Economic Inefficiencies of Cost-based Market Designs

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Outline

- Introduction
- The case for cost-based markets
- Other challenges of cost-based markets
- Conclusions and perspectives

Introduction

- Many deregulated power systems operate under a cost-based scheme
  - Private generation firms select investments
  - System dispatch is based on audited cost information instead of bids
  - “Mechanical” or “simulated” spot market (Joskow, 2008)
  - E.g.: Chile, Peru, Bolivia, Brazil, and Panama

- Why implementing a cost- instead of a bid-based market? A survey of opinions
  - “Limit exercise of market power in the short run in concentrated markets”
  - “Prevent strategic allocation of water of large hydro generators”
  - “Implementing a bid-based trading floor is too expensive”
  - “Prices are too volatile in bid-based markets, generators don’t like it”
  - “Submitting bids is too complicated for generators”
  - Etc.

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Remembering some basic economic principles

- Economic efficiency in electricity markets:
  - Allocative efficiency: Prices = MC of producing an additional unit of energy
  - Productive efficiency: Demand is supplied in the most cost-efficient manner (cheapest dispatch and generation mix)
- In theory, a perfectly competitive electricity market can achieve both (Green, 2000)
  - Bidding true costs (including opportunity costs) is a dominant strategy in the short term => Allocative efficiency
  - No barriers of entry + efficient prices => Efficient investments = Productive efficiency

Introduction

- But in practice markets fail
  - Generators have incentives to bid above marginal costs or withhold capacity if residual demand is not perfectly elastic
  - In practice, bid-based markets have market monitoring departments
  - Missing markets for risk, electricity markets are inherently incomplete (Wilson, 2002)
- Our question:
  - Do cost-based markets solve these problems?
- Our answer:
  - Market power: sometimes they do, but often they do not
  - Efficient prices: unlikely to yield efficient ones if opportunity costs are hard to audit or compute for ISO

Introduction

- **Impact of market rules can be counterintuitive**
  - Regulating a monopoly: Averch & Johnson (1962)
    - Regulated rate-of-return gives a monopolist incentives to increase expenditures on capital
    - Reverse Averch-Johnson effect if price-cap is set too low and operating costs are subject to pass-through provisions
  - Forcing renewables into system: Deng et al. (2015)
    - Some countries give renewables absolute priority dispatch (no spillage)
    - Authors find that if spillage is not allowed emissions can increase w.r.t. solution that allows spillage

Introduction

- **Impact of market rules can be counterintuitive**
  - Implementing a CO2 tax: Downward (2010)
    - Simple 2-node and 2-firm example with transmission congestion
    - Increasing CO2 tax increases emissions due to market power!
  - Forcing “perfect competition” in spot market: Arellano & Serra (2007) and Wogrin et al. (2013)
    - Firms invest in capacity and later compete in a spot market (bi-level models)
    - If ”perfect competition” is forced in the lower level, firms have incentives to bias the generation mix by overinvesting in the peaking technology
    - Here we extend Wogrin et al. (2013) by focusing on cost- vs bid-based market designs

Market power

- Deregulating the spot market, standard short-term analysis:
  - Fixed number of firms
  - Fixed generation capacities

Bertrand competition (cost-based) = Perfect competition

VS.

