Central- versus Self-Dispatch in Electricity Markets

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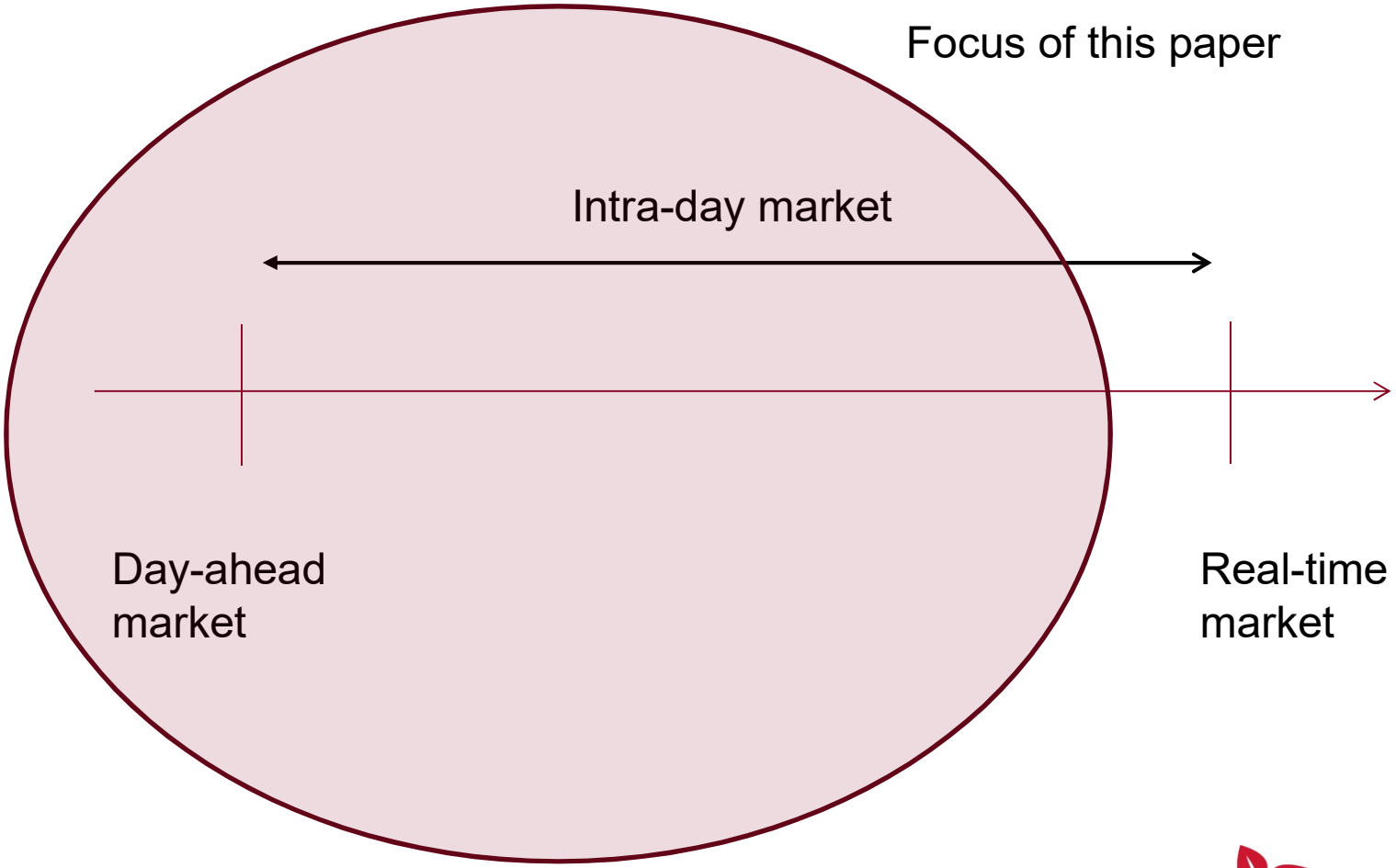
The wholesale electricity market



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US versus European day-ahead markets

- In US, producers provide detailed cost data for every plant, and system operator decides how much to produce in every plant.
- In Europe, producers commit to deliver a certain amount of energy in each zone, but each producer decides how much to produce in each plant. It could also pay a competitor to do the job.

