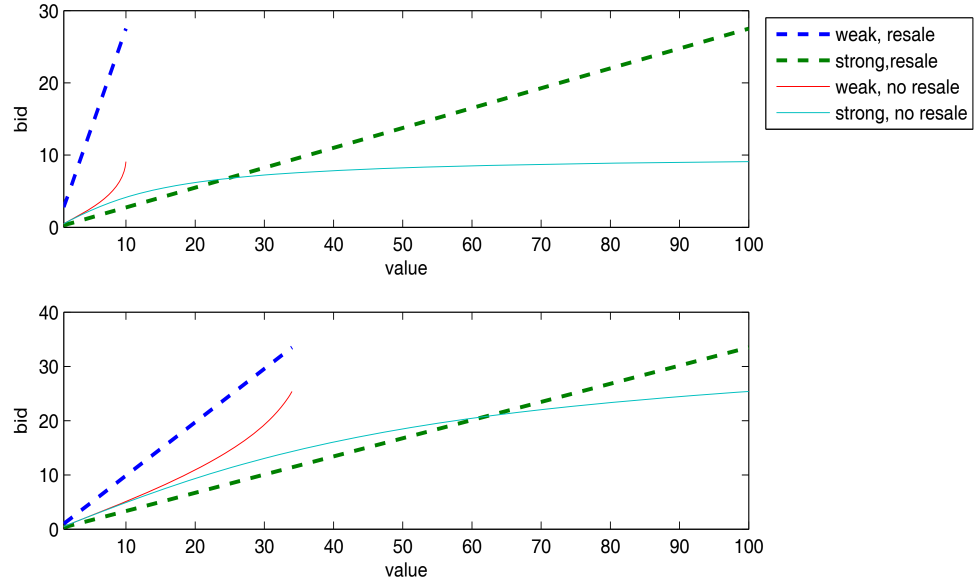

Figure 1: The equilibrium bid functions for the case of two bidders with supports in [0,10] and [0,100] (upper panel) and [0,34] and [0,100] (lower panel), with and without resale.

their values are very different. The resulting bid distributions are shown in Figure 2 for both cases. With resale, a third party observing the bids, but not knowing the bidders values, would not be able to distinguish between strong and weak types.

A number of other comparative static predictions hold for auctions with resale. At the market level auction prices should be higher, on average, with resale than without and auction efficiency (interim efficiency) will be dramatically lower as weak bidders are expected to be high bidders half of the time. Following resale there will still be some inefficiency as weak bidders win but are unable to sell in the secondary market. However, efficiency is expected to improve relative to the auction outcome and relative to the no resale case.

In order to maximize profits in the second stage, the winner has to set an optimal reserve price. The optimal reserve price r^* given a winning bid b_i is calculated by first updating the support of the opponent's value. Given a belief that their opponent is using the RNNE bidding strategy $b_j(v_j)$ the updated support is $[0, b_j^{-1}(b_i)]$. The optimal reserve price is then $1/2b_j^{-1}(b_i)$.

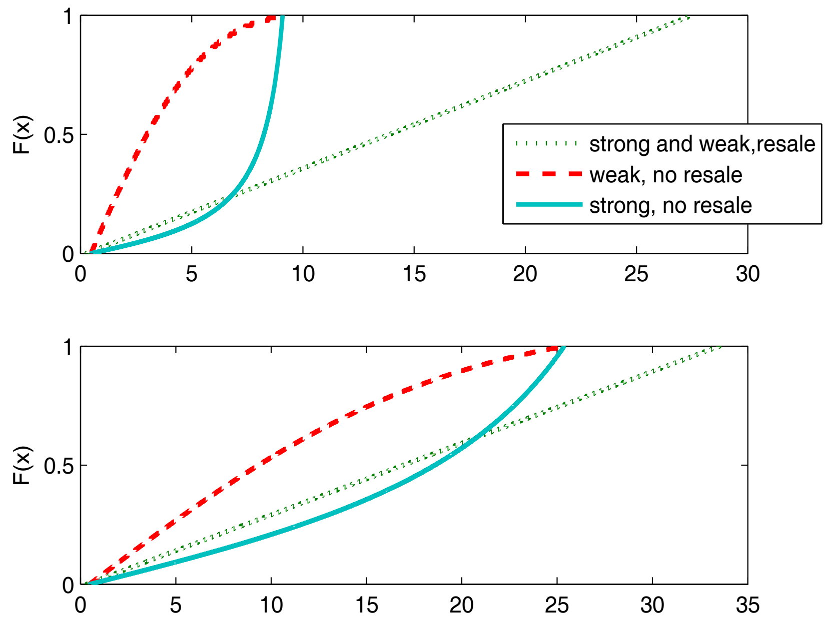

Figure 2: Cumulative distribution functions for the case of two bidders with supports in [0,10] and [0,100] (upper panel) and [0,34] and [0,100] (lower panel), with and without resale.

3 Experimental Design and Procedures

The first six sessions were evenly divided between the W10 and W34 treatments all involving only auctions with resale. This was followed by two dual market W34 sessions where subjects first bid in an auction with no opportunity for resale, but before these results were reported back, as second auction with the opportunity for resale was conducted. Bidders' values were the same in both markets so that one can compare directly individual subject bids with and without resale opportunities along with market prices and efficiency.

