Should Speculators Be Welcomed in Auctions?

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- When resale after an auction is allowed,
  speculators (who have no use value for auction prize)
  may participate in order to resell to high-value bidders

"Should the seller encourage speculators, because additional bidders create more competition in the auction?

Or should the seller discourage them, because value captured by speculators must come from someone else's payoff – possibly the seller's?" (Milgrom, 2004)

... it depends on bidders' relative valuations:

(i) if bidders' valuations are *clustered*,
resale and speculators *increase* the seller's revenue

(ii) if bidders' valuations are *dispersed*,
resale and speculators *reduce* the seller's revenue

– *Can speculators win an auction?*
– *Why should a high-value bidder let speculators win?*

- In **single-object** auctions, it is unclear why a high-value bidder should prefer to buy in the resale market

- In **multi-object** auctions, bidders often bid less than value for marginal units to reduce the auction price (*Demand Reduction* ≡ DR)
  (Wilson, 1979; Ausubel & Cramton, 1998)
  (e.g., FCC auctions, German GSM auction, California electricity markets ...)

⇒ A high-value bidder may *strictly* prefer to let speculators win some objects in order to keep the auction price low for the objects she wins
(and then buy from speculators in the resale market)

Example

- **Single-object** ascending auction (with full information):
  - 1 bidder (B) with value 8
  - 1 speculator (S) with value 0

- With equal sharing of resale surplus, if S wins, he resells at price $\frac{1}{2}(8+0)=4$

$$\Rightarrow \begin{cases} S \text{ is willing to bid up to } 4 \text{ in the auction} \\ B \text{ is willing to bid up to } 4 \text{ in the auction} \end{cases}$$

- B is *indifferent* between winning the auction and buying from the speculator

$\Rightarrow$ Multiple equilibria, but resale is not robust to an (arbitrarily small) resale cost

Related Literature

- Resale can take place in **single-object** auctions:
  - if some bidders do not participate in the auction (Milgrom, 1987; Bikhchandani & Huang *RFS*, 1989 ...)
  - if bidders' valuations change after the auction (Haile *GEB*, 2003; *JET*, 2003)
  - in 1^{st}-price asymmetric auctions with uncertainty (Gupta & Lebrun *EL*, 1999; Hafalir & Krishna *AER*, 2007 ...)
  - if speculators induce bidders to bid 0 by bidding "aggressively" (Garratt & Tröger *Econometrica*, 2006)
  - if the auction price affects bargaining in the resale market (Pagnozzi *RAND*, 2007)
- But resale arises much more naturally in **multi-object** auctions ...

Example (Cont.)

- **Multi-object** uniform-price auction**:**
  - 2 units, 1 bidder (B), 1 speculator (S)
  - 2 highest bids win and pay 3rd-highest bid

	1st unit	2nd unit
B	8	8
S	0	0

$\overset{\text{resale}}{\Rightarrow}$

	1st unit	2nd unit
B	4	4
S	4	4

- As before, B can win the 2 units in the auction at price 4 ... but ...
- With DR $\left\{ \begin{array}{l} B \text{ bids } (4;\ 0) \\ S \text{ bids } (4;\ 0) \end{array} \right\}$, B and S win one unit each and S resells:

$$\pi_B = \underbrace{8-0}_{\text{auction profit}} + \underbrace{8-4}_{\text{resale surplus}}$$

$\Rightarrow$ B *strictly* prefers DR

$$\Rightarrow \left\{ \begin{array}{l} \text{Resale is (the Pareto dominant for } B \text{ and } S\text{) equilibrium} \\ S \text{ wins and the seller's revenue is } 0 \end{array} \right.$$

Example (Cont.)

