HOW WELL CAN ONE MEASURE MARKET POWER IN RESTRUCTURED ELECTRICITY SYSTEMS ?

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INTRODUCTION

1. Context

- Discussion of relative impact of market structure and architecture on restructured electricity markets

- Ex post vs. ex ante action of regulators

- The European electricity system in background

  → A European architecture could improve the structure. But it is not put in place

  → Electricity law did not work

  → Let us try competition law

2. Focus

- Using market simulation models
- Two questions

  → ex post measurement of market power

  → ex ante assessment of market power
- Of the simple Stacking/equilibrium type

3. General theme of the talk

- Firms can and may try to exert market power (even when one expects they would not do so (the beginning of the Pool))
- But we know very little on how this really happens (ex post)
- And may thus still be less equipped to foresee how this will happen (ex ante)
- We lack unambiguous models of market power of restructured electricity systems
- And hence may fail in designing appropriate remedies

4. On the use of Stacking/equilibrium type models

- In the US

  Vast literature (Borenstein, Bushnell, Joskow, Kahn, Mansur, Saravia, Wolak, ...)

  California, New England, PJM

- In Europe

  Cambridge, ECN, IIT, MSC (Netherlands)

Principle:

Take a Stacking model

Estimate a net demand function (import/competitive fringe)

Run the equilibrium models in perfect competition and Cournot

5. **A multi-zone example** (Chao and Peck, 1998)

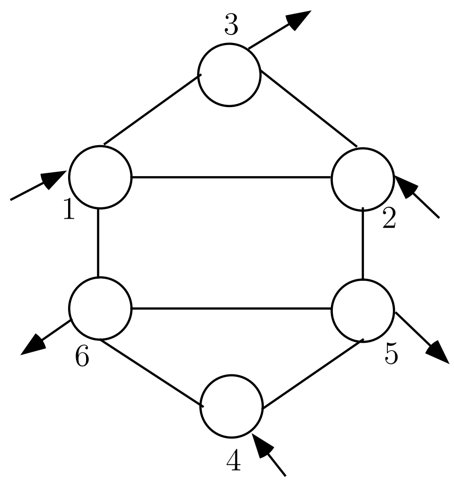


Figure 1: A simplified example

Assume two firms

$f = 1$ plants located in 1 and 2 $\quad$ $C_i(g_i)$ is the plant variable cost in i

$f = 2$ plant located in 4

Demand located in 3,5,6 $\quad$ $P_j(d_j)$ is the net inverted demand in j

Part I

MEASURING MARKET POWER

1. General remarks

- Emphasis of economists on excessive prices for which the jurisprudence of competition law is relatively scant
- Relatively ad hoc approach of European competition authorities on fundamental questions such as the relevant market

  With no quantitative assessments of economic concepts such as the hypothetical monopoly test (even in FERC ?)

  (If one is able to measure excessive prices, then one is able to apply the SSNIP)
- We follow suit and concentrate on excessive prices

ENERGY MARKETS ONLY

The spot market

1. The simplest possible Stacking/equilibrium model (energy market only: suppose no transmission)

- Firm 1

$$\max_{s_{1j}} \sum_{j=3,5,6} P_j(s_{1j} + s_{2j})s_{1j} - \sum_{i=1,2} C_i(g_i)$$

$$\text{s.t.} \quad 0 \leq g_i \leq G_i$$

$$\sum_{j=3,5,6} s_{1j} = \sum_{i=1,2} g_i$$

- Firm 2

$$\max_{s_{2j}} \sum_{j=3,5,6} P_j(s_{1j} + s_{2j})s_{2j} - C_4(g_4)$$

$$\text{s.t.} \quad 0 \leq g_4 \leq G_4$$

$$\sum_{j=3,5,6} s_{2j} = g_4$$

2. Implication

Notation: $\dfrac{\partial P_j}{\partial s_j} = P'_j$; $\dfrac{\partial C_i}{\partial g_i} = C'_i$ (short run marginal cost)

Suppose both firms supply all markets (in order to simplify the discussion); let C'_{fi} be the marginal cost of plant i of firm f

Equilibrium condition

$$P_j - MP_{1j} = C'_i + \text{scarcity rent if plant at capacity} \qquad j = 3, 5, 6;$$

$$P_j - MP_{2j} = C'_{24} + \text{scarcity rent if plant at capacity} \qquad j = 3, 5, 6$$

Measure of exercise of market power of firm f in market j

$$MP_{fj} = P_j - C'_{fm} - \text{ scarcity rent if plant at capacity}$$

3. Application: measuring market power ex post

$P_j - C'_{fi}$ - scarcity rent if plant at capacity = 0 signals no exercise of market power

