ECON-C5100 Digital Markets

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Lecture 5: Market design

Agenda

Last week

- Industry structure and equilibrium behavior
- Basics of auction theory

This week

- Designing markets, the case of ad auctions
- Online markets

Uses of game theory in market design

- Study existing markets
  - Identify "the rules of the game," the incentives for the participants, and how they behave. Then try to understand why the market functions well, or not so well.
- Design new markets
  - Identify the economic problem to be solved, the players and their incentives and information. Then try to understand what sort of market rules would lead to a desired outcome.
- Economic theory provides a conceptual framework, but need to use data and experiments to test hypotheses, and identify things models may have missed.

Mechanism design

- Game theory is helpful in describing the rational strategic interactions between agents.
- Mechanism design turns the question around:

  Assuming that the agents will play a strategic interaction game, what should the rules for the game be?

Revelation principle

Given the vast amount of possibilities, is there hope to determine the best possible design? Somewhat surprisingly: Yes!

- Definition of the game:
  - Suppose that we have buyers with a type (private value) v_i and a seller able to commit to some mechanism Γ to sell an item
- Alternative game: Direct mechanisms
  - When reported type v, the seller allocates the good with probability $q(v)$ if the buyer pays $t(v)$
- The *Revelation principle*:
  - Given Γ, a buyer with type v_i chooses the best response $\sigma(v_i)$
  - For every Γ and equilibrium σ there is a *direct* mechanism Γ' which 1) gives the same expected allocation and payoffs as with σ and 2) it is optimal for the buyer to report the true type
  - Task to design allocation and payment rules that are *incentive compatible* and *individually rational*.
- Deeper look in the theory left for further classes.

Designing auctions – Auction mechanisms

- From last week, what to expect in a Nash equilibrium:
  - In an efficient allocation the high value bidder wins.
  - Expected revenue is the same in many auction methods.
- Is there a potential to improve the expected revenue for the seller? Yes, in particular by
  - Introducing reserve prices.
  - Increasing competition.