- Resale is an equilibrium even with:

  (i) Different sharing of resale surplus, and even a take-or-leave offer by S

  (ii) Not fully efficient resale market (e.g. if $0 < \Pr[\text{no resale}] \leq \frac{1}{3}$)

  (iii) (Not too large) resale cost (i.e. if $c < \frac{1}{3} \cdot B$'s value)

e.g.(ii)**:** Assume with prob. $\frac{1}{4}$ resale does not take place

$\Rightarrow$ In the resale market B and S obtain expected surplus $\frac{3}{4} \cdot 4 = 3$

	1[st] unit	2[nd] unit
B	8	8
S	0	0

$\overset{\text{resale}}{\Rightarrow}$

	1[st] unit	2[nd] unit
B	5	5
S	3	3

- B can win the 2 units in the auction at price 3 and obtain profit 10 ... but ...
- With DR $\left\{ \begin{array}{l} B \text{ bids } (5;\ 0) \\ S \text{ bids } (3;\ 0) \end{array} \right\}$, B obtains:

$$\pi_B = \underbrace{8 - 0}_{\text{auction profit}} + \underbrace{\tfrac{3}{4}(8 - 4)}_{\text{resale surplus}} = 11$$

$\Rightarrow$ B *strictly* prefers DR

Example (Cont.)

- Resale is an equilibrium even with:

  (i) Different sharing of resale surplus, and even a take-or-leave offer by S

  (ii) Not fully efficient resale market (e.g. if $0 < \Pr[\text{no resale}] \leq \frac{1}{3}$)

  (iii) (Not too large) resale cost (i.e. if $c < \frac{1}{3} \cdot B$'s value)

e.g.(iii)**:** Assume resale costs 2 (or B's value is reduced to 6 after the auction)

$\Rightarrow$ In the resale market B and S obtain surplus 3

	1st unit	2nd unit
B	8	8
S	0	0

$\overset{\text{resale}}{\Rightarrow}$

	1st unit	2nd unit
B	5	5
S	3	3

- B can win the 2 units in the auction at price 3 and obtain profit 10 ... but ...
- With DR $\left\{\begin{array}{l} B \text{ bids } (5;\ 0) \\ S \text{ bids } (3;\ 0) \end{array}\right\}$, B obtains:

$$\pi_B = \underbrace{8-0}_{\text{auction profit}} + \underbrace{6-3}_{\text{resale surplus}} = 11$$

$\Rightarrow$ B *strictly* prefers DR

UK 3.4GHz Auction (June 2003)

- Simultaneous Ascending Auction for 15 licenses for broadband wireless services
  - **PCCW** (a Hong-Kong telecom company) was the highest-value bidder and was expected to win 15 licenses
  - **Red Spectrum** and **Public Hub** were companies created for the auction and chose to be eligible for only 1 license

- As soon as PCCW, RS and PH were the only bidders left, PCCW reduced demand to 13 licenses to end the auction
- PCCW's failure to win all licenses was described as
  - "a surprise, ... a gaffe"
  - "a costly mistake that may cost the chance of offering a nationwide service"

But was it really a mistake?

- By March 2004, PCCW took over RS and PH and obtained all licenses

Model

- Uniform-price auction for k (identical) units

  (k highest bids win and pay $(k+1)^{\text{th}}$-highest bid)

  $\begin{cases} n \text{ bidders with values } v_1 > v_2 > \ldots > v_n & \text{(flat demand)} \\ k - n \text{ speculators} & \text{(more speculators cannot make profit)} \end{cases}$

	1^{st} unit	2^{nd} unit	$\cdots$	k^{th} unit
B_1	v_1	v_1	$\cdots$	v_1
B_2	v_2	v_2	$\cdots$	v_2
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
B_n	v_n	v_n	$\cdots$	v_n
S_1	0	0	$\cdots$	0
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
S_{k-n}	0	0	$\cdots$	0

- Assumptions:

  (i) B_i and S_i know values, seller does not – e.g., Wilson 1979

  (ii) No weakly dominated strategy

  (iii) In the resale market, a unit can be traded only once and players equally share the gains from trade (Nash bargaining)

Bargaining for Resale

– *At what price does S_i resell to B_1?*

- Our qualitative results hold with many alternative assumptions on bargaining:

1. Equal sharing of the gains fro trade: $\frac{1}{2}v_1$

2. Take-it-or-leave-it offer: v_1

3. "Multi-parties" bargaining: $\frac{1}{2}(v_1 + v_2)$

   (when a unit can be sold more than once)

4. Unequal bargaining power: $\alpha_S \cdot v_1, \quad 0 < \alpha_S \leq 1$

   ...