Observe P and use the Stacking model to simulate C'_i and find scarcity rent

Looks simple

while Courts in general refrain from estimating marginal cost, the common wisdom has been that these are easy to evaluate in electricity and can be assimilated to the fuel cost of the most expensive plant in the merit order

4. Some literature has contested our ability to measure the marginal cost simply as fuel cost

- Papers by Harvey and Hogan (2000), (2001), (2002)

  Rajaraman and Alvarado (2003)

  Mansur (2005) and Wolak (2004)

- The difficulty: measuring C_i' requires detailed operational data which are not publicly available

- "While the overall implications of ignoring start up costs and other cost non convexities may be ambiguous, BBW argue that the overall effect is negligible when including margins from peak and off-peak hours" (Mansur, 2006)

5. Reported difficulties of measuring marginal cost

Harvey and Hogan, Rajaraman and Alvarado

- sensitivity to data when system is tight
- chronological demand that makes

  short run marginal cost $\neq$ variable cost

  short run marginal cost meaningless (startup cost, minimal run up and shut down constraints, ...)
- aggregation of hours into blocs (reduce marginal cost)
- limited energy plants

  pumped storage and reservoir

- decision under uncertainty

    hydro availability

    stochastic price process

- network constraints
- maintenance and plant availability

The way out ? "Dynamic oligopolistic electric power network competition with ramping costs and joint constraints" (Frietz, Mookherjee, Rigdon and Hobbs, 2005), several papers by Conejo and coauthors

Can one check the claim that "the overall effect is negligible" ?

6. The typical phenomenon

Suppose

1. a pure stacking model, and

2. one with various unit commitment features (2) (costs include fuel and CO_2 allowances)

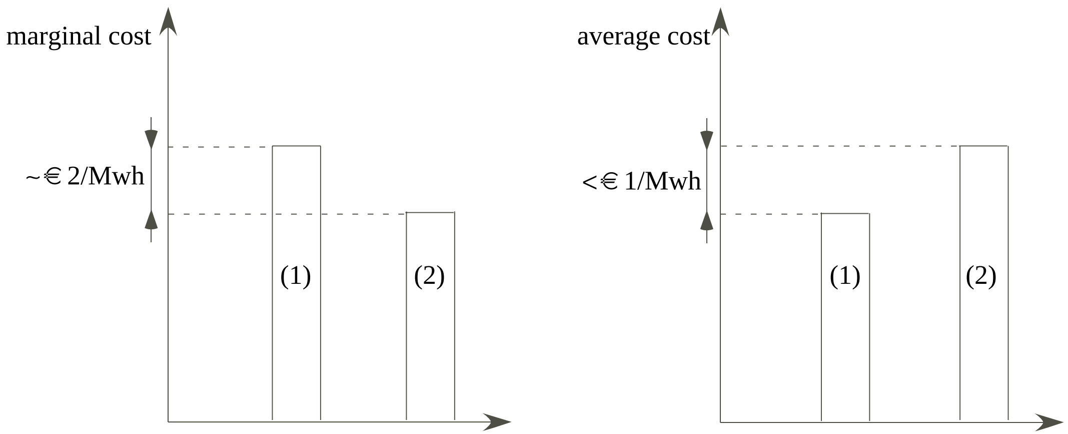


Figure 2: A typical phenomenon

7. Attempts to model these phenomena (the OR people)

- The convex features

  inclusion of ramping rate constraints

  (to OR people:) why directly work on a dynamic oligopolistic model ?

- The non convex constraint

  → O'Neill et al. treat non convex constraints by introducing nonlinear tariffs

  → Implication:

  ⋆ (to economists:) what does "$P_j - MP = C_i' +$ scarcity rent" become in nonlinear tariff ?

  ⋆ (to OR people:) how does one find non linear tariffs for minimal downtime constraints ?

8. Attempts to model these phenomena (the ECON group)

- Mansur (2005) "Measuring Welfare in Restructured Electricity Markets"

  "Many studies find substantial inefficiencies in restructured electricity markets using a common method of measuring competitive behavior. This method overstates actual welfare loss by ignoring production constraints that result in non-convex costs".

- Wolak (2004) "Quantifying the Supply-Side Benefits from Forward Contracting in Wholesale Electricity Markets"

  "The empirical analysis finds statistically significant evidence consistent with the existence of ramping costs"

9. In the following

Neglect this (real) problem

and concentrate on the most commonly used methodology

assess current market behaviour with respect to counterfactual assumptions

perfect competition

Cournot competition

(e.g. Bushnell, Mansur and Saravia, June 2006)

10. Discussion of the simple Stacking/equilibrium model

- The model compares price to short run marginal cost
- There is an old theorem that says $SRMC = LRMC$

  but only in perfect competition when investments are optimal
- It is commonly argued that
  - variable cost pricing (and spark and dark spread) do not justify new capacities
  - variable cost and CO_2 opportunity cost may justify new capacities (as observed on compensated spark and dark spreads)

    But it is not the role of the EU-ETS to induce new generation capacities!