At the start of each session instructions were read out loud with subjects having a copy to read along with. The instructions explained the auction procedures in detail followed by a short quiz to make sure subjects understood the payoffs with the resale opportunities, as well as the general auction procedures. Each experimental session began with two dry runs followed by 40 auctions played for cash (except for the first session which had 30 cash auctions).

New valuations were drawn randomly at the start of each auction period with the matching between strong and weak bidders changed randomly prior to each auction. Bidder valuations were integer draws from their respective distributions. Half the subjects were randomly chosen to start as weak types and half as strong types, with these roles held constant for the first half of the paid periods. After this roles were switched for the rest of the auctions.

In the auctions with resale, the highest bidder in each auction was awarded the good and paid a price, p_1, equal to what she bid. Following this the auction winner had the opportunity sell the item to the losing bidder setting a reservation price r. The losing bidder after observing the resale price, decided to buy the item or not. Sellers did not have any choice whether to put the item up for sale or not. However, they were advised that if they did not want to sell the item they could set $r = 101$. If the losing bidder chose not to buy the item, payoffs remained the same as in the auction. If she accepted, she obtained the good and paid r with final payoffs of $r - p_1$ for the first stage winner and $v_i - r$ for the second stage winner. In the dual market sessions, subjects were paid randomly on the basis of the outcome in either the no resale or the resale auction.

Feedback after the final allocation was determined consisted telling winning biders their net profits, both players bids and their corresponding valuations, along with their type. Corresponding information from past periods was available on players computer screens as well. In the dual market treatment feedback form the no resale market was only available after completion of the auction with resale.

Subjects received an initial capital balance of 250 experimental currency units (ECUs) in treatment W10 and 100 ECUs in W34. Any profits or losses were added to these starting capital balances with subjects paid their end of session balances in cash at the exchange rate of \$1 = 17 ECUs in W10 and \$1 = 15ECUs in W34. There was no show up fee. These different starting capital balances and conversion rates were adopted in view of the lower expected profits for weak players in the W10 treatment along with the greater threat of bankruptcy. Bankrupt bidders, of which there were two, were no longer permitted to bid and dismissed with a cash payment of \$7.[2] Average profits were \$35.6

[2] After a bankruptcy a bidder was chosen at random each period to stay out, as the number of players left was odd.

Session	Treatment	Exchange rate	Endowment	Paying periods	Number of Subjects
1	W10	17	250	30	12
2	W10	17	250	40	16
3	W10	17	250	40	16
4	W34	15	100	40	16
5	W34	15	100	40	14
6	W34	15	100	40	18
7	W34Dual	15	100	40	16
8	W34Dual	15	100	40	18

Table 1: Summary of sessions

and $36.6 in the W10 and W34sessions, respectively.

Subjects were recruited from the undergraduate student population at Ohio State University. Software for conducting the auctions was developed using zTree (Fishbacher, 2007). Table 1 summarizes the parameters for each experimental session along with the number of subjects in each session.

4 Experimental Results

Results are presented separately for the W10, W34, and W34Dual sessions. There are two learning phases to each session, once in the beginning and once when they switch roles. To focus on more experienced bidding we exclude data from periods 1-10 and 21-30.[3]

4.1 Weak Bidders with Value Draws [0, 10]

Figure 3 reports bids for strong and weak bidders pooled across experimental sessions in the form of box plots where each box represents the interquartile range for the distribution of bids (IQR, which covers 75% of all bids) in the neighborhood of each the discrete values reported on the horizontal axis. The whiskers go from the end of the box to the most extreme value within 1.5 times the IQR, covering all but the most extreme outliers. The straight line within each box represents the median bid. In each case the thin dashed line

[3]Session 1 had only 30 periods in total, so to be consistent we only consider periods 10-20 from this session.

	First Stage			**Second Stage**	
	Prices	**Interim Efficiency**	**Weak type wins**	**Prices**	**Efficiency**
predicted	18.8	0.54	0.50	22.1	0.82
actual	20.0	0.78	0.26	20.9	0.89

Table 2: Summary of results in treatment 10.

through the origin represents the RNNE bid. The thick solid line is the 45 degree line, where bids are equal to values.

Strong bidders overbid somewhat relative to the RNNE for low values and underbid very slightly for values between 80 and 90. Weak bidders tend to bid above their values as the theory predicts, with most bids lying above the 45 degree line. However they underbid relative to the RNNE, and to a much greater extent than strong bidders overbid relative the RNNE, with the upper end of the IQR just a little above 10 except at the highest value and the median bid below 10 throughout. This compares to the RNNE bid which is already at 11 for $v_i = 4$ for weak bidders and goes as high as 27.5 for $v_i = 10$. This underbidding by weak bidders results in them winning only about half of the auctions they are predicted to win (25.6% actual versus 49.9% predicted; see Table 2 above).