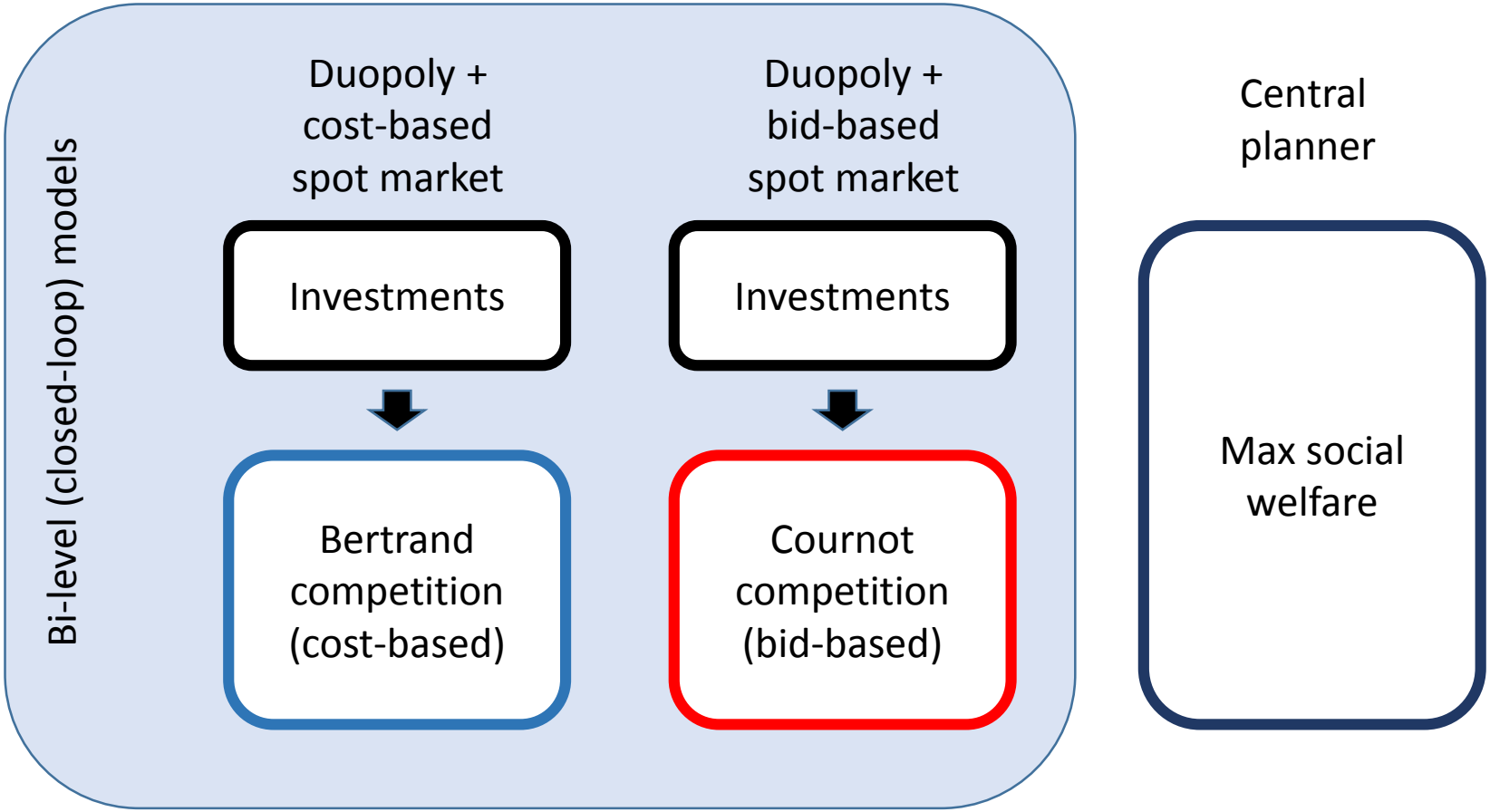
Cournot competition (bid-based)

- Cost-based is always better than Cournot, no need to run a model

- Incomplete analysis, pricing affects investments!