– because of short term price inelasticity one does not observe the rationing cost scarcity rent (Stoft's market failures in electricity)

– that was fine with excess capacity but one is now concerned about resource adequacy

Question: one sees little of long run marginal costs in Stacking/equilibrium models. Why ? Can one do something about it ?

11. Choosing some instruments

- In the old days: LOLP
- Today: include the reserve (Stoft, 2002; Hogan, 2005; Cramton and Stoft, 2006)

I work with LOLP and associates

Why ?

i) because they give an (almost) analytic solution of a stochastic equilibrium model

ii) going from an LOLP to a regulated demand for reserve essentially consists in moving between two different equilibrium formulation of different complexity but does not change the concepts

LOLP: Probability that load is not served

Take the two zone problem as a single area

$$LOLP = Pr[s > G]$$

where

$$s = \sum_{j=3,5,6} s_j$$

$$G = \sum_{i=1,2,4} G_i$$

if s and G are made random

Alternative criterion: expected unserved energy

$$EUE = E[\max(s - G; 0)]$$

12. Discussion

LOLP has bad mathematical/risk properties

EUE has good mathematical/risk properties

(and a nice interpretation of shortage cost)

Both are simple to compute and LOLP is the derivative of EUE

Simply stated: let $R^m(s, G)$ be the reliability criterion in monetary terms: $R^m =$ value $\star R$ where $R =$ EUE. (m for "monetary").

Transpose the former pool LOLP idea (suggested by D. Newbery): the price paid by the consumer includes a contribution due to marginal R^m (or LOLP). (Drop reference to scarcity rent for convenience.)

13. Perfect competition pricing

$$P_j = C'_{fm} \text{ becomes } P_j = C'_{fm} + \frac{\partial R^m}{\partial s}$$

14. Cournot competition pricing

$$P_j - MP_{fj} = C'_{fi} \text{ becomes } P_j - MP_{fj} = C'_{fi} + \frac{\partial R^m}{\partial s}$$

We have a different measure of market power

$$P_j = C'_{fm} + \frac{\partial R^m}{\partial s} \text{ (competitive case)}$$

$$\text{vs. } P_j - C'_{fm} - \frac{\partial R^m}{\partial s} = MP_{fj} (= -P'_j s_j \text{ in the Cournot case})$$

We would have market power if

$$P_j - \left(C'_{fm} + \frac{\partial R^m}{\partial s} \right) > 0$$

Reminder: In contrast with some common wisdom LOLP, EUE and their derivatives are quite easy to compute in a single area problem (more on this infra)

15. Stacking/equilibrium model with reliability

It is easy to introduce reliability in the Stacking/perfect competition model.

In this example

$$\max \sum_{j=3,5,6} \int_0^{s_j} P_j(\xi_j) d\xi_j - \sum_{i=1,2,4} C_i(g_i) - R^m(s, G)$$

$$\text{s.t. } 0 \leq g_i \leq G_i$$

$$s = \sum_{j=3,5,6} s_j; \quad G = \sum_{i=1,2,4} g_i$$

But note the different treatment of

$\sum C_i(g_i)$ which is deterministic

$R^m(s, G)$ which is an expectation

Alternatively let

$$R(s, G) \text{ be the physical measure of reliability}$$

One can write

$$\max \ \sum_{j=3,5,6} \int_0^{s_j} P_j(\xi_j) d\xi_j - \sum_{i=1,2,4} G_i(g_i)$$

$$\text{s.t. } 0 \leq g_i \leq G_i$$

$$s = \sum_{j=3,5,6} s_j; \ G = \sum_{i=1,2,4} g_i$$

$$R(s, G) \leq \overline{R}$$

16. Consider the corresponding complementarity conditions

$$0 \leq -P_j + C'_{fm} + \lambda \frac{\partial R}{\partial s} \perp s_{fj} \geq 0$$

where λ is exogenous or

$$\begin{aligned} 0 &\leq -P_j + C'_{fm} + \lambda \tfrac{\partial R}{\partial s} \perp s_{fj} \geq 0 \\ 0 &\leq \overline{R} - R(s, G) \perp \lambda \geq 0 \end{aligned}$$

where λ is endogenous

The first one corresponds to a Nash Equilibrium problem

The Regulator determines λ and the TSO charges λ when there is curtailment (as in Crampton and Stoft, 2006)