Effect of reserve prices to revenues

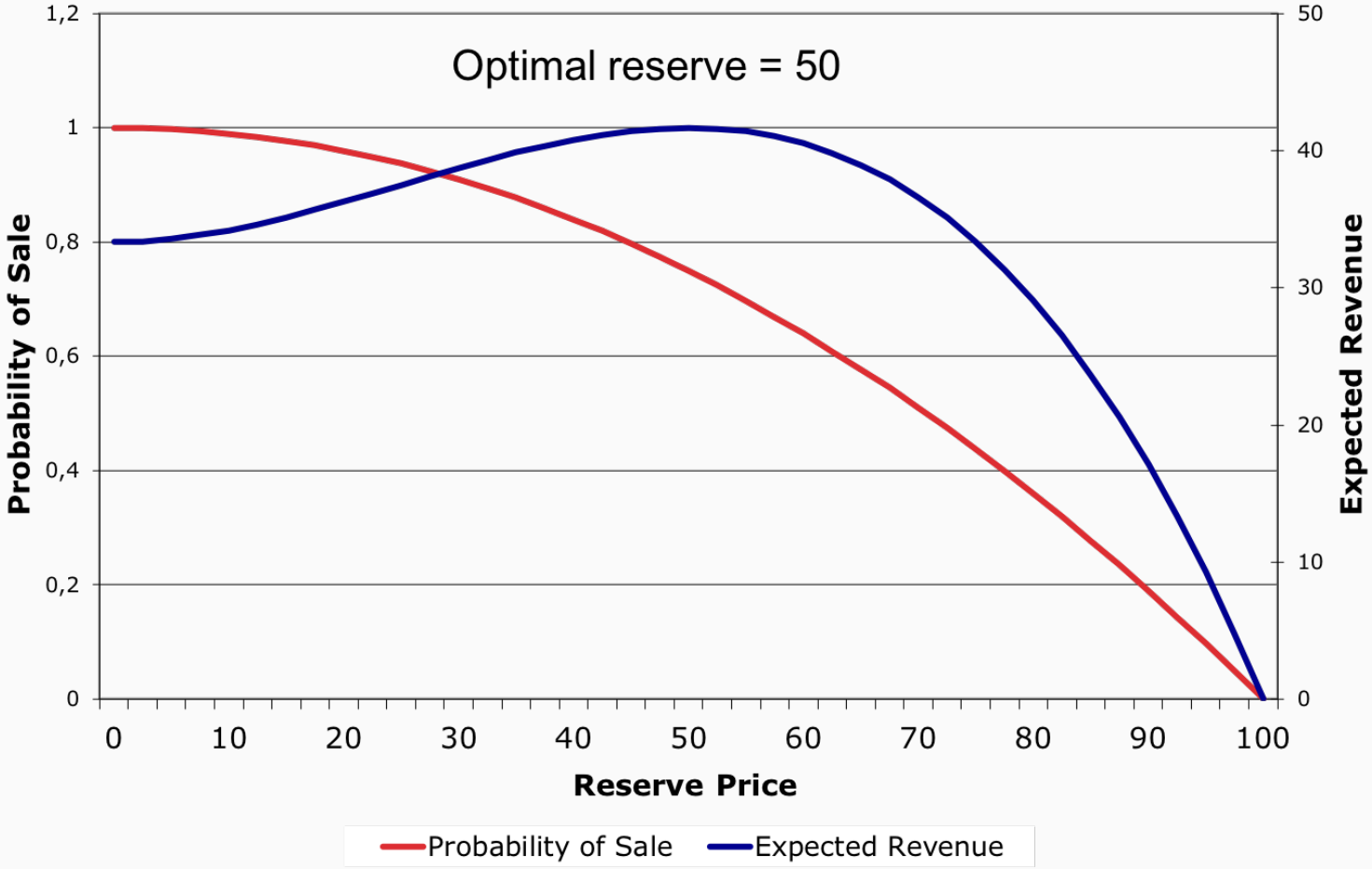


Figure. Optimal reserve price for N=2 in an ascending price auction.

Figure: J. Levin.

