The competitive effects of linking electricity markets across space

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Motivation

- Regional virtual hubs for forward contracts is one of the proposed changes for a reformed EU market design
- Regional forward contracts settle against an average of short-term prices across multiple bidding zones
- In the Nordics, standard contracts settle against the common system price
- Purpose is to increase liquidity in the forward market relative to current market design

Motivation

- This paper investigates the consequences for liquidity and efficiency of
  - A regional forward market
  - A regional short-term market (consumers pay average of local short-term prices)

Table 1: A taxonomy of market designs

	Local forward market	Regional forward market
Local short-term market	Default US market design	PJM, CAISO
Regional short-term market	Theory	NYISO, ISO-NE, Singapore, Italy

Modeling assumptions

- Two symmetric local markets (physically separate)
- One large consumer in each local market has inelastic demand D for electricity
- One large generation owner in each local market produces electricity at marginal cost c
- A competitive fringe supplies residual demand in each local short-term market
- No uncertainty

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- A forward contract is a mechanism which
  - increases efficiency in the short-term market
  - enables consumers and producers to split the efficiency gains

Timing of the game

- Each local producer commits to a forward price f
- Each large consumer purchases forward quantity k
- Each local producer supplies q to the short-term market
- Solve the game backwards

Short-term market

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Profit of the large producer in a local forward market

$$[f - P(q)]k + [P(q) - c]q$$

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Production $q(k)$ solves

$$-P'(q)k + P(q) - c + P'(q)q = 0$$

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Profit of the large producer in a regional forward market

$$[f - \frac{1}{2}\{P(q) + P(\tilde{q})\}]k + [P(q) - c]q$$

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Regional forward quantity half the pro-competitive effect

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Demand for forward contracts

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Demand $k(f)$ for local forward contracts

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Profit of the large consumer in a regional forward market

$$-[f - \frac{1}{2}\{P(q(\frac{k}{2})) + P(q(\frac{\tilde{k}}{2}))\}]k + [v - P(q(\frac{k}{2}))]D$$

Demand for forward contracts

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Demand $k(f, \tilde{f})$ for regional forward contracts

$$f - \frac{1}{2}\{P(q(\frac{k}{2})) + P(q(\frac{\tilde{k}}{2})\} = -\frac{1}{2}P'(q(\frac{k}{2}))q'(\frac{k}{2})(D-k)$$

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Forward premium smaller in regional forward market

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Equilibrium in a regional forward market

$$k^R + [f^R - p^R]\frac{\partial k(f^R, f^R)}{\partial f} - P'(q^R)q'(k^R)\frac{k^R}{4}\frac{\partial k(f^R, f^R)}{\partial \tilde{f}} = 0$$

Equilibrium in the forward market

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- A smaller forward premium
- A cross-price effect on the settlement price
- A larger own-price elasticity of forward demand

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- A smaller forward premium
- A cross-price effect on the settlement price
- A larger own-price elasticity of forward demand
- Regional forward market increases liquidity and market performance: $k^R \geq 2k^I$

Conclusions

- Novel mechanism for explaining forward contracting
  - forward quantity increases efficiency in short-term market
  - forward price splits value of efficiency gains between consumers and producers
- Market design affects gains from trade and their distribution
- A regional virtual hub increases liquidity and efficiency in the short-term market because of a substantial increase in own-price elasticity of demand
- Holds for any number of local markets and asymmetries
- Do not model costs of pooling local forward markets under uncertainty