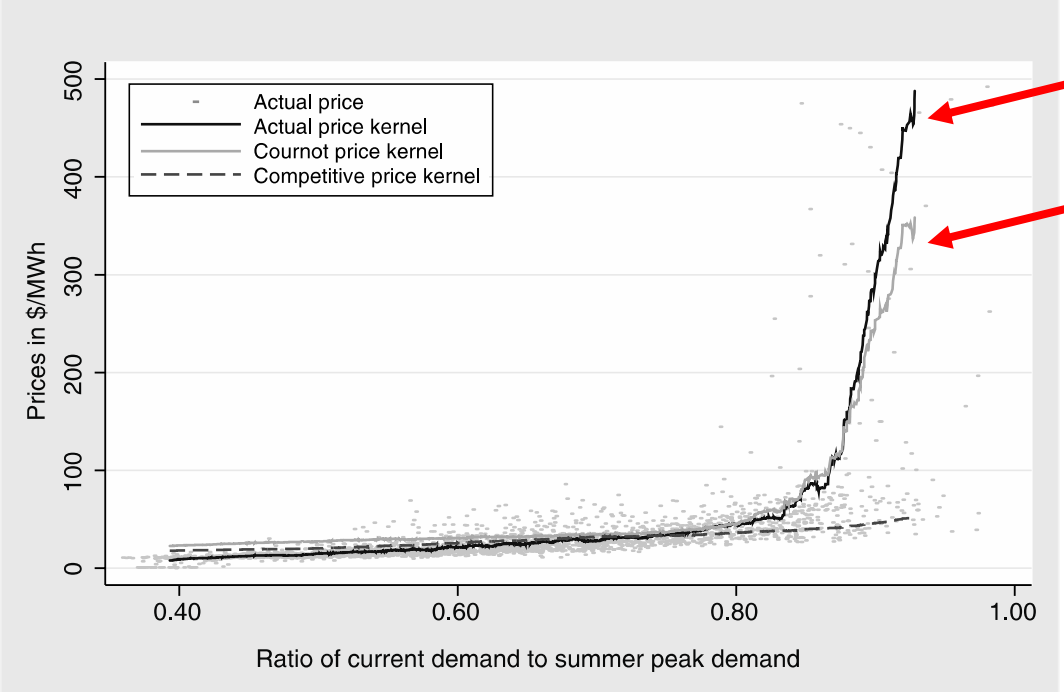
Market power

- A simple numerical example:
  - 2 load periods, price-sensitive demand
  - 2 firms (duopoly), endogenous investments



Market power

- Why do we use Cournot to emulate a bid-based market?
  - Cournot assumes a quantity setting, bidding mechanism is not accurately represented
  - But there is empirical evidence that prices in bid-based markets are close to the ones predicted by static Cournot models (Bushnell et al., 2008; Puller, 2007; Willems et al., 2009)



Actual prices

Cournot prices

Source: Bushnell et al. (2008)

FIGURE 6. VERTICAL ARRANGEMENTS IN PJM
(Actual, competitive, and Cournot price kernels)