The second one corresponds to a Generalized Nash Equilibrium problem: the Regulator does not determine λ, there is market failure because the market cannot express the value of reliability (as in Crampton and Stoft, 2006)

17. Discussion

Is this well received ? No! LOLP is an “old engineering trick”

But it is just appearance: consider

$$0 \leq -P_j + C'_{fm} + \lambda \frac{\partial E_\omega[\max(s - G; 0)]}{\partial s} \perp s_{fj} \geq 0$$

or

$$0 \leq -P_j(\omega) + C'_{fm}(\omega) + \lambda \partial \max(s(\omega) - G(\omega); 0) \perp s_{fj}(\omega) \geq 0 \quad \forall \omega$$

$C'_{fm}(\omega) + \lambda \max(s(\omega) - G(\omega); 0)$ is the dual variable of the first constraint of

$$\begin{aligned} \min \ & \sum C_i(g_i; \omega) + \lambda \xi(\omega) \\ \text{s.t.} \ & \sum g_i(\omega) + \xi(\omega) \geq \sum s(\omega) \\ & 0 \leq g_i(\omega) \leq G_i(\omega) \end{aligned}$$

which is itself a simplified version of

$$\min \sum C_i(g_i;\omega) + \mathrm{VOR}[\mathrm{res}(\omega)] + \lambda\xi(\omega)$$

where

$$\sum g_i(\omega) + \xi(\omega) \geq \sum s(\omega)$$

$$\mathrm{res}(\omega) = \max[\sum s(\omega) - \sum g_i(\omega); 0]$$

$$0 \leq g_i(\omega) \leq G_i(\omega)$$

Both the LOLP and the demand for reserve lead to a stochastic equilibrium problem but

the LOLP can be put of the form $\lambda(E(\cdot)$

while the demand for reserve requires $E(\lambda(\omega)\cdot)$

Take a very simple version of R

$$R(s_3 + s_5 + s_6; G) \equiv G - (1 + \alpha)(s_3 + s_5 + s_6)$$

where α is a reserve margin

This will lead to a capacity market if one makes the G_j endogenous.

In all cases the exercise of market power is measured by

$$P_j - C'_{fm} - \lambda \frac{\partial R}{\partial s} \text{ if } s_{fj} > 0$$

A really difficult issue: a local reliability criterion

- the LOLP/EUE computation is inherently single node (the convolution)
- the demand for reserve requires a stochastic program (solving the problem for each ω)
- the local reliability criterion requires a much more complicated stochastic program

18. Conclusion on the Stacking/equilibrium model extended to reliability

One can introduce reliability in models of restructured markets

The former mechanism of the E & W pool and the LOLP/EUE suggest the way and lead to ideas quite similar to those of Cramton and Stoft (2006)

This has obvious implications on the measure of the exercise of market power

Models that would account for LOLP/EUE or data difficulties cause no major computational in a single area problem

Can it be extended to a multiarea problem ?

- Yes provided one makes the assumption that each area faces its own reliability criterion in real time.
- Which is the current situation in Europe
- Difficult otherwise: reliability is indeed quite difficult to compute (and even define) in multiarea problems

19. Alternatively, an investment model

The old theorem of perfect competition: "price = LRMC = SRMC" was proved in an investment model under perfect competition (or optimally adapted system)

The principle: Transform firm 1 model into

$$\max \sum_{j=3,5,6} P_j(s_{1j} + s_{2j})s_{1j} - \sum_{i=1,2}[C_i(g_i) - K_i G_i]$$

$$\text{s.t. } 0 \le g_i \le G_i$$

$$\sum_{j=3,5,6} s_{1j} = \sum_{i=1,2} g_i$$

(with a similar model for firm 2)

20. Equilibrium conditions

Suppose both firms supply all markets from all plants

$$P_j - MP_{j'} = C_i' + \text{ scarcity rent if plant } i \text{ at capacity}$$

becomes, for all plants for which there is investment $(G_i > 0)$

$$P_j - MP_{j'} = C_i' + K_i$$

We again get a different view of market power where

$$P_j - MP_{j'} = C_{fm}'$$

is replaced by

$$P_j - MP_{j'} = C_i' + K_i \qquad (G_i > 0)$$

There is exercise of market power if $P_j - C_i' - K_i > 0$

21. Discussion

The problem is technically more complicated because

i) one does not invest for a single time segment

ii) investment models were also formulated with a reliability criterion with the consequence that

$$P_j - MPj = C_i' + K_i$$

is not the true equilibrium condition if one accounts for that criterion

Take (i) first: it is not a real difficulty to construct a more general model

Firm 1.

