Association des Economistes de l'Energie (AEE) &
Centre de Géopolitique de l'Energie des Matières Premières (CGEMP)
Université Paris-Dauphine, July 1, 2011

Market Power

"It is rare for anyone but an economist to suppose that price is predominantly governed by marginal cost" (J.M. Keynes, 1921)

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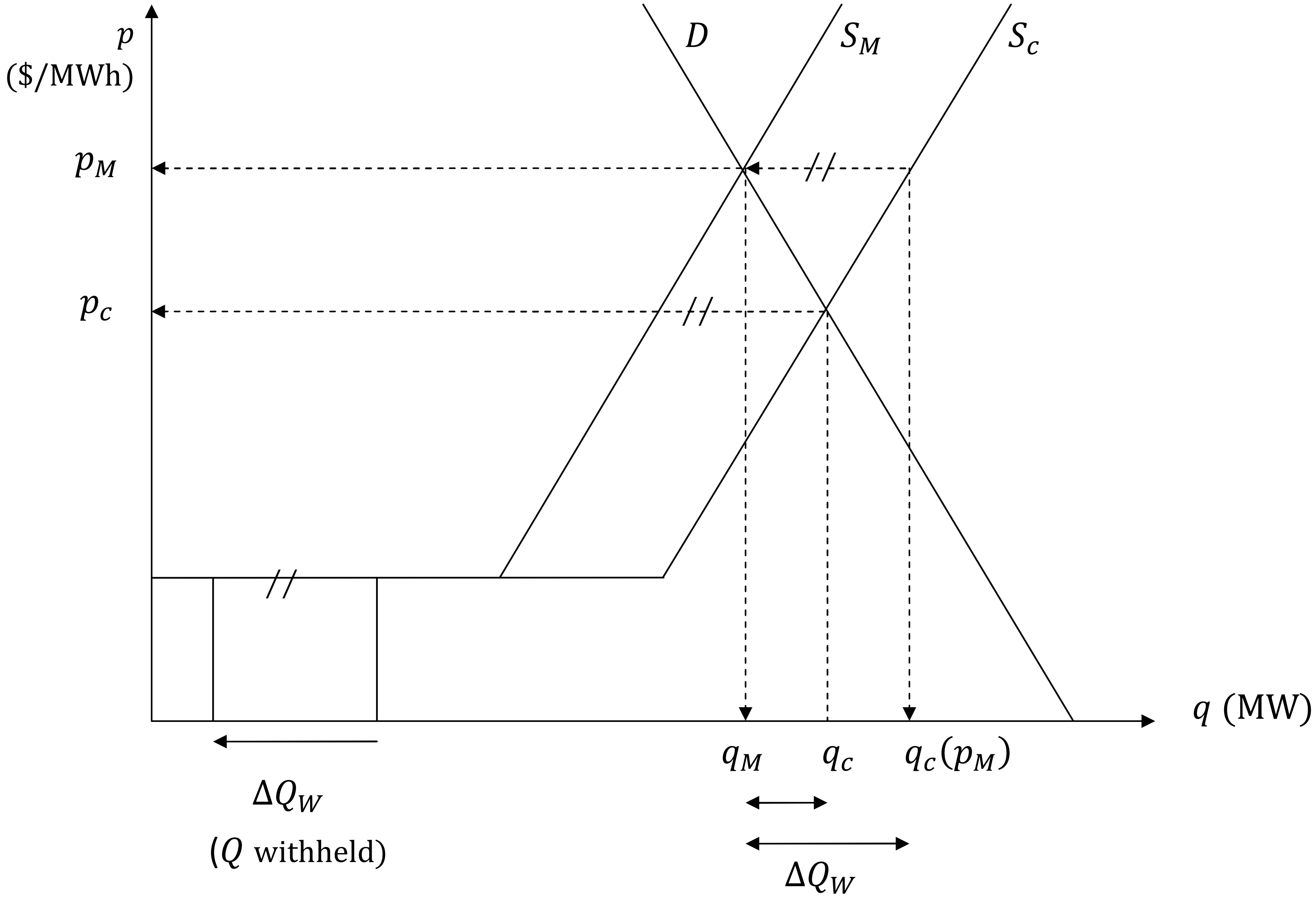
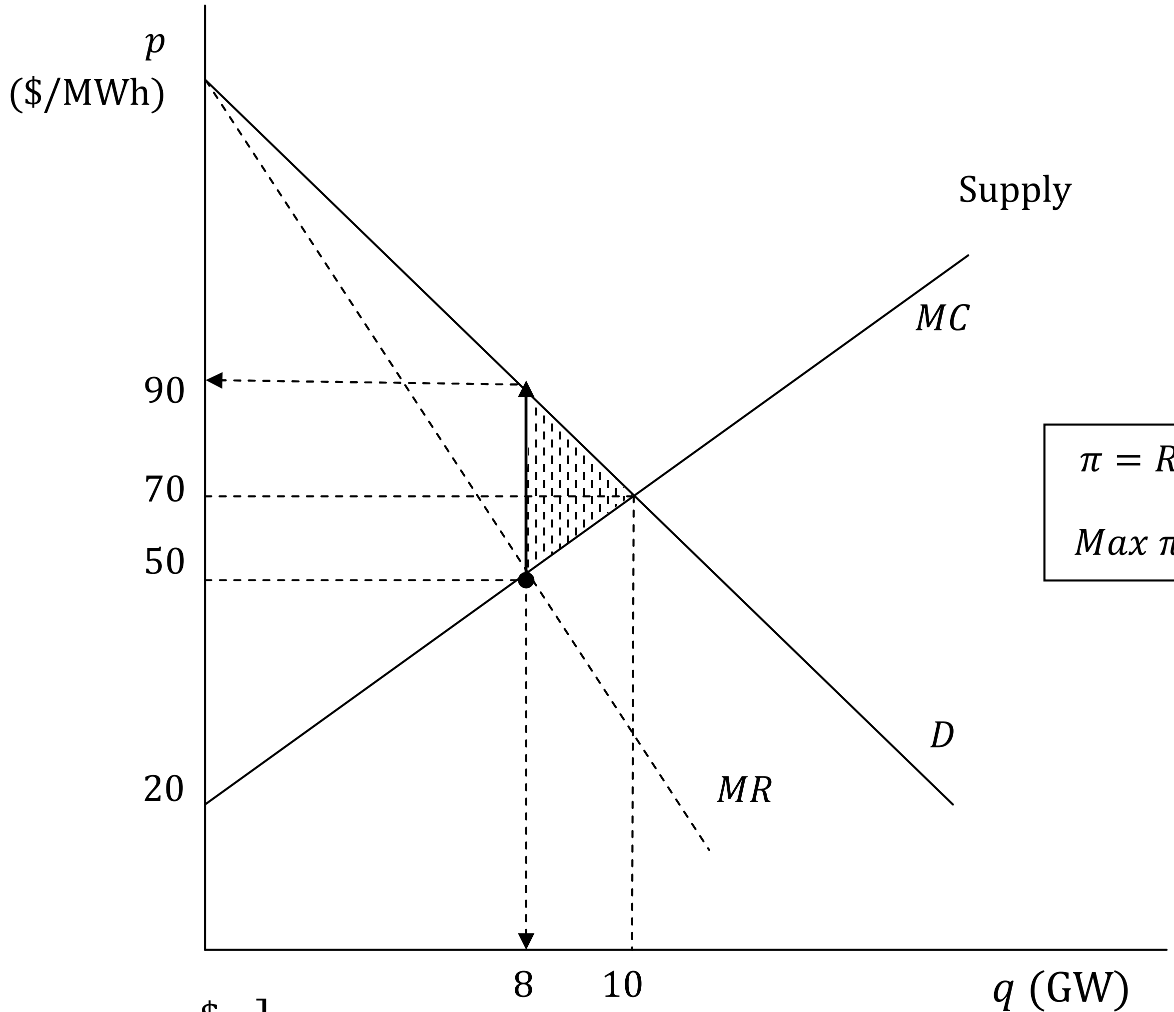
1. Microeconomics : some reminders