Market power

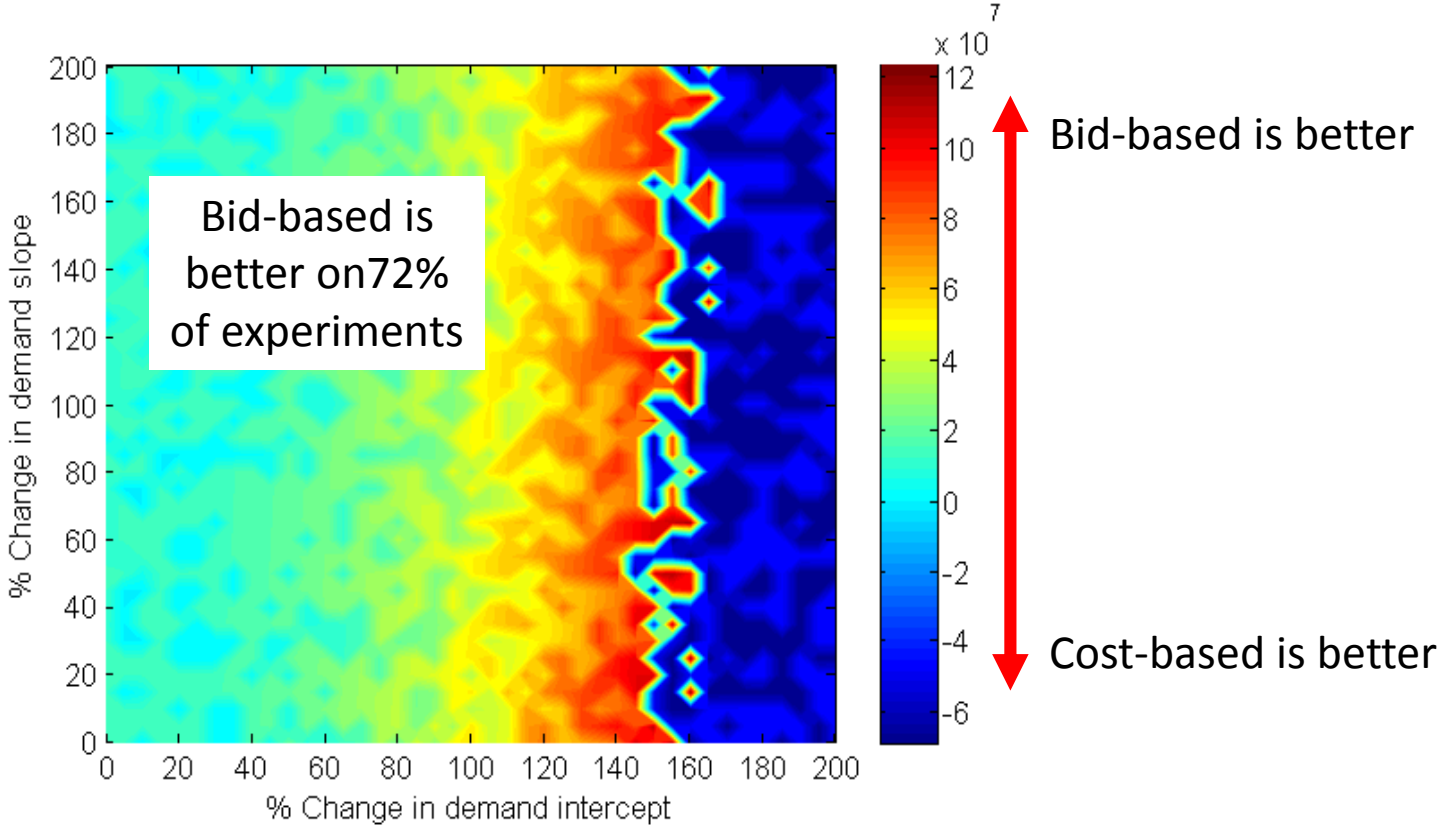
- One counterexample disproves a theory

	Central planner
Investments per firm [MW]	904
p_{peak} [$/MWh]	24.0
p_{base} [$/MWh]	11.8
Consumer surplus [Billion $]	1.38
Total profits [Billion $]	0
Total welfare [Billion $]	1.38

- Firms prefer to underinvest in gen. capacity if they know that market will be cost based (Bertrand)
  - Market power is exercised on investments
  - With more technologies firms overinvest in peaking technology w.r.t. central planner (Arellano & Serra, 2007)

Market power

- How sensitive are these results to parameters?



- Results sensitive to changes in demand intercept (difference between peak and off-peak)

- How is the demand profile of the system in question?

Other challenges of cost-based markets

- Even in the absence of market power, auditing the true cost of generation units could be extremely challenging
  - Short-term dispatch and prices can be inefficient!
- True costs of generation:
  - Directly attributable expenses (fuel, O&M, wear & tear, etc.)

    ➡ Can show a receipt for these!

  - Opportunity costs (foregone opportunities to make a profit)

    ➡ No receipt to back these up!
- *Stoft (2002) "except for hydro, almost all generators at almost all times prefer to run rather than not run if they are paid just a little more than their variable costs…(Consequently) in real time, opportunity costs are usually minimal"* (ibid., p. 371).

?

