Multi-Unit Auctions with Resale: An Experimental Analysis

Marco Pagnozzi          Krista Jabs Saral

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*Should resale be allowed?*
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How does resale affect bidders’ strategies, efficiency and the seller’s revenue?

Should resale be allowed?

How should the resale market be structured?
Why does resale happen?

- Bidders do not participate in the auction (Milgrom, 1987; Bikhchandani & Huang, 1989)
- Bidders’ valuations change after the auction (Haile, 2000, 2003)
- Value uncertainty (in 1st-price auctions) (Gupta & Lebrun, 1999; Hafalir & Krishna, 2007)
- Auction price affects bargaining in resale market (Pagnozzi, 2007)
- Strategic behavior: demand reduction and speculation (Garratt & Tröger 2006; Pagnozzi, 2009, 2010)
In **multi-object** auctions, bidders often bid less than value for marginal units to keep the auction price low (Demand Reduction – Wilson, 1979; Ausubel & Cramton, 98) (e.g., FCC auctions, German GSM auction, electricity)
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Demand reduction reduces the seller’s revenue and yields an inefficient allocation, making bidders willing to trade
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**Resale** induces weak (low-value) bidders to *speculate*: bid aggressively to win and sell to strong (high-value) bidders.
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Demand reduction reduces the seller’s revenue and yields an inefficient allocation, making bidders willing to trade

Resale induces weak (low-value) bidders to speculate: bid aggressively to win and sell to strong (high-value) bidders

Resale increases strong bidders’ incentive to reduce demand, because they can purchase after the auction the units lost
Overview

In multi-object uniform-price auctions with asymmetric bidders and resale through bargaining:

1. Without resale, asymmetry between bidders affects demand reduction.
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2. Demand reduction and speculation emerge when the auction winner can resell
Overview

In *multi-object* uniform-price auctions with *asymmetric* bidders and resale through *bargaining*:

1. Without resale, asymmetry between bidders affects demand reduction

2. Demand reduction and speculation emerge when the auction winner can resell

3. Effect of resale on efficiency and seller’s revenue
Overview

In multi-object uniform-price auctions with asymmetric bidders and resale through bargaining:

1. Without resale, asymmetry between bidders affects demand reduction

2. Demand reduction and speculation emerge when the auction winner can resell

3. Effect of resale on efficiency and seller’s revenue

4. Effects of changing the resale market structure
THEORETICAL BACKGROUND
Model

- 2 units of an identical good for sale

- **Uniform-price auction**: the 2 highest bids win, and winner(s) pay the 3rd-highest bid for each unit

- 2 asymmetric bidders:
  - $S$ (strong) demands 2 units and has high value $v_s \sim U[30; 50]$
  - $W$ (weak) demands 1 unit and has low value $v_w \sim U[10; 30]$

$\rightarrow$ Either $S$ wins both units or $S$ and $W$ win one unit each
**W’s Bidding Strategy without Resale**

- It is a dominant strategy for $W$ to bid $v_W$ (as in a single-object 2\textsuperscript{nd}-price auction)
S's Bidding Strategy without Resale

- Since \( W \) bids \( v_W \), \( S \) can

\[
S \text{ reduces demand if and only if } v_S > 2(v_S E[v_W]) \quad \text{or} \quad v_S < 2(E[v_W]) = 40
\]

\( S \)'s incentive to reduce demand giving up 1 unit is lower when he has a higher value.
**S's Bidding Strategy without Resale**

- Since $W$ bids $v_W$, $S$ can
  - win 2 units at price $\mathbb{E}[v_W]$ and obtain $2(v_S - \mathbb{E}[v_W])$, or
  - bid 0 for the 2nd unit (reduce demand), win 1 unit letting $W$ win 1 unit, and obtain $v_S$. $S$ reduces demand if and only if $v_S > 2(v_S - \mathbb{E}[v_W]) = 40$. $S$'s incentive to reduce demand giving up 1 unit is lower when he has a higher value.
S’s Bidding Strategy without Resale

