# Empirical Studies of Pricing: Homogenous Goods

Goal: Infer the "competitiveness" of market from data;

**The Structure Conduct Performance Paradigm (SCPP)**

- Question: How does concentration effect conduct?

- "Theory": (we saw this in the first lecture)

  Basic conditions → Market Structure → Conduct → Performance

- The ideal experiment: randomly assign market structure and see how performance is effected;

- The actual procedure: look at profitability as a function of concentration.

  For example: in Cournot equilibrium $\frac{p-mc}{p} = \frac{HHI}{\eta}$; used to loosely motivate the regression

$$\ln(PCM_j) = \alpha_0 + \alpha_1 * C4_j + \alpha_2 \ln\eta + \epsilon_j \quad \text{or} \quad \ln(PCM_j) = \beta_0 + \beta_1 * C4_j + \epsilon_j$$

  where $PCM = \frac{p-mc}{p}$, C4 share of top 4 firms, j= 1 ... J – cross section of firms.

  The second is the "plain vanilla" version of a SCPP regression;

- Problems

(a) Data:

(i) Dependent variable: accounting profits/returns on assets, PCM from Census of Mnfr;

None of these are true economic margins, which is what we want.

(ii) Additional variables: elas of demand, BTE, product differentiation;

Rarely observed → cannot control for differences across mkts/industries.

(iii) Market definition: needed to define concentration

(b) "Experiment"/ Simultaneity issues:

Comparison across industries – do we think that concentration is exogenous? Especially since there is little control for industry characteristics.

(c) Interpretation;

Positive correlation between C4 and profits can be due to cost advantage (good performance) or high markups (bad performance)

- Where does this leave us?

    1) Not all is lost – Example, Salinger (1990) uses panel data to introduce industry fixed effects (to deal (?) with simultaneity problem) and additional regressions (to address (?) interpretation issues);

    2) Can't answer original question, all we can hope for are empirical regularities (Schmalensee, HIO)

    3) "New Empirical IO"

        (i) PCM are not assumed to be observed, rather mc are estimated.

            Deals with the main data problem.

        (ii) Study a specific industry, using time series or a cross section of geographical mkts.

            Deals with the simultaneity problem.

        (iii) Conduct is viewed as a parameter to be estimated.

            Ties more directly to theory (not always) and deals with interpretation.

# NEIO – The question of identification

(based on Bresnahan, *Economic Letters*, 1982)

Can conduct be identified (jointly with cost and demand parameters) from equilibrium price and quantity data from different markets (time periods)?

**A non-identification result**

Demand : $Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \epsilon_t$

$Q_t$ = Quantity in period *t;* $P_t$ = Price in *t;* $Y_t$ = exogenous demand shifter;

Marginal Cost: $MC_t = \beta_0 + \beta_1 Q_t + \beta_2 W_t + \eta_t$

$W_t$ = exogenous cost shifter;

Supply: $P_t = \theta(-Q_t/\alpha_1) + \beta_0 + \beta_1 Q_t + \beta_2 W_t + \eta_t$

$\theta$ is a (conduct) parameter that indexes different models of pricing. Later we will talk where it comes from. For now note that $\theta$=1 is monopoly pricing and $\theta$=0 is marginal cost pricing.

Using the exogenous variables $Y_t$ and $W_t$ we can identify $\alpha_0,\ \alpha_1,\ \alpha_2,\ \beta_0,\ \beta_2$ and $\beta_1 + \theta/\alpha_1$. But we cannot separate the conduct parameters from economics of scale.

We can also see this graphically.