$$\max \sum^h \sum_{j=3,5,6} P_j^h(s_{1j}^h + s_{2j}^h)s_{1j}^h - \sum_{i=1,2} C_i^h(g_i^h) - K_i G_i$$

$$\text{s.t.} \quad 0 \leq g_i^h \leq G_i \qquad \nu_i^h$$

$$\sum_{j=3,5,6} s_j^h = g_1^h + g_2^h \qquad \mu_1^h$$

But the measurement of the exercise of market power with respect to the perfect competition assumptions is more difficult

$$P_j^h(-MP_{ji}^h) = \mu_i^h \qquad \text{if } s_{1j}^h > 0$$

$$\mu_i^h = C_i'^h + \nu_i^h \qquad (\text{or } \mu_1^h \geq C_i'^h)$$

$$\sum \nu_i^h = K_i \qquad \text{if } G_1 > 0$$

Again $\mu_i^h > C_i'^h$ if capacity is tight

But in contrast with $\dfrac{\partial R}{\partial s}$ that can be easily computed for each h

$$\nu_i^h \text{ requires to take care of } \sum \nu_i^h = K_i$$

Take (ii) : add the payments/remuneration for reliability

$$\max \sum\nolimits^h \ \sum\nolimits_{j=3,5,6} \left[P_j^h(s_{1j}^1 + s_{2j}^h) - \lambda \tfrac{\partial R^h}{\partial s_{1j}} \right] s_{1j}^h$$

$$- \sum\nolimits_{i=1,2} C_i^h(g_i^h) - (K_i - \lambda \sum\nolimits^h \tfrac{\partial R^h}{\partial G_i}) G_i$$

$$0 \leq g_i^h \leq G_i \qquad \nu_i^h$$

$$\sum\nolimits_{j=3,5,6} s_j^h = g_1^h + g_2^h \qquad \mu_1^h$$

22. Conclusion

Market power is commonly measured by comparing prices and short run variable costs and not prices with long run marginal costs

This may lead to the strange conclusion that firms prices that are too low to pay for capital expansion are excessive!!!

Very much like the simplification made for computing C_i', neglecting to account for long run marginal cost artificially influences the "measurement" of the exercise of market power

The above models are conceptually not difficult; they tie in well with current(US) discussion of resource adequacy.But they might raise interesting computational issues

Again, assume these problems away in the following

PART II

CAN ONE FORESEE THE EXERCISE OF MARKET POWER ?

1. A stylized (but realistic) situation

Suppose (a few years ago) a market where

- a company serves 90 % of the market
- electricity price is 35 €/Mwh, insufficient to invest in new capacities
- reserve rate is becoming negative

Suppose a model that tells that

- splitting the incumbant and dominant company in 4 reduces the computed price from €80/Mwh to €50/Mwh

- but splitting the company in 4 reduces the computed price from €80/Mwh to €40/Mwh
- therefore one recommend splitting the company in 4

Is this useful ?

Some regulators think so because this reduces the potential for exerting market power.

These are ex ante measures

2. Can one trust models of market power ?

- What is well known:

  The results significantly depend on the price elasticity and on whether one constructs a short run or a long run model

- What begins to be known (the Ralph brothers)

  The results significantly depend on the assumed model of imperfect competition; (e.g. Cournot or supply function equilibrium)

- What one knows since a long time but does not seem to care about

  Some models of imperfect competition do not have solution or have many because they are intrinsically non convex

ENERGY MARKETS ONLY (2)

Long term contracts

1. Simple Stacking/Cournot model

Let s^c_{fj} be the forward contract of firm f to consumer j (set at zero if there is no forward constraint)

Firm 1.

$$\max_{s_{1j}} \sum_{j=3,5,6} P^f_j s^c_{1j} + P_j(s_{1j} + s_{2j})(s_{1j} - s^c_{1j}) - \sum_{i=1,2} C_i(g_i)$$

$$\text{s.t.} \quad 0 \leq g_i \leq G_i$$

$$\sum_{j=3,5,6} s_{1j} = \sum_{i=1,2} g_i$$

$$s_{1j} \geq 0$$

2. Equilibrium Cournot conditions

Assume again that both firms supply all markets from all plants

We move beyond the sole measurement of the exercise of market power on the spot market to compare P_j where

$$P_j + P_j'(s_{1j} - s_{1j}^c) = C_i' + \text{ scarcity rent if plant at capacity} \quad j = 3, 5, 6; i = 1, 2$$

and P_j where

$$P_j + P_j' s_{1j} = C_i' + \text{scarcity rent if plant at capacity}$$

Assuming no scarcity rent, one has if C'_{fm} is the marginal cost of firm m

$$
\begin{array}{ll}
s^c_{1j} > s_{1j} & P_j < C'_{fm} \\
s^c_{1j} = s_{1j} & P_j = C'_{fm} \\
s^c_{1j} < s_{1j} & P_j > C'_{fm}
\end{array}
$$