- *Withholding of output*



- *The "deadweight loss" of monopoly*



$$\pi = R - C$$

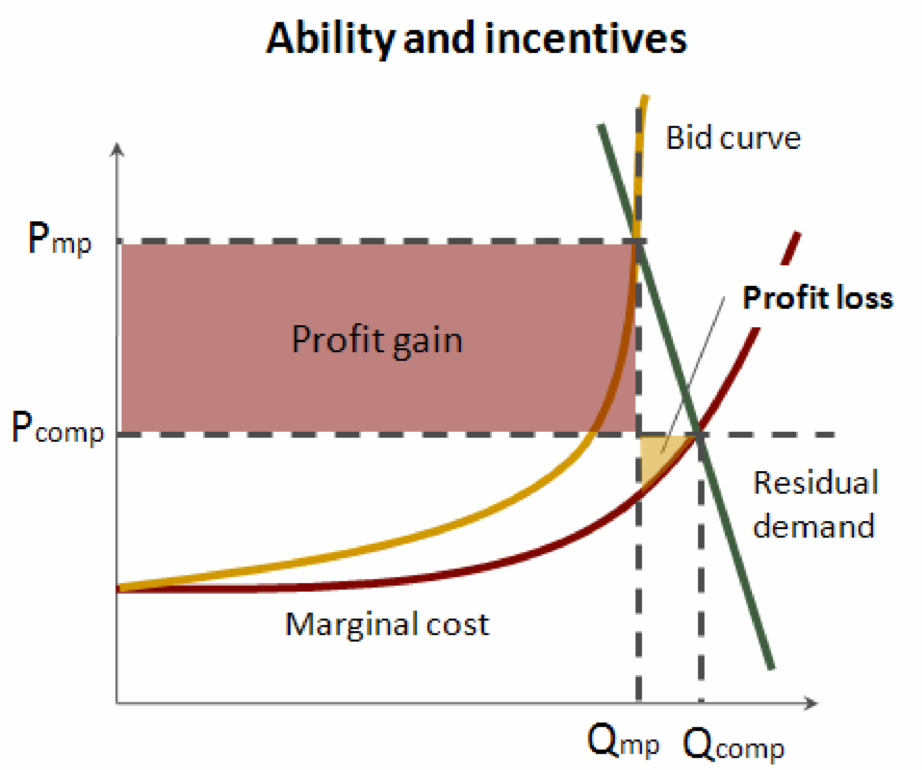
$$Max\ \pi: MR = MC$$

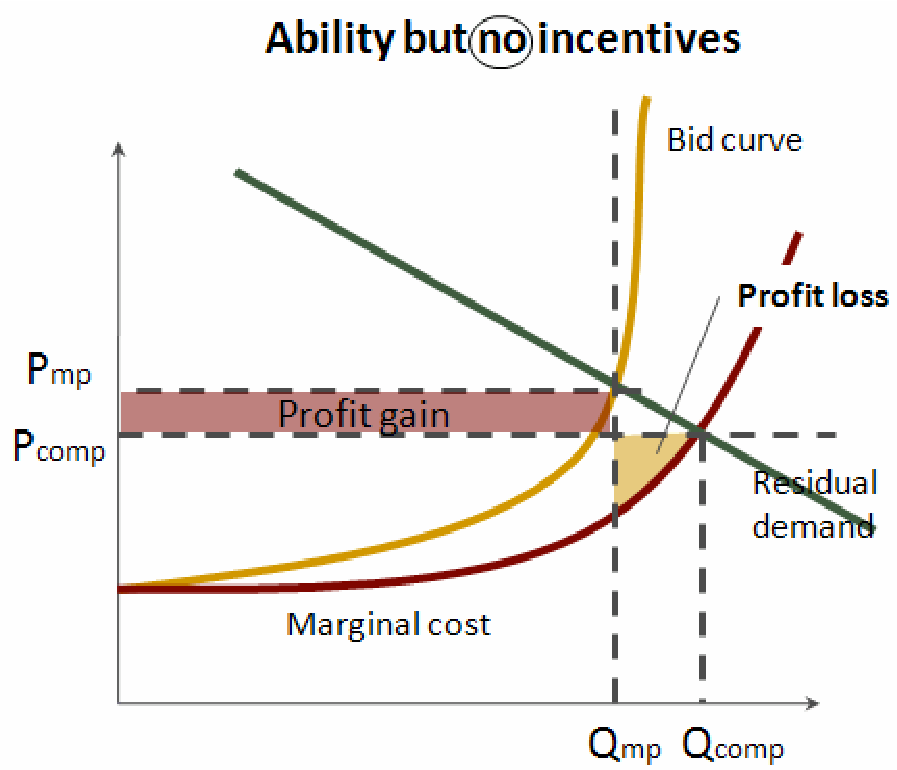
Monopoly
inefficiency:
"The deadweight loss"

$$DW = \frac{1}{2}\left[2 \cdot 10^3 MW \times (90 - 50) \frac{\$}{MWh}\right]$$

$$= \$40.000/h$$

- *The **ability** and **incentive** to raise prices above the competitive level*
  ("… the ability to *maintain profitably* prices above competitive level", DOJ, 1997)





2. Measuring market power and the electricity sector

- ***The Lerner index***

$$L = \frac{p - Cm}{p} (\%)$$

where p is the price charged by the company and Cm is its marginal cost. In perfect competition, $L = 0$ and if $L > 0$ this can indicate *the possibility* for the company to charge, for various reasons, a price above its marginal cost.

- ***The reference to the structure of the industry: the HHI index***

Economic theory suggests that, all other things being equal, the level of competition in a given sector is related to the *number of companies* active in that sector.

$$HHI = \sum_{i=1}^{n} {s_i}^2$$

where s_i is the *market share* of company i expressed as a %.

If $i = 1$ (monopoly), HHI reaches a maximum value of 10,000. Its value decreases when the number of companies increases.

These indexes are based on a *Cournot model* which makes it possible to link L and HHI as well as formulate a number of remarks.

Let us consider a market where n companies are active, with each firm i $(i = 1 \dots n)$ being characterized by:

- its marginal cost Cm_i ;
- its market share s_i ;
- its production q_i ;
- and its total cost $C_i(q_i)$.

The market is characterized by a demand curve $p(q)$ and elasticity ε, with the production of the *other* companies being indicated as q_{-i}. The basic hypotheses for a Cournot model postulate, among other things, that the good is *homogeneous*.

