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)

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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

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Partial Acquisitions 2001

Size Ranking	Value of Transaction ($ mil)	% Acquired	Date Announcement	Target Name	Target Nation	Acquiror Name	Acquiror Nation
1	3,054.18	50.00%	06 Nov 2001	Birka Energi AB	Sweden	Fortum Oyj	Finland
2	1,647.51	44.80%	03 Dec 2001	Bewag Aktiengesellschaft AG	Germany	Vattenfall	Sweden
3	745.74	21.00%	04 Dec 2001	Hidroelectrica del Cantabrico SA	Spain	Electricidade de Portugal SA - EDP	Portugal
4	326.6	24.00%	11 Sep 2001	Energie Steiermark Holding AG (ESTAG)	Austria	Electricite de France (EdF)	France
5	193.8	1.20%	08 Nov 2001	Tractebel SA	Belgium	Suez Lyonnaise des Eaux	France
6	146.0	34.00%	01 Oct 2001	Espoon Sahko Oyj	Finland	E.On	Germany
7	73.4	10.00%	28 Sep 2001	Societe Publique d'Electricite - SPE NV-SA	Belgium	Electricite de France (EdF)	France
8	66.1	51.00%	18 Jun 2001	Oslo Energi AS	Norway	Vattenfall	Sweden
9	55.4	74.00%	10 May 2001	Kainuun Sahko Oy	Finland	Graninge AB	Sweden
10	37.6	1.43%	19 Sep 2001	Verbund	Austria	Energie Baden-Wuerttemberg AG - EnBW	Germany
11	16.1	4.03%	06 Jun 2001	Hafslund ASA	Norway	Sydkraft AB	Sweden
12	n/a	50.00%	12 Jul 2001	Virgin Energy Ltd	United	Electricite de France (EdF)	France
13	n/a	35.00%	06 Aug 2001	Stadtwerke Kapfenberg	Germany	Kaerntner Elektrizitaets-AG	Austria
14	n/a	20.00%	08 Aug 2001	Energiefinanzierungs AG	Germany	Elektrizitaetsgesellschaft Laufenburg AG (EGL)	Switzerland
15	n/a	50.00%	07 Dec 2001	TroenderEnergi	Norway	TXU Corp, Statkraft SF, Sydkraft AB	Sweden

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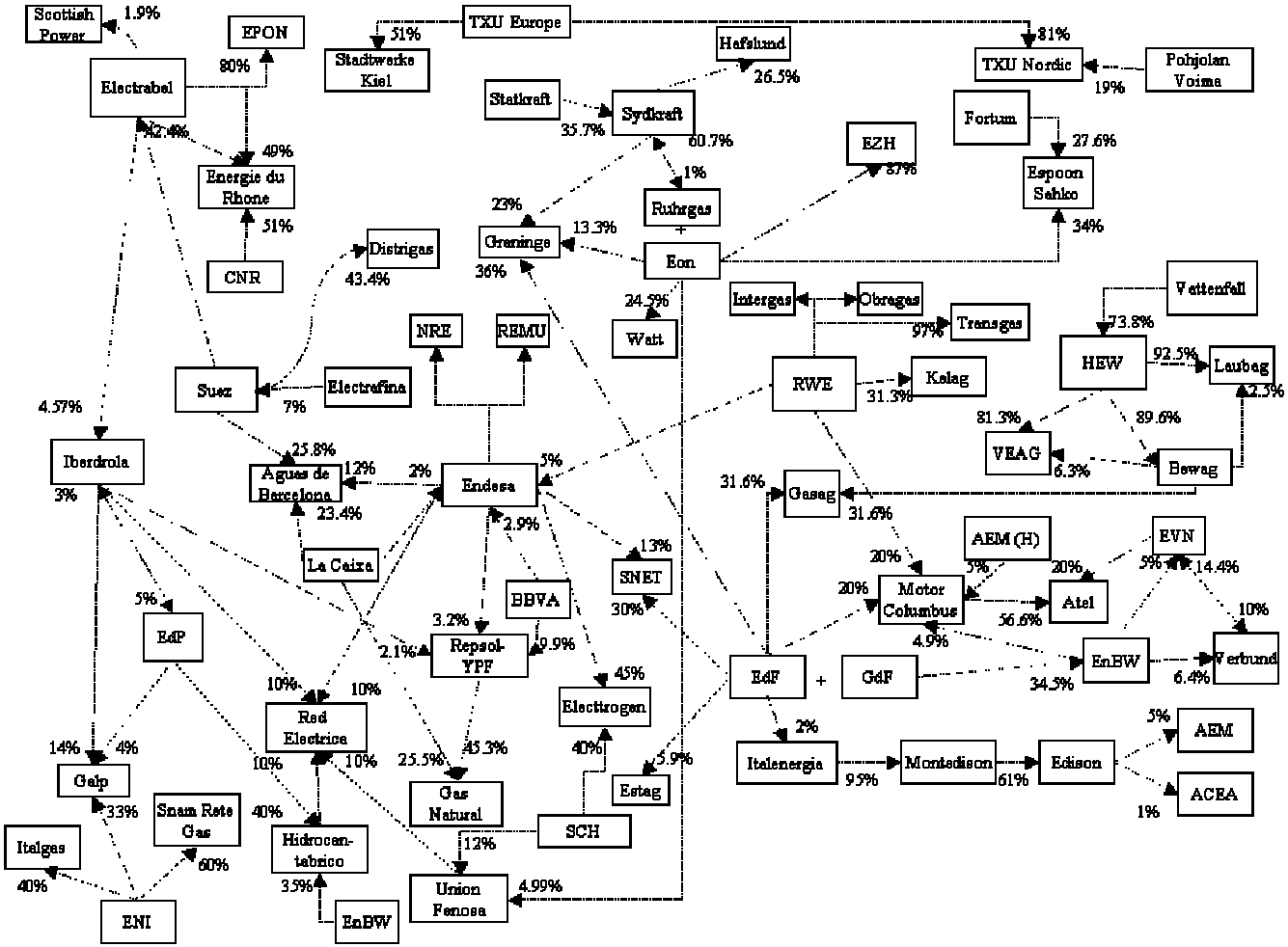
Cross-border partial acquisitions in the EU electricity industry, 2001.
Source: *PricewaterhouseCoopers' Analysis of Global Cross Border Electricity Deals 2001*