Example from eBay auctions

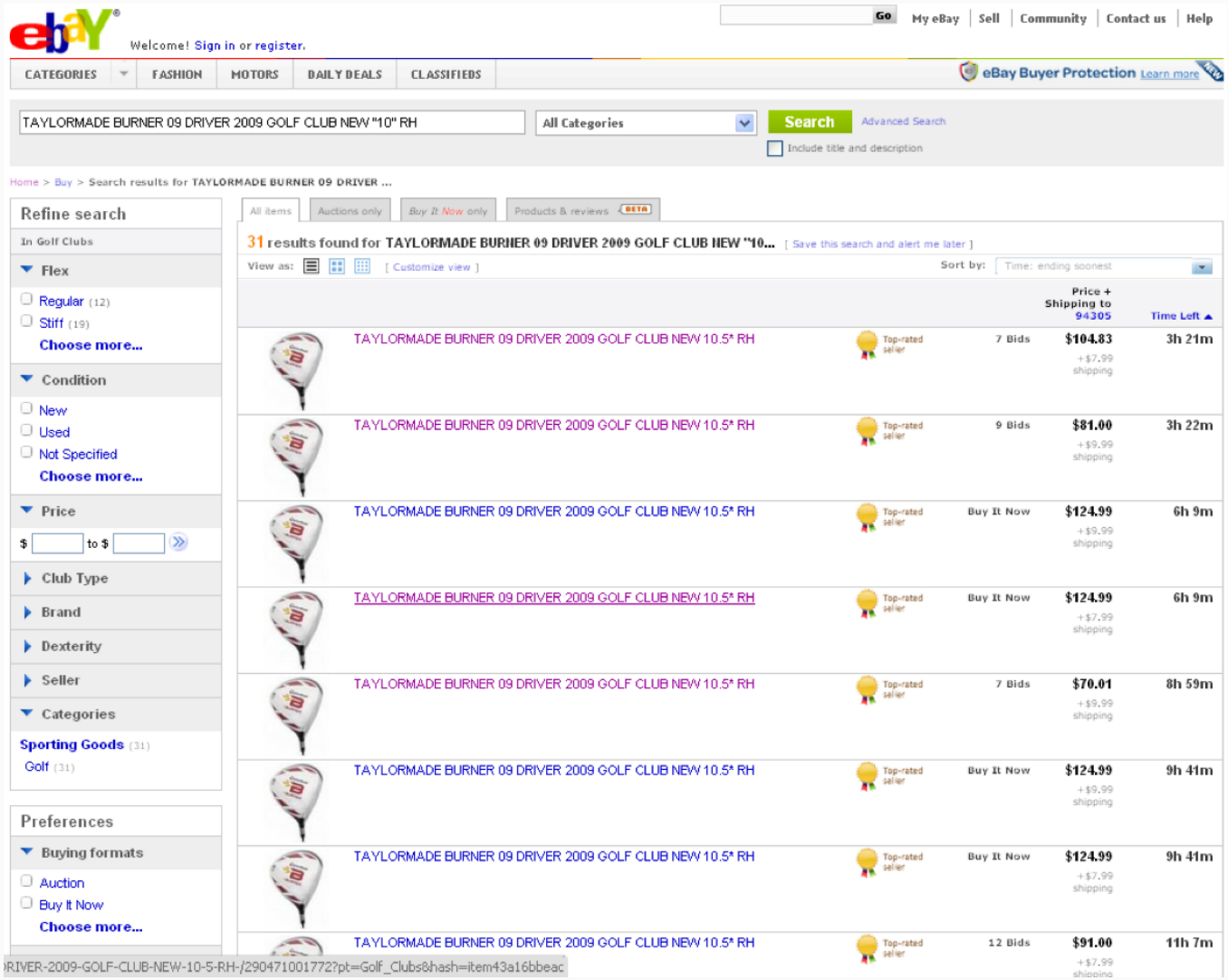


Figure: Einav et al. 2012.