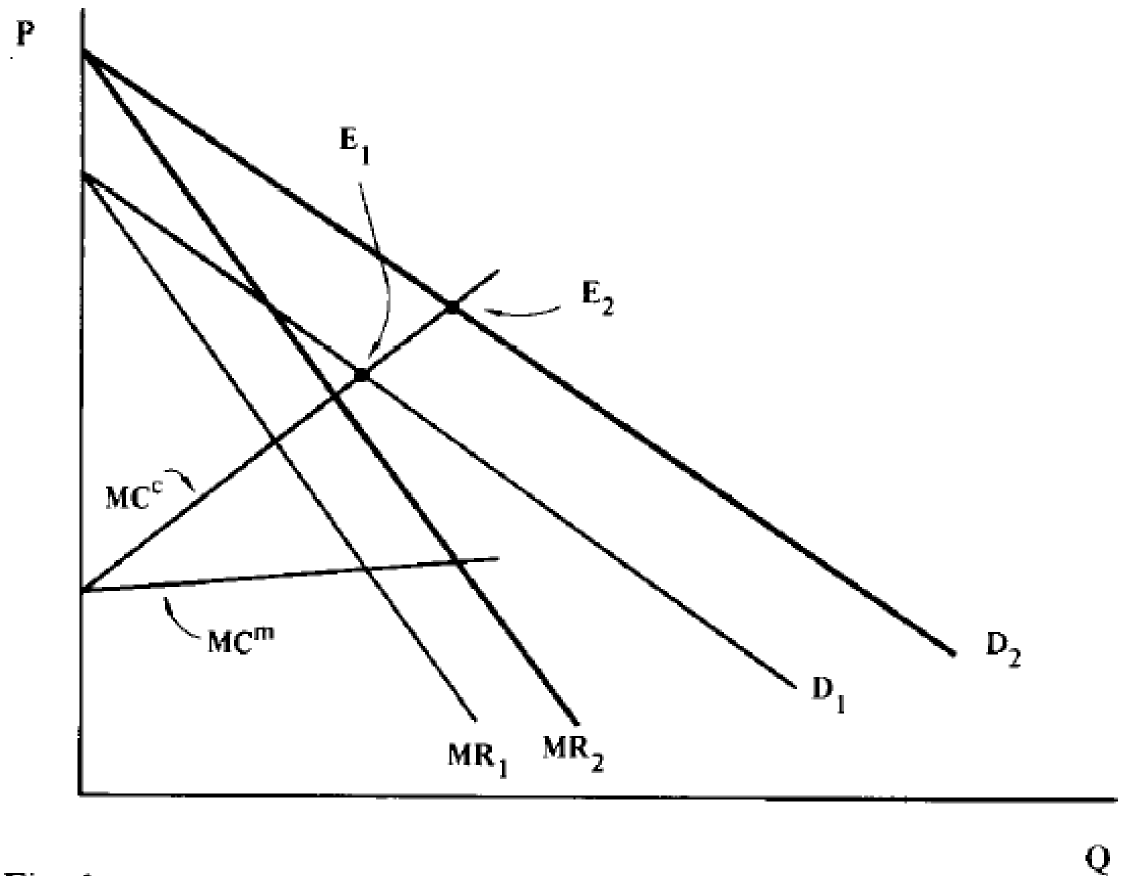



Fig. 1.

**Identification through rotation of demand**

Suppose we alter the model by adding a variable that exogenously rotates the demand curve.

Demand : $$Q_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \alpha_3 P_t Z_t + \epsilon_t$$

$Z_t$ = exogenous variable;

The supply relation now becomes

Supply: $$P_t = \theta(-Q_t/(\alpha_1 + \alpha_2 Z_t)) + \beta_0 + \beta_1 Q_t + \beta_2 W_t + \eta_t$$

Since the demand parameters are identified treat them as known and define $Q_t^* = -Q_t/(\alpha_1 + \alpha_2 Z_t)$, so supply can be written as

$$P_t = \beta_0 + \beta_1 Q_t + \beta_2 W_t + \theta Q_t^* + \eta_t$$

Now all the parameters are identified

Graphically:

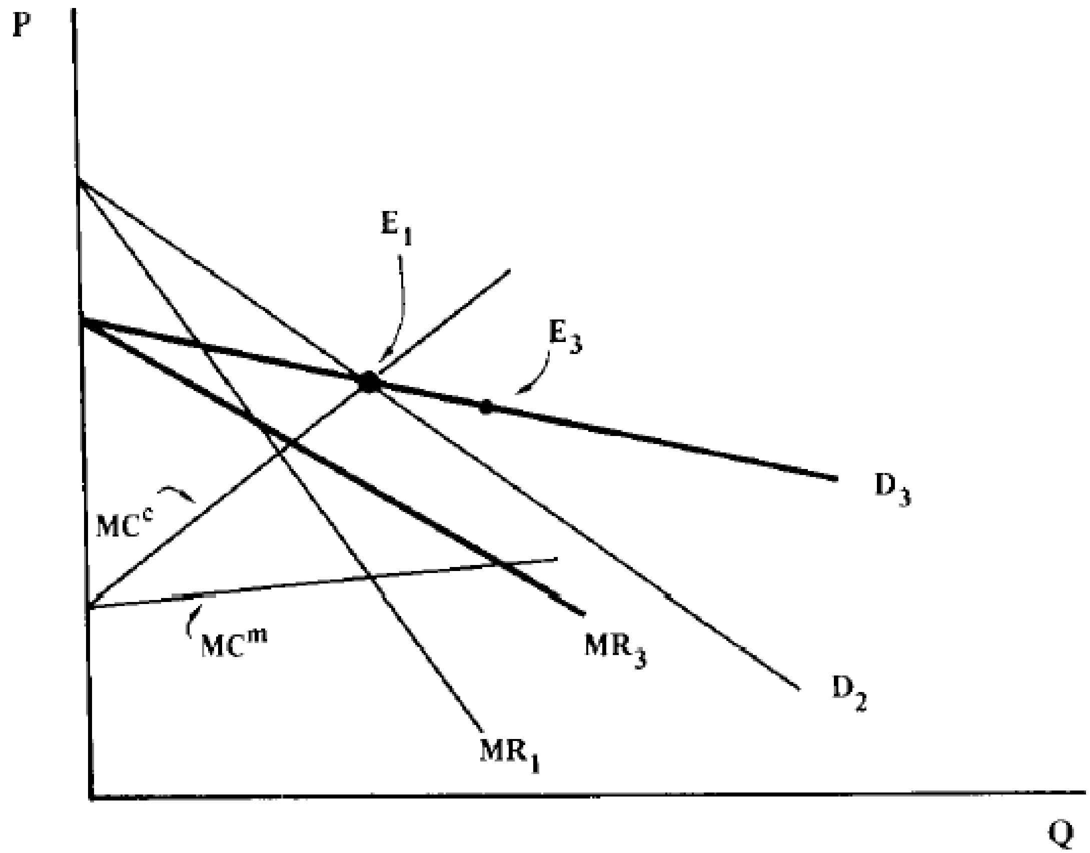



Fig. 2.

Comments:

1) The above can be generalized beyond linear demand and supply curves (see Lau, *Economic Letters*, 82).

2) There are alternative assumptions we could make to get identification. For example:
– fixed marginal cost ⇒ $P_t = \theta(-Q_t/\alpha_1) + \beta_0 + \beta_2 W_t + \eta_t$;
– (lack of) supply shocks (Porter, 83);
– comparative statics in cost;
– direct measures of cost;

3) How should we think of the parameter $\theta$?

Note: a key point in the above analysis is that $\theta$ is constant over time, as we will see below this is important for the interpretation.

**Identification through supply shocks**
(Porter, 1983, "A Study of Cartel Stability: the JEC 1880-1886)

Q: We observe price (and quantity) shifts over time. Are they due to (exogenous) shifts in the demand and cost functions? Or are they due to price wars?

Background: The JEC was a cartel that controlled the eastbound railway grain shipment. It preceded the Sherman Act and therefore was explicit.

The cartel used an internal enforcement mechanism similar to the trigger strategy.

Theory (Green-Porter, 84):

- firms compete in prices;
- demand uncertainty;
- firms collude: set price between Bertrand and monopoly;
- firms observe demand, which is a noisy signal of competitors behavior. (low demand could be due to a deviation in collusion or aggregate low demand);
- if the demand falls below a threshold (trigger) then firms switch to Bertrand pricing for T periods, i.e., there is a price war;

Prediction: along the equilibrium path price wars occur.
(Other predictions: timing of price wars (triggers) and no cheating in equilibrium).

Model:

Demand: $\log(Q_t) = \alpha_0 + \alpha_1 \log(P_t) + \alpha_2 L_t + U_{1t}$
where $L_t$ = 1 if Lakes were open, 0 otherwise;

$N$ symmetric firms with costs $C_i(q_{it}) = a_i Q_{it}^{\delta} + F_i$

where $\delta$ is a constant greater than 1.

Homogenous product so the firm-level supply for different behavioral models can be summarized by

$$P_t(1 + \theta_{it}/\alpha_1) = mc_i(q_{it}) \qquad i = 1, \ldots, N$$

The estimation uses aggregate data so this is aggregated to market level supply. Let $\theta_t = \sum_{i=1}^{N} \theta_{it} S_{it}$, where $S_{it} = q_{it}/Q_t$, and

$$P_t(1 + \theta_t/\alpha_1) = \sum_{i=1}^{N} S_{it} mc_i(q_{it}) = DQ_t^{\delta - 1}$$

where $D = \delta\left(\sum_i a_i^{1/(1-\delta)}\right)^{1-\delta}$.

