HÁSKÓLI ÍSLANDS

Contracts, vertical integration and liquidity in the electricity industry

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Background

- Increased integration of generators into retail and vice versa
- Reduced liquidity in the spot market
- Concerns:
  - spot market
  - competition
  - entry

Aim of this project

- Understand drivers of push for integration
- Implications of different regulatory regimes
- Note: Project in startup phase – preliminary results

Vertical integration: Standard pros and cons

- Cons
  - Cost of supplying own factors of production higher
  - Management costs rise
  - Costs of complying with legal restrictions
- Pros
  - Lower transaction costs
  - Hedging uncertainty
  - Secure supply
  - Correct market failure (externalities)
  - Avoid government regulation
  - Gain market power
  - Eliminate market power

Transaction Costs

- Specialized assets
- Costs of contracting
- Information
- Coordination
- Uncertainty

Market power

- Upstream
  - raise prices in wholesale market
- Downstream
  - raise prices in retail market
- Market segmentation
- Entry deterrence

Uncertainty and hedging of risk

- Price risk
  - Wholesale and retail
- Quantity risk
  - Outages, consumer demand
- Hedging
  - Vertical integration
  - Long-term contracts
  - Depends on contracts
- Contracts are always incomplete

Recent related research

- Mansur (2003) analyzes impact of market power in PJM market
  - Relatively competitive behavior due to
    - vertical integration
    - nonconvexities
- Kühn and Machado (2004) analyze impact of market power in Spanish market
  - little impact on spot market prices (due to vertical integration)
  - substantial productive inefficiencies
  - supply function approach
- In both cases retail prices are assumed to be fixed and regulated

Our model

- Supply: Generators
- Demand:
  - Retailers
  - Price-elastic net non-retail demand in spot market
- Markets:
  - Spot market
  - Retail market
  - Contract market
- Key features:
  - Uncertainty
  - Risk aversion
  - Market power

Retail

- Several “outlets”
- Each outlet is served by *one* retailer
- Price at each outlet is typically regulated, but there may be different regulatory regimes, e.g.
  - Fixed retail price
  - Retail price indexed to spot price with regulated markup
- Non-integrated retailers buy power in
  - (Long-term) contract market
  - Spot market

Generation

- Each generator owns a number of generation plants
- Can integrate vertically into retail by buying retail outlets
- A generator can sell his output through:
  - Contract market
  - “His” retail outlets
  - Spot market

Uncertainty

- Several possible sources:
  → Non-retail demand in spot market, D(p,w)
  – Demand at each retail outlet
  – Generation costs and plant shutdowns

Order of events

1. Retail involvement and structure
   - Quantities
   - Price regime (e.g. fixed or indexed)
2. Long-term contracts written
3. Quantities bid into spot market (Cournot)
4. Generation at each plant determined
5. Uncertainty revealed

   → Non-retail demand in spot market realized, D(p,w)
6. Spot market clears

   → Price

   → Sales of each generator

   → Purchases of each retailer

Spot market equilibrium

- Demand:
  - Non-integrated retailers, Z
  - Non-retail demand, D(w,p)
    - May be positive
      - large consumers participating directly in spot market
      - net exports
    - May be negative
      - supply from IPPs
      - net imports
- Supply:
  - Bids from generators, y(n)
  - May be positive, net sellers
  - May be negative, net buyers
    - In this case own generation does not suffice to cover retail sales and contract sales combined
- Equilibrium: Demand = Supply
- Since quantities are determined before the demand shock, w, is realized, the spot market price, p, must vary so that non-retail demand, D, adjusts to achieve equilibrium

Bidding without risk aversion

- Given retail and long-term contracts with fixed prices, how do generators bid into spot market?
- In absence of risk aversion generators maximize expected profit
- Competitive market:
  - Marginal cost = Expected price, MC = E(p)
  - No effects of position in spot market (i.e. whether integrated generators/retailers are net sellers or buyers in spot market)
  - No effects of vertical integration

Bidding without risk aversion: Market power

- Profit maximization: MC = E(MR)
  - R = p·y, where y are spot market sales
  - MR = p+y·dp/dy
    - < p if y > 0
    - > p if y < 0
- Net sellers in spot market:
  - E(MR) < E(p)
  - Will undersupply, relative to competitive benchmark
- Net buyers in spot market:
  - E(MR) > E(p)
  - Will oversupply, relative to competitive benchmark
- No hedging motive – pure profit maximization

Hedging of spot market risk: Competitive Market

- Bids into spot market with risk averse generators who do not have or do not use their market power
- Risk aversion:
  - Some sacrifice of profit in “exchange” for reduction in exposure to spot market fluctuations
  - Net sellers: undersupply,
    - MC < E(p)
  - Net buyers: oversupply,
    - MC > E(p)
- Looks qualitatively like outcome with risk neutral firms which exert market power

Sketch of proof

- For two random variables X,Y:

  $$E(XY)=E(X)E(Y)+Cov(X,Y)$$

- Max. $E(U(\pi))$ yields FOC for competitive market

  $$E(U'(\pi)[p-c'])=0$$

- If profits, π, are increasing in spot market price, p (as they are for net sellers) ...
- ... then $U'(\pi)$ is decreasing in p

$\Rightarrow$ $U'(\pi)$ and p are negatively correlated

$$0 = E(U'(\pi)[p-c']) \leq EU'(\pi)\cdot E[p-c']$$

$\Rightarrow$ $$c' \leq Ep$$

which is the undersupply result for net sellers

Hedging with market power and risk aversion

- Bids into spot market when generators have market power and are risk averse
  - Net sellers: undersupply
    - MC < E(MR)
  - Net buyers: oversupply
    - MC > E(MR)
- Looks qualitatively the same as the “pure” market power case or a competitive market with risk averse firms
- Effect is stronger when risk aversion is added to market power
- Hedging risk exacerbates distortions due to market power