Partial Ownership in EU Electricity



Source: PricewaterhouseCoopers' Analysis of Global Cross Border Electricity Deals (2001) and Codognet et al (2002)

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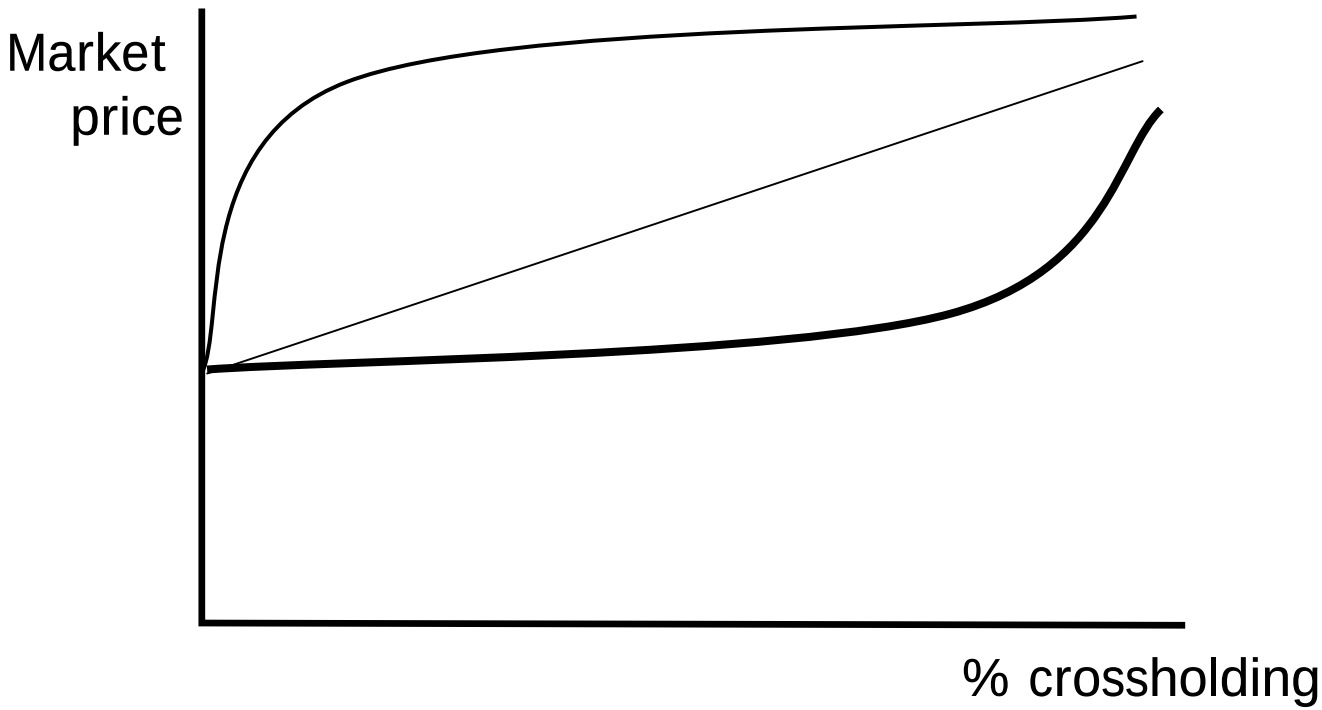
Regulators' Implicit Assumption?