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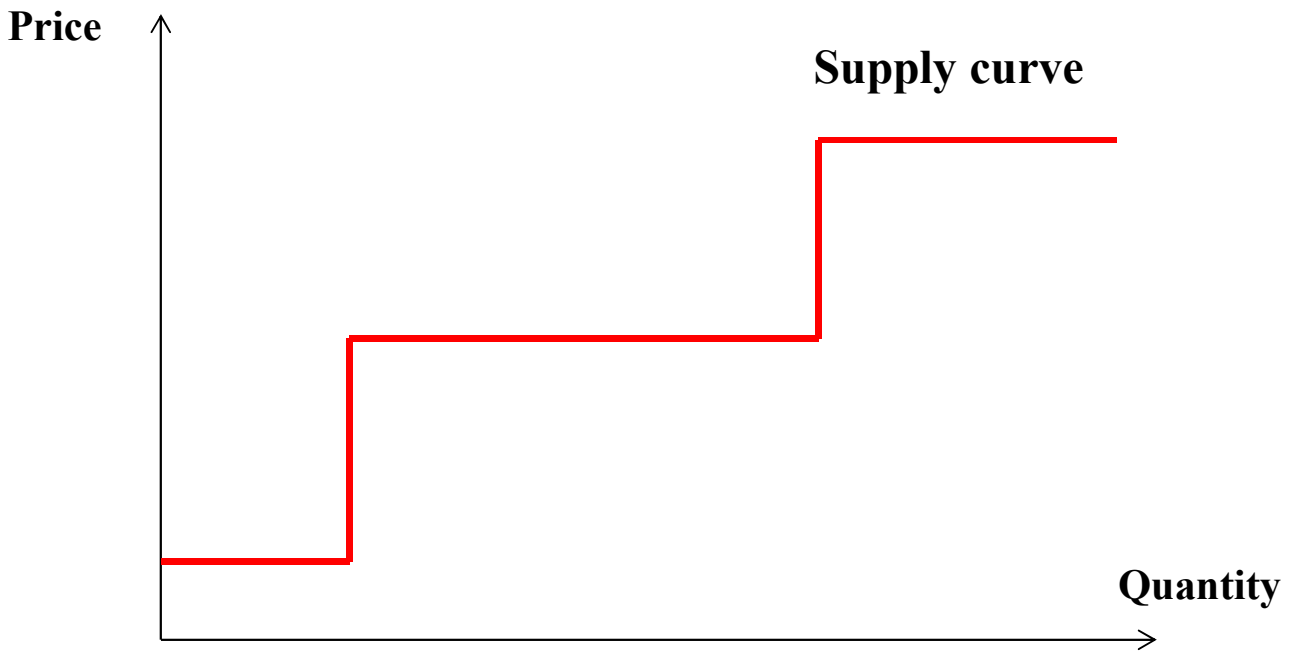
Ideal market

Ideally a producer knows its own cost for each delivery hour and it would submit a non-decreasing supply curve to the day-ahead market for each hour, in accordance with its marginal cost.