We express this as:

$$\pi_i = q_i \cdot p(q_i + q_{-i}) - C_i(q_i)$$

Its maximization is obtained through:

$$\frac{\partial \pi_i}{\partial q_i} = p + q_i p' - Cm_i(q_i) = 0$$

$$= p - Cm_i(q_i) + \frac{q_i}{Q} \cdot Qp' = 0$$

Where $\frac{q_i}{Q} = s_i$, with Q being the overall quantity produced $(Q = q_i + q_{-i})$

And therefore:

$$p\left[\frac{p - Cm_i}{p} + s_i Q \frac{p'}{p}\right] = 0$$

or

$$L_i = -s_i Q \frac{p'}{p} = -s_i \frac{Q}{p} \cdot \frac{dp}{dq}$$

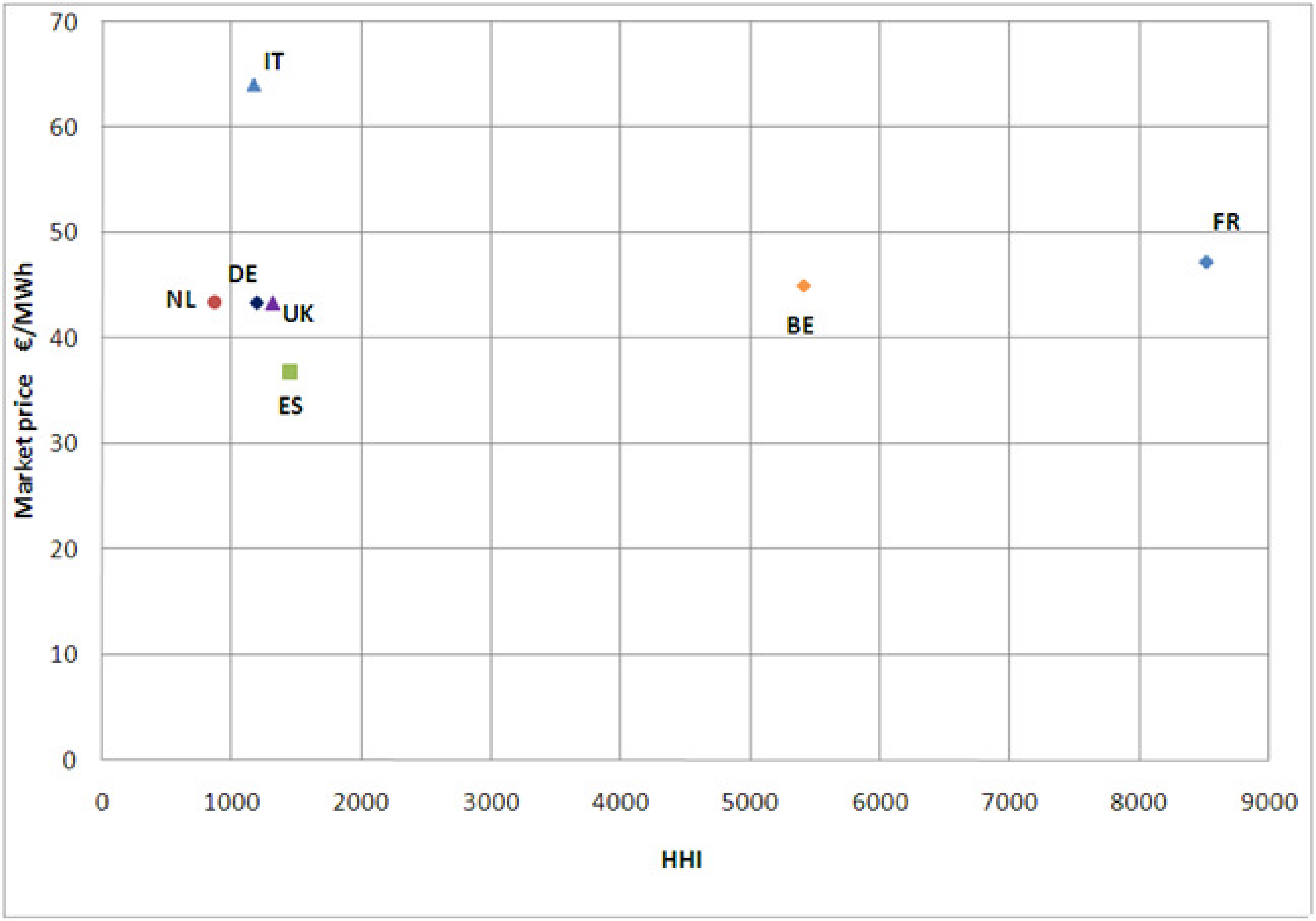
$$L_i = \frac{s_i}{|\varepsilon|}$$

With L_i being the Lerner index for company i and $|\varepsilon|$ the absolute value of the homogeneous good's elasticity/price and L_i representing the *margin rate* on the marginal cost for i.

If we calculate the mean margin weighted by the market shares for the entire sector we obtain:

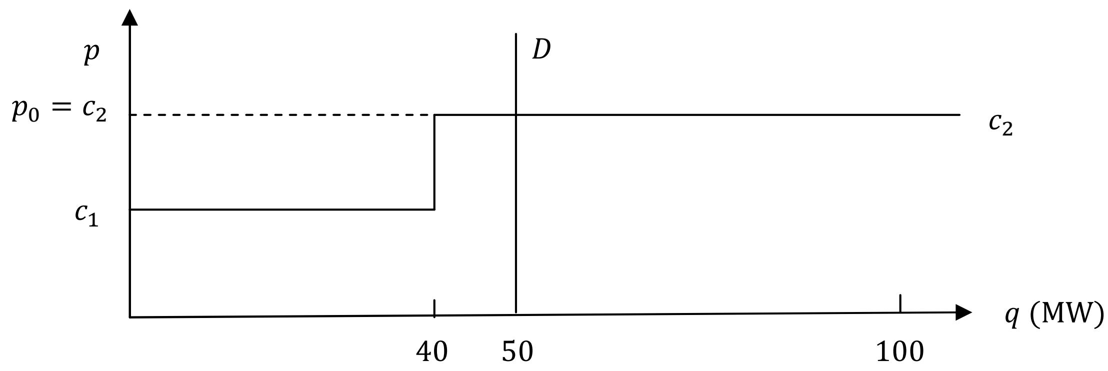
$$M = \sum_{i=1}^{n} s_i \left(\frac{p - Cm_i}{p}\right) = \sum_{i=1}^{n} \frac{{s_i}^2}{|\varepsilon|} = \frac{HHI}{|\varepsilon|}$$

- *Does it work?... Not really*



(Counter)Example: let us imagine a power system consisting of two (types of) machines:

- nuclear capacity of 40 GW with a marginal cost of c_1 ;
- fossil-fuel capacity of 60 GW with a marginal cost of $c_2 > c_1$;
- other fossil-fuel capacity spread out among a very large number of small operators;
- non-elastic demand of 50 GW.



The market price will be $p_0 = c_2$.

In the case of a *nuclear duopoly*, for example, where each operator has a 40% market share with the remainder being held by numerous small operators, we will obtain:

$$HHI = (40)^2 + (40)^2 = 3\,200.$$

Whereas in the case of a *nuclear monopoly* where the operator holds 80% of the market we calculate:

$$HHI = (80)^2 = 6\,400.$$

With an identical price the HHI index varies by 100%...

- ***The pivotal indexes***

A supplier is referred to as *pivotal* if the combined capacity of all its competitors is not sufficient to meet total demand. We then define:

- the PSI index (Pivotal Supplier Index) established per supplier and which has a value of 1 if the supplier is *pivotal* and 0 if otherwise;
- the RSI index (Residual Supply Index) established for supplier k and which is a *continuous* measurement calculated by means of:

$$RSI_k = \frac{\text{sum of the capacity of the other suppliers}}{\text{quantity consumed}}$$

where $RSI_k < 1$ if k is *pivotal*.

