MANAGERIAL ECONOMICS

LECTURE 9: AUCTIONS

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Aims of this lecture

- Explain how auctions work
- Describe the importance of auctions
- How to use auctions in strategic decisions

A short history of auctions

It is an old form of market transaction:

- Ancient Greece, Babylon: Mineral rights, women
- Roman authorities:
  - Collected debt through auctions of goods (slaves)
- Candle auctions:
  - Auction is limited until a candle burned out
- Procurement auctions
  - Government sells rights: To build motorways, schools, ...
- Auction use expanded rapidly with the development of the Internet and e-commerce in the 1990s.
- Radio spectrum: Auctions of bandwidth for mobile telephones

Types of Auctions I

English Auction (ascending-bid):

- Initial bid set at seller's reservation (minimum) price
- Auctioneer bids up using a fixed step size
- Bidders indicate whether they accept the offer or not
- The last bidder buys the good at her bidding price
- Information about willingness to pay is revealed
- Sometimes there are time limits
  - Sniping: When bidders time their bids to the last possible moment (software)
- **Other ascending auctions:** Clock or Japanese auctions
- **Examples:** Art auctions, livestock, online-auctions

Types of Auctions II

Dutch Auction (descending-bid):

- Starts with a high initial price
- The price is lowered over time
- First bidder who accepts buys the good
- Used for Dutch flower auctions
- Very fast format
- Convenient when it is important to auction goods quickly

Types of Auctions III

Sealed-bid auctions:

- One bid per person in a sealed envelope
- First-price sealed bid auction: bidder with the highest bid receives the good at her stated price
- Reverse sealed-bid auctions
  - bidder with lowest cost wins
  - public procurement: construction (highway)
- Mineral rights auctions, oil leases

Types of Auctions IV

Second-price sealed-bid auction:

- "Vickrey" auction
  - William Vickrey, Prize in Economic Sciences in Memory of Alfred Nobel 1996
- The highest bidder receives the good, but she has to pay only the price of the second-highest bidder

Why use an auction to sell anything?

- Rules of the auction can easily be changed
- Goods are limited (often unique, but not necessarily)
- A way to elicit willingness to pay from consumers
- Online auctions are easily organized

How do auctions work?

Assumptions:

- Bidders are symmetric
  - Bidders who have identical reservation prices and who observe the same signal will submit the same bids.
  - Bidders select their bid from the same distribution of possible bids
  - But they do not necessarily choose the same bid
- Bidders are risk-neutral (i.e., expectations matter)
- Bids are based on signals from an independent distribution of valuations
  - My valuation of the object does not influence your valuation

Taxonomy of auctions

- Private-value auctions:
  - Bidders have different, private valuations of the good being sold
  - Reservation prices are a function of information and utility
  - E.g., art, paintings, collectors' items
- Common-value auctions:
  - Auctions in which all bidders value the good similarly
  - Each bidder forms expectations about the true value based on (incomplete) information about the good being sold
  - E.g., rights to extract oil from an oil field

Mechanism and Revenues

Revenue equivalence theorem

The type of auction does not affect the expected total surplus and hence does not affect the expected revenues for the seller.

Notation:

- b: bid (an amount of money a customer is willing to pay for a good)
- p: price paid by winning bidder
- $P[W]$: probability of winning the auction
- Expected profit: $P[W] \times (b - p)$
- Expected profit is the same for the four types of auctions.

Optimal bidding strategies

- Bidders should always be willing to bid up to their reservation prices.
  - If the current bid is higher than or equal to your reservation price, don't bid.
  - If the current bid is lower than your reservation price, increase the bid.

Bidding strategies

- **English auction**:
  - Bidders learn about others' reservation prices
  - Always bid up to the reservation price (in fact, bid one cent above the last bid of the others)
  - Good is sold at the reservation price of the *second-highest bidder* (plus 1c or the minimum additional step size)
- **Second-price sealed bid auction:**
  - Dominant strategy to bid exactly the reservation price
  - Vickrey auction is a "revealing mechanism":
    - The design of the auction ("the game") provides bidders with an incentive to reveal their true willingness-to-pay
    - The study of such mechanisms, "mechanism design", has become an important branch of economics.