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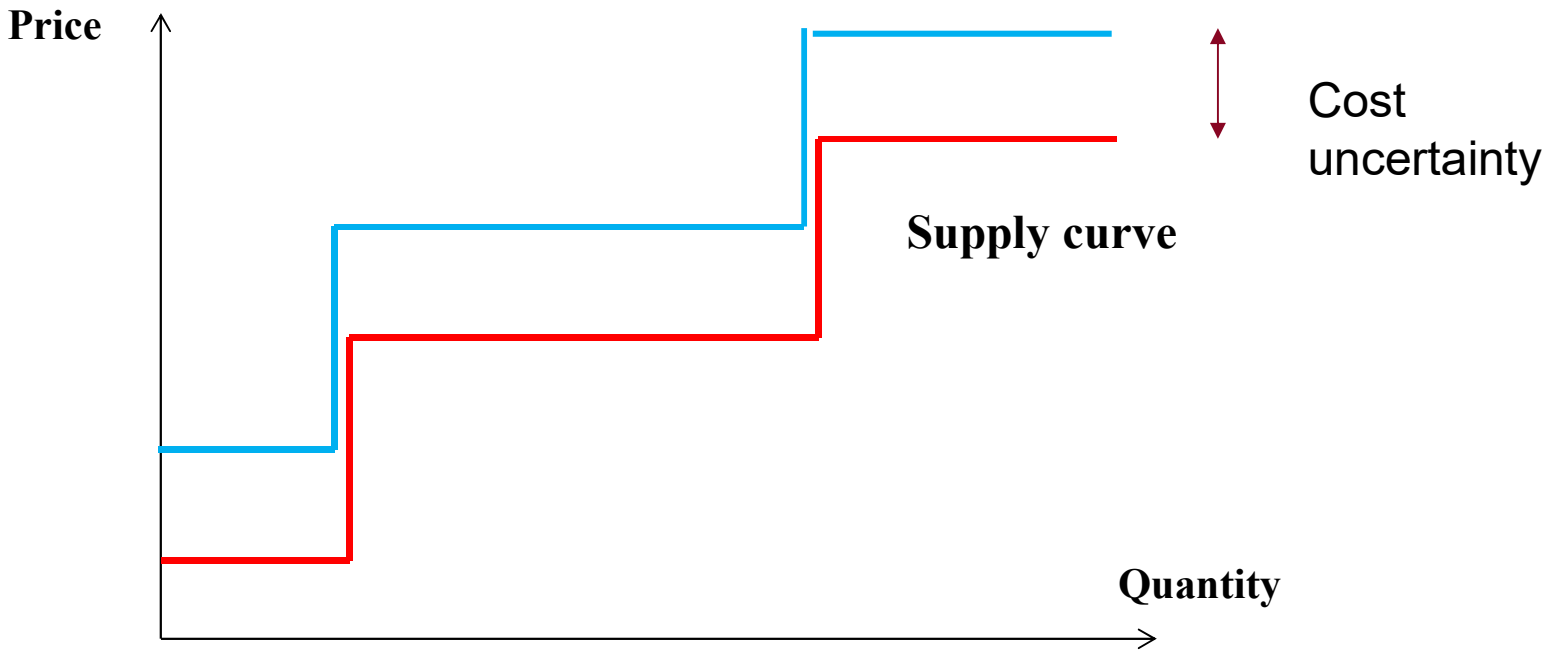
Imperfection 1: Economies of scope

Economies of scope => cost for one hour depends on output for other hours.



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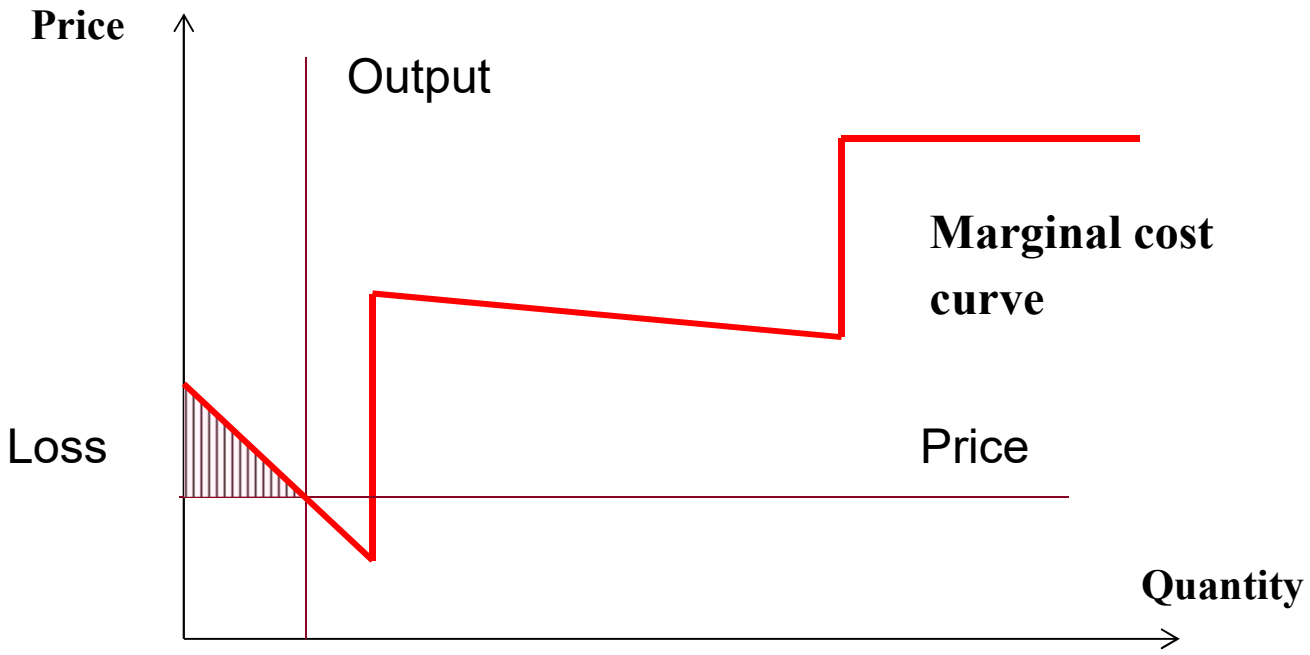
Imperfection 2: Non-convexities