The following test to gauge the level of competition is sometimes put forward: there would be too little competition if the RSI of the biggest supplier were *below 110% more than 5% of the time*.

The pertinence of these indexes is also limited. So, for example, in a system characterized by:

- 50 GW of power in CCGT with a marginal cost of € 50/MWh;
- numerous small suppliers with in total 60 GW in low-efficiency power plants with a marginal cost of € 100/MWh;
- and demand of 40 GW ;

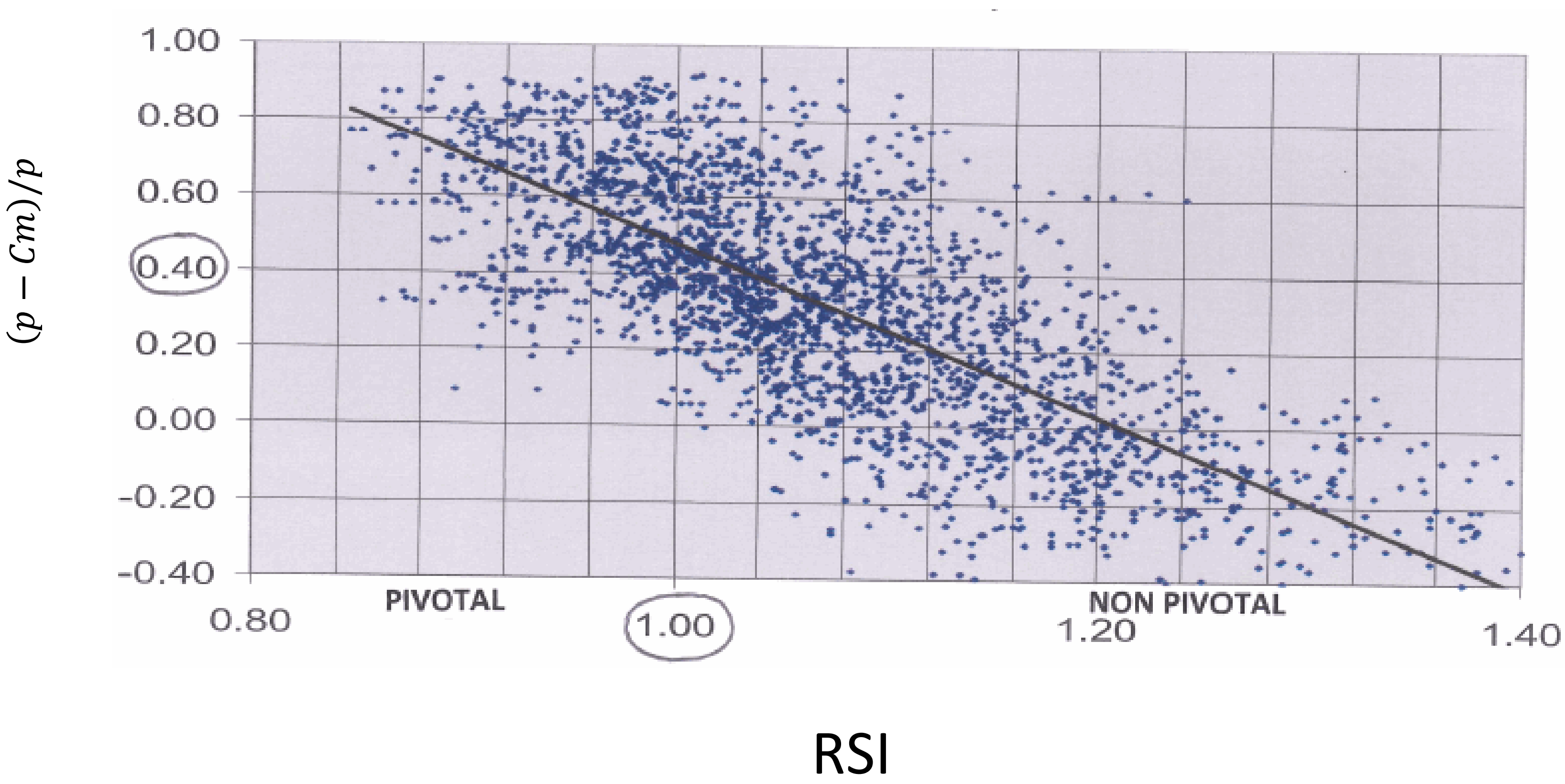
there is *no pivotal supplier* in that system, regardless of the level of concentration of the CCGTs.

In the case of a *CCGT monopoly*, we will see a price which is just under 100 and a margin rate of 50%, despite a PSI index = 0 and RSI index = 60/40 = 150%>1.

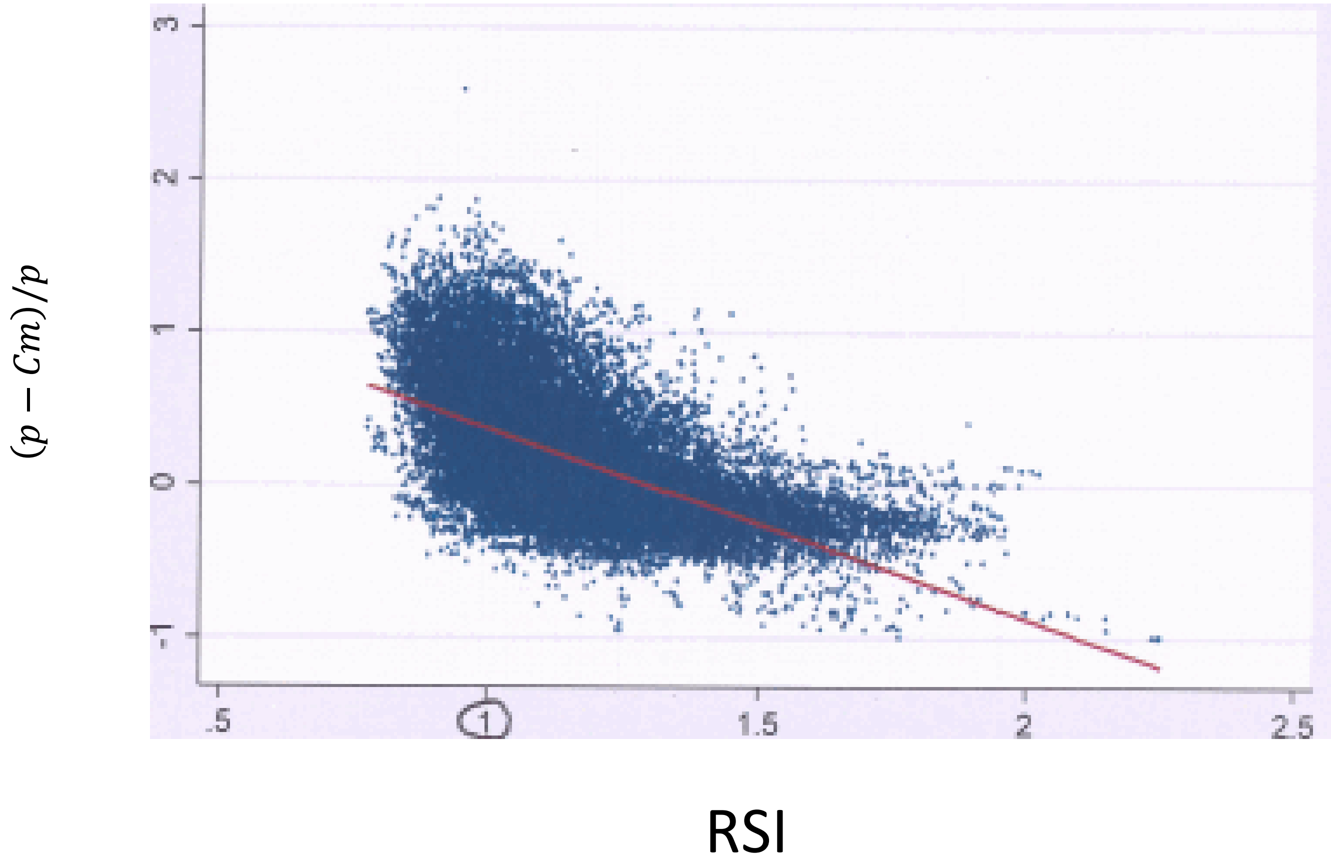
In the case of *perfect competition* between CCGTs, we will see a price of € 50 and a margin rate of zero and pivotal PSI index = 0 and RSI index = 110/40 = 275%>1.