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



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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)

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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

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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 (ψ)
- 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)

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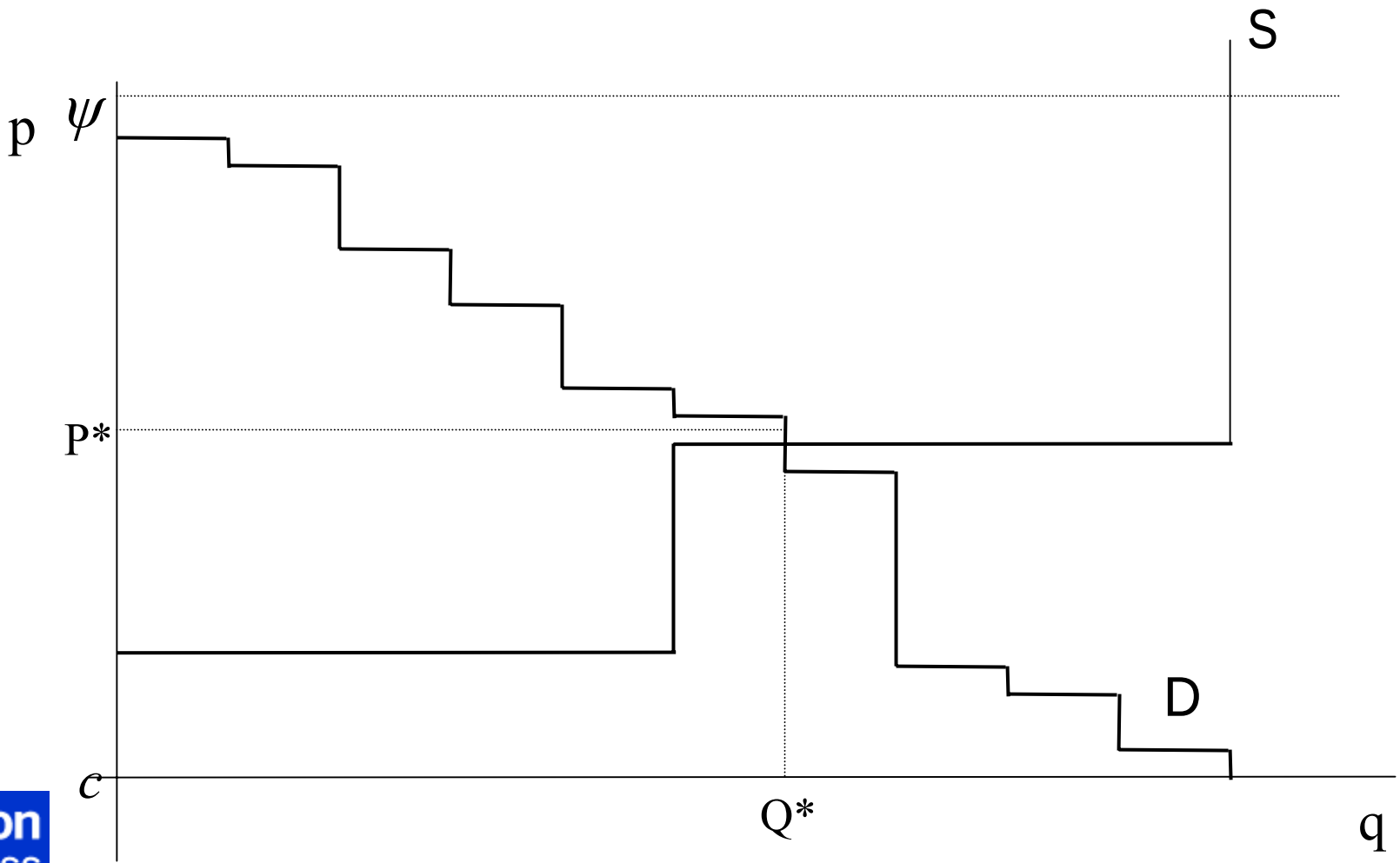
The Setting (Cont.)



