

ECO557: Market Design

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CREST, École Polytechnique

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Introduction of the class

Focus: Auction and Matching

Organization of the Class

- PART I: Auction (by Pierre Boyer)
- PART II: Matching (by Yukio Koriyama)

Lecture notes/slides will be made available.

Course outline

- PART I: Auction

- ▶ Auction theory
- ▶ Auction design
- ▶ Common-value auctions, multi-unit auctions
- ▶ Multi-item auctions and matching
- ▶ Sponsored-search auctions, spectrum auctions, package auctions

- PART II: Matching

- ▶ Two-sided matching, one-to-one matching, one-to-many matching, deferred-acceptance algorithm (Gale and Shapley)
- ▶ Marriage market, residency choice, school choice
- ▶ One-sided matching, top-trading-cycle algorithm
- ▶ Housing allocation, kidney exchange

Introduction

- Market Design is a field in which theoretical developments are actively ongoing, and also there are many real-world applications with great economic successes.
- 2018 John Bates Clark Medal: Parag Pathak
- 2012 Nobel Prize in Economics: Alvin Roth and Lloyd Shapley



Pioneers of market design in economics literature

Lloyd Shapley and Herb Scarf (Journal of Mathematical Economics, 1974):

“How can people trade indivisible goods if everyone needs just one, has one to trade, and can't use money?”

Mandatory reading

Popular book:

Alvin Roth “Who Gets What – and Why: The New Economics of Matchmaking and Market Design” HMH (2015)

Textbooks

- Alvin Roth and Marilda Sotomayor “Two-Sided Matching Markets” Cambridge U. Press (1989)
- Paul Milgrom “Putting Auction Theory to Work” Cambridge U. Press (2004)

Other references:

- Nir Vulkan, Alvin Roth and Zvika Neeman (Ed.) “The Handbook of Market Design” Oxford University Press (2013)

What about you?

- Background
- Interests: why are you here?
- Expectations
- ...

What is Market Design?

- In many problems of resource allocation, using the price system would encounter legal and ethical objections (e.g. allocation of students to public schools, allocation of doctors seeking residencies, finding matching for human organ transplants).
- Furthermore, there are many examples in which traditional assumptions of perfect competition are not satisfied even approximately. In particular, when goods are indivisible and heterogeneous, market for each type of good may be very thin.

What is Market Design?

- In this course, we consider economic allocation problems in which traditional markets with the price system would not function properly, or even not exist, and study how to **design** allocation systems in which desirable properties are satisfied (e.g. efficiency, stability, strategyproofness).

Auctions and Matching \in Market Design

Definition (from NBER's Market Design Working Group):

“Market design” examines the reasons why markets institutions fail and considers the properties of alternative mechanisms, in terms of efficiency, fairness, incentives, and complexity.

Market Design \in Mechanism design

What is mechanism design? The theory of mechanism design deals with the following questions:

- Which economic outcomes are achievable?
- How should we structure the interaction of economic agents so that we achieve a desirable outcome?

Why is this challenging?

- The goals of the mechanism designer and the interests of economic agents are not necessarily aligned.
- The relevant information may be in the hands of the economic agents.

Applications of mechanism design

I. Information Aggregation

- Public Goods
- Regulation of environmental externalities
- **Auctions and Matching**
- Multilateral trade

II. Screening

- Regulation of natural monopolies
- Optimal taxation
- Optimal pricing
- Optimal wage contracts

This course

Objectives

- To understand essential concepts in Market Design
- To see how these concepts can be applied to the problems of designing a marketplace with desirable properties

Two main areas

- Matching Theory (typically, without monetary transfers)
- Auction Theory (typically, with monetary transfers)

Keywords

- Matching, auction
- Efficiency, stability, strategyproofness
- Revenue equivalence theorem, VCG mechanism

What we plan to achieve

- Canonical model of auctions and matching: Workhorses
- Material primarily theoretical but ability to apply this knowledge to practical design of auctions
- Graduate class = Ability to understand (develop) research frontier in market design (reading of research papers/surveys)
- You are going to deliver a great Pitch!