- ***Empiric illustration***

RSI and Lerner Index



California, summer 2000, peak



Spain, wholesale price, 2003-2005

Source : LE-GED DG Comp Study

3. Supply-Curve Biddings: reducing market power?

- Suppliers don't bid *quantities*, but *Supply-Curves*...

- ... because demand is *uncertain*: unknown at the time bids are submitted.

- Supply-Curve Biddings increase competition:

  - When one supplier bids a Supply-Curve, it reduces the market power of other suppliers

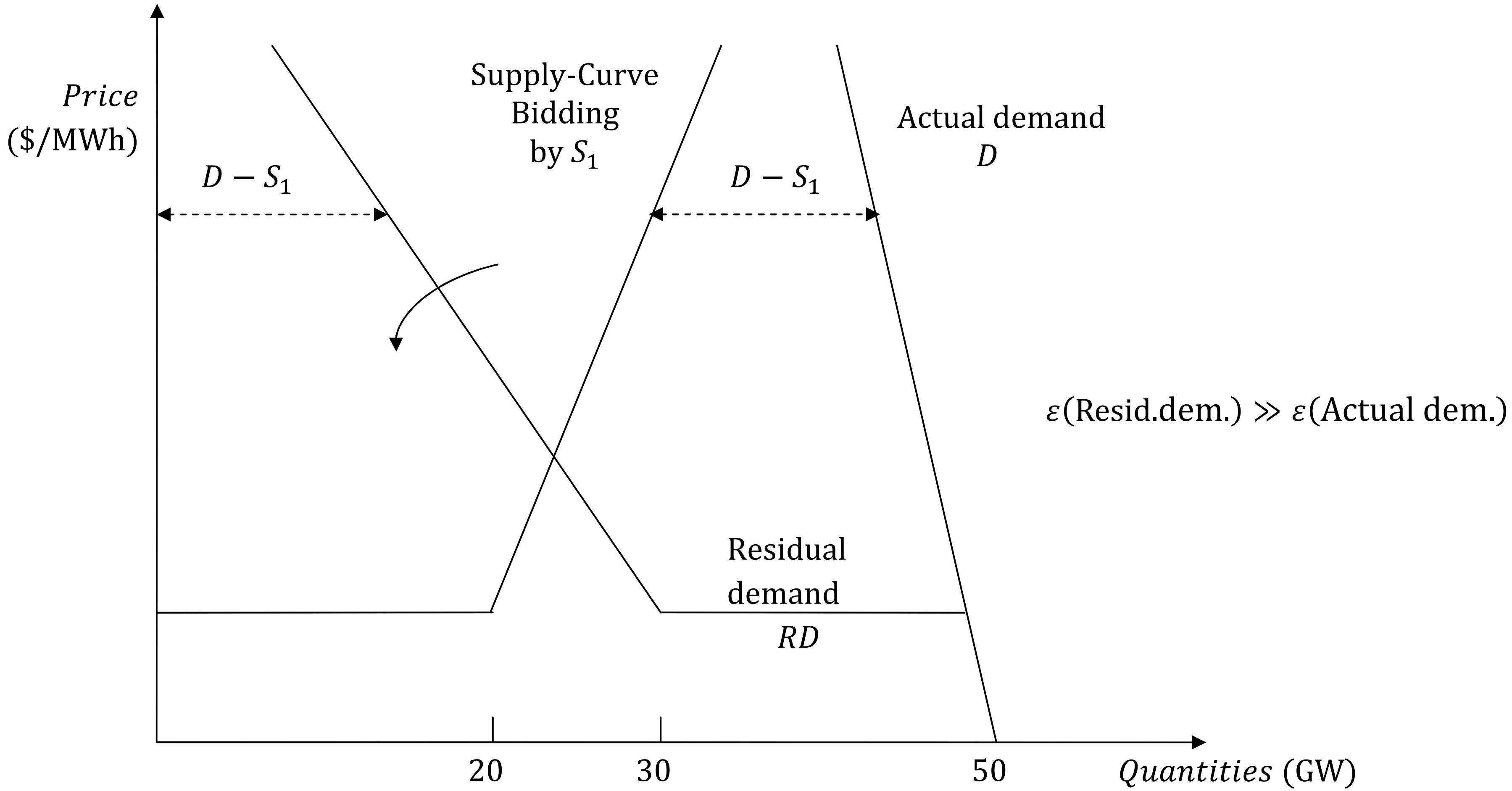
  - Example (two suppliers)

    - Supply-Curve Bidding of S_1 : if $p \uparrow, D \downarrow, SCB$ of $S_1 \uparrow$

    - "Residual demand RD"= $D - S_1$: "available" for S_2

    - RD much more price-sensitive than D

  - With Supply-Curve Bidding, *each* supplier makes the other supplier's/s' RD more price-sensitive.



Supply-Curve Bidding with two suppliers

- *Mark-Up and Supply-Curve Bidding*[1]

$$p_i - MC_i = \frac{Q_i}{\frac{dS_{-i}(p)}{dp} - \frac{dD(p)}{dp}}$$

With

- p_i: bid price for Q_i units
- MC_i: marginal cost for Q_1 units
- $D(p)$: actual demand
- $S_{-i}(p)$: supply from all suppliers other than i (i.e. "residual supply")

———————

(1) • General theory: Klemperer and Meyer (1989)
• Application to electricity market design : Green (1992, 1996), Baldick and Hogan (2001)