Other challenges of cost-based markets

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Intertemporal limits on starts, operating hours, and energy

- Standard example: The future value of water in hydro systems
  - Treated as a thermal unit in the short term
  - Bid-based markets (Norway), hydro units bid their op. costs
  - Cost-based markets, central authority determines water allocation

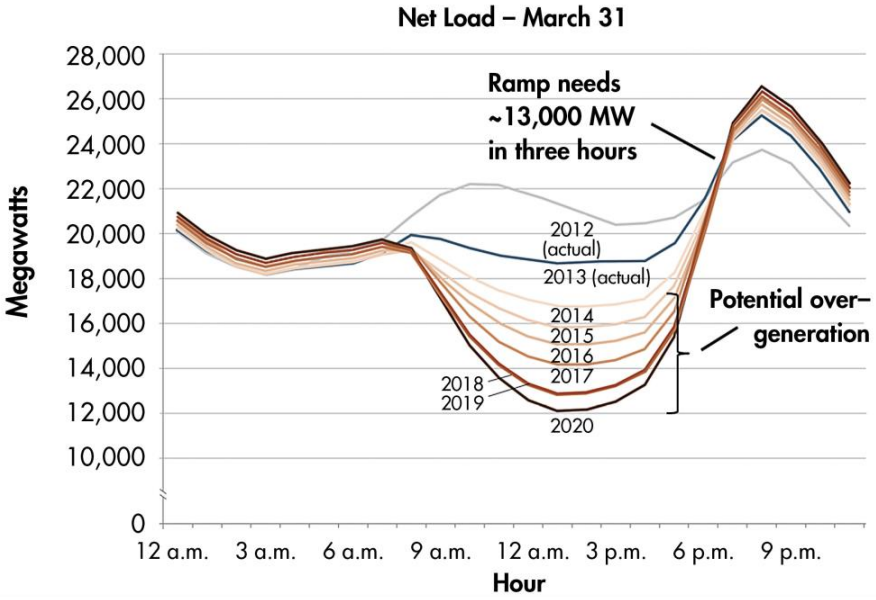
If hydro sets the price, P> 0 in most cases

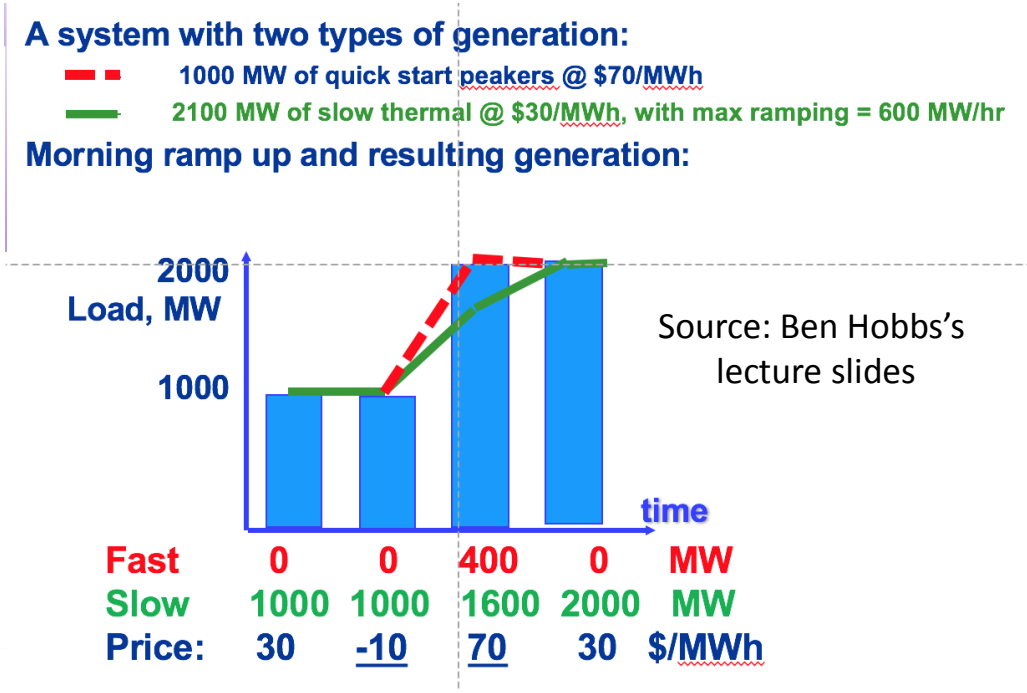
- Philpot et al. (2010) empirical study for New Zealand
  - Showed that central optimization of water resulted in savings of ~4%
  - But can't really tell if results are driven by internalization of complex constraints and information, market power, or assumption of risk neutrality