Example from eBay auctions

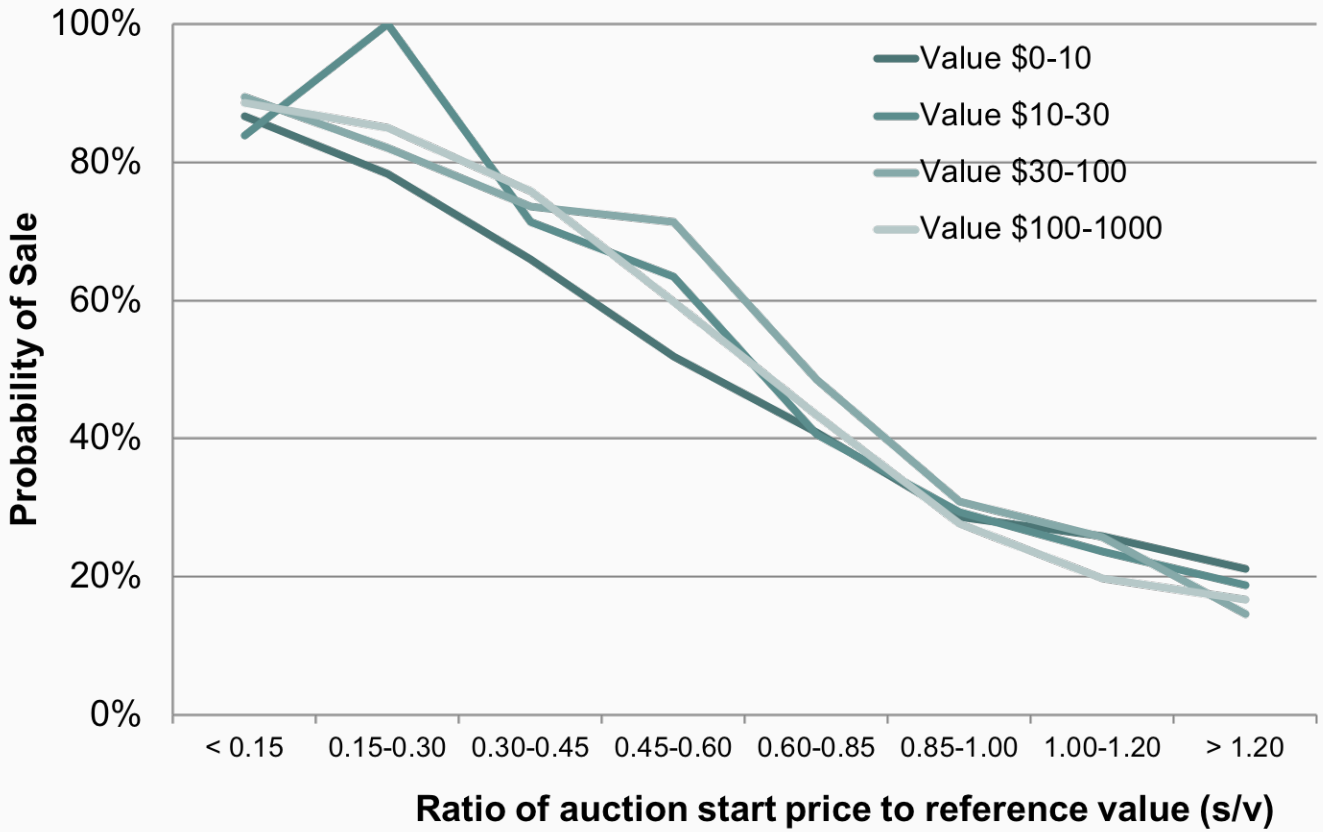
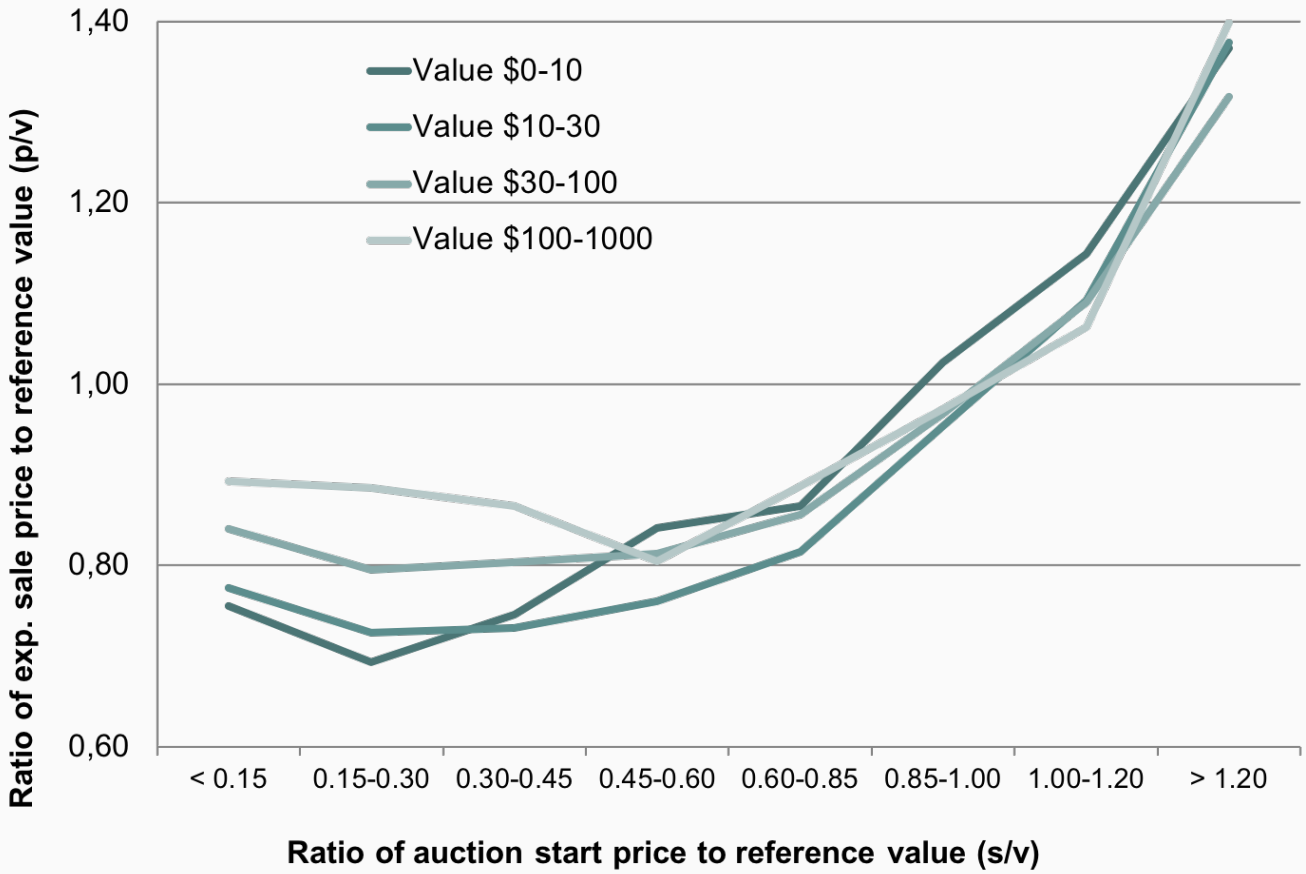