Cases

1. Belgium
2. California

Comparison of bids with marginal costs

Marginal bid

- Highest accepted hourly sell bid or
- Highest unaccepted hourly buy bid

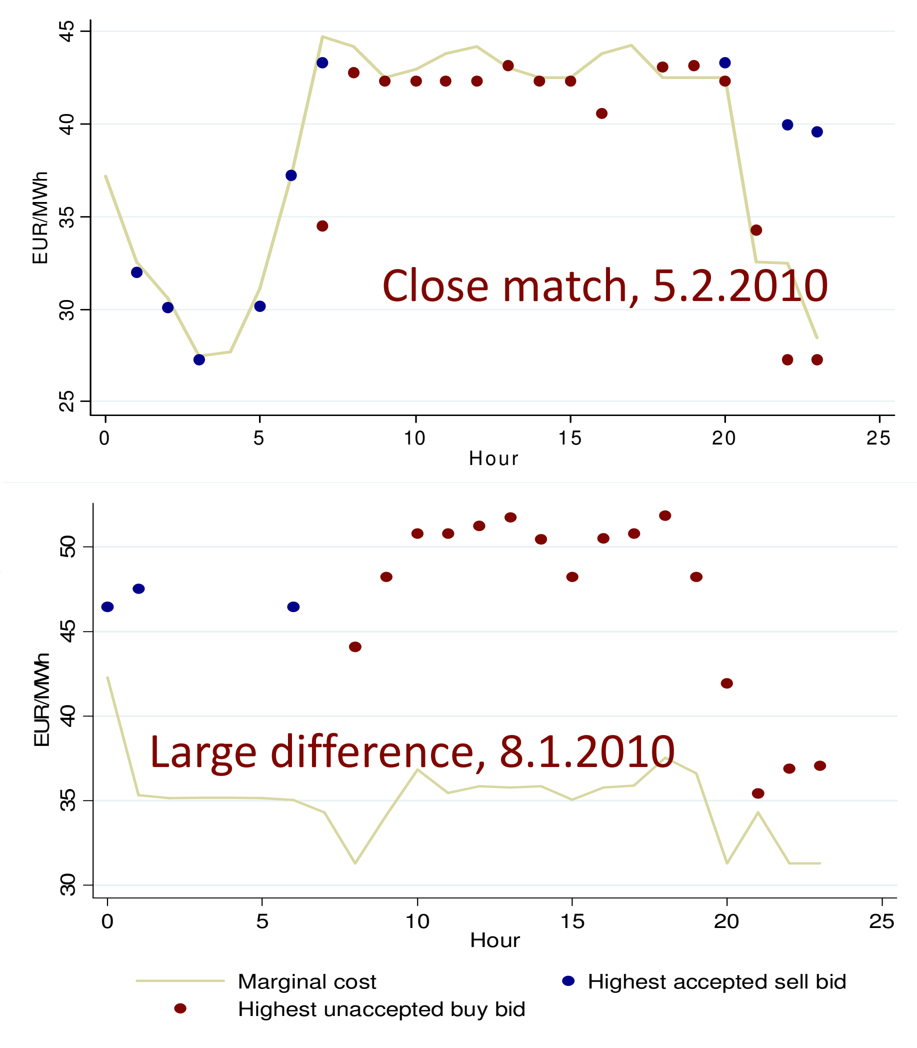
Hourly post-Belpex marginal costs

- Estimate of hourly marginal cost of the schedule cleared on Belpex

Observed results

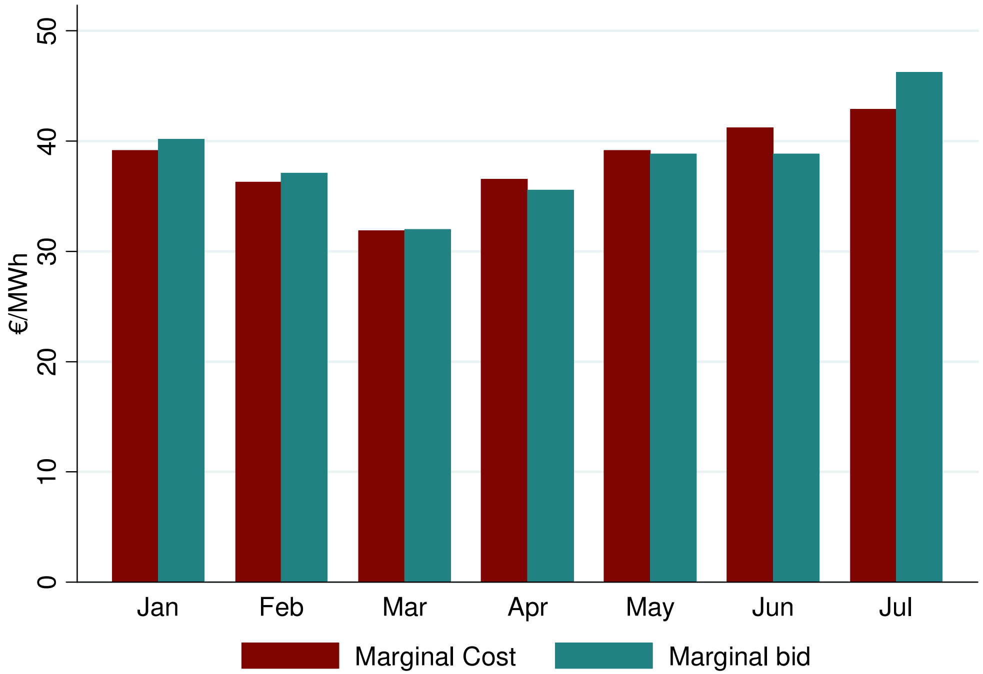
- A variation of degree of consistency across analyzed days and hours

Examples of marginal costs and bids



Comparison of bids with marginal costs

Monthly marginal costs and marginal bids



Results in Jan-Jul 2010

- General consistency (~1% difference over the analyzed period)
- Occasional divergence
- Absence of marginal bids during off-peak hours (e.g. no accepted buy bids or no unaccepted sell bids)

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Analysis of capacity withholding

Total capacity less reserves

- Available thermal capacity and hydro output less capacity needed to meet the reserve requirements

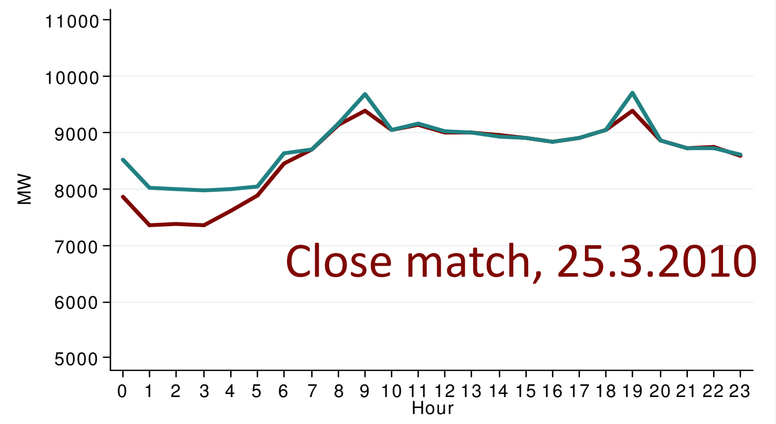
Total capacity offered

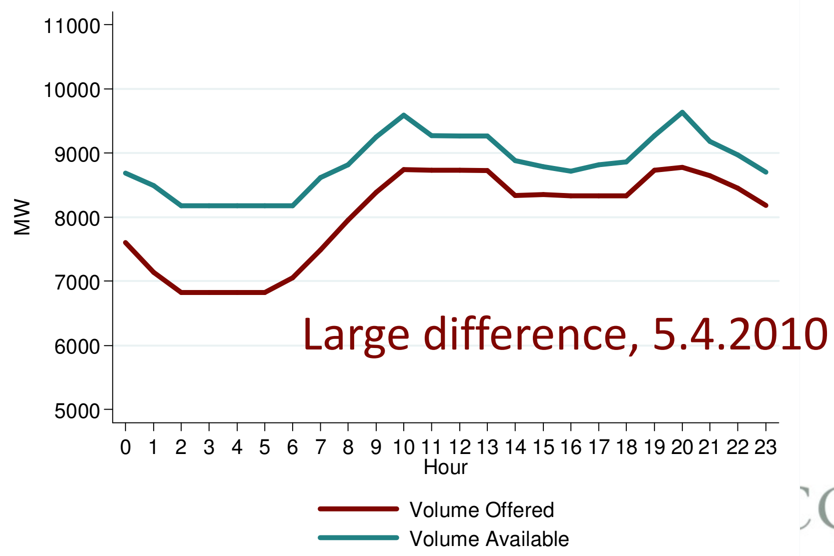
- Volumes needed to meet EBL load commitments, sold in Belpex and OTC, and offered but not sold in Belpex