Methods

- Use of economic models
- Models as a tool to develop arguments coherently with a rigorous logical basis
- ⇒ Models provide a guide to the consequences of new policies (few experimentation and past experience cannot always be relied on)
- ⇒ Each model intended to be a simplified description of the part of the economy that is relevant for the analysis
- Incorporation of independent decision-making by firms and consumers

Evaluation

- This course requires intensive participation.
- A chapter of Roth's book (individual) presentation in the first part of the course.
- A pitch (individual) at the end + report on your pitch.

- Lecture notes focuses on common frameworks but frequent references to real-world. One of pitch's objectives is to nudge you into practical market design.
- Empirical counterpart in Applied Econometrics.

Presentation

- Selection of chapters of the book: Now.
- Presentations: October 12th (Roth's book). No slides.
- Preliminary slides pitch: 10 min talk (where are you with your pitch?) on November 9th. Send slides November 6th.
- Presentation of pitch: November 23rd and November 30th (send slides 5 days before presentation). Deadline report on pitch December 14th.

Tips from Al Roth's book for your pitch

- Opportunity to do well by building a good marketplace can arise whenever there are desirable but underused resources that take too much time to find and transfer.
- Marketplaces have to solve the problems of creating a **thick market**, managing **congestion**, and ensuring that participation is **safe and trustworthy**

Tips from Al Roth's book for your pitch

- Opportunity to do well by building a good marketplace can arise whenever there are desirable but underused resources that take too much time to find and transfer.
- Marketplaces have to solve the problems of creating a **thick market**, managing **congestion**, and ensuring that participation is **safe and trustworthy** but they also have to keep solving and re-solving these problems as markets evolve.

Thick market: Buyers like to choose among many sellers, and sellers like to see lots of buyers. But those same buyers don't want a bunch of other eager buyers driving up prices, and sellers hate that competitors might deprive them of a sale.

- Market can move too fast \Rightarrow prevent from having thick market
- Markets unravel so that offers become progressively earlier (could be later too) as participants seek to make strategic use of the timing of transactions (“Jumping the gun”)

E.g. Exploding offers on labor markets: recruiting younger and younger soccer players or X students before 4A.

- Thick markets have good properties

But, excessively slow transactions can hurt the markets...

Congestion: Markets can be too slow or congested.

- So markets have to be quick even when it is thick.
- Careful: Congestion is also one motivation for unraveling.

Safe and trustworthy

- Market participants have to feel safe to communicate essential information they might otherwise keep for themselves (e.g. revealed preferences used against them by auctioneer, reveal some information to other competitors).

E.g. Package auctions instead of one unit at the time for markets where a business plan depends on assembling a package of licenses (e.g. radio spectrum).

- Important that participants understand the rule of the game. Know at what stage they are, how they are doing when multiple items to deal with.

From design to implementation

Implementation:

“Good ideas may not be enough on their own to fix a market.

It's often also necessary to gather broad support from participants to get those ideas adopted and implemented.”

- Not all advices may be adopted: better to figure out what is essential. E.g. Note IPP #41 by Combe et al. (June 2019) and Projet de loi relatif à la bioéthique (July 2019).
- Stability also important in practice: would people matched want to change partner or not. Help avoid unraveling (stable match reduces value of moving late: e.g. keeping open seats in schools).

From design to implementation

Generalist *and* specialist:

- Details matter in design.
- ⇒ Necessary to know formal and informal rules.

Your pitch: more details

Presentation:

- 30-45min including questions (you will get a lot of them).
- Good pitch from previous years: exciting topics, well motivated (i.e. econ motivation: market size, potential growth in the sector, current competitors, etc), good details on actual institutions, use concepts from class, got people in the class onboard...

So a lot of preparation needed!

- Main problems identified: not tried before the day of presentation (use your colleague/friends/family), weak preparation, weak understanding of the rules of the pitch.
- Examples from previous years: platform for real estate exchange, shotgun in X-Forum, time allocation of flight sessions, booking of parking slots in Paris, allocation of permits to drive a car in China (pollution), allocation of seats in a public library, platform to match start-ups and investors or peer-to-peer services.