Reserve prices for weak bidders when they do win are shown in Figure 4, along with predicted reserve prices (the straight line through the origin) (r^*_{Nash}) and the empirical best response line (the wavy, almost horizontal line) (r^*_{BR}) given the distribution of strong bidders' bids (in conjunction with the rather heroic assumption that bidders have observed the whole empirical distribution of bids).[4] The r^*_{BR} is high as it is sensitive to the fact that there are some strong types who underbid a lot which skews the best response upward. The observed reserve prices were almost always between the ones predicted by the Nash equilibrium (r^*_{Nash}) and the ones best responding to the empirical distribution (r^*_{BR}). Note, that strong bidders rarely rejected a resale offer that would have given them a positive profit.[5]

Profits of weak bidders were consistently negative conditional on winning the

[4] For every possible bid b_i we find the private values of the opponents that bid less than this bid, $(v_j | b_j < b_i)$ and search for the reserve price r that would yield the highest expected payoff.

[5] Profitable offers were rejected about 15% of the time in the first 10 auctions, but none after that.

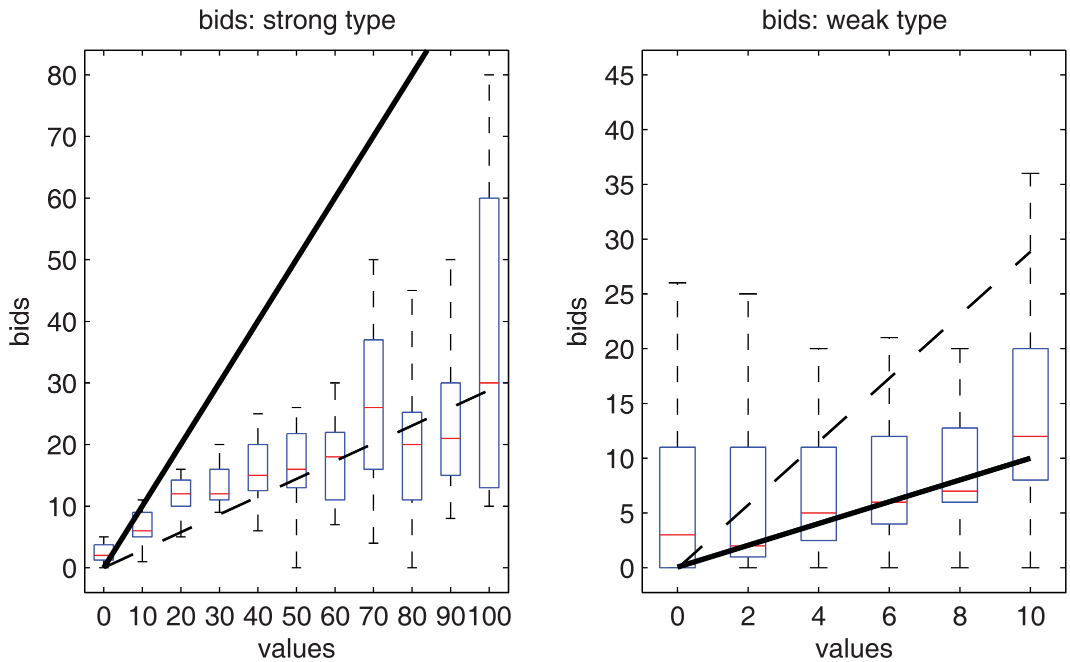

Figure 3: Series of boxplots of private values vs bids for the low and high types in treatment 10. Each box drawn represents the distribution of the bids for a block of values. The length of the box represents the interquartile range (IQR). The whisker extends from the box to the most extreme data value whithin 1,5 times the IQR. The dashed thin straight lines through the origin represent the equilibrium bids and the solid thick lines represent the 45 degree line.

auction, averaging -3.5 per period on average. Average profits of weak players conditional on winning would have been -3.1 if they set reserve prices according to r^*_{Nash} versus -1.0 setting them according to r^*_{BR}. These low/negative profits for weak bidders can be accounted for by several factors. First, there were very little profits to be made in the first place, as (unconditional) expected profits are around 1 ECU per period, with a rather unappealing distribution: weak bidders lose money almost as often as they make money (48% vs 52%) with mean profits of 15.2 when earning positive profits and mean profits of -11.8 when they lose money. The latter would tend to push weak players bids down on account of risk (or loss) aversion. While, other things equal, this would have helped weak types to make greater than predicted profits conditional on winning, it results in them winning far less often than predicted. The other factor that accounts for the negative profits is the tendency of strong players to bid above the RNNE. This means that when weak players win, strong players values are lower than what they would have been had the strong player bid the RNNE. This in turn results in lower profits conditional on winning for weak players. The data are entirely consistent with this: If both players had bid according to the RNNE, weak players would have won with a bid above the strong players bid 26.6% of the time, thereby earning negative profits. In contrast, weak players won with a bid above the strong players's value 41.0% of the time, around 50% more often than predicted, thereby generating a substantially higher frequency of winning and losing money as a consequence. In other words, strong types bidding above the RNNE (even by a modest amount) substantially reduces weak players opportunities to earn positive profits. This, in conjunction with the low predicted profits to begin with, pushes weak players' profits over the edge to earning small negative profits.