Bushnell, Mansur and Saravia (2006) and Mansur (2006) explore these results on different markets and find the remarkable result that while the Cournot assumption applied to the single spot market is unrealistic, it is quite satisfactory when taking contracts into account

3. Discussion

- The Stacking/equilibrium model is easily modified to account for forward contracts, but one may encounter some data problem

  → but one knows almost nothing in Europe on forward contracting (Platt's publication/some exchanges trade futures)

  → and hence one cannot identify the model (e.g. $P_j < C'_{fm}$ can be due to long term contracts or unit commitment constraints)

- Forward contracts are endogenous

  → their modeling depends on whether one believes more in

  ⋆ arbitrage between the two periods

  ⋆ possible discrimination through time because arbitrageurs are afraid of exercise of market power

- European competition authorities systematically oppose forward contracting by incumbents (because of foreclosure)

  Even though economists have argued, and BMS (2006) and MS (2006) confirm, that they effectively mitigate market power

- But: the contracts also raise methodological questions. Forward contracts are endogenous

  → the amount of forward trading is determined ex ante under an assumption of arbitrage/discrimination

  → and the problem becomes a two stage equilibrium problem

  → we can invoke Allaz Villa

  But is this always sufficient ?

4. Are we sure that forward contracting always suffices to mitigate market power ?

Back to resource adequacy

Allaz-Vila is a two stage game

that is entirely stated in equality form

therefore a convex problem

Capacities involve inequalities and endogenous capacities give firms a new instrument

that may enhance / hamper the prisoner dilemma effect of Allaz-Vila

Works in progress (Zoettl, 2005-2006 and Murphy-Smeers, 2005-2006) show that capacities may completely destroy the Allaz-Vila phenomenon

5. Announcement

The assumption of arbitrage and the solution of two stage equilibrium problems appear in a recurrent way in

- asymmetric conditions of competition in energy and service markets
- representation of endogenous investments
- representation of endogenous long term contracts

We look at two-stage model by focusing on transmission (the most debated case)

ENERGY AND TRANSMISSION

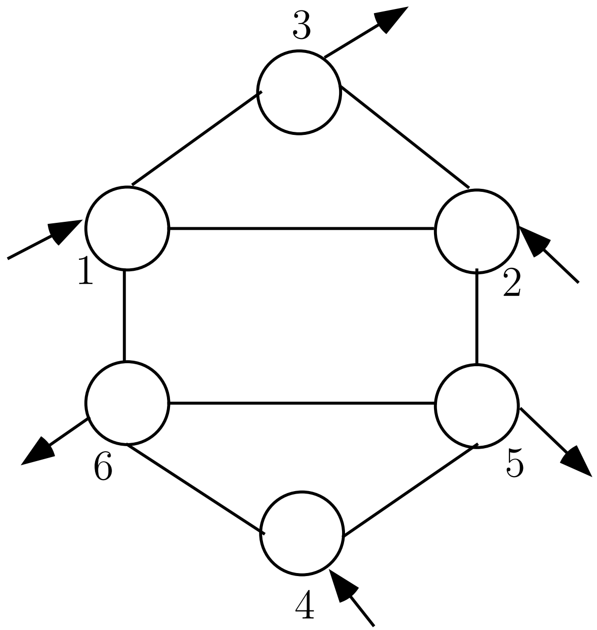
1. Transmission, single and two stage models

- Recall from Part I, reliability is an externality which is assumed to be priced in a perfectly competitive market in the above models; we know from the history of the Pool in England & Wales that it can be subject to market power. Suppose we want to represent market power on reliability (e.g. on spinning reserve), then the asymmetry of assumption between energy and spinning reserve is thus inadequate, both in theory and practice

- The grid is another externality that we also know can be also subject to market power. It has been extensively explored: the problem of extending the Cournot assumption to the grid (and to other services) is the following

- We have a demand function for energy but not for reliability or transmission. A temptation is to assume market power on energy and perfect competition on reliability or transmission

2. Reminder of the example



3. Modeling transmission

The PDF representation

- select a hub node (e.g. 6)
- take the DC approximation of load flow equations
- compute PDF: flow on some line due to injection/withdrawal at nodes

In the example: two constrained lines (1–6) (2–5); i node

$$PDF_{i(1-6)} \quad PDF_{i(2-5)}$$

The constraints due to the grid can be written

$$\sum_{i=1,2,4} PDF_{i(1-6)} g_i - \sum_{j=3,5,6} PDF_{j(1-6)} s_j \leq \overline{F}_{1-6}$$

with a similar constraint for (2-5).