   (Assumptions 2 and 3 favour speculators and reinforce our results)

"Valuations" with Resale

- If S_i wins, he resells to B_1 for $\frac{1}{2}v_1$
- If B_i, $i \neq 1$, wins, he resells to B_1 for $\frac{1}{2}(v_1 + v_i)$

$\rightarrow$ With resale, S_i's and B_i's "valuation" is higher for the option to resell

- B_1 can buy in resale market for at most $\frac{1}{2}(v_1 + v_2)$

	1^{st}	$\cdots$	k^{th}
B_1	v_1	$\cdots$	v_1
B_2	v_2	$\cdots$	v_2
$\vdots$	$\vdots$	$\ddots$	$\vdots$
B_n	v_n	$\cdots$	v_n
S_1	0	$\cdots$	0
$\vdots$	$\vdots$	$\ddots$	$\vdots$
S_{k-n}	0	$\cdots$	0

$\overset{\text{resale}}{\Rightarrow}$

	1^{st} unit	2^{nd} unit	$\cdots$	k^{th} unit
B_1	$\frac{1}{2}(v_1 + v_2)$	$\frac{1}{2}(v_1 + v_2)$	$\cdots$	$\frac{1}{2}(v_1 + v_2)$
B_2	$\frac{1}{2}(v_1 + v_2)$	$\frac{1}{2}(v_1 + v_2)$	$\cdots$	$\frac{1}{2}(v_1 + v_2)$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
B_n	$\frac{1}{2}(v_1 + v_n)$	$\frac{1}{2}(v_1 + v_n)$	$\cdots$	$\frac{1}{2}(v_1 + v_n)$
S_1	$\frac{1}{2}v_1$	$\frac{1}{2}v_1$	$\cdots$	$\frac{1}{2}v_1$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
S_{k-n}	$\frac{1}{2}v_1$	$\frac{1}{2}v_1$	$\cdots$	$\frac{1}{2}v_1$

(Zero-Price) Demand Reduction Equilibrium

- Bidding your "valuation" for the 1st unit is a dominant strategy

Def.: In a **DR equilibrium** each player bids $\begin{cases} \text{her "valuation" for the 1}^{\text{st}}\text{ unit} \\ 0 \text{ for all other units} \end{cases}$

$$\rightarrow \begin{cases} B_1 \text{ bids } \left(\frac{1}{2}(v_1 + v_2)\,;\ 0; \ldots;\ 0\right) \\ B_i \text{ bids } \left(\frac{1}{2}(v_1 + v_i)\,;\ 0; \ldots;\ 0\right), \quad i \neq 1 \\ S_i \text{ bids } \left(\frac{1}{2}v_1;\ 0; \ldots;\ 0\right) \end{cases}$$

$\Rightarrow$ Each player wins 1 unit at price 0 and $B_2, ..., B_n, S_1, ..., S_{k-n}$ resell:

$$\pi_S^* = \underbrace{\tfrac{1}{2}v_1}_{\text{resale price for } S_i} \qquad\qquad \pi_i^* = \underbrace{\tfrac{1}{2}(v_1 + v_i)}_{\text{resale price for } B_i}, \quad i \neq 1$$

$$\pi_1^* = k \cdot v_1 - \sum_{i=2}^{n} \underbrace{\tfrac{1}{2}(v_1 + v_i)}_{\text{resale price from } B_i} - (k-n) \cdot \underbrace{\tfrac{1}{2}v_1}_{\text{resale from } S_i}$$

Bidding

- S_i has no incentive to deviate from the DR equilibrium (because to win more units he has to pay at least $\frac{1}{2}v_1$)
- B_1 has no incentive to deviate from the DR equilibrium (because to win more units in the auction he only increases the auction price)