Figure. Impact of reserve price to sales probability.

Figure: Einav et al. 2012.

Example from eBay auctions



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Optimal mechanisms

- Myerson (1981): Expected revenue maximizing auction is the second price auction with a reserve price.
  - With some assumptions on buyer valuations (independently drawn from a regular distribution).
- But reserve prices can introduce inefficiency:
  - If the reserve price is not met, then there is no trade even though some buyer might have been willing to buy above cost.
- Trade-off between efficiency and extracting information.

Trade-off between reserve prices and competition

- What if the number of buyers is not fixed? Is more competition or optimal reserve prices better?
- Bulow-Klemperer (1996) find:
  - The expected revenue of the second-price auction on $n+1$ agents is at least the expected revenue of the optimal auction on n agents.
- For the seller, it is better to recruit one more bidder for a second-price auction without a reserve price than to run the optimal auction with reserve price.

Now to ad auctions

Global ad spend estimated to be 650 billion U.S. dollars in 2020:

- 30 % to TV
- 23 % to Google
- 13 % to Facebook

Source: CNBC, 24 Oct 2019.

Ad auctions

- Google ad auctions were introduced in 2002. Auctions are now widely used for selling advertisement space online.
- Advertisers send their money bids by search term:
  - E.g. loans, vodka, head ache, rehabilitation.
  - Offer a payment per click.
- Google arranges separate ad auctions for *every query*.
  - Conditional on sufficient number of bidders.
- Ad space also auctioned outside Google search.
  - Various mechanisms, including first price auctions.