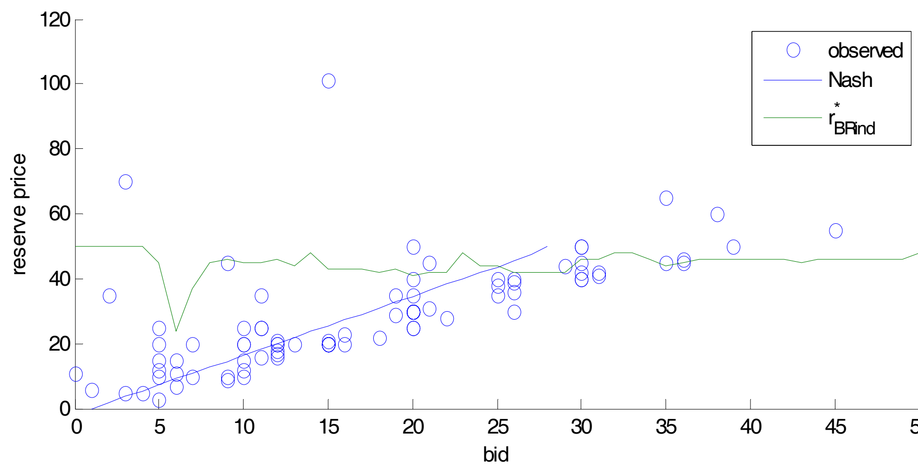

Figure 4: Reserve prices in treatment 10. We plot the observed ones, the ones that should be set according to theory and the ones that would be a best response to actual behavior.

Loss (or risk) aversion, in conjunction with the negative average profits realized helps to explain why weak players bid below the RNNE, as well as why there is no convergence to equilibrium. In fact, as Figure 5 shows, what learning/adjustment in bidding there is for weak types was to bid lower over time. Also note there is a deviation from the trend line towards lower bidding around period 20 when roles were switched. However, after a few periods, weak players bids revert back to lower bidding over time.

Looking at strong bidders, average profits were quite close to the level predicted under the RNNE: 28.9 per period versus 30.2. Given the underbidding of weak types, they could have done even better than predicted, earning 33.8 per period if they best responded to the weak bidders and bid less.

Despite the fact that subjects deviate from the equilibrium bidding, auction prices were close to the level predicted (see Table 2 above). This however should not be attributed to the theory predicting bids correctly, but to the fact that bids of both types deviate from the theory in such a way as to get close to predicted prices: Weak types underbid and win much less often than they should, resulting in strong bidders winning more often than predicted. And they are bidding reasonably close to equilibrium or slightly above it so that auction prices are slightly higher than predicted. Although we do not have any data for bidding in this treatment, without resale we would never expect prices to exceed $10+\varepsilon$, as minimally rational weak bidders would not overbid and strong bidders would anticipate this.[6] Using this as an upper bound for what prices would have been absent resale, we can say that resale would have resulted in essentially doubling prices compared to the no resale case.

Interim efficiency, defined as the percentage of cases where the highest value bidder wins the auction, is predicted to 0.54, but is much higher at 0.79. Resale of course improves on this with average efficiency after accounting for resale of 0.89.

4.2 Weak Bidders with Value Draws [0, 34]

The underbidding by weak types in the W10 treatment more than likely resulted from the relatively high probability of losses as weak types bid substantially above their resale values in equilibrium and suffer losses close to half the time on winning the auction. In contrast under the W34 treatment weak bidders bid their value in equilibrium so that any risk from playing the equilibrium bidding strategy has been eliminated. However, here too profits conditional on winning are relatively low for weak types which may serve to dampen

[6] See Gueth et al (2005) for asymmetric auctions without resale with supports similar to those employed here. They observe that strong bidders rarely bid more than the highest possible value in the support of the weak bidder.

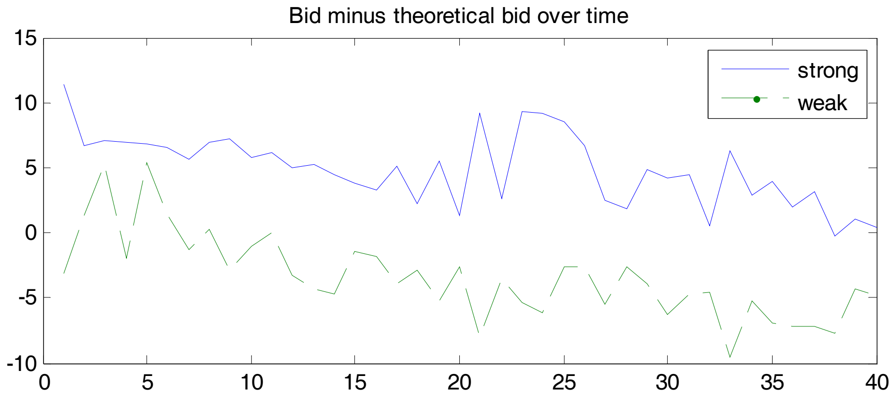

Figure 5: Bid deviation over time for both types in treatment 10.

	First Stage			**Second Stage**	
	Prices	**Interim Efficiency**	**Weak type wins**	**Prices**	**Efficiency**
predicted	22.0	0.69	0.50	24.9	0.93
actual	26.0	0.78	0.37	27.2	0.92

Table 3: Summary of results in treatment 34.

their incentives, plus they need to figure out how to set reserve prices so as to maximize expected earnings. The downside of setting a_W higher to eliminate the possibility of weak types suffering losses in equilibrium is that the larger a_W is relative to a_S, the smaller the effect of resale compared to the no resale case.