- B_2 does not outbid S_i to win $(k-n+1)$ units iff:

$$\pi_2^* = \underbrace{\tfrac{1}{2}(v_1+v_2)}_{\text{resale price for 1 unit}} > \underbrace{(k-n+1)\cdot\tfrac{1}{2}(v_1+v_2)}_{\text{resale price for } k-n+1 \text{ unit}} - \underbrace{(k-n+1)\cdot\tfrac{1}{2}v_1}_{\text{auction price for } k-n+1 \text{ unit}}$$

$$\Leftrightarrow \quad \boxed{v_1 > (k-n)\,v_2} \qquad (\dagger)$$

$$\begin{cases} \text{high } v_1 \Rightarrow \text{high willingness to pay for } S_i \\ \text{low } v_2 \Rightarrow \text{low resale price for } B_2 \end{cases}$$

→ with high v_1 and low v_2, outbidding speculators is too costly for B_2

Bidding

- B_2 does not outbid B_j, $j > 2$, to win $(k-j+2)$ units iff:

$$\pi_2^* = \underbrace{\tfrac{1}{2}(v_1+v_2)}_{\text{resale price for 1 unit}} > \underbrace{(k-j+2)\cdot\tfrac{1}{2}(v_1+v_2)}_{\text{resale price for } k-j+2 \text{ unit}} - \underbrace{(k-j+2)\cdot\tfrac{1}{2}(v_1+v_j)}_{\text{auction price for } k-j+2 \text{ unit}}$$

$$\Leftrightarrow \quad \boxed{(k-j+2)\,v_j + v_1 > (k-j+1)\,v_2, \quad j = 3,...,n} \qquad (\ddagger)$$

$$\begin{cases} \text{high } v_1 \text{ and } v_j & \Rightarrow \text{high willingness to pay for } B_j \\ \text{low } v_2 & \Rightarrow \text{low resale price for } B_2 \end{cases}$$

→ with high v_1, v_j and low v_2, outbidding B_j is too costly for B_2

- B_2 has the strongest incentive to deviate from the DR equilibrium
  ⇒ If B_2 does not deviate, no other bidder deviates

⇒ There is a DR equilibrium iff (†) and (‡) are satisfied — e.g., if $\boxed{v_1 > (k-2)\,v_2}$

Equilibria

There are 2 types of equilibria:

1. **DR equilibrium**:

   if values are **dispersed** (e.g., if $v_1 > (k-2)\,v_2$)
   bidders reduce demand and accommodate speculators

   $\Rightarrow$ Speculators win and the auction price is 0

- When it exists, the DR equilibrium is the *Pareto dominant equilibrium* for B_i and S_i (among all equilibria in undominated strategies)

2. **Positive Price equilibrium**:

   if values are **clustered** (i.e., if (†) and/or (‡) are not satisfied)
   B_2 outbids lower-value bidders and/or speculators to win more units

   (Multiple equilibria: B_i can win $1, \ldots, k$ units)

   $\Rightarrow$ Speculators lose and the auction price is $\geq \frac{v_1}{2}$

Effect of Resale and Speculators on Seller's Revenue

- *Should the seller allow resale and welcome speculators?*

- Resale and speculators have 2 effects on seller's revenue:

(i) **Competition Effect:**

– Speculators increase the number of competitors so (low-value) bidders may bid higher to beat speculators

(ii) **Demand Reduction Effect:**

– Resale makes DR more profitable for high-value bidders because they buy in the resale market the units they lose in the auction

– Resale makes it more costly for a bidder to deviate from DR and outbid lower-value competitors, because they bid higher when they can resell

Effect of Resale and Speculators on Seller's Revenue

- Speculators may not participate in the auction for 2 reasons:
  - Resale is not allowed and so speculators do not want to participate
  - Resale is allowed but speculators are not allowed to participate

→ We compare 3 scenarios:

Resale \ Speculators	Yes	No
Yes	Scenario 1	Scenario 3
No		Scenario 2

Scenario 1 vs 2: Effect of Resale

- Assume there are **2 bidders and 2 speculators**

(1) With resale (and speculators):

$$\text{seller's revenue is } \Pi_R = \begin{cases} 0 & \text{if } v_1 > 2v_2 \quad \text{(i.e., with DR)} \\ \frac{v_1}{2} & \text{if } v_1 < 2v_2 \quad \text{(i.e., without DR)} \end{cases}$$