We will get a session dedicated to give you feedbacks on your pitch.
So start thinking about potential subjects now!

Report:

- 20 pages max (12pt, 1.5 line spacing).
- Introduction. Institutional background. Analysis (model/empirics/mechanism). Results. Concluding remarks (potential for future work).
- Good reports: more analytical details than in the presentation, polished writing, easy to read.

Auctions

Auctions are not a new idea:

- One of the earliest uses of an auction is the “Babylonian Wives” auction reported by Herodotus (~484-425 BC).
- Romans auctioned everything from war booty and slaves to debtors’ property.
- In modern world auctions used to conduct a huge volume of economic transactions.

Sponsored Search Auctions

- Google advertising revenues in 2015 (USD \$ in millions): 67,390 (up from 36,531 in 2011).

- Hal Varian, Google chief economist:

“What people don’t realize is that all that money comes pennies at a time.”

- Main Google revenues comes from selling ads: there is an auction each time someone enters a search query.
 - ▶ Bids in the auction determine the ads that appear at the top of the page.

FCC and Radio Spectrum

- Federal Communications Commission (FCC) regulates the use of electromagnetic radio spectrum: used for broadcast TV, radio, cell phones, etc.
- Why regulate?
 - ▶ There is a limited amount of spectrum.
 - ▶ There are many potential users
 - ▶ There are interference problems if users overlap
- So how should FCC decide who gets a license to use spectrum?
- Historically, licenses were allocated administratively (TV and radio stations) or by lottery.

Coase and Spectrum Auctions

- Coase (1959) suggested that the FCC should auction spectrum licenses.
 - ▶ If there were no transaction costs, the initial assignments of ownership would not matter (the Coase theorem, agents bargain their way to an efficient allocation).
 - ▶ But in the real world, there are transaction costs, so decentralized trade may not lead to efficient allocations.
- In the early 1990s, the FCC started to think about auctions as a way to allocate licenses efficiently, and adopted a new design proposed by Stanford economists.
- Many countries now use auctions that result in billions of government revenue (some failures too, due to poor design).

Spectrum Auctions in France

- In France, spectrum is regulated by the ARCEP (Autorité de régulation des communications électroniques et des postes).
- The auction for the 700MHz band was run between Nov. 16-17 2015:
 - ▶ 6 blocks of 5MHz duplex for sale.
 - ▶ 4 buyers: Bouygues Telecom, Free Mobile, Orange and SFR
 - ▶ All 6 blocks were allocated, the price of a block reached 466M euros for a total revenue of 2.796 billion euros.

**arcep**autorité de régulation
des communications électroniques
et des postes

République Française

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opérateurs mobiles

Derniers avis et →

décisions publiés

Les consultations →

publiques en cours

Fréquences →

(e-spectre / formulaires)

Analyse des marchés →

(tableaux)

Numérotation →

(recherche)

Revue de presse →

Les données en OPEN →

DATA

Actualité / Communiqué de presse

**BANDE 700 MHZ****Début des enchères pour l'attribution des fréquences de la bande 700 MHz**

Paris, le 12 novembre 2015

L'enchère pour l'attribution de la bande 700 MHz démarre lundi. Quatre candidats (Bouygues Telecom, Free Mobile, Orange et SFR) y participent.

Jusqu'à la fin de l'enchère, qui peut durer un ou plusieurs jours, l'ARCEP communiquera chaque jour, en fin de journée, l'état d'avancement de l'enchère, à savoir :

- quel prix par bloc a été atteint en fin de journée ;

- si, à ce prix, l'enchère est terminée (c'est-à-dire que les 4 candidats demandent au total 6 blocs) ou si elle se poursuit le lendemain (c'est-à-dire que les 4 candidats demandent encore, au total, plus que 6 blocs) ;

Tant que l'enchère se poursuit, l'ARCEP ne communiquera aucune information sur les demandes faites par les candidats.

Quand l'enchère s'achèvera, l'ARCEP communiquera la quantité de fréquences obtenue par chaque candidat, ainsi que le prix atteint par l'enchère.

