Congestion and Policy from Market Design Perspective

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Outline

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  - Applications
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- Applications to Airport Slot Auctions
  - Practical issues
  - Theoretical issues
- Conclusion

Key words: (Re-)Design, Market failures, Game theory, Nash equilibrium, Mechanism design, Simultaneous ascending bid auctions, Deferred acceptance algorithm, Thickness, Congestion, Safe.

INTRODUCTION TO MARKET DESIGN

What is Market Design?

- Applying new insights in microeconomic theory, market design tries to (re-)design actual markets and to fix market failures.
- Experiments/simulations are used to check the performance. => Engineering (Roth, 2002)
- New mechanisms proposed by economists are implemented in real world. => Practical

$\Rightarrow$ Let's see the real life examples!

[1] Spectrum Auctions

- The first spectrum auction was operated in New Zealand in 1990, which was not so successful.
- How can we appropriately sell spectrum licenses with potentially highly interdependent values?
- In 1994, on the advice of economists, the Federal Communications Commission (FCC) of the U.S. started the simultaneous ascending bid auctions: "The Greatest Auction Ever" (NY Times, 1995)
- The British spectrum auction of 2000 designed by economists raised about 22.5billion pounds!

[2] Markets for New Doctors

- In each year, around 20000 new American doctors are assigned to their hospitals via a centralized clearinghouse: National Resident Matching Program.
- Both students and hospitals submit their ranking orders, and assignments are made based on these reported preferences.
- This matching program was re-designed in 1998: (student-proposing) deferred acceptance algorithm.
- Japan (2003-) and some regions in UK adapted the same resident matching program.

[3] Kidney Exchange

- The shortage of transplantable kidneys is a serious problem: 11000 transplants / 70000+ waiting list.
- A live-donor may want to donate her kidney to a particular patient, say to her husband, but often it is biologically incompatible.
- Economists provided a way to resolve this mismatch problem in 2004: pooling incompatible patient-donor pairs and appropriately exchange their partners.
- This kidney exchange mechanism is implemented in New England, and started to save patients' life!

[4] School Choice Program

- School choice, which enables students to choose public schools beyond their residence area, is implemented in many countries.
- Its idea has broad public support, but how to operate school choice remains actively debated.
- Based on economists' advise, NYC and Boston redesigned their mechanisms in 2003 and 2005.
- Both practically and theoretically important issues remain to be solved: frontier of market design!

Informal Definition

- Market design is a new field that applies game theory (especially mechanism design) and focuses on designing markets and institutions.

$\Rightarrow$ How is Market Design different from traditional Economics?

$\Rightarrow$ What is Game Theory about?

$\Rightarrow$ How can we use Game Theory?

$\Rightarrow$ What is Mechanism Design?

Traditional Econ. vs. Market Design

Traditional Economics

- Markets/Institutions are exogenously given.
- Mainly focuses on ideal markets, i.e., perfectly competitive market.
- Supply and demand analysis.
- Rely on market mechanism.

$\Rightarrow$ Importance of laws, custom, and the role of government are often under evaluated.

Market Design

- Market/Institutions can be constructed.
- Enable us to analyze other markets or institutions than competitive market.
- Game theoretical analysis.
- Try to fix market failure.

$\Rightarrow$ Institutional (re-)design that makes markets well-functioned is crucial.

Introduction to Game Theory

- In principle, any social/economic problem can be modeled as a game.
- Is there a general law that people follow?
  - Yes, Nash equilibrium!

$\Rightarrow$ Look at the situation in which no one has incentive to change one's own behavior.

- Changing the structure/rules of games, we can analyze variety of real life phenomena.

How to use Game Theory

- Step 1: Formalize/adjust structure of the game to make it fit the phenomenon to analyze.
- Step 2: Solve for Nash equilibria.
- Step 3: Compare the theoretical outcome(s) with the observation in real world.