Incentives to integrate under risk neutrality: Competitive market

- Unit increase in retail sales leads to increase in expected profits iff retail price is higher than expected spot market price

$\Rightarrow$ Incentive to integrate as long as $r > E(p)$

- Indifferent if and only if $r = E(p)$
- Independent of position in spot market
- Independent of generation – there are pure profits to be made if $r > E(p)$

Incentives to integrate under risk neutrality: Market power

- Unit increase in retail sales leads to increase in expected profits iff retail price is higher than expected marginal revenue

⇒ Profit incentive to integrate as long as r > E(MR)

- If retail price is regulated such that r = E(p)
  - Net sellers
    - r > E(MR)
    - profit incentive to increase retail sales
  - Net buyers
    - r < E(MR)
    - profit incentive to decrease retail sales

Incentives to integrate under risk aversion: Competitive market

- Unit increase in retail sales leads to increase in expected utility if retail price is higher than expected spot market price

$\Rightarrow$ Incentive to integrate vertically as long as

$$r \geq E(p)$$

- Want to integrate even if $r = E(p)$
- Independent of position in spot market

Incentives to integrate under risk aversion: Market Power

- Unit increase in retail sales leads to increase in expected utility if retail price is higher than marginal cost
  - Net sellers: MC < E(MR)
    - ⇒ Incentive for net sellers to integrate as long as r ≥ E(MR)
    - Suppose retail price is regulated such that r = E(p) > E(MR)
    - ⇒ Net sellers want to increase retail sales
  - Net buyers: MC > E(MR)
    - ⇒ Incentive for net buyers to deintegrate as long as r ≤ E(MR)
    - Suppose retail price is regulated such that r = E(p) < E(MR)
    - ⇒ Net buyers want to decrease retail sales
- If retail price is regulated such that retail price is equal to expected spot market price:
  - net sellers in spot market want to increase retail involvement
  - net buyers want to decrease retail involvement

Motives for vertical integration under fixed retail price regulation

- Suppose retail price is regulated such that it equals (net of distribution costs) expected spot market price
- Then, in general, there are both profit motives and hedging motives for
  - net sellers in spot market to vertically integrate into retail
  - net buyers to reduce retail involvement
- Vertical integration vs. long term contracts:
  - Abstracting from synergies and incompleteness of contracts there is no difference between the two in our treatment so far
  - If vertical integration is more attractive than long-term contracts – given equal terms in other respects – then clearly vertical integration will win out

Variable retail price

- Assume retail price varies with wholesale price: r = p
  - regulated retail price with complete cost pass-through
  - regulated contracts with price indexed to wholesale price
- Retail market a perfect substitute for spot market
- No hedging motive in retail market, only long-term contract market provides hedge
- Bids in spot market under risk neutrality
  - Profit maximized: MC = E(MR)
  - Competitive market: MC = E(p)
    - Since E(r) = E(p) there are no incentives (nor disincentives) to integrate

Variable retail price

- With market power or risk aversion the critical question is now:
  - Is generator a net seller or buyer in combined retail and spot market?
  - ⇔Has generator written long-term contracts for more than all his production or less than his production?
- Results from previous case carry over to this case with
  - Combined retail and spot market taking role of spot market alone
  - Long-term contracts taking role of integration into retail

Motives for long-term contracting under variable retail price regulation

- Recall: we assume retail price is regulated such that it equals (net of distribution costs) spot market price
- Then, in general, there are both profit motives and hedging motives for generators who are...
  - net sellers in combined retail and spot market to increase their long term contracting
  - net buyers in combined retail and spot market to reduce their long term contracting

Market equilibrium

- In equilibrium, positions in spot market will equal the sum of
  - Spot market demand of non-integrated retailers, Z
  - Non-retail demand in spot market, D(w,p) (may be negative, e.g. due to supply from IPPs)
- If these cancel out approximately, then positions in spot market must also cancel out
  - Some producers are net sellers, others net buyers
- Hence, total supply / market price with hedging and/or market power may be lower or higher than in their absence
- May well hit the “right” price
- Production will be inefficient (some producers are producing too much, others too little)
- There will be too little trade in the spot market
- Reduced liquidity, market viability suffers

Symmetric market equilibrium

- If generators are all alike then they are either all net sellers or net buyers
- If all are net sellers (Z+D>0) then all will supply too little into spot market
  - Industry characterised by under-production (under-investment) in generation and excess integration of generation and retail
- If all are net buyers (Z+D<0) then all will supply too much into spot market

Further research

- Long-term contracts
- Capacity
- Retail market
- Liquidity
  - Interesting line: financial market microstructure

Market performance, liquidity and market microstructure

- Market microstructure
  - Focus on market details and information – a look inside “black box”
  - Due to frictions asset prices need not reflect full expectations of value
- Topics:
  - Price formation and price discovery
  - Market structure and design, e.g. trading protocols
    - Affects speed and quality of price discovery, liquidity and cost of trading
  - Information, market transparency
  - Implications for corporate finance, asset pricing etc.

Liquidity

- "Order flow necessary to move prices by a unit amount"
- Spreads are wider for riskier and less liquid securities
- Too much transparency can reduce liquidity – adverse effects greatest in thin markets
- Expected returns are a decreasing function of liquidity
  - Less liquidity ⇒ higher risk premia
- Liquidity begets liquidity
  - Traders avoid illiquid markets
  - ⇒ Illiquidity is self-perpetuating