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Vertical Integration and Long-Term Contracts in Risky Markets

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DG Comp 2006 Energy Sector Inquiry

"Vertical integration of generation and retail within the same group reduces, all other things being equal, the need to trade on wholesale markets. In turn, this can lead to a ***reduction of liquidity of wholesale markets****. ... Lack of liquidity can have many negative effects, such as:* ***high volatility of prices****, which* ***increases costs for hedging*** *... and a lack of trust that the exchange price reflects the overall supply and demand balance in the wholesale market (****reduced reliability of the price signal****). A lack of liquidity may also initiate a vicious circle by creating further incentives to vertical integration because operators do not want to rely on the wholesale market for their electricity supply."*

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Recent Related Research

- Vertical relations tend to improve market performance
  - reduce incentive to exercise market power; cf Powell (1993), Green (1999), Wolak (2000), Hortaçsu and Puller (2004), Kühn and Machado (2004), Bushnell (2005), Fabra and Toro (2005), Willems (2005), Bushnell, Mansur and Saravia (2006), Mansur (2007)
  - may or may not reduce scope for collusion; cf Green and Le Coq (2006) and Liski and Montero (2006)
  - make entry easier, cf. Newbery (1998)
- Common themes of this literature
  - (unilateral or collective) market power
  - (regulated) fixed retail (or contract) prices
  - no uncertainty or risk
  - vertical integration and long-term contracting essentially the same

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This Project

- Aim: further our understanding of
  - interplay between vertical integration and contract and spot markets
  - effects on market performance, particularly wrt liquidity
  - implications of different regulatory regimes
- Key elements
  - non-strategic behaviour (extension to oligopoly)
  - risk (uncertain spot price)
  - market participants care about risk (risk aversion)
  - vertical relations: vertical integration, spot and long-term contracts
  - fixed retail prices (extension to spot-linked retail prices)
  - vertical integration removes market trade
  - market adjustments

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Market participants

- Non-integrated retailers
  - each serve one "outlet" with demand k
  - buy power spot and/or on contract, $k = z+z_L$
  - maximise expected utility of profits, $E(V(rk - p_L z_L - pz))$
- Generators
  - own a number of generation plants
  - may integrate into retail by taking over outlets
  - sell power in own outlets, spot and/or on contract, $q = x+y+y_L$
  - maximise expected utility of profits, $E(U(rx + p_L y_L + py - c(x+y_L+y)))$
- Net non-retail spot demand
  - large consumers and/or independent producers
  - imports and exports
  - summarised by net demand function: $\Phi(p,\theta)$

Markets

- Spot market
  - participants: independent retailers, generators and net non-retail demand
  - equilibrium: $\sum_m z_m + \Phi(p,\theta) = \sum_n y_n$
- Contract market
  - participants: independent retailers and generators
  - equilibrium: $\sum_m z_{Lm} = \sum_n y_{Ln}$
- Retail market
  - first: fixed retail price
  - subsequently: retail price linked to spot price

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Order of play

1. Extent of vertical integration determined
2. Trade takes place in the long-term contract market
3. Bids are submitted to the spot market
4. Uncertainty is revealed
   - shock to net non-retail demand in spot market, θ
   - net non-retail demand, $\Phi(p,\theta)$, determined
5. Spot market clears and payoffs are realised
   - price adjusts to align net non-retail demand with net supply

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Spot-Market Equilibrium

- Equilibrium: $Z + \Phi(p,\theta) = Y$
- Non-integrated retailers, Z
  - residually determined (retail demand less purchases on contract)
- Generators, Y
  - (quantity) bids
- Net non-retail demand, $\Phi(p,\theta)$
  - adjusts with price so as to clear the market
  - spot price becomes *ex ante* stochastic (fluctuates with θ)
- Note: Z, Φ and Y may be positive or negative
  - net supply/demand

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Generator Bidding Behaviour

- Risk-averse generators who do not wield market power
  - maximise expected utility of profits
  - first-order condition: $E(U'(\pi^g)[p\text{-}c'])=0$
  - note $E(U'(\pi^g)[p\text{-}c'])=E(U'(\pi^g)E(p\text{-}c')+Cov(U'(\pi^g)[p\text{-}c'])$
- Observe
  - net sellers: π increasing, so $U'(\pi^g)$ decreasing, in p
  - net buyers: π decreasing, so $U'(\pi^g)$ increasing, in p
- Sacrifice profit for reduction in exposure to spot-price risk
  - net sellers under-produce, $c'<E(p)$
  - net buyers over-produce, $c'>E(p)$