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The General Model

- The seller's problem:

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

- The buyer's problem:

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

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An Intermediate Cognition Algorithm: Roth and Erev (1995)

Agents experimenting and improving bidding behaviour with four parameters:

- *'Reinforcement'* (ε)
- '*Persistent local experimentation*' (ρ)
- '*Extinction in finite time*' (μ)
- '*Gradual forgetting*' (γ)

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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 ρ, μ and γ 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. ε
9. Back to 2

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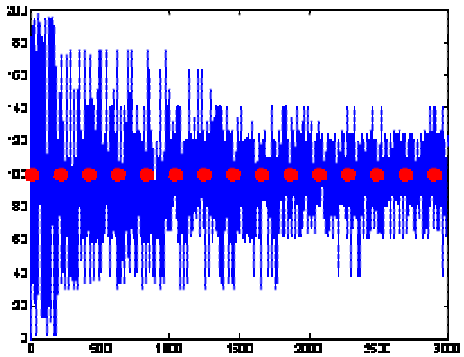
Theoretical Validation

Monopoly = 100



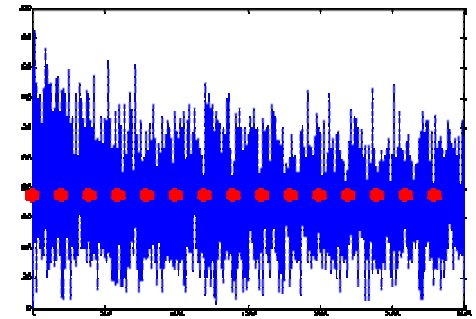
NASH PRICES

Cournot one sided auction:

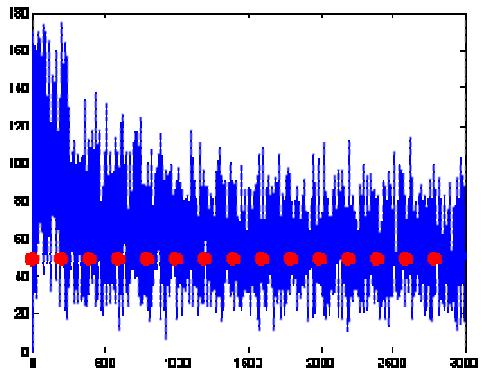
Demand curve:

P = 200 - Q

Duopoly = 66



Triopoly = 50



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Theoretical Validation (Cont.)

COURNOT

	monop. 2	monop. 100	0%	10%	20%	30%	40%	50%
first simulation	102.32	103.86	70.90	73.92	68.19	74.39	77.84	80.76
second simulation	94.40	100.40	65.08	72.41	72.88	75.22	75.76	82.97
third simulation	101.04	100.36	70.52	63.60	74.46	76.39	73.51	71.13
fourth simulation	101.96	99.52	68.32	69.24	71.95	74.75	80.38	83.07
fifth simulation	99.70	102.32	64.29	74.36	69.72	75.48	83.15	76.50
averages simulations	99.88	101.29	67.82	70.71	71.44	75.25	78.13	78.89
standard deviation	2.89	1.58	2.72	3.98	2.23	0.68	3.39	4.55
simulation av. Ind. profit	9999.99	9998.33	8964.58	9141.86	9184.33	9387.24	9521.62	9554.20
closed form solution	100.00	100.00	66.67	70.97	75.00	78.79	82.35	85.71
closed form profit	10000.00	10000.00	8888.89	9157.13	9375.00	9550.05	9688.58	9795.92
algorithm's accuracy	100.00	99.98	99.16	99.83	97.97	98.30	98.28	97.53

EMPIRICAL VALIDATION (Small games):
Roth and Erev (1995), Erev and Roth (1998), Feltovich (1999), Rapoport et al. (1997) and Erev and Rapoport (1998)