Taking logs

$$\log(P_t) = -\log(1 + \theta_t/\alpha_1) + \log(D) + (\delta - 1)\log(Q_t)$$

For the estimation the supply equation will be

$$\log(P_t) = \beta_0 + \beta_1 \log(Q_t) + \beta_2 S_t + \beta_3 I_t + U_{2t}$$

where $I_t = 1$ if industry is in collusive state at time $t$; $S_t$ = is a vector of structural dummy variables that reflect entry and acquisitions.

If during non-collusive states the industry plays Bertrand then $\beta_0 = \log(D)$ and $\beta_1 = \delta - 1$. If during collusive states firms max joint profits then $\beta_3 = \log(\alpha_1/(1+\alpha_1))$.

Identification and Estimation:

- $U_{1t}$ and $U_{2t}$ are assumed to be distributed joint normal;
- If the sequence $\{I_1, \ldots, I_T\}$ is known the model can be estimated using 2SLS;
- If instead $I_t$ is unknown and assumed to be distributed

$$I_t = \begin{cases} 1 & \text{with probability } \lambda \\ 0 & \text{with probability } 1-\lambda \end{cases}$$

then the model becomes a "switching model" and can be estimated by ML (either directly or using an E-M algorithm).

The key identifying assumption is that there are no systematic supply shocks missing from the supply equation. Or that $U_{2t}$ does not have a bi-modal distribution.

# Results

**TABLE 1 List of Variables***

| | |
|---|---|
| *GR* | grain rate, in dollars per 100 lbs. |
| *TQG* | total quantity of grain shipped, in tons. |
| *LAKES* | dummy variable; =1 if Great Lakes were open to navigation; =0 otherwise. |
| *PO* | cheating dummy variable; =1 if colluding reported by *Railway Review;* =0 otherwise. |
| *PN* | estimated cheating dummy variable. |
| *DM1* | =1 from week 28 in 1880 to week 10 in 1883; =0 otherwise; reflecting entry by the Grand Trunk Railway. |
| *DM2* | =1 from week 11 to week 25 in 1883; =0 otherwise; reflecting an addition to New York Central. |
| *DM3* | =1 from week 26 in 1883 to week 11 in 1886; =0 otherwise; reflecting entry by the Chicago and Atlantic. |
| *DM4* | =1 from week 12 to week 16 in 1886; =0 otherwise; reflecting departure of the Chicago and Atlantic from the JEC. |

* The sample is from week 1 in 1880 to week 16 in 1886.

**TABLE 2 Summary Statistics**

| Variable | Mean | Standard Deviation | Minimum Value | Maximum Value |
|---|---|---|---|---|
| *GR* | .2465 | .06653 | .125 | .40 |
| *TQG* | 25384 | 11632 | 4810 | 76407 |
| *LAKES* | .5732 | .4954 | 0 | 1 |
| *PO* | .6189 | .4864 | 0 | 1 |

**TABLE 3 Estimation Results***

| Variable | Two Stage Least Squares (Employing *PO*) Demand | Supply | Maximum Likelihood (Yielding *PN*)** Demand | Supply |
|---|---|---|---|---|
| *C* | 9.169 | −3.944 | 9.090 | −2.416 |
| | (.184) | (1.760) | (.149) | (.710) |
| *LAKES* | −.437 | | −.430 | |
| | (.120) | | (.120) | |
| *GR* | −.742 | | −.800 | |
| | (.121) | | (.091) | |
| *DM1* | | −.201 | | −.165 |
| | | (.055) | | (.024) |
| *DM2* | | −.172 | | −.209 |
| | | (.080) | | (.036) |
| *DM3* | | −.322 | | −.284 |
| | | (.064) | | (.027) |
| *DM4* | | −.208 | | −.298 |
| | | (.170) | | (.073) |
| *PO/PN* | | .382 | | .545 |
| | | (.059) | | (.032) |
| *TQG* | | .251 | | .090 |
| | | (.171) | | (.068) |
| $R^2$ | .312 | .320 | .307 | .863 |
| $s$ | .398 | .243 | .399 | .109 |

* Monthly dummy variables are employed. To economize on space, their estimated coefficients are not reported. Estimated standard errors are in parentheses.