Annexe - rappel du mécanisme d'enchère

Pour rappel, l'enchère se déroule sur les 6 blocs de 5 MHz duplex en même temps, avec un prix unique par bloc.

Tout au long de la procédure, l'ARCEP, à la manière d'un commissaire-priseur, augmente le prix graduellement :

- Au tour initial, l'ARCEP demande aux candidats combien de blocs ils sont prêts à acquérir au prix de 416 millions d'euros.

- À chaque tour, l'ARCEP augmente ensuite le prix par bloc de 5 millions d'euros par rapport au tour précédent.

A chaque tour, les candidats indiquent combien de blocs ils sont prêts à acquérir au prix du tour en cours. Free Mobile peut demander jusqu'à 3 blocs, et les 3 autres candidats jusqu'à 2 blocs.

Quand la somme des demandes des candidats est égale à 6 blocs, l'enchère s'arrête et les blocs sont attribués au prix d'équilibre ainsi atteint.

Les autres communiqués

Année

Toutes les années ▾

Thème

Tous les thèmes ▾

Mot-clés

Valider

Les documents associés

→ Tous les documents utiles »

British CO₂ Auctions

- In 2002, the British government decided to spend £215 million paying firms to reduce CO₂ emissions.
 - ▶ But what price to pay per unit? And which firms to reward?
 - ▶ Solution: run an auction to find the “market price”.
- Greenhouse Gas Emissions Trading Scheme Auction:
 - ▶ Per unit price starts high and decreases each round.
 - ▶ Each round, bidders state tons of CO₂ they will abate at this price.
 - ▶ Cost to UK gov't: (Tons of Abatement) \times (Price).
 - ▶ Auction ended when total cost equal to the budget.
- Result: 34 firms paid to reduce emissions by a total of 4 million metric tons of CO₂.

Coming back to communication

A paradox of market design: as communication gets easier and cheaper, it sometimes also gets less informative:

E.g. Email versus hand-written letter, applications to Master programs,...

Why using an auction?

Auctions have the advantage to create a way to send costly signal that are not wasted:

In auctions the cost of the signals to the signaler is exactly equal to the benefit to the recipient

⇒ High bid not only signals how goods should be allocated but also pays the seller of the goods.

Winning bid isn't just a costly signal: it is also an efficient, direct transfer of wealth to the seller from the bidder who values it the most and signals with his high bid that he should be the one to get it.

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⇒ Auction serves as a mechanism for price discovery.

- Now that you chose to do an auction, there are many different ways (designs) to run an auction.

⇒ Look at the classics.

- Auctions are commonly used to sell (and buy) goods that are idiosyncratic, or hard to price.
 - ▶ Real estate
 - ▶ Art, antiques, estate
 - ▶ Collectibles (eBay)
 - ▶ Used cars, equipment
 - ▶ Emission permits
 - ▶ Natural resources: timber, gas, oil, radio spectrum...
 - ▶ Financial assets: treasury bills, corporate debts.
 - ▶ Bankruptcy auctions.
 - ▶ Sale of companies: privatizations, IPOs, takeovers, etc.
 - ▶ Procurement: highways, construction, defense.
- Auction theory also has close ties to standard price theory (monopoly theory) and matching.

Why does Google use an auction to determine the ads that appear on my pages?

“The ad auction is used to select the ads that will appear on your pages and determine how much you’ll earn from those ads. In a traditional auction, interested bidders state the maximum price they’re willing to pay to buy a specific item. Similarly, our ad auction allows advertisers to state the price they’re willing to pay for clicks on ads or for impressions served on AdSense pages.

Because the ad auction ranks advertisers based on their bids and Quality Score, it creates a win-win-win situation: it assigns the ad unit to the advertisers who value it the most; the winning ads are therefore from the advertisers who are willing to pay the most; and the Quality Score-based approach ensures good user experience.”

Outline of the class

Lecture 1: Introduction

Lecture 2: Auction theory and design

Lecture 3: Common-value and Multi-unit auctions

Lecture 4: Multi-item auctions and matching, sponsored-search auctions, spectrum auctions, package auctions