Dutch and sealed-bid auction

The bidder's problem: Should you write your true WTP in the envelope in a first-price sealed-bid auction? Dutch and first-price sealed bid auction are strategically similar

- There is no dominant strategy; you have to consider what the others are bidding
- In a Dutch auction: you should not bid your reservation price, because if you buy the good, there is no surplus.
- If the distribution of valuations is known, bidders can anticipate bidding.
- Nash strategy: assume others are behaving rationally; then you should maximize your expected profit

Dutch and sealed-bid auction II

Nash-strategy:

- Estimate the reservation price of the second-highest bidder and bid it.
- How to do it?
- Number of bidders n is important: the more bidders, the closer you should bid to your own reservation price
- Example: If distribution of bids is uniformly distributed between L (lowest value) and v (the bidder's reservation price):
- Bid: $v - [(v - L)/n]$

Example

Consider a descending auction or a first-price sealed-bid auction:

- Assume: $v = 3$
- Assume: $L = 0$
- $n = 2$: Your bid $= 3 - [(3 - 0)/2] = 1.50$
- $n = 3$: Your bid $= 3 - [(3 - 0)/3] = 2.00$

Efficiency vs. Expected revenues

- The seller aims at getting the highest possible revenues
- Another aim is to sell the item to the bidder with the highest valuations
- Consider procurement auctions where the government is the seller:
  - E.g., license to construct a highway
  - Aim: to guarantee lowest construction cost
  - Bidder with lowest cost estimate should get the deal.
- With symmetry, all four auction formats are efficient

Optimal Strategy for the Seller

Auctions can be interpreted as being similar to *third-degree price discrimination*

Example:

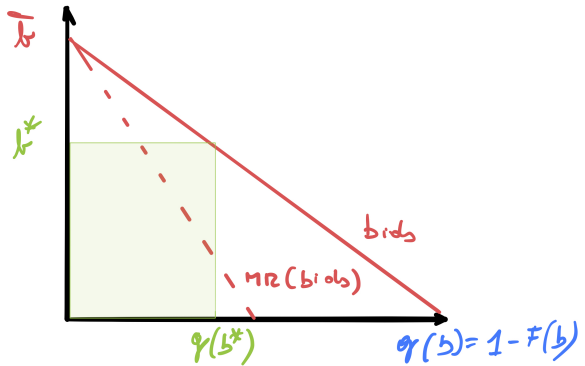
- Four units to sell, $MC = 0$
- Six consumers with different WTP: 90, 60, 50, 40, 20, 15
- Expected revenues from an ascending auction vs. a fixed price of 40?

Calculation of expected revenues

Consumers	Reservation price	Consumer surplus	
		Price = 40	Auction
1	90	50	29.99
2	60	20	9.99
3	50	10	9.99
4	40	0	19.99
5	20	–	–
6	15	–	–
Total consumer surplus		80	69.96
Total seller surplus		160	170.04
Total surplus		240	240

Notes: The auction is an ascending auction where customer 1 bids 60.01 to win the object, et cetera. Maximum surplus with these valuations is 240. (Why?) With an auction, sellers can obtain a greater share of the overall surplus. Tables 13.1 and 13.2 in Allen et al., *Managerial Economics* (8th ed.), p511.

Seller's expected revenue and Bidder's expected marginal revenue



Notes: Bidder i values a good at $\bar{b}$, this is the maximum she is willing to pay for it. Her bid and all other bids are from some distribution $F(b)$. The probability that a bid is the winning bid is given by $1 - F(b)$. Each point on the curve b is the probability that this is the winning bid. Denote b^* the actual winning bid (in this case, the reservation price of the second highest bidder). The seller's expected revenue is $b^*[1 - F(b^*)]$, this is the shaded area. This is also the expected marginal revenue of the winning bid. Figure 13.1 in Allen et al., *Managerial Economics* (8th ed.), p511.