(2) Without resale (and so no speculator):

– B_2 has no incentive to deviate from a DR equilibrium

$\Rightarrow$ There is a DR equilibrium iff B_1 does not want to outbid B_2:

$$\max \pi_1 (\text{DR}) > \pi_1 (\text{No DR}) \quad \Leftrightarrow \quad 3(v_1 - 0) > 4(v_1 - v_2) \quad \Leftrightarrow \quad \boxed{v_1 < 4v_2}$$

– If bidders' valuations are **clustered**, B_1 prefers to win fewer units at price 0 because outbidding B_2 to win more units is too costly

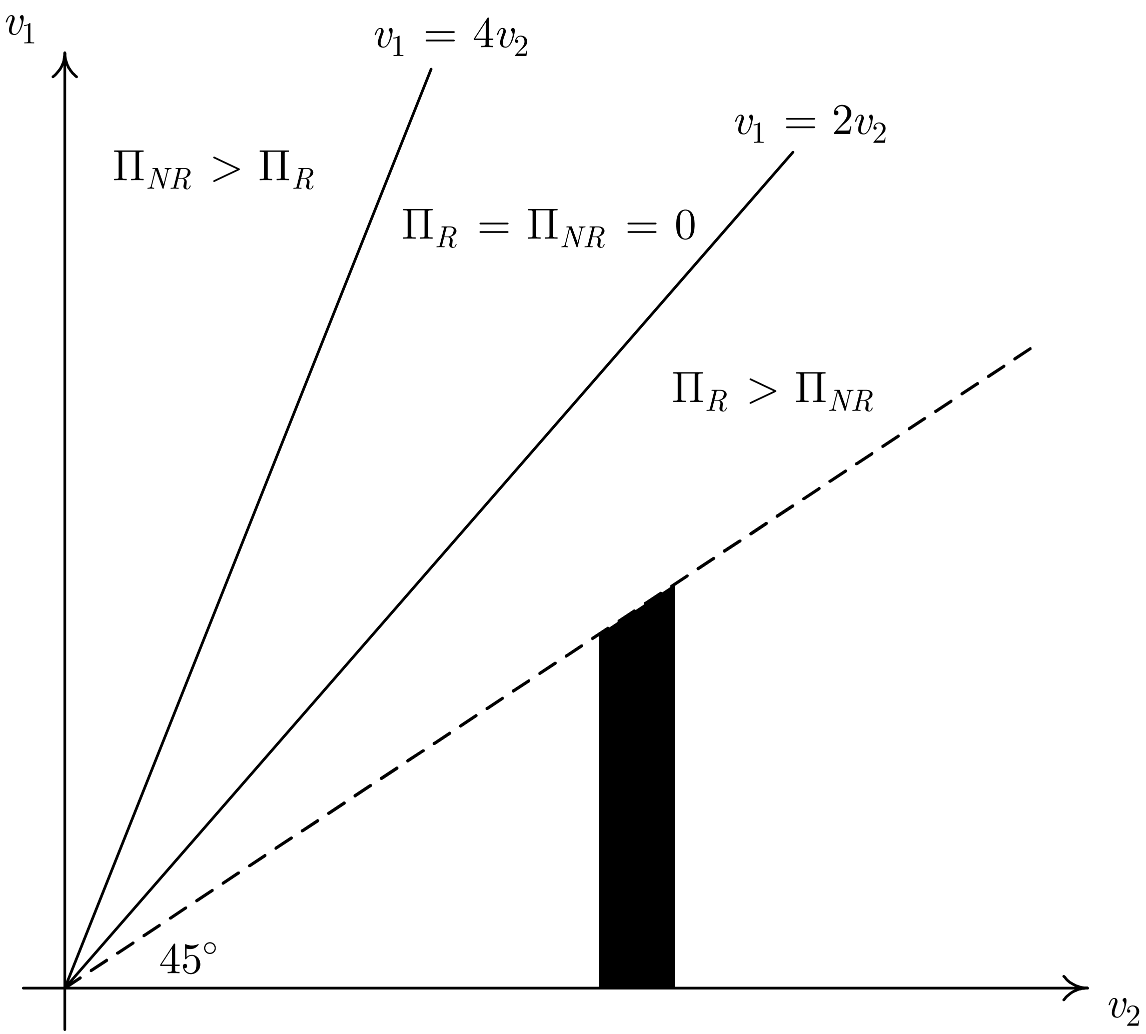
$$\text{seller's revenue is } \Pi_{NR} = \begin{cases} 0 & \text{if } v_1 < 4v_2 \quad \text{(i.e., with DR)} \\ v_2 & \text{if } v_1 > 4v_2 \quad \text{(i.e., without DR)} \end{cases}$$