** *PN* is the regime classification series ($\hat{I}, \ldots, \hat{I}_T$). The coefficient attributed to *PN* is the estimate of $\beta_3$.

**TABLE 4 Price, Quantity, and Total Revenue for Different Values of *LAKES* and *PN****

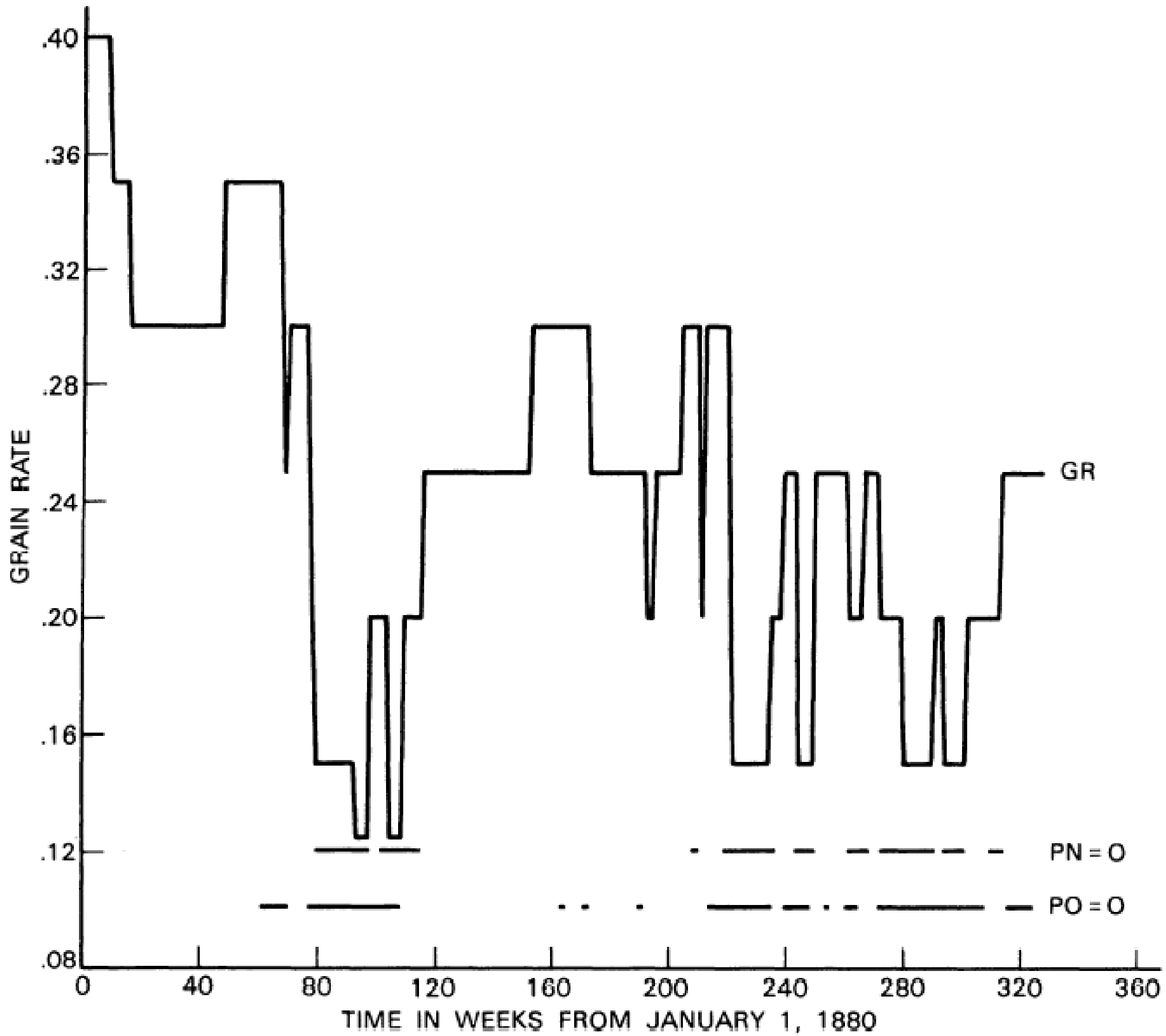
| Price | *LAKES* 0 | 1 |
|---|---|---|
| *PN* 0 | .1673 | .1612 |
| 1 | .2780 | .2679 |
| **Quantity** | ***LAKES* 0** | **1** |
| *PN* 0 | 38680 | 25904 |
| 1 | 25775 | 17261 |
| **Total Revenue**** | ***LAKES* 0** | **1** |
| *PN* 0 | 129423 | 83514 |
| 1 | 143309 | 92484 |

* Computed from the reduced form of the maximum likelihood estimates of Table 3, with all other explanatory variables set at their sample means.