Non-convex costs => Locally decreasing MC => Price=MC may not cover all costs.



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How does markets deal with the imperfections?

Central approach: System operator has information about economies of scope and non-convexities. Taken into account in clearing process. Producers are paid individual uplifts => no producer makes a loss.

Decentralised approach: Producers guess output in neighbouring hours to estimate its marginal cost. If guess is wrong, it can make new and better guesses in intra-day market (Wilson, 2002). Producers bid with mark-up to avoid losses.

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General advantages/disadvantages with centralisation

- Ideally centralization is better for organizations where communication to the central decision maker is costless, without delays and perfectly informative.
- Organizations decentralize decisions when communication is too costly, distorted or agents have limited abilities to communicate and process information, see for example Hayek (1945), Kaplan (1982), Melumad and Reichelstein (1987) and Melumad et al. (1997).

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Problems with centralized electricity markets

- Restrictions in bidding format prevent producers from forwarding all cost relevant information to central operator (Sioshansi et al., 2009).
- Inflexibility, two-settlement market.
- Uplift-payments in centralized markets => producers have incentives to overstate costs when making offers. Thus, central operator will receive distorted cost information (Oren and Ross, 2005).

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Method

- Survey of literature
- Use previous literature and experience from related problems to compare centralized and decentralized day-ahead markets.
- Policy discussion

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Centralized market approach

Producers report imperfections as part of their bids. In U.S., system operators accept three-part bids that include: 1) start-up costs, 2) no-load costs and 3) marginal cost.

Most centralized markets have a make-whole/up-lift payment to ensure unit does not make a loss.

=> unit-commitment. System operator decides how much each unit should produce and has tailor-made contract with each unit.

Most/all centralized markets would have nodal pricing.

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Examples of centralized day-ahead markets

- US markets: New England, PJM, Midwest, New York, California (new), Texas (new)

* Old pool in UK.

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Advantages with centralized markets

+ If bids reflect all costs and producers bid truthfully => optimal day-ahead clearing.

+ Easy to use for producers if they bid truthfully;

they simply state their costs/restrictions, and they can make the same bid for every hour that a unit is available.

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Problem 1 with centralized markets: inflexibility

Each unit has an individual commitment and a tailor-made contract, which is difficult to trade => No intra-day trading. Disadvantage for:

1) Up-dated prognoses for output of renewable power and outages
2) Units with complicated costs that cannot be well-represented by 3-part bids. For example, CCGT has sawtooth shaped marginal costs. Another example, hydroelectric power along a river.
3) Bidding format needs up-dating for new technologies, e.g. storage and demand response.

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Issue 2 with centralized markets: pay-as-bid flavour

Up-lifts/make-whole payments are individual and start-up/no-load costs are often compensated as stated => elements of a pay-as-bid auction:

+ Reduces risk of collusive outcomes.

- Costs are overstated
- Individual payments => not well-defined spot price and/or hedging spot price is not a perfect hedge for individual payments.
- Volatile bidding with unpredictable price variations and potential welfare losses (Anderson et al., 2013).

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Problem 3 with centralized markets: not budget balanced

In theory centralized markets could result in socially optimal dispatches. But make-whole/uplift payments have to be financed with tariffs or taxes => welfare losses. Tariffs/taxes can be used cleverly to minimize welfare losses.

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Problem 4 with centralized markets: difficult clearing

- Computationally demanding to clear a centralized day-ahead market, especially for a large market with nodal pricing.
- “Black box”: Ex-post it can be difficult for a producer to understand why a bid was accepted/rejected.

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Decentralized market approach (Energy-only)

- Each producer submits a supply-curve for each zone.
- After clearing, each producer is committed to deliver a certain amount in each zone, but the producer can choose how to best do this (self-commitment).

