Evaluating the Effects of Crossholdings and Information on Wholesale Energy Prices

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Four Features of the European Energy Industry

• Undergoing gradual de-regulation

• Spot markets take the form of capacity-constrained price auctions (Bertrand-Edgeworth)

• Different degrees of transparency (anonymity, bids, capacities...)

• Many horizontal acquisitions of small stakes in potential rivals are proposed (and approved)
Information and Market Power

- Maximise total industry profits is not supportable. Retaliation + collusion is (Green and Porter, 1984)

- No conclusive results on the effects of informational regimes on market power:
  - More information increases potential for collusion: Bidders can observe each other, coordinate and enforce the agreement by punishing deviations
  - More information increases competition: Avoidance of the “winner’s curse” => less uncertainty and potential for more aggressive bidding

- Informational effects of crossholdings? Regulators prefer transparency rather than opacity
Partial Acquisitions 2001

<table>
<thead>
<tr>
<th>Size</th>
<th>Value of Transaction ($ mil)</th>
<th>% Acquired</th>
<th>Date</th>
<th>Target Name</th>
<th>Target Nation</th>
<th>Acquiror Name</th>
<th>Acquiror Nation</th>
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<td>1</td>
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<td>06 Nov 2001</td>
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<td>Finland</td>
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<td>Electricidade de Portugal SA - EDP</td>
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<td>11 Sep 2001</td>
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<td>08 Nov 2001</td>
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<td>Suez Lyonnaise des Eaux</td>
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<td>34.00%</td>
<td>01 Oct 2001</td>
<td>Espoon Sahko Oyj</td>
<td>Finland</td>
<td>E.On</td>
<td>Germany</td>
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<td>7</td>
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<td>28 Sep 2001</td>
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<td>Sweden</td>
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<td>10 May 2001</td>
<td>Kainuun Sahko Oy</td>
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<td>11</td>
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<td>4.03%</td>
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<td>Norway</td>
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<td>Stadtwerke Kapfenberg</td>
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<td>Kärntner Elektrizitaets-AG</td>
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<td>20.00%</td>
<td>08 Aug 2001</td>
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<td>Germany</td>
<td>Elektrizitaetsgesellschaft Laufenburg AG (EGL)</td>
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<td>15</td>
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<td>TroenderEnergi</td>
<td>Norway</td>
<td>TXU Corp, Statkraft SF, Sydkraft AB</td>
<td>Sweden</td>
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</table>


Source: PricewaterhouseCoopers’ Analysis of Global Cross Border Electricity Deals 2001
Partial Ownership in EU Electricity

Regulators’ Implicit Assumption?

Cross-holdings tend to increase market prices (Reynolds and Snapp (1986), Farrell and Shapiro (1990), Reitman (1994), Amundsen and Bergman (2002)) \textit{BUT, the market power effect of crossholdings is quite convex: small crossholdings do not affect prices considerably…}
Our Objective

• Check the regulators’ implicit assumption (crossholdings / market power relationship is convex); in the context of pure transparency and opacity in trading

• One difficulty: Bertrand-Edgeworth auctions cannot have analytical solutions; Empirical approaches (Alley (1997) and Parker and Roller (1997)) lack sufficient data

• Double-sided auctions => How does market structure on one side affect market power on the other?

• Our alternative: “intermediate cognition simulations”: computational experiments where agents try to optimise objective functions based on experience and limited cognitive abilities (Roth and Erev (1995) algorithm)
A Computational Experiment

- A large number of simulations are run for varied crossholding and informational assumptions
- Stationary values are extracted
- The data is used as input in econometric models to estimate a crossholdings / market price function, in the context of:
  - Public and private information and
  - Capacity-constrained price bidding
The Setting

- Duopoly wholesale commodity market (2 sellers; 10 buyers)
- Uniform double-sided middle price Bertrand-Edgeworth auction
- Agents willing to buy / sell up to their capacities. Suppliers sell up to their capacity at an *exogenously determined* tariff in the end-user market ($\psi$)
- Marginal costs = 0
- Firms are homogeneous
- Total production capacity = supply capacity; no excess capacity

- We run SENSITIVITY ANALYSIS for:
  - Private information / public information
  - Different crossholding assumptions (for wholesalers)
The Setting (Cont.)
The General Model

- The seller’s problem:

\[
\text{MAX } \prod_{p} i,t = (p - c)(x_{i,t} + \Phi x_{\sim i,t})
\]

- The buyer’s problem:

\[
\text{MAX } \prod_{p} j,t = (\Psi - p)x_{j,t}
\]

Agents experimenting and improving bidding behaviour with four parameters:

- ‘Reinforcement’ ($\varepsilon$)
- ‘Persistent local experimentation’ ($\rho$)
- ‘Extinction in finite time’ ($\mu$)
- ‘Gradual forgetting’ ($\gamma$)
Pseudo-code

1. Initial values provided
2. Definition of the set of possible strategies
3. Definition of the propensity to play each strategy
   Affected by the $\rho$, $\mu$ and $\gamma$ parameters
4. Definition of the probability to play each strategy
   Normalisation by the sum of all propensities
5. Randomisation over the strategies, on the basis of the distribution of probabilities
6. Market clearing
7. Assignment of the quantities to sell and buy to each player
8. Alteration of propensities. $\varepsilon$
9. Back to 2
NASH PRICES

*Cournot one sided auction.*

Demand curve:

\[ P = 200 - Q \]

- **Monopoly = 100**
- **Duopoly = 66**
- **Triopoly = 50**
Theoretical Validation (Cont.)

