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Is larger always better?
Economics of power market integration

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Introduction

- EU’s Directorate-General for Energy and several other institutions push for a deeper integration of Europe’s electricity markets.
- Meanwhile, several EU member countries split their electricity markets to different price zones

- Question risen by those opposing trends:
Is there anything like an optimal market size?

- This presentation will discuss benefits and problems of market integration from a theoretical point of view

Introduction

- When simple examples are used, the following assumptions are made:
  - There are two markets
  - Demand for market 1 is described by $p = 15 - x$, for market 2 by $p = 15 - 2x$
  - Supply for market 1 is described by $p = 2 + 0{,}5x$, for market 2 by $p = 2 + 0{,}25x$
  - If both markets are combined, demand is thus $p = 15 - 0.667x$ and supply $p = 2 + 0.167x$

Benefits of market integration: Converging prices

- If two markets are not identical, combining them will lead to an increase of total surplus:
  The market with lower initial prices generates additional electricity, prices converge
- This implies: Gains from market integration are asymmetric

- In the simple world,
  - price in market 1 decreases (from 6.333 to 4.600)
  - Surplus in market 2 increases, while it decreases for market 2; overall surplus is around 8 per cent higher.

Benefits of market integration: Converging prices

	Separate markets			Combined market		
	Market 1	Market 2	Overall	Market 1	Market 2	Overall
p_S		3.444		4.600	4.600	
p_D	6.333	3.444		4.600	4.600	
x_S	8.667	5.778		5.200	10.400	
x_D	8.667	5.778		10.400	5.200	
Virtual flow	0	0		-5.200	5.200	
Real flow	0	0		-5.200	5.200	
c_R						
CS	37.556	33.383	70.938	54.080	27.040	81.120
PS	18.778	4.173	22.951	6.760	13.520	20.280
TS	56.333	37.556	93.889	60.840	40.560	101.400

Benefits of market integration: Market power

- It is obvious that market integration reduces market power: More generators compete
  - The gains from market integration are higher the higher the market power in the initial situation is
  - The gains are particularly high if two markets with monopolies are integrated, moving them to Cournot competition: In the simple model, moving from two monopolies to a two-company oligopoly would result in a 20 per cent growth of surplus.
  - The gains from market integration becomes smaller the larger the market already is.

Benefits of market integration: Market power

	Separate markets			Combined market		
	Market 1	Market 2	Overall	Market 1	Market 2	Overall
c_S	4.600	2.765		4.424	3.542	
p_D	9.800	8.882		7.655	7.655	
x_S	5.200	3.059		4.847	6.169	
x_D	5.200	3.059		7.345	3.672	
Virtual flow				-2.497	2.497	
Real flow				-2.497	2.497	
c_R						
CS	13.520	9.356	22.876	26.972	13.486	40.458
PS	33.800	19.882	53.682	21.540	30.133	51.673
TS	47.320	29.239	76.559	48.512	43.619	92.130

Benefits of market integration: Volatility

- TSOs must purchase reserve capacity to ensure reliability of the system
- Those system costs reduce total surplus
- Assume that
  - combined volatility of generation and demand is normal distributed around the scheduled volume (x) with variance σ^2
  - That the level of reliability is set to 0.99
  - That volatility is independent for all markets
- In this case, the operator has to buy additional reserve capacity of approximately $1.645\sqrt{2\sigma^2}$ for each market

Benefits of market integration: Volatility

- Combining n markets reduces the necessary reserve capacity:
  - For separated markets: $\sum_{i=1}^{n} 1.645\sqrt{2\sigma_i^2}$
  - For integrated markets: $1.645\sqrt{2\sum_{i=1}^{n}\sigma_i^2}$
- For the special case $\sigma_1^2 = \sigma_i^2 = \sigma_n^2 = \sigma^2$:
  - For separated markets: $1.645n\sqrt{2\sigma^2}$
  - For integrated markets: $1.645\sqrt{2n\sigma^2}$

Benefits of market integration: Volatility

- For the simple model – and the assumption that $\sigma^2 = 0.01x_D^2$:
  - In equilibrium for market 1, the system operator has to buy additional capacity of 1.992
  - For market 2, the necessary capacity is 1.338
  - Surplus is 55.016 in market 1 and 37.242 in market 2, summing up to $92{,}258$
  - If both markets are combined and there is no congestion, surplus rises to 122.016
  - The percentage increase of surplus is stronger than in a model not considering volatility ($+33\%$ to $+8\%$)

Benefits of market integration: Volatility

- Gains due to reduced volatility are high for the first market to integrate, but become low if the market is already large:

$$\lim_{n\to\infty}\left(\frac{\left(1.645\sqrt{2n\sigma^2}+1.645\sqrt{2\sigma^2}\right)-1.645\sqrt{2(n+1)\sigma^2}}{n+1}\right)=$$

$$=\lim_{n\to\infty}\left(1.645\sqrt{2\sigma^2}\,\frac{\sqrt{n}+1-\sqrt{(n+1)}}{n+1}\right)=0$$

- Gains are asymmetric: If combining a large and a small market, only the small benefits
- The higher volatility is, the higher are the gains from market integration.