Figure 6 reports bids for both strong and weak types under W34.[7] Now, except at the very highest values, strong bidders tend to overbid relative to the RNNE more than in the previous treatment, and bids have a larger variation for the middle range of values. On the other hand weak types bid much closer to their predicted values throughout. As a consequence, weak bidders win substantially more of often than in the W10 treatment, 36.6% of the auctions compared to 25.6% with W10. This is still significantly less than the 49.6% predicted in equilibrium (see Table 3), largely as a result of strong types bidding more than predicted.

Resale prices for weak bidders are shown in Figure **??** along with the reserve prices

[7]Note that for the weak type the RNNE and the 45 degree line differ a bit. This is because the RNNE predicts exact value bidding only when the maximum private value of the weak type is 100/3. In the experiment we rounded this up to 34.

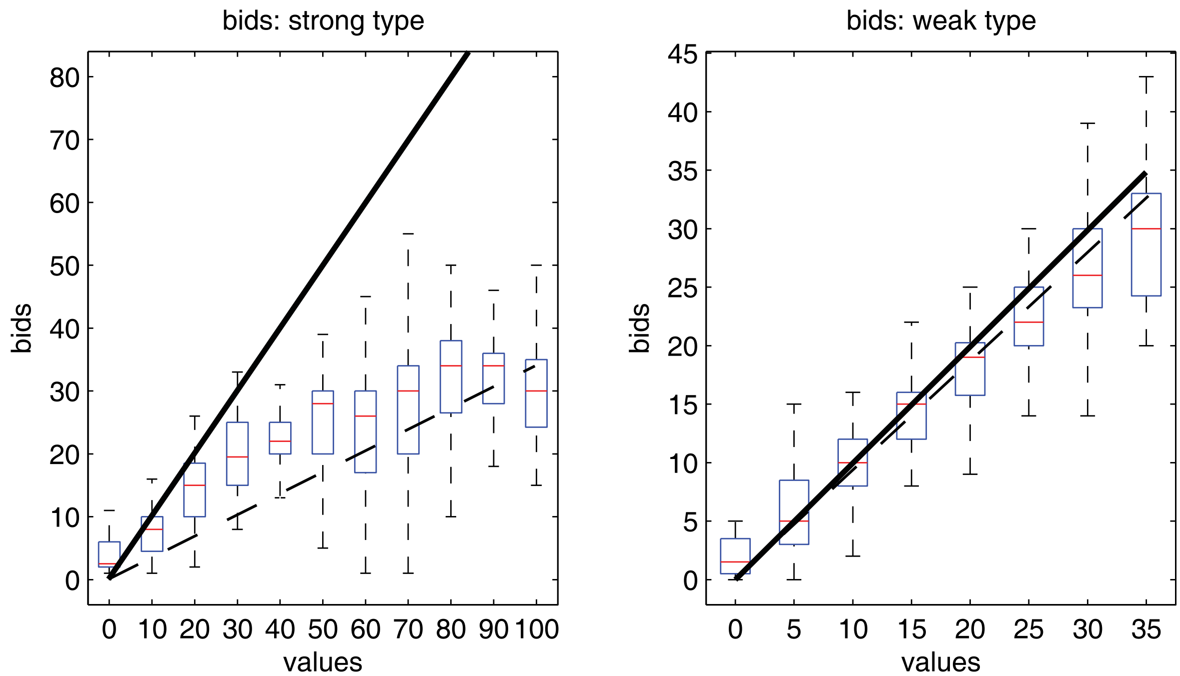

Figure 6: Series of boxplots of private values vs bids for the low and high types in treatment 34. Each box drawn represents the distribution of the bids for a block of values. The length of the box represents the interquartile range (IQR). The whisker extends from the box to the most extreme data value whithin 1,5 times the IQR. The dashed thin straight lines through the origin represent the equilibrium bids and the solid thick lines represent the 45 degree line.

predicted under the RNNE and with best responding to strong players bids. Except for a few outliers involving very high reserve prices, 100 or very close to it, that would preclude any opportunity for resale, reserve prices track the r_{RNNE} reasonably closely.[8] Note, that once again $r_{BR} > r_{RNNE}$, particularly when winning with relatively low bids, as weak bidders should take advantage of strong types' occasional very low bids.

Profits for weak types who won the first auction were 2.9 per period on average, very close to the level predicted under the RNNE[9] (3.5 per period) or had they best used best response reserve prices (3.8 per period). These positive profits are in marked contrast

[8]These seven very high reserve prices (80 or above) come from three subjects. In all cases these bidders had positive profits from bidding in the auction. There were occasional rejections of profitable resale proposals, 3.2% of all such offers.

[9]This is calculated given the actual bids of weak and strong types and assuming that they chose the Nash reserve prices in the resale stage.