COURNOT

<table>
<thead>
<tr>
<th></th>
<th>monop. 2</th>
<th>monop. 100</th>
<th>0%</th>
<th>10%</th>
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<th>30%</th>
<th>40%</th>
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<td>102.32</td>
<td>103.86</td>
<td>70.90</td>
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<td>69.72</td>
<td>75.48</td>
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<td>2.72</td>
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<td>0.68</td>
<td>3.39</td>
<td>4.55</td>
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<td>9998.33</td>
<td>8964.58</td>
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<td>closed form solution</td>
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<td>100.00</td>
<td>66.67</td>
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<td>10000.00</td>
<td>8888.89</td>
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<td>100.00</td>
<td>99.98</td>
<td>99.16</td>
<td>99.83</td>
<td>97.97</td>
<td>98.30</td>
<td>98.28</td>
<td>97.53</td>
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EMPIRICAL VALIDATION (Small games):
Informational Assumptions

• Private Information:

$$\text{privateprob}_{i,k}(t) = \frac{q_{i,k}(t)}{\sum_{k} q_{i,k}(t)}$$  \hspace{1cm} (propensity)  \hspace{1cm} (sellers)$$

$$\text{privateprob}_{j,l}(t) = \frac{q_{j,l}(t)}{\sum_{l} q_{j,l}(t)}$$  \hspace{1cm} (buyers)$$

• Public Information:

$$\text{publicprob}_{j,l}(t) = \sum_{j} (\text{mktshare}_j \ast \text{publicprob}_{j,l}(t))$$  \hspace{1cm} (buyers)$$

$$\text{publicprob}_{j,l}(t) = \text{publicprob}_{j,l}(t)$$
Prices and Crossholdings Under Linearity Specification

Private Information: Summary of Prices

\[ P = 82.360 + 16.036 \Phi \]

(0.000) (0.005)

Public Information: Summary of Prices

\[ P = 69.373 + 37.816 \Phi \]

(0.000) (0.000)

Volatility...
Crossholdings and Opacity

Value of Operating under Private Information

Private Info - Public Info

Mean ± 1 SE DIFF

N = 36, 36, 36, 36, 36, 36, 36, 36, 36, 36, 36, 36

CROSSOWN
Linear Specification

- Crossholdings lead to higher prices (as in literature)
- Private information leads to higher and less dispersed prices
- Slope is larger for public information: marginal value of crossholdings is higher in transparent markets
- However, the sellers’ advantage of keeping information private is reduced gradually. As crossholding size grows, the difference between public and private information becomes smaller
Analytical Discussion

• When information is public, learning is easier
• Social mimicry. More information increases competition because the computational agents imitate successful strategies
• Learning advantage on the demand side (2 sellers vs. 10 buyers) => lower prices than under private info (double auction!)
• Advantage progressively reduced by crossholdings. How fast? (concavity vs. convexity)
Alternative Specifications for Public Information

- Smooth quadratic

\[ p_{pub} = \alpha_{pub} + \beta_{pub} \Phi + \chi_{pub} \Phi^2 + u \]

- Threshold effect

\[ p_{pub} = \alpha_{0, pub} + \beta_{0, pub} \Phi + D\beta_{1, pub} \Phi + u \]
Results: Alternative Specifications

<table>
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<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
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<tr>
<td>1 (Constant)</td>
<td>66.586</td>
<td>2.284</td>
<td>29.148</td>
<td>.000</td>
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<td>PUSMACRO</td>
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<td>46.709</td>
<td>.561</td>
<td>.003</td>
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<td>KINK10</td>
<td>-90.102</td>
<td>41.089</td>
<td>-.419</td>
<td>.029</td>
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</table>

Crossholding threshold = 10%

- Concave functional form is highly significant
- A threshold effect is slightly more plausible than the polynomial model
- The linear specification provides the worst fit of the three
Analytical Explanation

• The crossholdings / market power relationship is not linear or convex but concave. Small crossholdings have a large learning / coordination effect

• “Social mimicry mechanism” unaltered through crossholdings: concavity result of learning through profit function (%crossholding)

• Scope for sellers to refine pricing strategies: limited by the private information prices, where info pooling on the seller side does not occur
Message(s)

- Public information favours the more competitive part of the market (social mimicry): info reduces market power
- Small crossholdings in a duopoly are sufficient to counterbalance the informational advantage (quasi-concavity). We expect:
  - When markets are settled, firms operating under transparent info seek many small crossholdings
  - Opaque markets should record fewer but larger crossholding deals
- The current screening of crossholdings might be insufficient
Supplementary Slides
Crossholdings, Information and Prices in a Bertrand-Edgeworth Double Auction

Derek W. Bunn
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Scope and Extensions

• Scope:
  - New general insights relevant to the global competitive energy industry and, in general, to all Bertrand-Edgeworth auctions
  - Computer-based experiment: contrast might be required. Empirical / analytical approaches have not succeeded, experimental economics?

• Extensions:
  - “Supply function equilibria”
  - Pay as bid vs. Pool Systems
  - Heterogeneous players (market share, capacity, access to information…)
  - Vertical relations