Scenario 1 vs 2: Effect of Resale

⇒ **Proposition:** *Allowing resale and attracting speculators*

(i) reduce the seller's revenue iff $v_1 > 4v_2$

(ii) increase the seller's revenue iff $v_1 < 2v_2$



Scenario 1 vs 2: Effect of Resale

⇒ **Proposition:** *Allowing resale and attracting speculators*

(*i*) *reduce the seller's revenue iff* $v_1 > 4v_2$

(*ii*) *increase the seller's revenue iff* $v_1 < 2v_2$

(*i*) If bidders' values are **dispersed** ($v_1 > 4v_2$), resale induces DR and reduces seller's revenue, even though it attracts speculators

⇒ *DR Effect* prevails

(*ii*) If bidders' values are **clustered** ($v_1 < 2v_2$), resale eliminates DR and raises seller's revenue, by making B_2 bid high to beat speculators

⇒ *Competition Effect* prevails

(Same qualitative results hold with n bidders and k objects)

Scenario 1 vs 3: Effect of Speculators

- If resale is always allowed:

(1) With speculators: the auction has a DR equilibrium iff:

$$\boxed{v_1 > (k-n)\,v_2} \quad (\dagger) \quad \text{and} \quad \boxed{(k-j+2)\,v_j + v_1 > (k-j+1)\,v_2, \quad j \geq 3} \quad (\ddagger)$$

(3) Without speculators (and with resale): Consider a DR equilibrium in which B_1 wins $(k-n+1)$ units and $B_2, ..., B_n$ win 1 unit each

- B_1 has no incentive to deviate from DR
- if B_2 does not deviate deviate from DR, no bidder deviates
- B_2 does not deviate from DR by outbidding B_j to win $(n-j+2)$ units iff:

$$\pi_2^* = \underbrace{\tfrac{1}{2}\,(v_1+v_2)}_{\text{resale price for 1 unit}} > \underbrace{(n-j+2)\cdot\tfrac{1}{2}\,(v_1+v_2)}_{\text{resale price for } n-j+2 \text{ unit}} - \underbrace{(n-j+2)\cdot\tfrac{1}{2}\,(v_1+v_j)}_{\text{auction price for } n-j+2 \text{ unit}}$$

$$\Leftrightarrow \quad \boxed{(n-j+2)\,v_j + v_1 > (n-j+1)\,v_2, \quad j \geq 3} \quad \underset{\text{since } k>n}{\Leftarrow} \quad (\ddagger)$$

Scenario 1 vs 3: Effect of Speculators

$\Rightarrow$ A DR equilibrium is "easier" without speculators:

$$\left\{ \begin{array}{c} v_i \text{ s.t. DR is an equilibrium} \\ \text{with speculators} \end{array} \right\} \subset \left\{ \begin{array}{c} v_i \text{ s.t. DR is equilibrium} \\ \text{without speculators} \end{array} \right\}$$

- Without a DR equilibrium, speculators cannot reduce the seller's revenue

- **Proposition:** *When resale cannot be prevented,*

  speculators (weakly) increase the seller's revenue

- Low-value bidders can themselves resell to high-value bidders so the *DR Effect* of resale is present even without speculators