Auctions to obtain more information about buyers

Consider a Repurchase Tender Offer (RTO), where a company wants to buy back shares from current shareholders:

- The RTO typically offers a premium over the current price at the stock exchange as owners are not required to sell
- The company may offer a price and wait how many shares will come back
- It could use a Dutch auction: firm announces a price range and current shareholders announce how many stocks they would sell for different prices
- These announcement are aggregated to the market supply

Citizens First's RTO

- Company wants to buy back 391,000 shares which were values at $14 per share
- Company assumes share is worth $20
- Modified Dutch auction TO (MDATO): Company will pay between $15 and $17 per share

Shareholder supply schedule

Price	Strong	Π_{Strong}	Medium	Π_{Medium}	Weak	Π_{Weak}
15	400,000	2,000,000	310,000	1,550,000	280,000	1,400,000
16	415,000	1,660,000	400,000	1,600,000	315,000	1,260,000
17	600,000	1,800,000	415,000	1,245,000	400,000	1,200,000
Probability	0.4		0.3		0.3	

Notes: Assumed distribution of current shareholders' willingness to tender. Probability states the chances of such a state of the world. Π give the profits if the true value of the share is $20. Table 13.3 in Allen et al., *Managerial Economics* (8th ed.), p517.

Fixed-price RTO

To set an optimal fixed price, Citizens First will have to assume how the willingness to sell is distributed among its current shareholders. (See previous slide for assumed distributions.)

The firm might set a price based on the expected value

- $EV(15) = 2.0 \times 0.4 + 1.55 \times 0.3 + 1.4 \times 0.3 = \$1.685$
- $EV(16) = 1.66 \times 0.4 + 1.6 \times 0.3 + 1.26 \times 0.3 = \$1.522$
- $EV(17) = 1.8 \times 0.4 + 1.245 \times 0.3 + 1.2 \times 0.3 = \$1.453$

The firm might therefore choose a price of 15.

MDATO

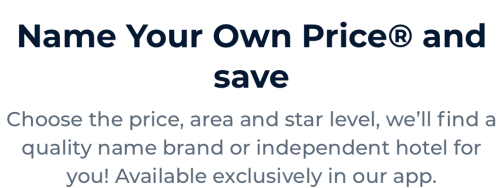
The price is set only after the auction, based on the response.

- The firm can exploit the response from the current shareholders: if the response is strong, it cab set the price at $15, if the response is medium, the price is set at $16, and the response is weak, the price will be set at $15.
- $EV = 2.0 \times 0.4 + 1.6 \times 0.3 + 1.4 \times 0.3 = \$1.700$
- The firm can now set a higher price in one of the cases, obtaining a greater profit.
- How does it work?
  - Importance of incentives to reveal the correct supply schedule (“truth-telling mechanism”)
  - Contract is needed: shareholders cannot sell more shares at the specified price (otherwise they would lie)

Auctions of airtickets

priceline:

- Auction for airline seats
- Airline seats are perishable goods, marginal costs are low, empty seats bring no cash
- Discounts endanger pricing structure of regular seats
- Buyers name the price they are willing to pay: if an airline accepts, the ticket is sold



Risk aversion

- In second-price auctions risk-aversion does not matter. (Why?)
- What about a first-price auction or Dutch auction?
  - Higher bids increase probability of winning
  - If risk-averse bidders want to avoid losing, they will increase their bid
- If bidders can be assumed to be risk-averse, then sellers should chose first-price auctions!

Asymmetries

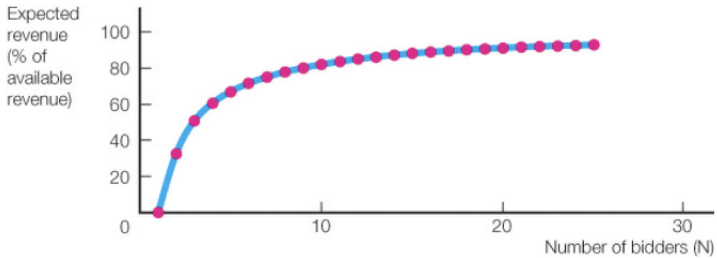
- In second-price auctions it does not matter whether bidders are asymmetric. (Why?)
- What about a first-price auction or Dutch auction?
  - Bidders with higher valuations will underbid more (“shade”) than bidders with lower valuations
  - Bidders with lower valuations may win, this is inefficient
- If bidders are (expected) asymmetric, then sellers should choose ascending auctions
  - But: It is easier for bidders to collude in ascending auctions

Number of bidders

More bidders will increase profit for the seller:

- Expected bid (sale) = reservation price of the second-highest bidder.
- Assume reservation price of bidders is uniform between 0 and 100
- Expected revenue for seller:
  - $E[\text{revenue}] = (N-1)/(N+1) \times (\text{highest reservation price})$

$E[\text{revenue}]$ and number of bidders



Notes: The $E[\text{revenue}]$ increases with the number of bidders as the probability of higher bids increases. Figure 13.2 in Allen et al., *Managerial Economics* (8th ed.), p519.