- Since \( W \) bids \( v_W \), \( S \) can
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  - bid 0 for the 2\(^{nd} \) unit (reduce demand), win 1 unit
    letting \( W \) win 1 unit, and obtain \( v_S - 0 \)
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\[ \Rightarrow \text{ } S \text{ reduces demand if and only if} \]

\[ v_S - 0 > 2(v_S - \mathbb{E}[v_W]) \iff v_S < 2\mathbb{E}[v_W] = 40 \]
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\[ S \] reduces demand if and only if

\[ v_S - 0 > 2(v_S - \mathbb{E}[v_W]) \iff v_S < 2\mathbb{E}[v_W] = 40 \]

- \( S \)'s incentive to reduce demand giving up 1 unit is lower when he has a higher value.
Resale Market

- After the auction, if \( W \) wins a unit, he can resell it to \( S \)
- Resale takes place through **bargaining**
- Gains from trade are \( \nu_S - \nu_W \)
- \( S \) obtains a share \( \alpha \) of the gains from trade
  \( W \) obtains a share \( (1 - \alpha) \) of the gains from trade

(results are robust to many alternative models of resale market)
**W's Bidding Strategy with Resale**

- W bids up to the expected resale price

\[ \alpha v_W + (1 - \alpha) \mathbb{E}[v_S] \equiv \mathbb{E}[r] \]
W’s Bidding Strategy with Resale

- \( W \) bids up to the expected resale price

\[
\alpha v_W + (1 - \alpha) \mathbb{E}[v_S] \equiv \mathbb{E}[r]
\]

- \( W \) speculate because of the option to resell and bids higher than \( v_W \)
S’s Bidding Strategy with Resale

Since $W$ bids $\mathbb{E}[r]$, in the auction $S$ can
S’s Bidding Strategy with Resale

- Since $W$ bids $\mathbb{E}[r]$, in the auction $S$ can
  - Outbid $W$ and win 2 units, obtaining $2(\nu_S - \mathbb{E}[r])$
**S’s Bidding Strategy with Resale**

- Since $W$ bids $\mathbb{E}[r]$, in the auction $S$ can
  - Outbid $W$ and win 2 units, obtaining $2(v_S - \mathbb{E}[r])$
  - Bid 0 (reduce demand), win 1 unit and then buy 1 unit in resale market at price $r$, obtaining

\[
(v_S - 0) + (v_S - r) = 2v_S - r
\]

- **Auction profit** + **Resale profit**
**S’s Bidding Strategy with Resale**

- Since $W$ bids $\mathbb{E} [r]$, in the auction $S$ can
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$$v_S - 0 + v_S - r = 2v_S - r$$

- Auction profit + Resale profit

$\Rightarrow$ $S$ always reduces demand (for every $\alpha$ and $v_S$)
**S’s Bidding Strategy with Resale**

- Since $W$ bids $\mathbb{E}[r]$, in the auction $S$ can
  - Outbid $W$ and win 2 units, obtaining $2(\nu_S - \mathbb{E}[r])$
  - Bid 0 (reduce demand), win 1 unit and then buy 1 unit in resale market at price $r$, obtaining

\[
\nu_S - 0 + \nu_S - r = 2\nu_S - r
\]

- $S$ always reduces demand (for every $\alpha$ and $\nu_S$)

- Demand reduction allows $S$ to win 1 unit at price 0 and then purchase the other unit from $W$ in resale (rather than pay $\mathbb{E}[r]$ for both units)
Summing up:

- **Without resale**, $W$ bids $v_w$ and $S$ reduces demand if and only if $v_s < 40$
Summing up:

1. **Without resale**, $W$ bids $v_w$ and $S$ reduces demand if and only if $v_s < 40$

2. **With resale**, $W$ bids above $v_w$ and $S$ always reduces demand
EXPERIMENTAL DESIGN
**Uniform-Price Ascending Clock Auction**

- Bidders choose when to drop out of the auction as the price increases
- When one bidder drops out, the auction is over (\# of units on sale = \# of units demanded)
- Winner(s) pay the dropout price for each unit
Treatments - between subjects design