  $\Rightarrow$ Speculators only have a *Competition Effect*

Seller's Strategy: Summary

- *If the seller cannot prevent resale,*
  he should always allow speculators to participate
- *If the seller can prevent resale and knows bidders' relative values, he should:*
  allow resale to attract speculators if bidders' values are clustered,
  prevent resale if bidders' values are dispersed

$$\Rightarrow \begin{cases} \text{Bidders accommodating speculators is bad news for the seller} \\ \text{Speculators increase seller's revenue only if they are outbid} \end{cases}$$

Scenario 2 vs 3: Effect of Resale without Speculators

- If there is no speculator:

(2) Without resale, DR is not an equilibrium iff bidders' vales are dispersed

(3) With resale, bidders' "values" are closer to each other and there is no countervailing effect on the number of competitors

$\Rightarrow$ Resale makes a DR equilibrium "easier"

$\Rightarrow$ **Proposition:** *With no speculator who may participate in the auction, allowing resale reduces the seller's revenue when it induces bidders to reduce demand*

- But without a DR equilibrium, resale may increase the seller's revenue because it may induce bidders (apart from B_1) to bid more aggressively

Resale and Efficiency

- Allowing resale is usually claimed to increase efficiency by letting bidders exploit profitable trade opportunities

- However:

(i) Since allowing resale may reduce the seller's revenue, the seller may face a *trade-off between revenue and efficiency*

(ii) If the resale market is not necessarily efficient (e.g., bidders are unable to trade with positive probability) *allowing resale reduces efficiency* when it induces a DR equilibrium

Inefficient Resale Market

- 2 units, 2 bidders ($v_1 = 10$, $v_2 = 2$), no speculator
- With probability $\frac{1}{4}$ resale does not take place

$\Rightarrow$ In the resale market B_1 and B_2 obtain expected surplus $\frac{3}{4} \cdot \left[\frac{1}{2}(10-2)\right] = 3$

	1st unit	2nd unit
B_1	10	10
B_2	2	2

$\overset{\text{resale}}{\Rightarrow}$

	1st unit	2nd unit
B_1	$10-3$	$10-3$
B_2	$2+3$	$2+3$

- B_1 can win the 2 units in the auction at price 5 and obtain profit 10 ... but ...
- With DR $\left\{\begin{array}{l} B_1 \text{ bids } (7;\ 0) \\ B_2 \text{ bids } (5;\ 0) \end{array}\right\}$, B_1 obtains $\pi_B = \underbrace{10-0}_{\text{auction profit}} + \underbrace{3}_{\text{resale surplus}} = 13$

$\Rightarrow$ With resale, B_1 prefers DR and the allocation is inefficient with prob. $\frac{1}{4}$

- Without resale, B_1 outbids B_2

$\Rightarrow$ Allowing resale reduces efficiency with prob. $\frac{1}{4}$

(This holds iff $\Pr[\text{resale}] > \frac{2(v_1 - 2v_2)}{v_1 + v_2}$ and $v_1 > 2v_2$)

Empirical Evidence

- The model's predictions are:

1. Resale price > (multi-object) auction price
(since bidders trade in resale market only after reducing demand in auction)

e.g.: – 1980s New Zealand auctions for import licenses
(McAfee, Tacks & Vincent, *RAND* '99)
– Italian treasury auctions

2. Auction price when speculators lose > auction price when speculators win

⇒ Inverse relation between trading volume in the resale market
(by auction speculators) and auction price

Conclusions

- Speculators are attracted by the possibility of resale
- In *multi-object* auctions, high-value bidders may let speculators win in order to keep the auction price low

- Resale and speculators $\left\{ \begin{array}{l} \text{increase competition } \textit{but} \\ \text{affect bidders' incentives to reduce demand} \end{array} \right.$

$\Rightarrow$ When bidders' values are *dispersed*, although resale attracts speculators, it induces accommodation by bidders and reduces the seller's revenue

- Speculators may increase the seller's revenue only if they eventually lose

- Without speculators, resale is even more likely to reduce the seller's revenue