4. A Stacking/Cournot energy market with a perfectly competitive transmission market

Let w_i be the injection/withdrawal charge for transmission at node i

Do not mention scarcity rent

From perfect competition in generation to Cournot generation

$$0 \leq -P_j + C_i' + w_i - w_j \perp g_i \geq 0$$

$$0 \leq \overline{F}_{(1-6)} - \sum_{i=1,2,4} PDF_{i(1-6)} g_i + \sum_{j=3,5,6} PDF_{j(1-6)} s_j \perp \lambda_{(1-6)} \geq 0$$

... (same for (2-5))

$$w_i = \lambda_{(1-6)} PDF_{i(1-6)} + \lambda_{(2-5)} PDF_{i(2-5)}$$

5. Discussion

General questions:

- Can one simply assume Cournot in energy market and perfect competition in transmission market ?
- If so does this represent unbundling well (does it suffice to retain the perfect competition formulation) ?

More specific questions:

- Price discrimination between customers and arbitrage opportunities
  - at some node (which is reasonable because of the Cournot assumption)
  - between nodes (which comes from the asymmetry of assumptions between the energy and transmission markets)

6. Is there always arbitrage ?

Not necessarily.

- For physical reason: implicit vs. explicit acutions (in EU parlance)

  several coordinated PX or a single PX in Europe

  ⇒ Various studies conclude that the market is not well arbitraged

- For economic reason: some markets are illiquid, possibly because of the danger of having a dominant agent as a counterpart.

7. Can one check that the market is well spatially arbitraged ?

- One can conduct systematic analysis (e.g. Siddiqui et al. 2003, Saravia 2003)
- (In Europe) Arguments in favour of implicit auctions in Forum and mini Fora
- Observation of the market in trading rooms
- Zachmann G. (2005). Convergence of electricity wholesale prices in Europe. A Kalman Filter Approach DIW Berlin

8. Suppose there is arbitrage among demand nodes (Hobbs et al. (2003))

$$\max \sum_{j=3,5,6} [P_j(s_{1j} + s_{2j} + a_j) - w_j] a_j$$
$$\text{s.t.} \quad \sum_{j=3,5,6} a_j = 0$$

implies

$$P_j - w_j = P_{j'} - w_{j'} \qquad j, j' = 3, 5, 6$$

Question: What is the role of arbitrage in the Stacking/Cournot model ?

9. How do generators behave with respect to arbitrageurs ?

One can assume two things

- Generators take the a_i as given when they go to the energy market (single stage problem)
- Generators foresee the action of the arbitrageurs when they go to the energy market (two stage problem)

Both assumptions give the same result (Metzler, Hobbs and Pang, 2003).

But suppose the two assumptions would give different results, would one be able to choose a priori which assumption is best ?

10. One can raise the same question for transmission

The TSO is an arbitrageur that

> buys and sells between all consumers nodes (because we did not assume any competitive fringe in generation and the Cournot assumption supposes a vertical supply curve)

> so as to satisfy the constraints of the network while maximizing welfare when injection from Cournot generators are given.

This is a constrained arbitrage (constrained by line capacities).

Let y_i be purchase/sale of the TSO at node i. Suppose the TSO does not exert market power.

11. Equilibrium conditions on the transmission market

$$0 \leq \overline{F}_{(1-6)} - \sum_{1,2,4} PDF_{i(1-6)} g_i + \sum_{j=3,5,6} PDF_{j(1-6)}(s_j + y_j)$$

$$\perp \lambda_{(1-6)} \geq 0$$

$$\sum y_i = 0$$

$$w_i = \lambda_{(1-6)} PDF_{i(1-6)} + \lambda_{(2-5)} PDF_{i(2-5)}$$

This is an EPEC problem.

And the nice result of the Hobbs et al.'s arbitrageur does not hold anymore: results are different on the energy market depending on whether Cournot players anticipate the action of the TSO or not

12. Is this useful ?

It is at least embarassing: the results depend on the assumptions of anticipation of the player!

One can try to make it useful

E.g. Ehrennman and Neuhoff (2006): Compares sequential and integrated transmission and energy markets in EU proposals

In the sequential markets: generators take the transmission rights of the traders as given when they behave according to a Cournot equilibrium: this is a single stage model (simplifying their representation of the competitive fringe).

In the integrated market Cournot players decided first and TSO and arbitrageurs come later: this is a two stage model

13. Is this a good interpretation ?

Probably as good as one can formalize the European transmission proposals; but

- the interpretation supposes an exceptional clairvoyance of the traders: they anticipate the behaviour of the TSO

  (but traders were claimed not to be conversant with electricity transport problems, and their lack of clairvoyance was one of the arguments to justify the sequential market!)