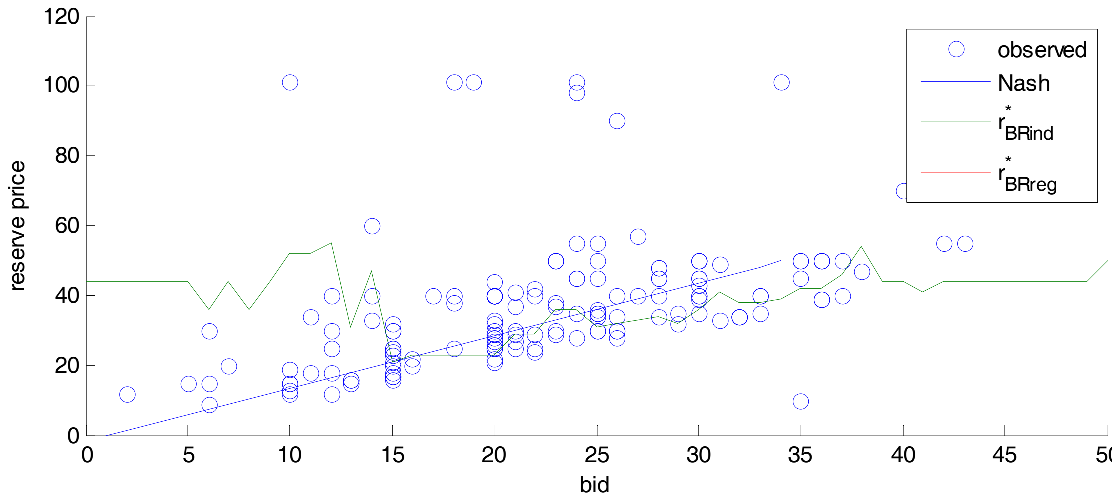

Figure 7: Reserve prices in treatment 34. We plot the observed ones, the ones that should be set according to theory and the ones that would be a best response to actual behavior.

to weak types negative profits in the W10 treatment. The positive realized profits, in conjunction with the fact that bidding ones value is a perfectly safe strategy for weak bidders helps to explain why weak types are bidding closer to equilibrium under the W34 treatment. That is, part of the explanation for weak types closer to equilibrium play results from the fact that the theory no longer requires them to continuously risk losses.

Average profit per period for strong types was 20.8. This too is very close to the RNNE of 21.5 per period, and a little less than with best responding, 24.8. Note that these somewhat lower profits relative to best responding can be fully accounted for by the fact that strong types consistently bid above the RNNE, a common characteristic of bidding in standard (no resale) first-price sealed bid auction experiments (see Kagel, 1995 and Kagel and Levin, 2008, for survey results on this point). The higher than predicted bids for strong types resulted in auction prices that were higher than predicted (26.0 versus 22.0; see Table 3) and weak types winning less often than predicted (36.6% of the time versus 49.6%).

Figure 8 plots bids over time. There is much less learning/adjustment in bids over time than in the W10 treatment.

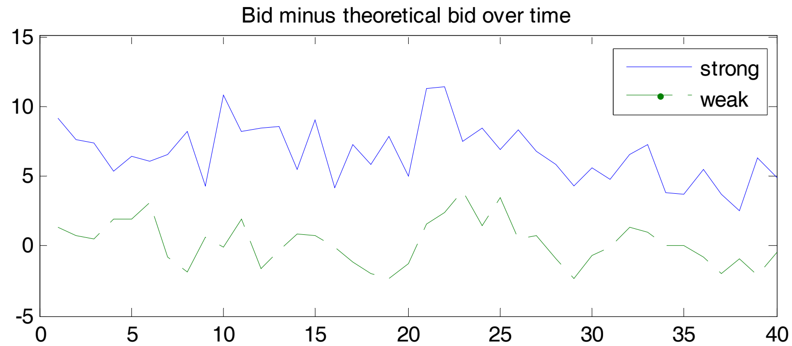

Figure 8: Bid deviation over time for both types in treatment 34.

4.2.1 Dual Markets

The dual market treatment is designed to establish a clear distinction between bidding with and without resale, as the same subjects were asked to bid using the same private values, first without resale and then with resale.

In the W34 treatment, there is not much difference in predicted bids for strong types with and without resale. But for weak types bids are predicted to increase uniformly with resale. Using individual subject data as the unit of observation, 73.5% (25 out of 34) of weak bidders bid higher on average with resale than without. Of these, 84.0% (21 out of 25) bid significantly higher with resale than without (based on a one tailed t-test, $p < 0.05$). Of the remaining bidders, 17.6% (6 out of 34) bid exactly the same with and without resale, and 8.8% (3 out of 34) bid less, but none significantly less (using a t-test).

Table 4 compares prices and efficiency with and without resale. Under the RNNE average prices are predicted to increase from 18.3 with no resale to 25.1 with resale, an increase of some 37.2%. Actual prices increased from 26.4 without resale to 32.0 with resale ($p < 0.00$, one-tailed t-test), an increase of 21.2%. The lower than predicted price increase can be accounted for by bidding above the RNNE by strong and weak types in the first-price auctions without resale (see Figure 9) which carries over, for strong types at least, to the resale option (recall Figure 6). Efficiency, as measured by the frequency with which the high value bidder wins the item, is predicted to increase very modestly from .91 without resale to .92 with resale. Actual efficiency moves modestly in the opposite