Observed results

- A variation of degree of consistency across analyzed days and hours

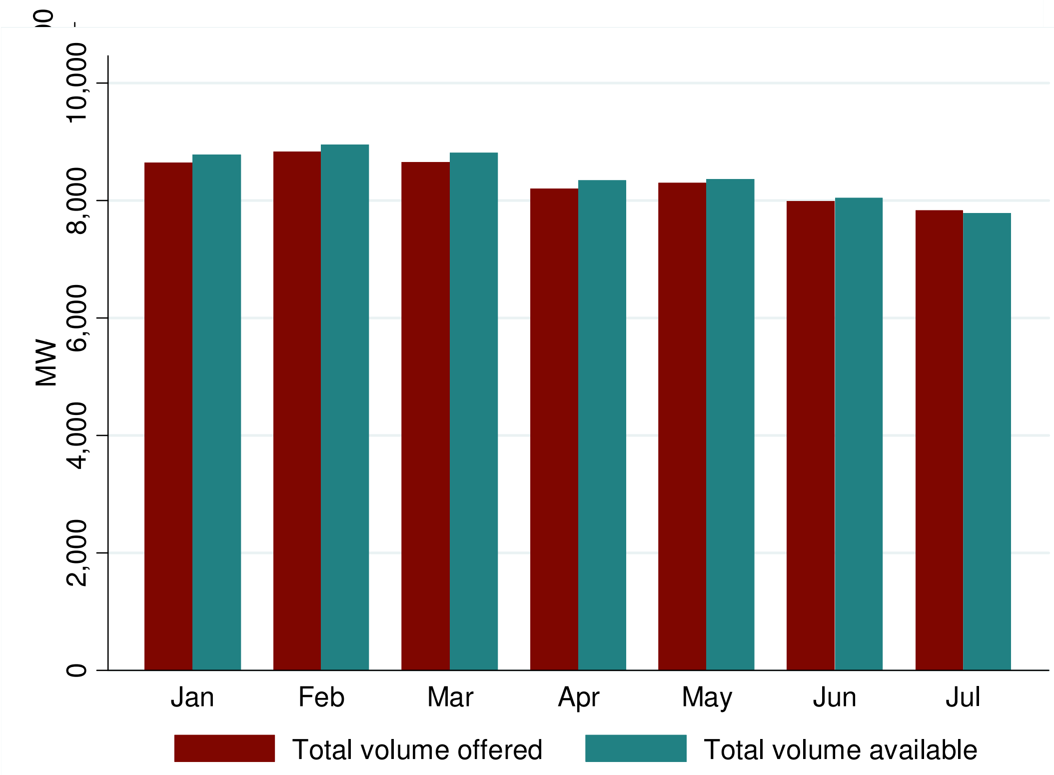
Examples of volumes offered and available





Analysis of capacity withholding

Monthly volumes offered and available



Aggregated results

- A close match on average (~1% difference over the analyzed period)
- Very close match during peak hours
- Less capacity offered than available during off-peak hours

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CALIFORNIA ISO

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Predicting Market Power Using the Residual Supply Index

Presented to

FERC Market Monitoring Workshop

December 3-4, 2002

Anjali Sheffrin
Department of Market Analysis
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Motivation and Objectives

Two sets of metrics to monitor market power

- Measure of Market Power Impact (Price-cost markup. Studies cited above)
- **Indicators of Market Structure :**
  - N-firm concentration or 20% Market Share
  - Traditional HHI
  - Pivotal Supplier Indicator, SMA indicator
  - Residual Supply Index (RSI)

What is the more accurate predictor of market power in electric markets?

- Theoretical analysis and empirical study can provide guidance

Development of Residual Supply Index

- Inadequacy of HHI and n-firm concentration index for electricity markets
  - HHI index below 2000 can mean significant price-cost markups
  - 1-firm concentration below 20% (market based rate screen) but many firms can bid to inflate prices
- Need for indicators which reflects three key factors affecting market outcomes: (1) Demand, (2) Total available supply and (3) Large suppliers' capacity share and contract position

Pivotal Supplier Indicator

- Pivotal Supplier Indicator -- A first attempt to capture the three key factors
- A binary variable: whether or not a supplier is pivotal in the market given the hourly supply and demand situation. Or without this supplier, can the residual supply meet the demand?
- Significant improvement in predicting market power over traditional indicators
- SMA is a form of pivotal supply indicator applied to annual peak condition
- Insufficiency of binary variable: ability to exercise market power when pivotal supply index close to but less than pivotal
- Extract further information: The RSI index

Definition of Terms in Residual Supply Index

RSI=(<u>Total Supply - Largest Seller's Supply</u>)
(Total Demand)

Total Supply = Total in-state supply capacity + Total net import

1. Total in-state supply Capacity = Thermal capacity [P_max – outage] + Must_Take_mw

   Note: Must_Take_mw includes all the other generators, such as hydro, nuclear, and cogeneration. It is measured as:

   Max [Energy bid in the market, Metered output]