Example: Google search

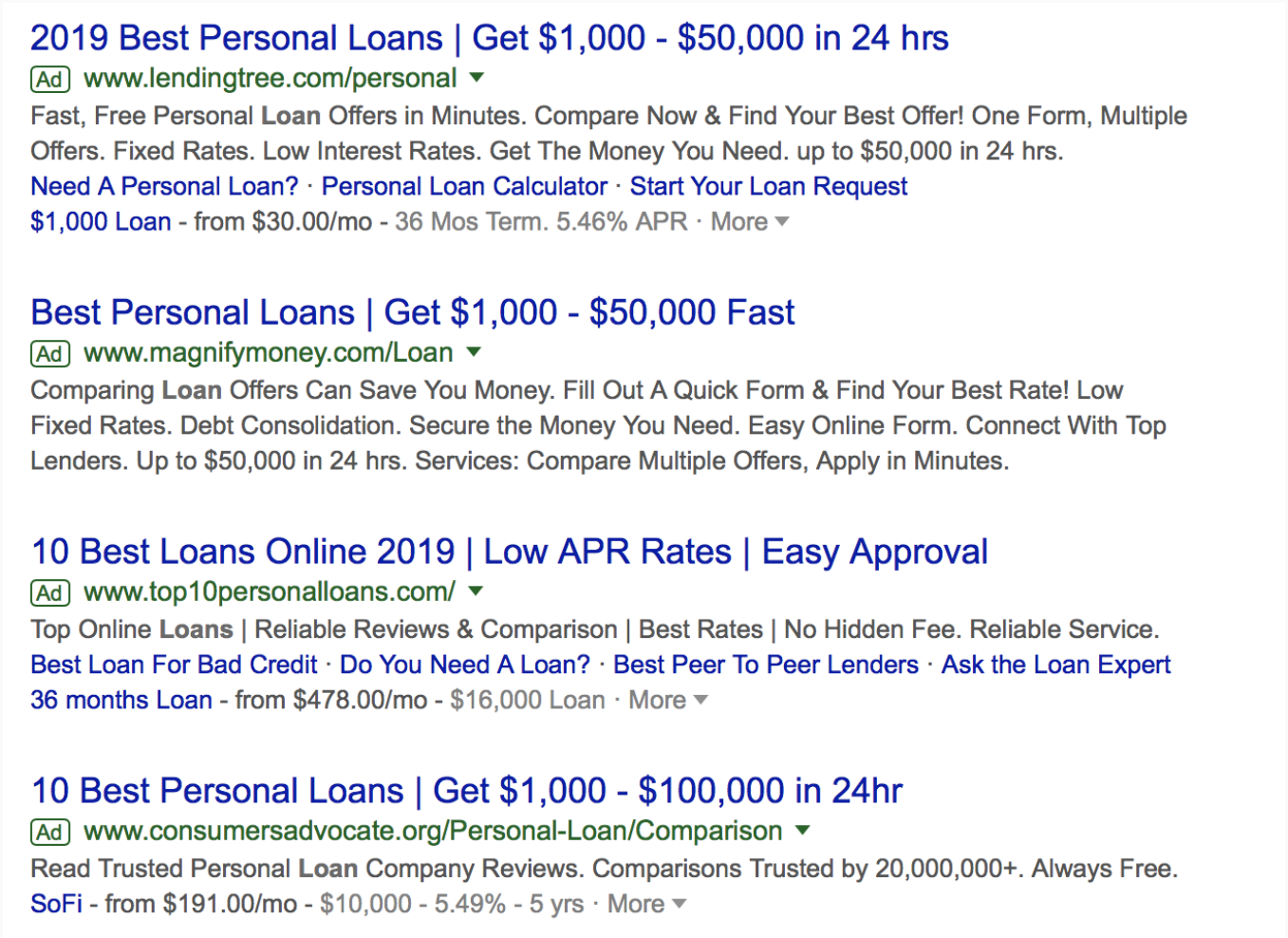


Figure. Search for "loans" in Google (U.S.).

Figure: Google.

Ad auctions

- Possibly several positions for sale.
- Auction mechanism is a "generalized second price" auction.
  - Positions are assigned in the order of bid.
  - Advertisers submit a single bid.
  - Advertisers pay the bid of the advertiser in the position below.
- If only one position, reduces to a second price auction.

Ad auctions

Assumptions:

- Positions $k = 1, \ldots, K$ and bidders $i = 1, \ldots, N$.
- Each position gets x_k clicks per day: $x_1 > x_2 > \cdots > x_K$.
- Each bidder has value v_i per click: $v_1 > v_2 > \cdots > v_N$.

This leads to:

- For bidder i, the value of position k is $v_i * x_k$.
- For bidder i, the profit from buying k is $(v_i - p_k) * x_k$.

Example: Ad auctions

- Two positions: receive 200 and 100 clicks per day.
- Three bidders with values of 10, 5, 2 cents.

	Value in €	
Bidder	1st position	2nd position
1	20	10
2	10	5
3	4	2

Table. Value of positions in € for each bidder.

- In an efficient allocation, the first position goes to the highest bidder and the second position to the second highest bidder.