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Informational Assumptions

- Private Information:

$$privateprob_{i,k}(t) = \frac{q_{i,k}(t)}{\sum_{\forall k} q_{i,k}(t)}$$

(propensity)

(sum of all Propensities)

(sellers)

$$privateprob_{j,l}(t) = \frac{q_{j,l}(t)}{\sum_{\forall j} q_{j,l}(t)}$$

(buyers)

- Public Information:

$$publicprob_{j,l}(t) = \sum_{\forall j} (mktshare_j * publicprob_{j,l}(t))$$

(buyers)

$$publicprob_{j,l}(t) = publicprob_{\sim j,l}(t)$$

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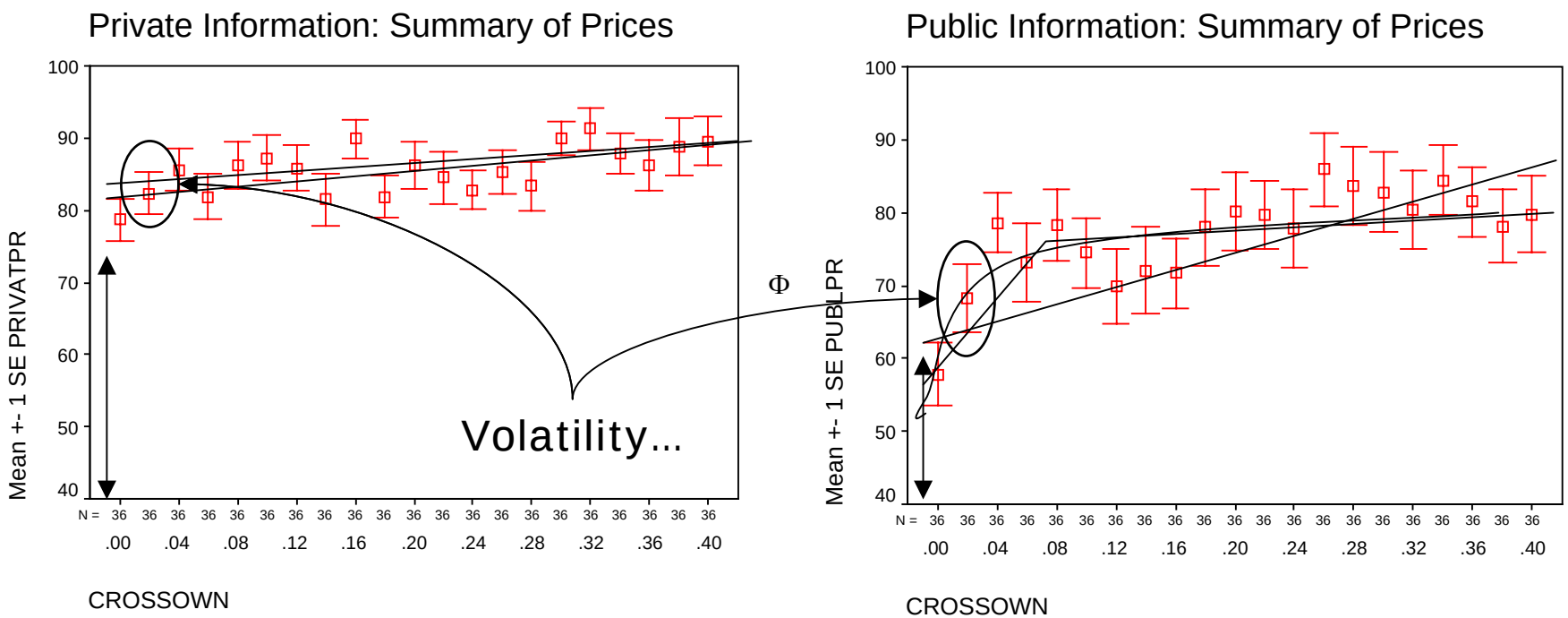
Prices and Crossholdings Under Linearity Specification



- Private information:

$$P = 82.360 + \underline{16.036}\ \Phi$$

(.000) (.005)

- Public information:

$$P = 69.373 + \underline{37.816}\ \Phi$$

(.000) (.000)

