Single Item Auctions

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Outline

1. Introduction

2. Auction Protocols
   - Common Auction Protocols
   - Revenue and Optimal Auctions
   - Common Value Auctions

3. Vulnerabilities in Auctions
   - Bidder Collusion
   - Misbehaving Auctioneers
   - Information Revelation
   - Sniping

4. Summary
Auctions

- Methods for allocating goods, tasks, resources,...
- Participants
  - auctioneer
  - bidders
- Enforced agreement between auctioneer and the winning bidder(s)
- Easily implementable (e.g. over the Internet)
- Conventions
  - Auction: one seller and multiple buyers
  - Reverse auction: one buyer and multiple sellers

Today's lecture will discuss the theory in the context of auctions, but this applies to reverse auctions as well (at least in 1-item settings).
Auction Settings

- **Private value**: the value of the good depends only on the agent’s own preferences
  - e.g. a cake that is not resold or showed off
- **Common value**: an agent’s value of an item is determined entirely by others’ values (valuation of the item is identical for all agents)
  - e.g. treasury bills
- **Correlated value (interdependent value)**: agent’s value for an item depends partly on its own preferences and partly on others’ value for it
  - e.g. auctioning a transportation task when bidders can handle it or reauction it to others
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All Pay Auction

- **Protocol:** Each bidder is free to raise their bid. When no bidder is willing to raise, the auction ends and the highest bidder wins. All bidders pay their last bid.

- **Strategy:** Series of bids as a function of agent’s private value, prior estimates of others’ valuations, and past bids

- **Best strategy:**
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4. Summary
Four Common Auctions

- English auction
- First-price, sealed-bid auction
- Dutch auction
- Vickrey auction
English auction
aka first-price open-cry auction

- **Protocol:** Each bidder is free to raise their bid. When no bidder is willing to raise, the auction ends and the highest bidder wins. Highest bidder pays its last bid.

- **Strategy:** Series of bids as a function of agent’s private value, prior estimates of others’ valuations, and past bids

- **Best strategy:**

- **Variations:**
  - Auctioneer controls the rate of increase
  - Open-exit: Bidders have to openly declare exit with no re-entering possibilities
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- **Protocol**: Each bidder submits one bid without knowing others’ bids. The highest bidder wins the item at the price of its bid.

- **Strategy**: Bid as a function of agent’s private value and its prior estimates of others’ valuations.

- **Best strategy**: 
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- **Strategy**: Bid as a function of agent’s private value and its prior estimates of others’ valuations
- **Best strategy**: 
Example

Assume there are 2 agents (1 and 2) with values \( v_1, v_2 \) drawn uniformly from \([0, 1]\). Utility of agent \( i \) if it bids \( b_i \) and wins is \( u_i = v_i - b_i \).

Assume that agent 2’s bidding strategy is \( b_2(v_2) = v_2/2 \). How should 1 bid? (i.e. what is \( b(v_1) = z \)?).

\[
U_1 = \int_{z=0}^{2z} (v_1 - z) \, dz = (v_1 - z)2z = 2zv_1 - 2z^2
\]

Note: given \( z = b_2(v_2) = v_2/2 \), 1 only wins if \( v_2 < 2z \)

Therefore,

\[
\arg \max_z [2zv_1 - 2z^2] = v_1/2
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Similar argument for agent 2, assuming \( b_1(v_1) = v_1/2 \).
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Example

Assume that there are 2 risk-neutral bidders, 1 and 2.

- Agent 1 knows that 2’s value is 0 or 100 with equal probability
- 1’s value of 400 is common knowledge

What is a Nash equilibrium?
Dutch auction

Descending auction

- **Protocol:** Auctioneer continuously lowers the price until a bidder takes the item at the current price
- **Strategy:** Bid as a function of agent’s private value and prior estimates of others’ valuations
- **Best strategy:**
  - Dutch flower market, Ontario tobacco auctions, Filene’s basement,...
Dutch auction

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Dutch (Aalsmeer) flower auction
Vickrey Auction
aka Second price, sealed bid auction

- **Protocol:** Each bidder submits one bid without knowing the others’ bids. The highest bidder wins and pays an amount equal to the second highest bid.

- **Strategy:** Bid as a function of agent’s private value and its prior estimates of others’ valuations.

- **Best strategy:**
  - Widely advocated for computational multiagent systems
  - Old (Vickrey 1961) but not widely used by humans
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Vickrey auction

The Vickrey auction is a special case of the Clarke Tax.

- **Who pays?**
  - The bidder who takes the item away from the others (making the others worse off)
  - Others pay nothing

- **How much does the winner pay?**
  - The declared value that the good would have had for the others had the winner stayed home (second highest bid)
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Results for Private Value Auctions

- Dutch and first-price sealed-bid auctions are strategically equivalent
- For risk neutral agents, Vickrey and English auctions are strategically equivalent
  - Dominant strategies
- All four auctions allocate item efficiently
  - Assuming no reservation price for the auctioneer
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4. Summary
Revenue

Theorem (Revenue Equivalence)

Suppose that

* values are independently and identically distributed and
* all bidders are risk neutral.