Example: Ad auctions

- Three bidders bid their values of 10, 5, 2 cents.
- Market clearing prices are determined by the bid (in cents) of the bidder below the winner.

	Value in €		Price
Bidder	1st position	2nd position	in cents
1	20	10	5
2	10	5	2
3	4	2	-

Table. Market clearing prices (if bidders bid their true value).

Goolge ad auctions

- In addition to the auction method above, Google uses a measure for "ad quality":
  - The quality of ad affects clicks, in addition to the position.
  - Google uses its data to predict the quality of an auction, i.e. how many clicks it will receive.
- Bids are made in terms of cost per click.
- Outcome of the auction is determined by ad rank that is calculated as the cost per click (bid) times the ad quality score (Google).
- Potential loss in the efficiency of the monetary allocation.

Auction games

- You can participate with your team or individually.
- Your reservation price, i.e. the maximum price you are willing to pay for the item is determined as follows:
  - For your team, choose the person who would be *last* in alphabetical ordering
  - Take the last two digits of that persons' student number and invert them
  - As an example, I'd have 69 (IIRC)
- You will design an ad and place a bid to get the ad published.

In-class exercise: Ad auction

Bidding rules:

- The ad can be shown in one of two slots.
- You will place a bid in terms of ¢ per click.
- These bids will be multiplied with ad quality.
  - Ad quality is determined by the votes that your ad gets.
- The highest quality weighted bid will get the first slot and the second highest the second slot.
- The winners pay the minimum amount needed to retain their positions.
- Payoff is the difference between the payment and your value, times the number of clicks.

In-class exercise: Ad auction

As an example Iivo V. could bid of 69 ¢ for his ad as follows:

IV: Economics is your new superpower, click to learn more! (69).

Use the vote in Presemo presemo.aalto.fi/digimar to place bids.

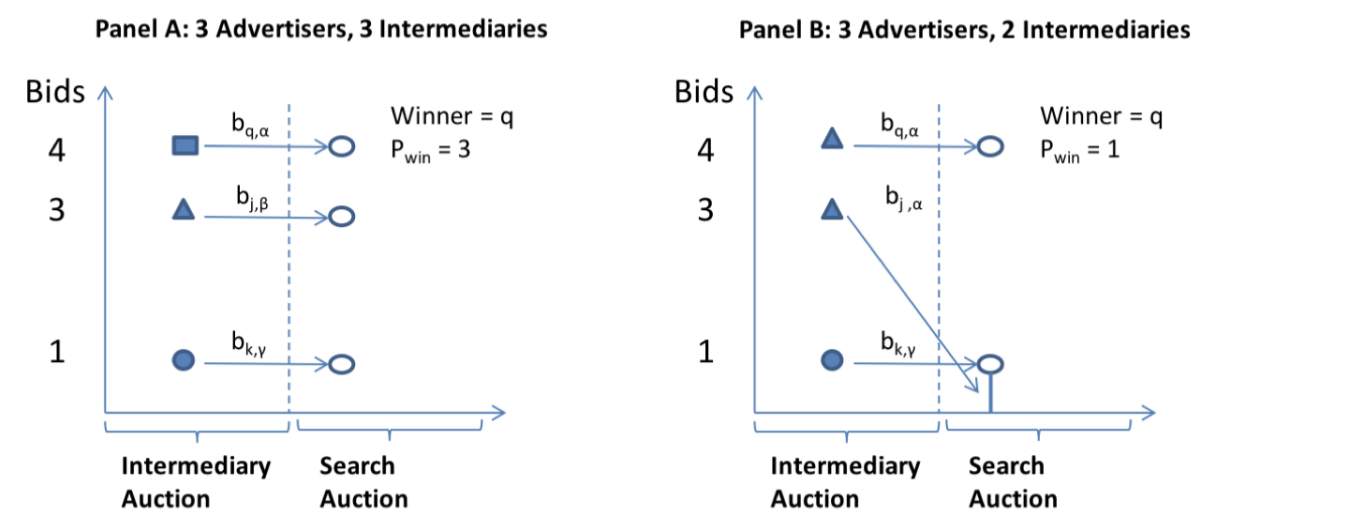
Discussion.