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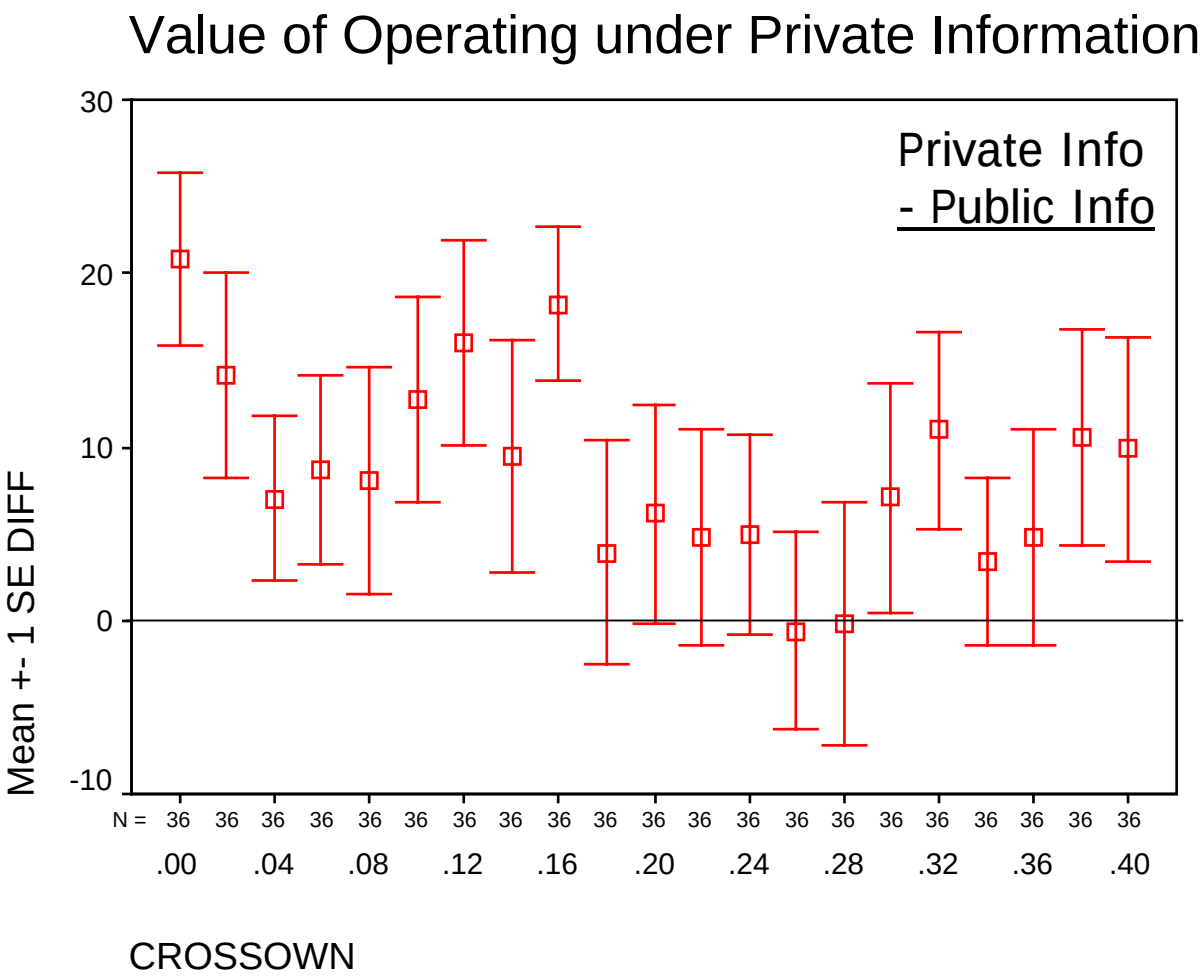
Crossholdings and Opacity



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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*

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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)

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Alternative Specifications for Public Information

- Smooth quadratic

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

- Threshold effect

$$p_{pub} = \alpha_{0,pub} + \beta_{0,pub}\Phi + D\beta_{1,pub}\Phi + u$$

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Results: Alternative Specifications

PUBLIC INFORMATION: Quadratic Fit

F = 10.20684 Model Significance = .0000

	B	T	Sig. T
CROSSOWN	100.075483	2.874	.0042
CROSSOWN**2	-156.882025	-1.867	.0623
Constant	65.533131	21.808	.0000

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	66.586	2.284		29.148	.000
	PUSMACRO	136.999	46.709	.561	2.933	.003
	KINK10	-90.102	41.089	-.419	-2.193	.029

a. Dependent Variable: PRKINK10

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

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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

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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

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Supplementary Slides

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Crossholdings, Information and Prices in a Bertrand-Edgeworth Double Auction

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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

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