1. No Resale

2. Complete Information Resale: after the auction, if W won, bidders learn values and participate in resale

3. Incomplete Information Resale: same as complete info, but bidders do not learn values before resale

Resale market: one bidder, chosen with probability $\frac{1}{2}$, makes take-it-or-leave-it offer to the other (Calzolari & Pavan ’06) ⇒ in expectation, bidders obtain $\frac{1}{2}$ of gains from trade

4. Bargain (unstructured): as Incomp Resale + bidders can make multiple offers and communicate in computerized chat
**Sessions Information**

- 3 sessions of 16 subjects per treatment (48 subjects per treatment)
- All sessions had 30 auction periods, except Bargain (20 periods due to 2 hour limit)
- All 12 sessions were run in the xs/fs laboratory at FSU in March and June 2011, and October 2012
- Mostly undergraduate subjects
RESULTS
No Resale:  *W bids value with high frequency*  

(Weighted scatterplot of observed bids vs. value)
Complete Information Resale: \( W \) bids above value with high frequency
- Without resale, $W$ tends to bid value
- With resale, $W$ bids above value much more often
Bidding by \( W \) – Random Effects Tobit
(unobserved bids censored at the auction price)

<table>
<thead>
<tr>
<th>( W )'s Bid</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.870</td>
<td>(1.444)</td>
</tr>
<tr>
<td>( v_w )</td>
<td>0.993***</td>
<td>(0.053)</td>
</tr>
<tr>
<td><strong>Comp Resale</strong></td>
<td>13.248***</td>
<td>(2.285)</td>
</tr>
<tr>
<td><strong>Incomp Resale</strong></td>
<td>6.951***</td>
<td>(2.162)</td>
</tr>
<tr>
<td><strong>Bargain</strong></td>
<td>6.747***</td>
<td>(2.545)</td>
</tr>
<tr>
<td>( v_w \times \text{Comp} )</td>
<td>-0.316***</td>
<td>(0.092)</td>
</tr>
<tr>
<td>( v_w \times \text{Incomp} )</td>
<td>-0.117</td>
<td>(0.084)</td>
</tr>
<tr>
<td>( v_w \times \text{Bargain} )</td>
<td>-0.236**</td>
<td>(0.108)</td>
</tr>
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*** and ** indicate statistical significance at 1% and 5%

- Bids are higher with resale, especially in Complete Resale
Demand Reduction by $S$:

<table>
<thead>
<tr>
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<th>$S$’s bids $\leq 2$</th>
<th>$W$ Wins</th>
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<tr>
<td></td>
<td>$v_s &lt; 40$</td>
<td>$v_s &gt; 40$</td>
</tr>
<tr>
<td>No Resale</td>
<td>30%</td>
<td>12%</td>
</tr>
<tr>
<td>Comp Resale</td>
<td>37%</td>
<td>43%</td>
</tr>
<tr>
<td>Incomp Resale</td>
<td>29%</td>
<td>22%</td>
</tr>
<tr>
<td>Bargain</td>
<td>48%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>52%</td>
<td>25%</td>
</tr>
<tr>
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<td></td>
<td>74%</td>
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There is evidence of more demand reduction in later periods (learning)
No Resale: *S reduces demand more frequently when* $v_S < 40$, *less frequently when* $v_S > 40$
Complete Information Resale: $S$ reduces demand with high frequency for all values
- Without resale, $S$ reduces demand more when $v_s < 40$
- With resale, $S$ reduces demand more frequently, for all values
- Uncertainty in resale reduces demand reduction by $S$
**Bidding by S – Random Effects Tobit**  
(unobserved bids censored at the auction price)

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<td>Bargain $\times v_s &gt; 40$</td>
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- When \(v_S > 40\) in all resale treatments \(S\) bids lower than without resale.
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- When \( v_S < 40 \) in Comp Resale and Bargain

**S** bids lower than without resale
**Auction Efficiency**: with demand reduction, the auction allocation is inefficient $\Rightarrow$ symmetry and resale reduce auction efficiency