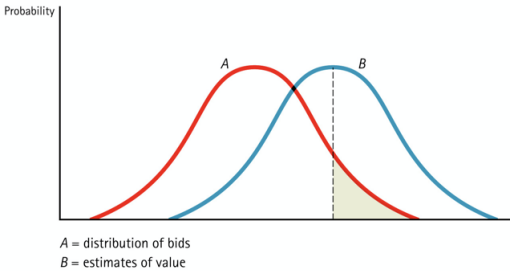
Is it always good to win the auction?

The Winner's Curse

When the true value of the good is unknown, the bidder with the highest bid might bid more than the good is worth.

- Assume That the true value of the good is not known for sure, but *common* to all (e.g., the profits from an oil field)
- Sealed-bid first price auction: The most optimistic bidder wins
- Similar in procurement auctions (reverse auction)

The Winner's Curse



Notes: Unbiased estimates of the good's true value are given by distribution B. The mean of this distribution is indicated by the dashed line. The distribution of bids will be to the left of B, e.g., the distribution given by A. Note that some of the bidders, whose estimates of the true value are in the right tail of A, will bid more than the mean of B. Figure 13.2 in Allen et al., *Managerial Economics* (8th ed.), p519.

How to avoid the winner's curse

- A bidder with relatively less information than others should bid lower.
- A bidder with relatively little confidence in his or her estimate of the value of the good should bid lower.
- *The more bidders there are in the auction, the lower the bid should be!*
- Be also aware of the winner's curse as a seller

Concerns for the seller

1. Collusion:

- Bidders may collude to prevent the seller from extracting surplus.
- Bidders may form a “ring” in which no one bids against the designated bidder. The goods are afterwards distributed among the members of the ring.
- Colluding bidders do not bid up prices.
- Collusion is more probable in multi-unit auctions (several units of a good are sold) or if the auction is repeated over time (different highway construction lots)

Collusive bidding

FCC spectrum auction: simultaneous ascending auctions for frequencies in *different* regions

- Bidders used the last few digits of a bid to encode messages.
- For example, GTE frequently used bids that ended in 483 — this is “GTE” on the telephone keypad.
- In the same auction, American Portable, a daughter of TDS, signaled interest by bids that ended in 837 (“TDS”)
- Firms used such prices to indicate their interest in certain markets and to coordinate their efforts.
- Collusive bidding lowers revenues and efficiency!

Collusive bidding

German GSM auctions:

- 10 equally sized (and valued) blocks of spectrum
- Mannesmann bid 18.18 mio on blocks 1-5 and 20.0 mio on blocks 6-10
- why different bids for equal products?

- T-Mobil increased their bid to 20.0 mio for blocks 1-5
- Both companies ended up sharing the market... “and the auction was over, before it had gained momentum”

Concerns for the seller

2. Few bidders:

- If it is clear to all bidders that one particular bidder will win, they are less likely to participate in the auction.
- If the seller sets a reserve price that is too high, then bidders are less likely to participate in the auction.
- If the seller sets a reserve price that is too low, it encourages collusion.

Strategic PR

Telekom Austria was cited in the newspapers, prior to frequency auctions:

“it would be satisfied with 2 out of the 12 blocks of frequencies on offer”,

but “it would bid for a 3rd block if one of its rivals did”

Further reading

- Auctions and Bidding: A Primer, Milgrom, Paul. 1989.
- What Really Matters in Auction Design, Klemperer, Paul. 2002.
- How Auctions Work for Wine and Art, Ashenfelter, Orley. 1989.
- Economic Insights from Internet Auctions, Bajari, Patrick, and Ali Hortaçsu. 2004.