Empirical IO

Wolfram (1999), "Measuring Duopoly Power in the British Electricity Spot Market"

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- Britain was the first to privatize electrical generation in April 1990;
- Three approaches to measure markups is used;
- Main findings is that the full advantage of market power is not used:
    1. Contracts;
    2. Threat of entry;
    3. Threat of regulatory intervention.

Structure of the presentation

I. The British Electricity Industry

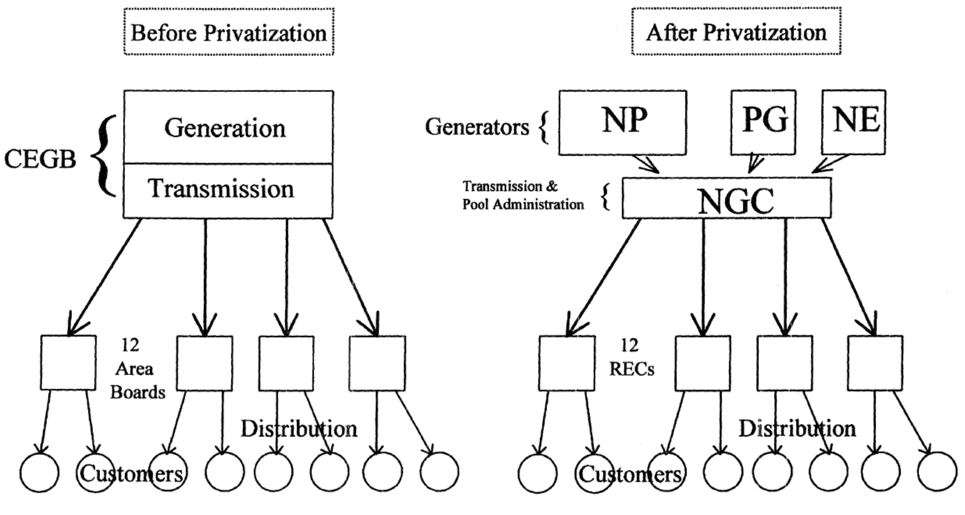
II. Empirical Framework

III. Direct Measure of the Generator' Price-Cost Markup

IV. Alternative Approaches to Measuring Markup

I. The British Electricity Industry

Before and After privatization



A,B: The Pool and Regulatory Oversight

The Pool

- "Day ahead" market with 48 half-hour periods;
- SMP clears market with info from generation and forecasted demand;
- One-way and two-way contracts.

Regulatory Oversight

- Office of Electricity Regulation (OFFER):
    - Four statements;
    - The fourth statement in 1994.
- Monopolies and Mergers Commission (MMC).

II. Empirical Framework

Empirical Framework

$$
\begin{aligned}
D_i &= D(P_t, \mathbf{X}_t, \varepsilon_t) \\
MC_{it} &= MC_i(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \\
\Pi_{it} &= P(Q_t, \mathbf{X}_t, \varepsilon_t)q_{it} - C(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \\
P_i &= MC_i(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) + \tilde{\theta}_{it} q_{it} P_Q(Q_t, \mathbf{X}_t, \varepsilon_t) \\
\theta_t &= \tfrac{P_t - MC(\cdot)}{P_t} \eta_t
\end{aligned}
$$

Demand description

$$D_i = D(P_t, \mathbf{X}_t, \varepsilon_t) \tag{1}$$

where t is a half-hour, P the pool price, $\mathbf{X}$ observed demand shifters;

- Several end-users buy directly from the pool, most have forward with a tie to the spot price;
- Possible responses to high prices:
  - Switch to a backup;
  - Temporal shut down;
  - Maintenance on electricity-intensive machinery.

Marginal-cost function description

$$MC_{it} = MC_i(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \tag{2}$$

where i is a generator suppling q_i, $\mathbf{Z_i}$ cost shifters

$$\Pi_{it} = P(Q_t, \mathbf{X}_t, \varepsilon_t)q_{it} - C(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \tag{3}$$

where $P(\cdot)$ is the inverse of (1), Q total industry demand, $C(\cdot)$ is the function whose derivative to q_{it} is (2)

Profit-maximization

$$P_i = MC_i(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) + \tilde{\theta}_{it} q_{it} P_Q(Q_t, \mathbf{X}_t, \varepsilon_t) \quad (4)$$

where $\tilde{\theta}_{it}$[1] characterizes behavior of i at t.