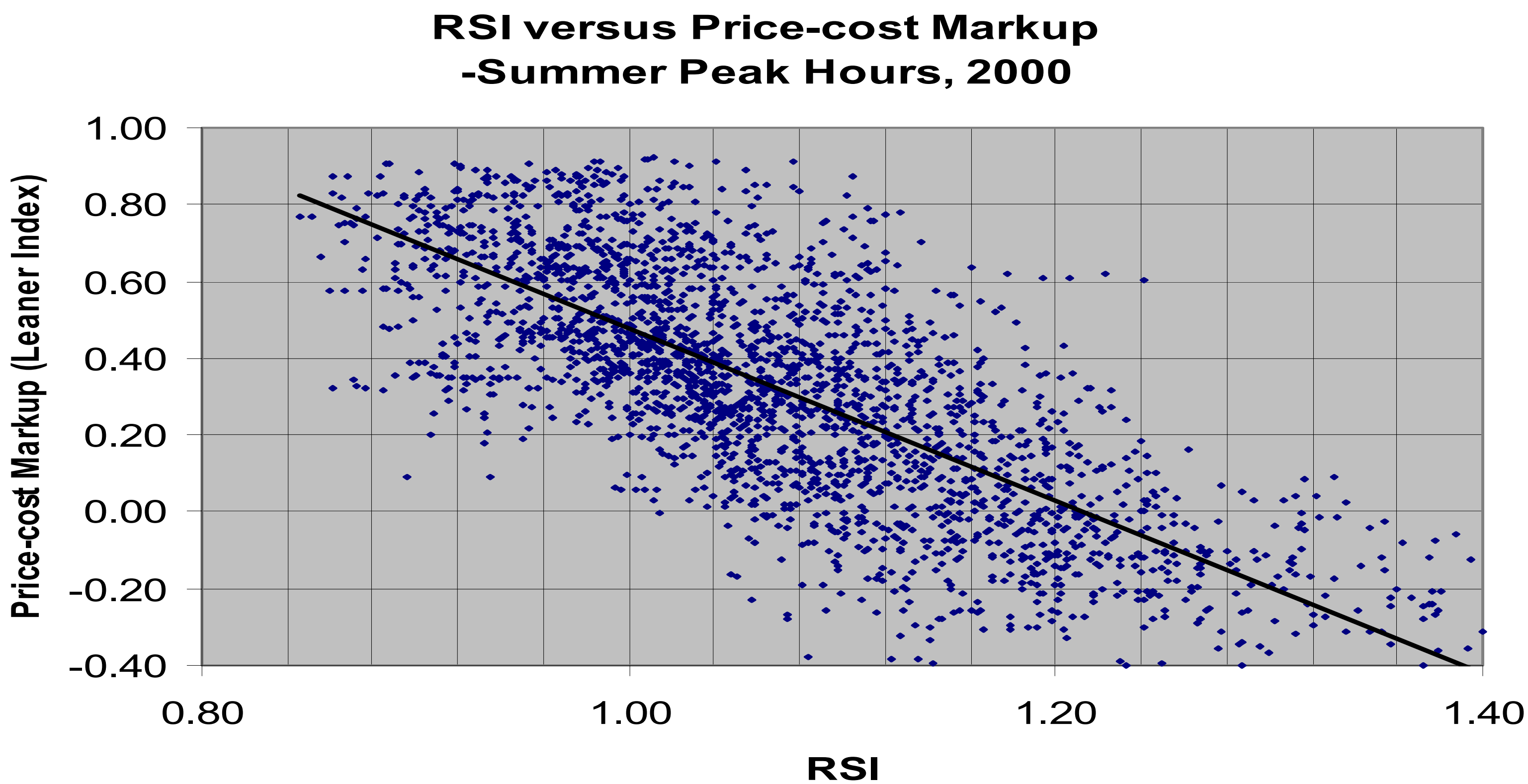
2. Total net import consists of total net hour-ahead schedule, import through real-time imbalance market, and OOM calls, and measured as: Max [Scheduled, metered]

Total demand = Metered Load + Purchased Ancillary Service

Largest Seller's Supply: Largest Seller's Capacity – It's Contract Obligation to Load

Explanation of Estimation Results

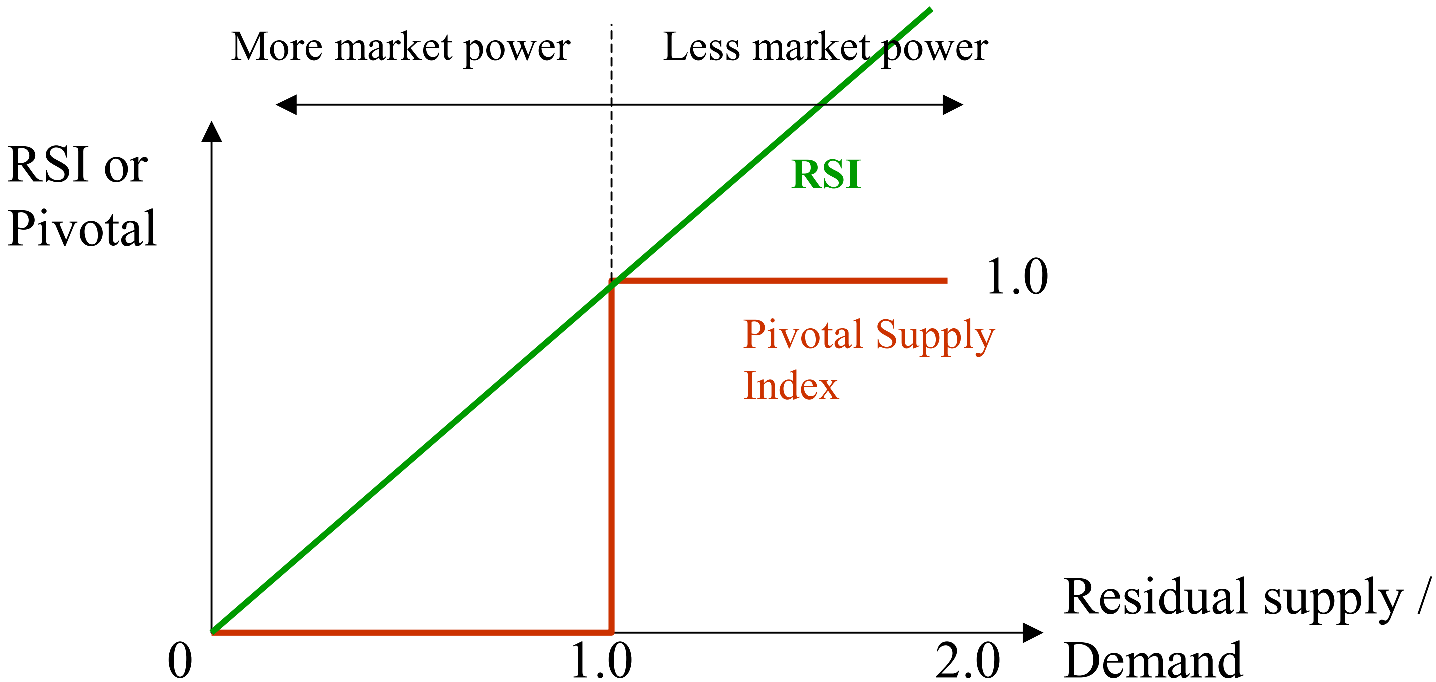
Significant correlation between the Lerner Index, RSI, and actual system load



RSI compared with Pivotal Supplier Index

Pivotal Supplier Index (and SMA) shows whether the residual supply is sufficient to meet market demand (binary index of 0 or 1)

RSI shows additional information of what the ratio of residual supply relative to demand is



Economic Rationale for RSI

Based on oligopoly pricing models (such as Green and Newberry, 1992)

$P_i - MC_i = Q_i/(dSr(p)/dp - dD(p)/dp)$;

P_i: bid price for Q_i units of supply

MC_i: marginal cost for Q_i units of supply

D(p): total demand at the price of p

Sr: supply from all suppliers other than firm i (residual supply)

- Q_i has a positive effect on price-cost markup
- Residual Supply elasticity has a negative effect on markup
- Demand elasticity has a negative effect on markup

Empirically, RSI and load are used to predict price-cost markup (demand elasticity is negligible currently, and can be incorporated later)

Illustration of RSI Computation for Entire Market in the Peak Hour

2000-2002

	Demand	Total Supply			Total Supply*	Largest Supplier Capacity**	**RSI Index**
Year	(MW)	Musttake (MW)	Thermal Capacity (MW)	Imported Energy (MW)	(MW)	(MW)	
2,000	50,421	23,995	17,798	2,386	47,443	4,002	**0.86**
2,001	45,197	21,674	19,186	2,309	47,155	3,683	**0.96**
2,002	48,070	21,019	20,036	7,353	49,474	4,424	**0.94**

* Total supply is slightly higher than the sum of musttake, thermal capacity, and imported energy because we also account for loss adjustment.
** Largest suppliers (not the same) on peak hour did not have any contract cover.

RSI Calculations for All Hours

Duration Curve for Three Years
June-September, 2000-2002