- a common TSO

  (the impossibility of which is also argued to justify the current proposal)

14. Do those differences matter ?

Except for the particular case of the arbitrageurs (assuming there is arbitrage), yes they matter

- single and two stage models give different results
- two stage models imply a lot of rationality and bounded rationality matters (Barkin et al. (2004))

The problem is: these assumptions matter but we are unable to select the right assumption.

15. Preliminary conclusions

- Single stage models of market power require unrealistic asymmetric assymptions of competition.
- Two stage models correct this drawback by requiring unidentifiable assumptions! The best discussion of these choices: Yao, Adler and Oren, 2006 and related papers

BACK TO SINGLE STAGE MODELS

1. Simplifying through

We did introduce two stage models to make assumptions of market power more symmetric in terms of

- behaviour of generators with respect to final demand
- behaviour of generators with respect to arbitrageurs
- behaviour of generators with respect to transmission

We had a similar question of asymmetry of behaviour with respect to the capacity market

We could imagine the same question vis à vis local emission permits (e.g. green certificates in the EU), probably not CO_2 allowances

Can we construct two stage models including all these ? No

Can we justify the underlying assumptions of these two stage models ? A possible (ad hoc ?) way out: The conjectured supply function approach (Day, Hobbs and Pang (2002) for energy; extension by Hobbs and Pang (2004) to the other markets)

Ad hoc ?: useful in good hands, subject to abuse otherwise

2. The congectured supply curve

Day et al. (2002). Let p^*, s^* be equilibrium values on a market.

We assume that firm f conjectures

$$s_{-fi} - s^*_{-fi} = SFC_{-f}(p_i - p^*_i)$$

This is similar (in fact identical after some transformations) to conjectural variations

$$\frac{ds_{-fi}}{ds_{fi}} = \gamma_f$$

3. Extension

On transmission, firm f believes that if it increases its injection/withdrawal at some node (e.g. 1 for injection and 3 for withdrawal) with respect to the equilibrium value, injection/withdrawal charge at node i becomes

$$-w_{fi} + \{w_{fi}^* + WC_{fi}(g_1 - g_1^*)\}$$

We can do the same "conjecture" for

price of emission allowance (e.g. green certificate)

reliability (e.g. capacity market)

4. Advantages and drawback

Single stage game: one can control the conditions of existence of an equilibrium.

Possibly ad hoc but not more than conjectural variation in which it is in one to one correspondance

Can be partially calibrated, but leaves a large room formore or less arbitrary assumptions.

CONCLUSION

- Stacking/equilibrium type models are proposed to examine
  - extent of market power (ex post)
  - extent of potential for market power (ex ante)

    in the sense of excessive prices

  and to suggest ex post and ex ante remedies (divestiture, virtual auctions)

- These models "abstract away from market design characteristics ..."

  (Bushnell, Mansur and Saravia, 2003, repeated insubsequent versions of the paper)

  Can they be trusted ?

- A general remark

  Economists concentrate on excessive prices but this is only one of the abuses of dominant position foreseen by Article 82 in European competition law. It is also one where Courts have been most reluctant to get into: difficult to compute costs, let alone marginal costs

  → But the situation is claimed to be different in electricity (since Wolfram, 1999)

  → Are we sure ?

- Ex post
  - marginal cost may not be that easy to measure
  - counter factual assumptions: perfect competition vs. Cournot
    * short run vs. long run marginal cost suggests the introduction of an other market (capacity/reliability) in the perfect competition paradigm
    * leads to asymmetric assumptions in imperfect competition that are also found as soon as one introduces other markets (e.g. transmission, forward contracts)
  - Can one remedy these asymmetric assumptions ?
    * yes, two stage models do
    * but they are vulnerable to a wide choice of equally plausible assumptions

– Can one avoid two stage models ?

 * yes, by using conjectured supply curves
 * but these cannot be calibrated when they are too many markets

Is this embarassing ? Consider the two following statements that refer to these approaches applied to the Californian market.

"With this clarification, the second conclusion is less well understood and more important. Namely, the record to date has not produced anything that has withstood analysis to support a finding that market manipulation, including the exercise of market power, had a major impact on prices during 2000-2001" (Hogan, September 2003).

"The firm-level results presented below are consistent with the view that the enormous increase in the amount market power exercised in the California market beginning in June of 2000 documented in BBW was due to a substantial increase in the amount of unilateral market power possessed by each of the five large suppliers in California. (Wolak, June 2003).

These are different ex post assessments

- Ex ante

  → if we cannot measure ex post, what can we say ex ante ?

- The cause

  → we do not have a good theory of oligopoly

  → as revealed by the reasoning of competition authorities in concentration cases which sometimes appears incredibly soft