- $\tilde{\theta}_{it} = 1$ imply Cournot;
- $\tilde{\theta}_{it} = 0$ imply perfect competition.

Industry-level MC: take average of (4) over i:

$$P_i = MC(q_{it}, \mathbf{Z}_{it}, \varepsilon_{st}) + \frac{P_t}{\eta_t} \left[\sum_{i=1}^{N} \kappa_{it} \frac{q_{it}}{Q_t} \tilde{\theta}_{it} \right] \quad (5)$$

where $\eta = -D_p P/Q$ elasticity, κ weigh of i.

[1] $\tilde{\theta} = 1 + \sum_{j \neq i} dq_{jt}/dq_{it}$

Profit-maximization

To simplify notation (5) can be rewritten as:

$$P_i = MC(q_t, \mathbf{Z}_t, \varepsilon_{st}) + \frac{P_t}{\eta_t}\theta \tag{5a}$$

Note that if $\kappa_{it} = 1/N$ and $\tilde{\theta}_{it} = \tilde{\theta}_t$ then $\theta_t = \tilde{\theta}_t/N$.

- $\theta_{it} = 1$ firms are joint profit maximizers;
- $\theta_{it} = 1/N$ firms play Cournot;
- $\theta_{it} = 0$ firms are perfectly competitive.
- $1/\theta_t$ interpreted as "equivalent number of firms" in industry.

Profit-maximization

- (5a) can be rewritten in terms of θ_t:

$$\theta_t = \frac{P_t - MC(\cdot)}{P_t}\eta_t \tag{6}$$

- θ_t is essentially an elasticity-adjusted price-cost markup;
- For a given price-cost markup, a larger value of θ_t indicates that the deviation from the competitive equilibrium has led to more dead-weight loss:
  - because the higher demand elasticity means that the same price increase causes more of a demand reduction.
- Empirical sections measure: unadjusted price-cost markups and θ.

Empirical Framework

$$
\begin{aligned}
D_i &= D(P_t, \mathbf{X}_t, \varepsilon_t) \\
MC_{it} &= MC_i(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \\
\Pi_{it} &= P(Q_t, \mathbf{X}_t, \varepsilon_t)q_{it} - C(q_{it}, \mathbf{Z}_{it}, \varepsilon_{sit}) \\
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\theta_t &= \tfrac{P_t - MC(\cdot)}{P_t} \eta_t
\end{aligned}
$$

III. Direct Measure of the Generator' Price-Cost Markup

A: Measuring Marginal Costs

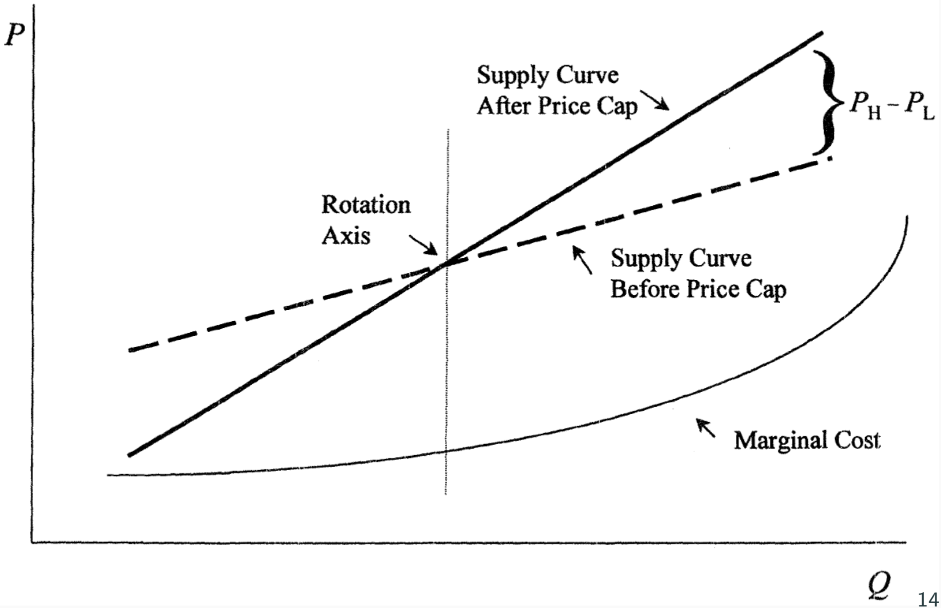
- Market fuel prices for the oil, gas-leaking and combined;
- Thermal efficiency under optimal operating conditions;
- Nuclear stations costs are assumed;
- A bid price for energy from France and Scotland;
- Accounting for incentive to withhold capacity.