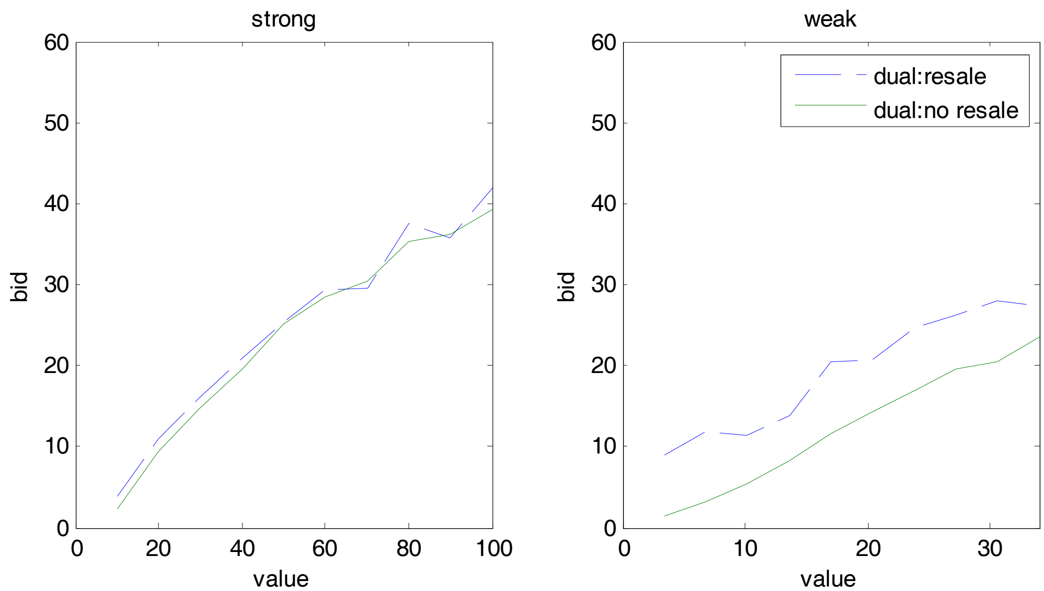

Figure 9: Bidding in the dual market treatment, with and without resale.

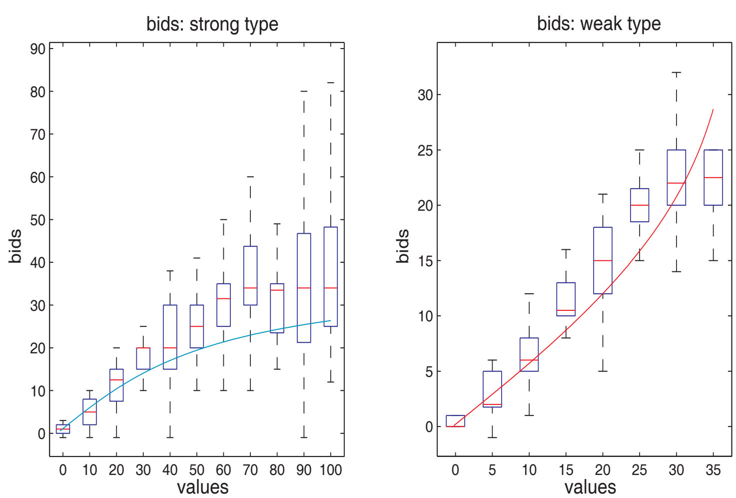

Figure 10: Boxplots of actual bids for the two types compared with the theory, in the dual market (no resale case).

direction, from 89 without resale to 88% with resale.

One of the key predictions of the model with asymmetric valuations and resale is that the distribution of bids will be symmetric with resale, but will be asymmetric absent resale. Figure 11, top panel, shows the distribution of bids with resale (left panel) and

		First Stage			Second Stage	
		Prices	**Efficiency**	**Weak type wins**	**Prices**	**Efficiency**
resale	predicted	22.3	0.70	0.50	25.1	0.92
	actual	30.3	0.75	0.40	32.0	0.88
no resale	predicted	18.3	0.91	0.27	-	-
	actual	26.4	0.89	0.27	-	-

Table 4: Summary of results in treatment 34dual.

absent resale (right panel) if everyone played according to the RNNE. The distribution on the left is essentially perfectly symmetric. The one on the right is not and has a higher frequency of high end bids. The bottom panel of Figure 11 shows the actual distribution of bids. There are several things worth noting. First, the actual distribution has a handful high bids well above the predicted upper bound of bidding (the upper bounds are 33.5 with resale, 25.4 without). Second, there is a clear change in the distribution of bids going from no resale to resale ($p < 0.01$ using a two sample Kolmogorov-Smirnov test). Third, and most importantly, there are more high end bids with resale (there is a bigger weight on bids between 30 and 40, with the tail of very high bids not much different between the two cases) and the distribution with resale is closer to uniform. Thus, although the point predictions of the model are not satisfied, as they rarely are in the experimental auction literature, the bid distribution moves in the direction predicted under the theory.

5 Conclusions

We have investigated Hafalir and Krishna's (2008) model of auctions with resale where bidders have asymmetric valuations. Theory predicts two strong effects. First, bidding by weak types should become more aggressive and auction prices should increase. Second the distribution of bids becomes symmetric so that one cannot distinguish between weak and strong types on the basis of their bids. While these results do not hold perfectly (or close to perfectly), we find that the resale opportunity causes weak bidders to bid more aggressively in the first stage auction in order to win and resell, with the result that