- Average efficiency (winner’s value/$S$’s value): No Resale 0.82, Comp 0.64, Incomp 0.71, Bargain 0.65
**Final Efficiency:** Resale increases efficiency after the auction, but also demand reduction ⇒ ambiguous effect on final efficiency

- Average efficiency not significantly different between No Resale (= 0.82) and Incomp Resale (= 0.85)
**Seller’s Revenue:**

- Resale reduces revenue because it induces $S$ to reduce demand
- Resale increases revenue (when $S$ does not reduce demand) because it induces $W$ to bid aggressively

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<th>Bargain</th>
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<tr>
<td>Average Revenue</td>
<td>14.61</td>
<td>11.94</td>
<td>14.05</td>
<td>8.47</td>
</tr>
<tr>
<td>Revenue - $W$ wins</td>
<td>8.01</td>
<td>8.64</td>
<td>9.98</td>
<td>5.25</td>
</tr>
<tr>
<td>Revenue - $S$ wins</td>
<td>18.81</td>
<td>21.85</td>
<td>21.06</td>
<td>17.22</td>
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- Significant difference between revenue with No Resale and either Comp Resale or Bargain (WMW, $p < 0.001$)
- No significant difference between revenue with No Resale and Incomp Resale ($p = 0.319$)
What are the effects of changing the resale market structure?

- **Comp Resale**: t-o-l offers with complete information
- **Incomp Resale**: t-o-l offers with incomplete information
- **Bargain**: multiple offers and communication

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<th>Resale Possible (W won the auction)</th>
<th>Successful Resale</th>
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<tr>
<td>Comp Resale</td>
<td>75%</td>
<td>81.1%</td>
</tr>
<tr>
<td>Incomp Resale</td>
<td>63.2%</td>
<td>42.2%</td>
</tr>
<tr>
<td>Bargain</td>
<td>73.1%</td>
<td>79.5%</td>
</tr>
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### Average Resale Price, Earnings, Offer

<table>
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<tr>
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<th>Resale Price (Auction Price)</th>
<th>Earnings Weak / Strong</th>
<th>Resale Offer Weak / Strong</th>
</tr>
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<tbody>
<tr>
<td>Comp Resale</td>
<td>29.56 (11.94)</td>
<td>9.45/10.20</td>
<td>32.47/25.45</td>
</tr>
<tr>
<td>Incomp Resale</td>
<td>27.38 (14.05)</td>
<td>8.74/12.59</td>
<td>32.45/17.93</td>
</tr>
<tr>
<td>Bargain</td>
<td>27.44 (8.47)</td>
<td>8.35/12.43</td>
<td>-</td>
</tr>
</tbody>
</table>

- Prices are higher in resale than in auction, and highest in Comp
- $S$ earns more than $W$ in resale
- $S$ makes more aggressive offers in Incomp (WMW, $p<0.001$)
Total Earnings: Auction + Resale Profits

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<th>Bargain</th>
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<tbody>
<tr>
<td><strong>Weak Bidder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Total Earnings</td>
<td>4.61</td>
<td>12.45</td>
<td>7.55</td>
<td>15.83</td>
</tr>
<tr>
<td><strong>Strong Bidder</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Total Earnings</td>
<td>38.33</td>
<td>37.43</td>
<td>34.93</td>
<td>44.62</td>
</tr>
<tr>
<td>(std. dev)</td>
<td>(17.061)</td>
<td>(18.348)</td>
<td>(17.905)</td>
<td>(17.147)</td>
</tr>
</tbody>
</table>

cumulative earnings restricted to 20 periods for comparison to bargain treatment

- \( W \) obtains higher profits with resale (WMW, \( p<0.001 \))
- \( S \) obtains higher profits with resale only in Bargain
Conclusions

- Experiments of **multi-object** auction with resale and
  - **asymmetric** bidders
  - resale through **bargaining**

- Without resale, strong bidders with low values reduce demand more
- With resale, weak bidders speculate and strong bidders reduce demand more frequently
- Resale does not necessarily increase efficiency and reduce the seller’s revenue
- More efficient resale market reduces auction efficiency and revenue