Mechanism design theory for complex processes: a paradox?

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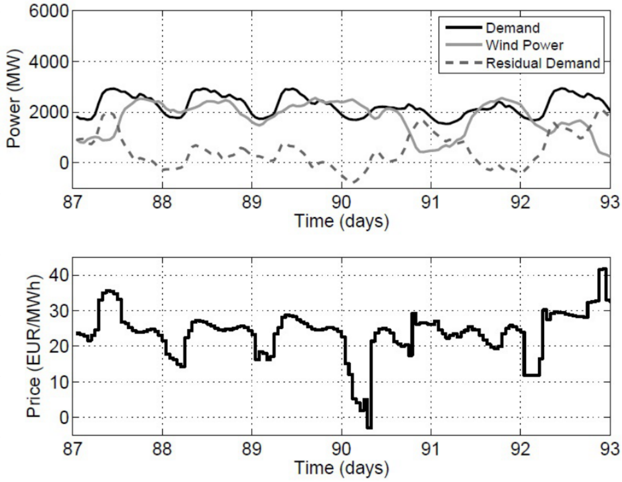
Example: Energy Scheduling



Energy prices Denmark, April 2012 (figure by Verzijlbergh, 2013)

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Example: Energy Scheduling

- Current energy supply is scheduled to match demand.
- Most sustainable energy supply (wind, solar) cannot be scheduled and is uncertain.
- Solution: adapt demand instead!

- Companies and households have private information regarding flexibility and costs.
- Does a mechanism exist to elicit this flexibility and cost for balancing in a socially optimal way?

Goals of mechanism design theory

Goals: for every situation a mechanism that

- elicits private information truthfully (strategy-proof),
- derives socially (or Pareto) optimal decisions (no dictatorship),
- meets participation constraints (individually rational), and
- is (weakly) budget balanced.

Common Assumptions

- Every player / agent has preferences over possible decisions
  - that do not change (preferences nor decisions),
  - that it knows itself,
  - that are independent of others, and
  - in which only the decision counts (ignoring long-term relationships, altruism).
- Full rationality (e.g., ultimatum game)
- No collusion (forming of cartels)

Overview

Impossibilities

Theorem

Making a Pareto optimal decision is not always possible (Arrow).

Theorem

Ensuring that strategic manipulation is not interesting is not always possible (Gibbard-Satterthwaite).

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If strategic manipulation should be prevented, the mechanism must be optimal (Robwert), while finding the optimal decision can be a (NP) hard problem. (Nissan)

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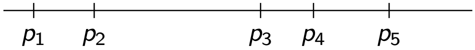
Single-peaked Preferences



Question: What time to go to the bar?

The median is p_3.

- Not a dictatorship: no single agent determines outcome
- Strategy-proof
  - in contrast to taking the average of all peaks

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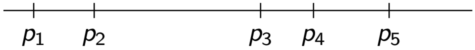

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The second-price auction

Definition

In a *second-price auction* the winner is the highest bidder and its payment is the second-highest bid.

Why is the second-price auction strategy-proof?

Theorem

The second-price auction is strategy-proof (Vickrey, 1961).

Intuition: You are never worse off by bidding exactly your true valuation, because the price is independent of your own bid.

- Your valuation: v_i
- Your bid: b_i
- The maximum bid of all others: b
- Your utility if you win: $v_i - b$

Consider bidding higher, lower, or exactly your valuation...

Other mechanisms

- VCG (or GVA): second-price idea works as long as ignoring a player does not decrease outcome for others
- d'AGVA (budget balanced, but IR only in expectation)
- matching (one-sided IC)
- majority vote (for two choices)

Current research: adding realism: dynamics, uncertainty, etc.

Adding Dynamics and Uncertainty

Some positive results to deal with uncertainty:

- Agents report only what they know
  - Online Mechanism Design (Parkes et al., 2008)
- Agents report their beliefs over all possible futures
  - Dynamic team mechanism / dynamic-VCG (Bergemann and Valimaki, 2008)
  - Dynamic-balanced (AGV) (Athey and Segal, 2007)
- The energy scheduling scenario is too complex for these results to be applied directly.
- Theoretical models are often too simple.

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Theoretical Model versus Practice

For example, tendering can be seen as a simple *reverse first price auction*, but what about

- transaction costs (for writing a proposal)?
- repeated interactions (building reputation, learning)?
- multiple criteria (besides price)?
- uncertainty in costs?
- possibility of continued work?
- long-term strategies (position in the market, competitors)?

My own research

Examples from last year

- en-route charging of electrical vehicles
- on-line scheduling of use of renewable energy

New projects

- Distribution network capacity management (Alliander)
- Balancing under uncertainty (NWO/STW URSES)

Work in progress

Next steps

- Apply mechanism design (even without theoretical guarantees): how bad is it? Can we fix it?
- Theory on better models: what aspects to focus on?
- Computational aspects: sequential decision making, scheduling, route planning, etc.

I'm interested in

- a real multi-actor case where data on behavior and decisions is collected (preferably energy or transport related), and
- cooperating with experimental/behavioural economists (e.g., co-supervising a PhD student).