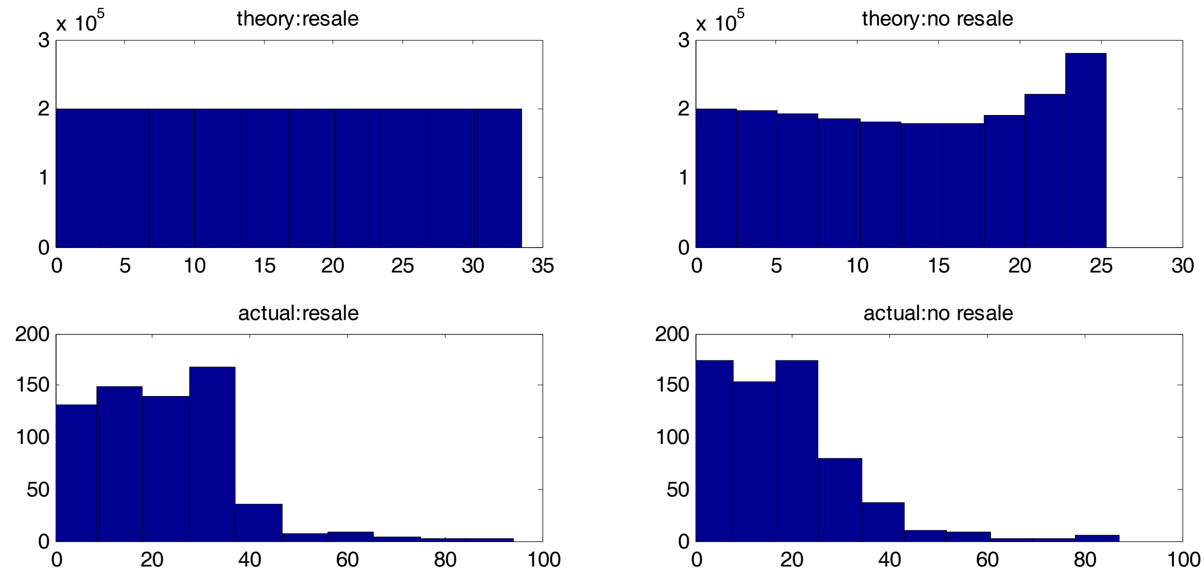

Figure 11: Bid distributions resulting from a monte carlo simulation (100.000 draws) of a resale market and a no resale market (upper panel). The weak bidder has a value in the support [0,34]. In the lower panel, actual bid distributions with resale (lower left panel) and without (lower right panel).

auction prices increase making sellers better off. The distribution of bids becomes more symmetric as well.

Auctions outcomes are much closer to the theoretical prediction when the equilibrium outcome for weak types does not require them to bid substantially above their private values with resale. Although weak bidders do, indeed, bid above their private values when the theory calls for them to do so, they do not bid nearly as high as the RNNE predicts. The latter probably results from a combination of risk (or loss) aversion and the fact that weak bidders earn negative average profits in this treatment. The negative average profits result from the low profit opportunities available to begin with in conjunction with the fact that strong players tend to bid more than the RNNE predicts, which substantially reduces the scope for profitable resale on weak player's part. Moving to treatment conditions in which the equilibrium calls for weak bidders to essentially bid their value, outcomes come much closer to the RNNE prediction. In fact they come remarkably close in a number of dimensions.

As noted, one problem with our first treatment in which equilibrium play calls for weak types to bid substantially above their private values is that there is little scope for profits for weak types and the rather unappealing distribution of earnings conditional on winning even if everyone follows equilibrium play perfectly. As such one area for future research will be to explore bidding in auctions with resale that call for weak types to bid above their values but not in quite such a hostile environment; i.e., one that has higher expected profits conditional on winning and/or a substantially higher probability of positive as opposed to negative profits conditional on winning.

References

[1] Garratt, Rod and T. Troeger (2006) "Speculation in Standard Auctions with Resale" *Econometrica* 74, 753-769.

[2] Georganas, Sotiris (2003) "Auctions with Resale: An Experimental Study", masters thesis, University of Bonn

[3] Guth, Werner, Radosveta Ivanova-Stenzel and Elmar Wolfstetter, (2005). "Bidding behavior in asymmetric auctions: An experimental study," *European Economic Review*, Elsevier, vol. 49(7), pages 1891-1913, October.

[4] Hafalir, Isa Emin and Vijay Krishna, "Asymmetric Auctions with Resale", (2008). *American Economic Review*

[5] Hafalir, Isa Emin and Vijay Krishna, "Revenue and Efficiency Effects of Resale in First-Price Auctions", (2009). *Journal of Mathematical Economics*

[6] Haile, Philip A. (2000) "Partial Pooling at the Reserve Price in Auctions with Resale Opportunities," *Games and Economic Behavior*, Elsevier, vol. 33(2), pages 231-248, November.

[7] Haile, Philip A. (2001) "Auctions with Resale Markets: An Application to U.S. Forest Service Timber Sales" *American Economic Review*, vol. 91, issue 3, pages 399-427

[8] Haile, Philip A. (2003) "Auctions with private uncertainty and resale opportunities", *Journal of Economic Theory* 108, 72-110

[9] Lange, Andreas, John A. List, Michael K. Price (2004) "Auctions with Resale When Private Values Are Uncertain: Theory and Empirical Evidence", NBER Working Paper No. w10639

[10] Plum, M, (1992). "Characterization and Computation of Nash-Equilibria for Auctions with Incomplete Information," *International Journal of Game Theory*, Springer, vol. 20(4), pages 393-418.