Further detail on auctions

- Generalized second price auction
  - Adopted early, dominant in search ad auctions.
  - "Easy" to understand.
  - Exposed to collusive bidding strategies.
- Vickrey-Clarke-Groves (VCG)
  - The winning bidder pays the cost their presence imposes on the other bidders.
  - Flexible, e.g. sell only 1 big ad for 3 slots.
  - Strategy proof: Always optimal to bid truthfully.
  - Collusion less of a concern.
  - More complex to understand.
- All auction forms have advantages and disadvantages, no single best mechanism.

Varian and Harris, 2014; Decarolis, Goldmanis and Penta, 2019.

Does it matter if auction scheme is not optimal in theory?



Notes: There are three advertisers (q, j and k) submitting arbitrary bids ($b_q = 4$, $b_j = 3$ and $b_k = 1$) to a second price auction held by the intermediary to which they are affiliated. In panel A, each advertiser has a different intermediary (α, β and γ). In panel B, q and j share intermediary α. The arrows indicate how the intermediary translates the bids in its own auction into the bids placed on the search auction. In panel A, bids are transmitted without distortions; in panel B, j's bid is reduced. q wins in both cases, paying the second highest bid which is either 3 (panel A) or 1 (panel B).

Figure. Example of how an ad intermediary can affect auction outcomes.

Decarolis and Rovigatti, 2019.

Market design in general

- Always a balance between what tasks are left to the competition/game in the marketplace to decide and what is decided by the rules.
- Choice of implementation detail will depend on the desired outcomes.
- There needs to be sufficient enforcement mechanisms in place to ensure that the actual outcomes meet desired outcomes.

Properties of good market design

1. Provide *thickness*
   - Attract a sufficient proportion of potential market participants to come together ready to transact with one another.
2. Overcome the *congestion* that thickness can bring
   - Ensure that market participants can consider enough alternative possible transactions to arrive at satisfactory ones.
3. Make it *safe* to participate in the market as simply as possible
   - As opposed to trading outside of the marketplace or engaging in strategic behavior.
4. Some markets can be *repugnant*: they should not exist.
5. *Experimentation* to diagnose and understand market failures and successes, and to communicate results to policy makers.

Source: Roth 2008.

Materials for this week

Reading assignment 3:

- **Ad auctions**. Easley, David and Jon Kleinberg (2010), Chapter 15 from "Networks, Crowds, and Markets: Reasoning about a Highly Connected World". Read at least Sections 15.1, 15.5, and 15.7.
- **Online markets**. Levin, Jonathan (2011) "The Economics of Internet Markets", NBER Working Papers 16852. Read Section 4.
- **Macro impacts**. Cavallo, Alberto (2018) "More Amazon effects: Online competition and pricing behaviors", NBER Working Paper 25138. Sections I Introduction and VI Conclusions enough.

Next time

Online markets

- Frictions between buyers and sellers
- Use of data
- Macro impacts

Appendix

Reserve prices

- Recall the ascending auction example with two bidder whose values are v_1 and v_2.
- Values are assumed to follow an uniform distribution $[0, 100]$.
- So the expected revenue for the seller is 33 $\frac{1}{3}$.
- What happens is the seller sets a reserve price of r?

Reserve prices

- Seller sets reserve price r and runs an ascending auction.
- Bidding starts from r.
- Three cases
  - Both bidder values below $r \rightarrow$ no sale.
  - One value above r, one below $r \rightarrow$ sale at r.
  - Both values above $r \rightarrow$ sale at lower value.

Impact of competition

	No reserve price		Optimal reserve price	
N	P(sales)	E[revenue]	P(sales)	E[revenue]
1	1	0	0.5	25
2	1	33	0.75	42
3	1	50	0.88	53
4	1	60	0.95	61
5	1	67	0.97	67

Table 1: Impact of competition to sales.

Regardless of the number of bidders, the optimal reserve price in the example is always $r = 50$.