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Spot-Market Outcome

- Market price lower or higher than under risk neutrality
  - depending on sign of net demand, $Z+\Phi$
- "Too little" trade in the spot market
  - relative to case of risk neutrality
  - sellers under-supply and buyers under-buy
- Efficiency
  - marginal costs not equalised across generators in all subgames
  - (however, in overall equilibrium marginal costs will be equalised)
  - marginal cost different from expected spot price
- Qualitatively similar to risk-neutrality + market power
  - market power would enhance incentives resulting from risk aversion

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Comparative Statics

- From now on assume U is of CARA form
  - constant absolute risk aversion: $U''/U' = \varrho$
- Suppose contract sales increase by dy_L
  - spot market supply falls by $-dy$: $-dy^L < dy < 0$
  - generation increases by $dy_L - dy > 0$
- So, overall supply increases and spot price goes down
- Effect on spot-price volatility depends on shape of $\Phi(p,\theta)$
  - linear, $\Phi = A\theta - Bp$: no effect
  - constant elasticity, $\Phi = A\theta\, p^{-\varepsilon}$: volatility falls
  - quadratic demand, $\Phi = A\theta - Bp^2$: volatility rises
- Corresponding results for increased retail involvement

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Contract-Market Equilibrium

- Generators
  - first-order condition: $p_L = c'(x+y_L+y)$
  - if costs are identical, all generators produce same amount
  - spot sellers if $p_L = c' < E(p)$
  - spot buyers if $p_L = c' > E(p)$
- Non-integrated retailers
  - first-order condition: $E(V'(\pi')[p-p_L]) = 0$
  - retailers choose symmetric contract positions
  - under-contracted (spot buyers) if $p_L > E(p)$
  - over-contracted (spot sellers) if $p_L < E(p)$
- At equilibrium, all active players on same side of spot market
  - determined by sign of net non-retail demand, Φ
  - note: all players face the same risk

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Comparative Statics

- Direct impact of increased retail involvement by generators
  - increased retail sales of generators offset by decrease in contract sales
  - no direct impact on generator behaviour in spot market
  - retailers taken over disappear from spot and contract markets
- Equilibrium effects: retailers net buyers in spot market
  - so (expected) spot price below contract price
  - spot market: net demand falls, price and trade reduced
  - contract market: net supply falls, price rises and trade reduced
  - so, less trade in both markets
  - and greater difference between expected spot price and contract price
  - output increases
- Corresponding result when retailers are net spot sellers
  - less trade and output and greater price difference between markets

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Vertical Integration

- Vertical integration of $dx = dk$ profitable iff $dW \geq dA$, where
  - $E(U(\pi^g(x+dx)-dW)) = E(U(\pi^g(x)))$
  - $E(V(\pi^r(k-dk)+dA))=E(V(\pi^r(k)))$
- Individual incentives
  - $dW/dx = r-c' = r-p^L = dA/dk$
- Market effects
  - $dW-dA = [y-z]E(dp) + [y_L-z_L]E(dp_L)$
    $+ y\text{cov}(U',dp)/E(U') - z\text{cov}(V',dp)/E(V')$
  - spot-market price effect: $[y-z]E(dp) > 0$
  - contract-market price effect: $[y_L-z_L]E(dp_L) > 0$ for some parties
  - risk effects: cannot in general be signed

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Variable Retail Price

- Retail price linked to spot price: $r = p$
  - regulation (eg. Denmark) or retail-market competition (eg. Norway)
  - retailers perfectly hedged when trading in spot market
  - for generators only long-term contracts provides spot-price hedge
- Results
  - combined retail and spot market take role of spot market alone
  - increased contract sales have same effect on spot market as before
  - contract price below expected spot price at equilibrium: $p_L < E(p)$
  - in contract market, retailers buy and generators sell
- Vertical integration
  - no direct effect on generator contract sales, only on spot sales
  - net demand falls in the contract market, increases in spot market
  - prices pushed apart
- So, qualitative effects independent of retail price determination

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Generator Market Power

- Spot market
  - generators sell when expected spot price is above contract price
  - and *vice versa*
  - *ceteris paribus* incentive to drive spot price further away from contract price
- Contract price above expected spot price
  - (if) generators sell on contract market
  - *ceteris paribus* incentive drive contract price away from spot price
  - overall effect to drive spot and contract prices further apart
- Contract price below expected spot price
  - generators sell on contract market
  - *ceteris paribus* incentive to drive contract price closer to spot price
  - overall effect?

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Conclusions

- Uncertainty + risk aversion
  - less market-based trade (output adjustments)
  - wedge between (expected) spot and contract prices
- Vertical integration
  - offset, but only partly, by market adjustments
  - reduces net trade ("liquidity") on spot market
  - may or may not increase spot-price variability
- Retail price formation
  - results qualitatively similar whether retail prices are fixed or variable
  - retail-price cap shifts trade from spot to contract markets
- Extensions
  - supply schedules
  - idiosyncratic risk (retail demand, costs, capacity availability)
  - discreteness