Then any symmetric and increasing equilibrium of any standard auction, such that the expected payment of a bidder with value zero is zero, yields the same expected revenue.

Revenue equivalence fails to hold if agents are not risk neutral.

* Risk averse bidders: Dutch, first-price $\geq$ Vickrey, English
* Risk seeking bidders: Dutch, first-price $\leq$ Vickrey, English
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Optimal Auctions
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Common Value Auctions

In a common value auction, the item has some unknown value and each agent has some partial information about the value. Each agent $i$ has signal $X_i \in [0, \omega_i]$. The value $V$ of the item is

$$V = v(X_1, \ldots, X_n)$$

**Examples**
- Art auctions and resale
- Construction companies effected by common events (e.g. weather)
- Oil drilling
Common Value Auctions

- At time of bidding the common value is unknown
- Bidders may have imperfect estimates about the value
- True value only observed after the auction has taken place
Winner’s Curse

- No agent knows for sure the true value of the item
- The winner is the agent who made the highest guess
- If bidders all had “reasonable” information about the value, then the average of all guesses should be correct
  - i.e. the winner has overbid!

Agents should shade their bids downward (even in English and Vicrey auctions).
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Results for Non-Private Value Auctions

- Dutch and first-price sealed-bid are strategically equivalent
- Vickrey and English are not strategically equivalent
- All four auctions are efficient

**Theorem (Revenue Non-Equivalence)**

*With more than 2 bidders, the expected revenues are not the same:*

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Bidder Collusion

Example: $v_1 = 20$ and $v_i = 18$ for other bidders.

- Collusive agreement for English auction: 1 bids 6 and others bid 5. This is self-enforcing.
- Collusive agreement for Vickrey auction: 1 bids 20 and others bid 5. This is self-enforcing.
- In first-price or Dutch auction, if 1 bids below 18, others are motivated to break the collusion.
- Need to identify coalition parties.
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Misbehaving Auctioneers

- Shill bidding is bidding to artificially increase an item’s price.
  - In theory, only a problem in non-private value auctions
  - English and all-pay auctions are vulnerable
    - Classic analysis ignores the possibility of shills
  - Vickrey, first-price, and Dutch are not vulnerable

- In Vickrey auction, auctioneer can overstate 2nd highest bid
- Auctioneer can refuse to sell once the auction has closed
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Undesirable Information Revelation

- Vickrey and English auctions reveal agents’ strategic marginal cost information since truthful bidding is a dominant strategy
  - Observed problems with subcontractors
- First-price and Dutch may not reveal this information as accurately
  - No dominant strategy and bidding decisions depend on beliefs of others
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Sniping

Sniping is bidding very late in the auction in the hopes that other bidders do not have time to respond. This is a real issue in online auctions.

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Predicted contribution to late bidding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic hypotheses</strong></td>
<td>All three strategic hypotheses suggest more late bidding on eBay than on Amazon, with a bigger effect for more experienced bidders. Plus (via the third point) more late bidding in categories in which expertise is important than in categories in which it is not.</td>
</tr>
<tr>
<td><em>Rational response to naïve English auction behavior or to shill bidders:</em> bidders bid late to avoid bidding wars with incremental bidders.</td>
<td></td>
</tr>
<tr>
<td><em>Collusive equilibrium:</em> bidders bid late to avoid bidding wars with other like-minded bidders.</td>
<td></td>
</tr>
<tr>
<td><em>Informed bidders protecting their information:</em> e.g. late bidding by experts/dealers.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-strategic hypotheses</strong></td>
<td>No difference between eBay and Amazon.</td>
</tr>
<tr>
<td>Bidders bid late because …</td>
<td></td>
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<tr>
<td><em>of procrastination;</em></td>
<td></td>
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<tr>
<td><em>search engines present soon-to-expire auctions first;</em></td>
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<tr>
<td><em>of a desire to retain flexibility to bid on other auctions offering the same item;</em></td>
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<tr>
<td><em>they remain unaware of the proxy bidding system;</em></td>
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<tr>
<td><em>of an increase in the willingness to pay over time caused by, e.g., an endowment effect; or because</em></td>
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<td><em>bidders don’t like to leave bids “hanging.”</em></td>
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</table>
Sniping

Figure 1a–Cumulative distributions over time of bidders’ last bids
Sniping

Figure 1b—Cumulative distributions over time of auctions’ last bids
Summary

- Auctions are nontrivial but often analyzable
  - Important to understand merits and limitations
  - Unintuitive auctions may have better properties (i.e. Vickrey auction)
- Choice of a good auction depends on the setting in which the protocol is used