** Total Revenue = 20 (Price × Quantity), to yield dollars per week.

FIGURE 1

PLOT OF GR, PO, PN AS A FUNCTION OF TIME



Comments:

– the paper documents the existence of price wars (subject to the identifying assumption and the functional forms).

– note the different use of $\theta$ relative to Bresnahan: (1) $\theta$ varies over time according to a theory of repeated interaction; (2) no attempt to measure which equilibrium is being played in each period just document that there are 2 different states (the assumption is that the equilibrium being played is constant within a regime).

Extensions:

– Ellison (*Rand,* 94) re-examines the model, generalizing it in several ways. He also looks at Rotemberg-Saloner theory, looks for triggers and looks for evidence of secret price cuts.

– Other papers have looked for evidence supporting other predictions of the model.

**Where do the Conduct Parameters (θ) come from?**

Suppose we observe prices and quantities of (single product) firms $i$=1, ..., $I$ at time (market) $t$=1,..., $T$. Write

$$p_{it} = mc_{it} + \theta_{it} \frac{Q_{it}}{\partial Q_{it} / \partial p_{it}}$$

Note: Since the conduct parameter varies over observations (and can take on any value) this is not restrictive;

We do not need error to fully explain data;

The same is true even if we impose a fn form on costs;

The restrictions (and any objections) come when we impose restrictions over observations and on values of θ.

How do we get the conduct parameters?

1) Specific theory (or a small # of theories). (e.g., static theories - Bertrand , Cournot, etc. or models of repeated interactions, like the Porter paper)
θ are often used as shorthand;
θ were written as a varying parameter but significant structure was imposed on it in the empirical work.

2) Conjectural Variations approach.
$\theta$ is treated as a continuous-valued parameter to be estimated;
The $\theta$ parameters are sometimes described in terms of firms conjectures (or expectations) about the reactions of other firms to their actions;
This has been widely criticized for many reasons including:
- lack of theoretical consistency;
- difficult interpretation;
- "as if" parameter/structural interpretation;
- identification (see below);

3) Specification test: estimate $\theta$ as a continuous parameter but use it only as a specification test (i.e., can you reject some specific theory).

**Final Comments on CPM:**

1) Empirical findings

The empirical work tends to find that θ is different from 0 and 1. In other words, both perfect competition (p=mc) and monopoly pricing are rejected (see survey in Bresnahan's Handbook chapter).

Maybe not surprising but coming from a Chicago-School view of the world this is useful.

2) The Cort's criticism (Corts, *Journal of Econometrics*, 98)

Criticizes the "as-if" interpretation of the continuous conduct parameter. The "as-if" interpretation says that the firms could be thought of as behaving as if they were using conjectural variations (even if they are not). The as-if conduct parameter measures an elasticity weighed price-cost margin. Corts claims

(i) That the estimated conduct parameter measures the average slope of the supply relation;

(ii) In general this will not equal the elasticity weighted price-cost margin;

(iii) In Monte Carlo studies he shows that not only are the two not equal, but they are not always positively correlated.

(iv) Calls for a structural model in order to infer conduct;

Note: as we saw, if θ varies with each observation it imposes no restrictions. So what Corts objects to are the equality restrictions over observations, which are often imposed without a clear model.

3) Direct Evidence of Performance

Wolfram (*AER*, 99) and Genesove and Mullin (*RAND*, 98) compare estimates from CPM to direct measures of market power and find that the two are similar.

4) Can we allow θ the vary over observations (and still point identify cost parameters)? Answer is generally no. But we might be able to set identify the parameters.

Rosen (2005): (1) assumes that θ is between 0 and 1 and (2) uses it to set identify the cost parameters. Interestingly he can then go back and ask what is the range of θ that is consistent with the range of cost parameters and the observed price and quantity (because of the parametric cost function the range for θ will not equal [0 1]).

Because θ varies over time this avoids the Corts critique.