Benefits of market integration Impact of renewables

- For price conversion, renewables do not change anything

- Renewables increase volatility in generation.
- This implies: Market integration becomes more advantageous if the role of renewables increases

- Renewables reduce market power: A part of new generation comes from new entrants
- Thus, renewables reduces gains from market integration

- There is evidence that the overall effect suggests more market integration with renewables

Benefits of market integration: Impact of congestion

- Congestion reduces the gains from all three sources:
  - Prices can not converge to equality
  - Market power persists
  - TSO must buy reserve capacity (partially) separated

- All those points reduce gains from market integration, but it remains beneficial

- The effect of congestion depends on congestion management: In the short run, re-dispatching saves more gains

Costs of market integration: Investment incentives

- Market integration can lead to distorting incentives for investment, leading to more congestion

- The effect depends on geographical coverage, network charges and congestion management

Costs of market integration: Investment incentives

- In the two-market model, generating in market 2 is significantly cheaper then in market 1
- This leads to a strong decline of producer surplus in market 1, if integration takes place (from 18.777 to 6.760 without congestion)
- Meanwhile, producer surplus in market 2 increases (4.173 to 13.520)
- This makes investments in market 2 more profitable
- If this happens, than congestion will arise

Costs of market integration: Investment incentives

- If congestion exists, the investment incentives depend on its management:
  - If zonal pricing is used, prices in the downstream market increases, leading to higher producer surplus
  - This sets an incentive to invest downstream
  - With redispatch, the costs of congestion are distributed proportionally over both markets
  - In the short run, this leads to higher total surplus than zonal pricing
  - But redispatch does not change investment incentives:
    In the long run, redispatch does not solve congestion, it might even aggravate it

Costs of market integration: Investment incentives

	Without congestion			Zonal Pricing			Redispatch		
	Market 1	Market 2	Overall	Market 1	Market 2	Overall	Market 1	Market 2	Overall
p_S	4.600	4.600		5.667	3.889		4.553	4.553	
p_D	4.600	4.600		5.667	3.889		4.789	4.789	
x_S	5.200	10.400		7.333	7.556		5.106	10.211	
x_D	10.400	5.200		9.333	5.556		10.211	5.106	
Virtual flow	+5.200	–5.200		+2.000	–2.000		+5.106	–5.106	
Real flow	+5.200	–5.200		+2.000	–2.000		+2.000	–2.000	
c_R									0.237
CS	54.080	27.040	81.120	43.556	30.864	74.420	52.133	26.067	78.200
PS	6.760	13.520	20.280	13.444	7.136	20.580	6.517	13.033	19.550
TS	60.840	40.560	101.400	57.000	38.000	95.000	58.650	39.100	97.750

Costs of market integration: Investment incentives

- Those misleading incentives are not far away for Europe:
  - Transportation costs of coal are lower for the coastal areas, for other fossil fuels close to the relevant importers
  - The costs of environmental regulation differ
  - The potentials for renewables are higher in certain regions, investments costs correspondingly lower (aggravated by potential import regions)
  - Particularly Germany believes in the “copper plate” of uniform pricing across the whole country

Costs of market integration: Other factors

- Congestion might set an incentive for strategic bidding: Generators might seek to provoke a congestion
- Solving congestion with grid expansion means investment costs
- Costs of managing the grid increases as the grid area becomes larger and more complicated
- Regulation of the grid becomes more costly, as more stakeholders and particularities must be considered.

Conclusions

- Market integration is beneficial for three reasons
  - Price conversion
  - Reduced market power
  - Reduced need for capacity reserve (reduced volatility)
- For the latter two points, gains becomes lower if markets are already large

- Market integration generates costs for several reasons.
- One important factor are misleading investment incentives, leading to (increasing) congestion

Conclusions

- Europa has already large integrated markets
- EU and stakeholders should reconsider if additional gains from additional market integration outweigh potential distortions

- Renewables sharpens this question in both directions:
  - More renewables mean increasing volatility – this results in higher gains from (further) market integration
  - Costs for renewables are significantly lower in several reasons – this could worsen the investment incentives in a large market.