B, C, D: Markups Calculated Using Actual Marginal Costs

Time period	$\frac{(P - MC)}{P}$	$\theta = \frac{(P - MC)}{P}\eta$	θ, based on highest SFE	Number of observations
January 1992–March 1993	0.241	0.043	0.28	12,704
	(0.129)	(0.030)	(0.06)	
April 1993–March 1994	0.259	0.057	0.29	8,637
	(0.228)	(0.055)	(0.06)	
After March 1994	0.208	0.067	0.33	4,298
	(0.416)	(0.086)	(0.07)	
Four weeks before a regulatory decision	0.329	0.071		3,216
	(0.150)	(0.051)		
Four weeks after a regulatory decision	0.156	0.028		2,671
	(0.213)	(0.040)		
By Quantity Level:				
January 1992–March 1993				
Above median	0.279	0.046	0.31	6,764
	(0.124)	(0.027)	(0.05)	
Below median	0.198	0.039	0.23	5,940
	(0.121)	(0.033)	(0.02)	
April 1993–March 1994				
Above median	0.299	0.056	0.33	4,530
	(0.184)	(0.044)	(0.05)	
Below median	0.214	0.058	0.24	4,107
	(0.261)	(0.065)	(0.02)	
After March 1994				
Above median	0.554	0.138	0.37	1,526
	(0.122)	(0.057)	(0.09)	
Below median	0.018	0.027	0.26	2,772
	(0.398)	(0.073)	(0.02)	

IV. Alternative Approaches to Measuring Markup

A: Markups Based on Changes in the Regulatory Environment



A: Markups Based on Changes in the Regulatory Environment

- Note the last two line on slide 13;
- Divide data into 25 groups based on the level of demand served during each period;
- And see if the average price for each group is higher after the cap;
- On slide 14 dashed line is the lowest quantity level where prices got higher after the cap;
- $^{(P_h - P_l)}/_{P_h}$, P_h (resp. P_l) average price for the group after (resp. before) the cap;
- The average for 14 quantity groups to the right of the rotation is 0.277 comparing with the last row in slide 13 imply the markups of about 50%.

B: Adjusted Markup Using Comparative Statics in Demand

To identify θ first step is to estimate (1):

$$Q_t = \mathbf{X}^{`}_t \alpha - P_t(\textit{winter wday})_t \beta_w - P_t(\textit{summer \& wend})_t \beta_s + \varepsilon_{dt} \tag{8}$$

And then (5a):

$$P_t = \mathbf{Z}^{`}_t \gamma + Q_t \delta + \frac{a_t}{b_t} \frac{\theta}{1+\theta} + \varepsilon_{st} \tag{9}$$

- ${}^{a_t}/_{b_t} = h_t$ is the ratio of the constant in the demand equation ($\mathbf{X}^{`}_t \alpha$) over $-D_p$ (estimated with $\hat{\beta}$);
- (8) is estimated with 2SLS, *nuclear availability* as instrument for prices (outages are exogenous to pool demand).

B: Adjusted Markup Using Comparative Statics in Demand

Independent variable	Coefficient	Standard error	Corrected standard error
Demand Equation:			
WINTER WEEKDAY PRICE	−71.4	24.9	108.2
SUMMER & WEEKEND PRICE	−45.1	20.8	78.4
TEMPERATURE	−331	15	57
$(\text{TEMPERATURE})^2$	9.86	0.54	1.66
COOLING POWER	5.38	1.46	4.32
CLOUDS	49.8	5.4	12.5
DUSK	518	74	223
NIGHT	1,816	177	674
Supply Relationship:			
Constant	11.0	2.2	5.13
NUCLEAR AVAILABILITY	−0.001	0.0005	0.0007
WINTER	−8.20	0.20	0.84
QUANTITY	0.001	0.0004	0.0007
θ	0.012	0.002	0.044

References

Wolfram, C. D. (1999). "Measuring Duopoly Power in the British Electricity Spot Market". In: *The American Economic Review* 89.4, pp. 805–826. ISSN: 00028282. URL: http://www.jstor.org/stable/117160.