$\Rightarrow$ Makes it possible to "analyze" markets and institutions beyond the competitive market.

What is Mechanism Design?

- Step 1': Set up the goal that social planner would like to achieve.
- Step 2': Check whether it is theoretically possible to implement the above goal.
- Step 3': Try to find a concrete mechanism (= game form) to achieve the goal.

$\Rightarrow$ Makes it possible to "design" markets and institutions beyond the competitive market.

Remarks on Mechanism Design

- Mechanism design, which is often considered as a sub-filed of game theory, takes the reverse procedure to game theory.
- Although Step 3’ is the key for market design, most of theoretical works on mechanism design consider only Step 1’ and 2’, or they propose unrealistic/unworkable mechanisms.

$\Rightarrow$ Insight from mechanism design must be complemented by experiments or empirics.

Three Most Related Fields

- Auction Theory: [1]
  - License auctions
  - Combinatorial auctions
- Two-sided Matching: [2], [4]
  - Marriage market: one-to-one
  - College admissions: many-to-one
- Assignment Problems: [3], ([4])
  - Housing market: exchanging houses
  - House allocation: no existing tenant

Lessons from Practices

- Al Roth (Roth, 2008) lists three key factors/lessons for successful market design: Marketplaces need to
  1. Provide thickness, that is, they need to attract a sufficient proportion of market participants.
  2. Overcome congestion that thickness brings, by making it possible to consider enough alternative transactions to arrive.
  3. Make it safe and sufficiently simple to participate in the market.

Key words: Externalities, Asymmetric information, Competition, Resale, Interdependent values, Budget constraints, Collusion.

APPLICATIONS TO AIRPORT SLOT AUCTIONS

Auction Examples

- Radio spectrum: US +
- Mobile phone licenses: EU +
- Treasury bills: Many countries
- Advertisement: Google, Yahoo
- Bus routes: UK

$\Rightarrow$ Formats and experience of these auctions can be helpful to design airport slot auctions. (See for example Milgrom, 2007)

Practical Issues on Auctions

- Selling slots sequentially or simultaneously?
- Open or closed-bidding?
- Homogeneous or heterogeneous prices?
- How many slots to sell?
- How to attract potential airlines, especially new entrants, to participate in the auction?
- How to exclude collusion?

Theoretical Issues (1)

- Interdependent values:
  - The value of each slot may depend on who gets the other slots. => Interdependence
  - Calculating slots' values become complicated.
- Externalities:
  - Congestion: Market Concentration is better. (Brueckner, forthcoming)
  - Consumer surplus: Concentration is worse. (Yasuda, 2008)

Theoretical Issues (2)

- Asymmetric information:
  - Bilateral trades cannot achieve efficiency. (Myerson and Satterthwaite, 1981)

  $\Rightarrow$ Resale and auction are no longer equivalent.
- Detail-free design, "Wilson Doctrine" (See for example Bergemann and Morris, 2005):
  - Dominant strategy equilibrium.
  - Ex-post equilibrium. => Also improves safeness.
- Overbids due to limited liability.

Should Resale be Allowed?

- In the presence of externalities or asymmetric information, resale (secondary markets) usually does not achieve socially efficient allocation of slots.
- If making favorable treatment to new entrants or small companies to facilitate market competition, resale should be prohibited.
- Possibility of resale may attract non-serious bidders which aim only to resale the slots.

Budget/Financial Constraints

- Some airline companies, typically small ones, may be financially constrained.
- If financial market is incomplete, centralized market mechanisms (including auctions) cannot achieve efficient allocation.
- Non-market mechanism may outperform centralized market mechanism in this situation. (Che and Gale, 2009)

Conclusion

- Market design perspective looks quite useful for re-design of airport slot allocations.
- In the presence of externalities or asymmetric information, simple centralized market mechanisms may not work properly.
- Practical issues as well as theoretical insights must be taken into account for designing.
- Experimental tests and careful empirical investigation are also very important.

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