Other challenges of cost-based markets

Intertemporal limits on starts, operating hours, and energy

- With more renewables, variability of net demand induces more ramping and cycling of thermal units





Source: Ben Hobbs's lecture slides

- E.g.: CAISO now allows generators to include opportunity costs from limited # of starts as part of their bids

Other challenges of cost-based markets

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Inflexible fuel contracts

- E.g. take-or-pay clauses in contracts for natural gas
- Contract price can be audited
- If more gas than what is needed is procured, what is the opportunity cost of it?
  - Contractual penalty?
  - Price of it in a secondary market?
  - Zero if it can be vented off?
    - If dispatched at MC=0 and gas units make profit, does it incentivize better forecasts for future contracts?

Other challenges of cost-based markets

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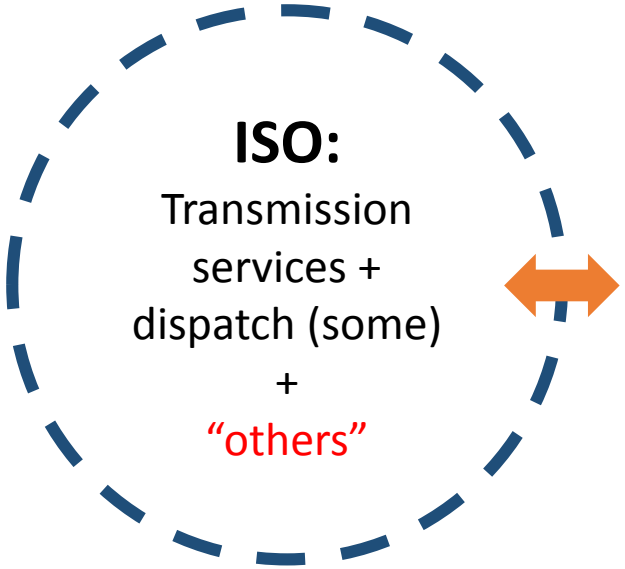
What are the boundaries of an ISO?



Price mechanism (bids)

- Start-up costs
- Ramping limits
- Limited number of starts
- Optimization of water on reservoirs
- Inflexible fuel contracts
- Emissions limits and CO2 taxes
- …
- The rest of the economy

- What should be incorporated as a constraint in the ISO's problem?
  - Some coordination is good, but ISO's problem can grow with no limit
- What should be internalized by generators and incorporated on bids?
- Are larger and larger optimization problems solved by the ISO the answer to optimal resource allocation?
  - Worth reading Hayek (1945), Hurwicz, (1973), and Wilson (2002)

Conclusions

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- A cost-based markets is no silver bullet to eliminate market power
  - "Market power is like gravity, you can't just get rid of it, it's better to manage it" Shmuel Oren
  - Cost-based markets could result in lower welfare than bid-based one because of perverse investment incentives
    - Issue is not just underinvestment (capacity payments as Band-Aid solution) but inefficient generation mix
- More renewables, distributed generation, and storage make auditing difficult
  - Market power is only one issue
  - No receipts for opportunity costs! How inefficient could dispatch and prices be in a cost-based system?

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Questions?

Paper draft available upon request

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