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Examples of decentralized markets

- Nord Pool
- NETA/BETTA in UK (new designs)
- Texas and California (old designs)
- Australia and NZ
- Chile

- NETA in UK was extremely decentralized in that there was no day-ahead market.
- Nord Pool is more central in that it has block bids.
- New Zealand and Chile are more central in that they have nodal pricing.

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Disadvantage 1 decentralized markets: Producers have to guess

Each producer needs to predict its dispatch.

If guesses are reasonably ok, decentralized markets can deal with economies of scope, non-convexities, and indivisibilities.

Guesses would improve with forward prices for each individual hour and for each zone ahead of the day-ahead market.

Producers can correct mistakes in the intra-day market.

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Disadvantage 2 decentralized markets: Welfare losses

In case of non-convexities (e.g. start-up costs), producers need a mark-up to cover losses => welfare loss for elastic demand. Probably higher than tariff-induced loss for centralized markets.

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Disadvantage 3 decentralized markets: zonal pricing

- Extra arbitrage profit (the inc-dec game) to producers in export-constrained nodes for zonal pricing with counter-trading. => Distorts price signal for investments (Holmberg and Lazarczyk, 2015).

Can be reduced/avoided in decentralized markets with small zones.

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Disadvantage 4 decentralized markets: collusive outcomes

- Increased sequential trading and uniform-pricing => increases risk of having collusive outcomes.

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Decentralized markets: Advantages

+ Commitment to delivery within a zone => standardized product traded in an intra-day market => up-dating of dispatch with respect to wind power etc.

+ Intra-day trading => producers can adjust their dispatch if they guess wrong.

+ Standardised product => large producers can make some adjustments internally to manage production imperfections.

+ Budget balance

+ Well-defined spot price, which can be used to hedge transaction prices.

+ Transparent and easy to clear.

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Independence of system operator

- Independent system operator (ISO) in centralized day-ahead market, i.e. it should not own the network. Otherwise, system operator could increase its congestion rents by manipulating the day-ahead dispatch.
- Not necessary to separate ownership of grid and operation of system in a decentralized day-ahead market. Is this an advantage?
- UK has chosen to separate ownership of grid and operation of system for a decentralized market.

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Theoretical comparisons

Sioshansi and Nicholson (2011) characterize Nash equilibria in a duopoly market with non-convexities. They identify circumstances where decentralized and centralized markets are equivalent. A problem with decentralized markets is that they have more equilibria and some of them are significantly worse than equilibria in centralized markets (≈collusive outcomes).

Results correspond to comparison of uniform and pay-as-bid pricing in Fabra et al. (2006).

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Empirical comparison

Zhang (2016) evaluates redesign of Texas market in 2010, from decentralized to centralized market. He finds that centralized market was 0.5% more efficient. Zarnikau et al. (2014) finds that spot prices were reduced by 2% on average.

Note that Texas also changed to nodal pricing and shortened delivery periods to 5 minutes in 2010.

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Simulation comparisons

Sioshansi, Oren and O'Neill (2009) find that changing to a decentralized central market in New England would increase production costs by 4.3% and total payments to producers by 56%.

But study based on heuristic assumptions. Centralized market is ideal by construction. Drawbacks with centralized market and advantages with decentralized market are neglected.

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Future work

Proper theoretical comparison of market designs should have the following properties:

- Nash equilibria (NE) should be used to predict bidding behaviour
- There should be market uncertainties (This is realistic and refines the set of NE)
- It should be a sequential game, so that bidders in a decentralized market can correct mistakes in the intra-day market.

There is no such theoretical model today.

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Concluding discussion

Centralized markets should perform better in markets with considerable start-up costs that can be well-described by 3-part bids.

If possible, centralized markets would become better if there would be a couple of intra-day redispatches, where the whole dispatch was reoptimized (Herrero et al., 2018).

Possibility to use tariffs cleverly to reduce welfare losses.

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Concluding discussion cont…

Decentralized markets tend to perform better in markets with considerable amounts of renewables, for which output is often up-dated intra-day.

Decentralized markets are more efficient with forward prices for each hour and small zones (or nodal prices).

Repeated intra-day trading may increase risk of collusion.

To improve liquidity (and to deal with inter-zonal transmission capacity more efficiently), it would be better with discrete intra-day auctions.

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