ORGANIZACIÓN INDUSTRIAL EMPÍRICA IN7E0

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Outline

Introduction

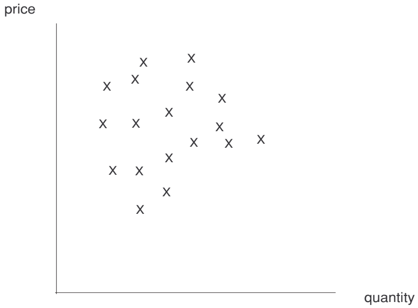
Last class we covered the first developments in IO, assuming:

- Static game
- Homogenous goods
- Cournot competition (control variable is quantity)

But we want to relax assumptions about cost being observable and studying one industry at the time. Thus, we need to estimate demand and supply for each industry.

Econometrics of Supply and Demand

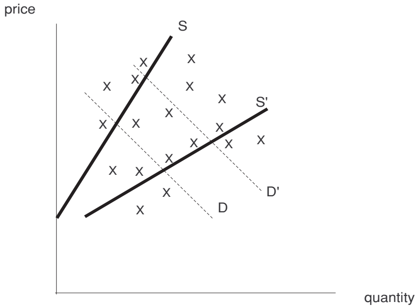
Can you imagine the exact supply and demand in this graph??



Hard? Yes, because we only observed equilibrium prices and quantities.

Econometrics of Supply and Demand

Several lines can fit some of the points.



This is called an identification problem. If everything moves at the same time how can I know what is what!

Linear Model of Demand and Supply

$$\begin{aligned} Demand\ (\alpha_1 < 0): \ P_t &= \alpha_0 + \alpha_1 Q_t + u_t \\ Supply\ (\beta_1 > 0): \ P_t &= \beta_0 + \beta_1 Q_t + v_t \end{aligned}$$

We need random terms in supply and demand, to rationalize all points.

$$\begin{aligned} Q_t^e &= \frac{(\alpha_0 - \beta_0)}{(\beta_1 - \alpha_1)} + \frac{u_t - v_t}{(\beta_1 - \alpha_1)} \\ P_t^e &= \beta_0 + \beta_1 \frac{(\alpha_0 - \beta_0)}{(\beta_1 - \alpha_1)} + \beta_1 \frac{u_t}{(\beta_1 - \alpha_1)} - \alpha_1 \frac{v_t}{(\beta_1 - \alpha_1)} \end{aligned}$$

More important, both shocks (u and v) appear in price and quantity, so we will always have an **endogeneity problem**.

Hence, How to estimate the parameters? Clearly, both regressions will yield the same coefficients!!.

Demand

To have a different regression and parameters we must have something in the Demand side different from the Supply side.

Demand Shifters: Consumers' income, prices of substitutes or complements, anything that affects demand but not supply. Denote x_t

$$P_t = \alpha_0 + \alpha_1 \underbrace{x_t}_{Demand\ shifter} + \alpha_2 Q_t + u_t$$

There is the same demand for every firm because we are looking at **homogenous goods**.

Supply

- Suppose perfect competition or Bertrand paradox, hence from theory we know that supply should be related to unobservable marginal costs.
- Suppose that we individual producer data, so we can estimate the Supply for each firm i (although they can have common parameters).
- If only aggregate quantities are observed, then you can aggregate the individual supply functions.

Supply

Supply Shifters: Variables that only affects marginal costs (maybe to all producers) but not demand. Example: input prices, technology shocks, transport costs, wages if different from consumers' income. Denote w_t.

$$\begin{aligned} MC_{it} &= \beta_0 + \beta_1 w_t + \beta_2 q_{it} \\ P_t = MC_{it} &= \beta_0 + \beta_1 \underbrace{w_t}_{Supply\ shifter} + \beta_2 q_{it} + v_t \end{aligned}$$

- $\beta_2 \neq 0$ is related to economics of scale. Suppose perfect competition (P=MC as in the Bertrand case).
- Notice that this supply is at firm level q_{it}, although you can construct $Q_t = \sum_i q_{it}$.

What happens if the degree of competition is unknown? What happens if there is Cournot competition?

New Empirical Industrial Organization (NEIO)

Bresnahan (1989) summarizes this empirical research line through the following main assumptions:

1. Assumption 1: Price-Cost margins are not taken to be observable. Marginal costs are inferred from firm's behavior.
2. Assumption 2: Individual industries are taken to have important idiosyncracies.
3. Assumption 3: Firm and industry conduct are viewed as unknown parameters to be estimated. Market power will be inferred from the data.

NEIO and conjectural variations

Recall that Cournot FOC can nest all degree of competitive behavior

$$
\begin{aligned}
P - \frac{\partial C_i(q_i)}{\partial q_i} &= -q_i \frac{\partial P(Q)}{\partial q_i} = -q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} \\
\Leftrightarrow \theta &\equiv \frac{\partial Q}{\partial q_i} = \frac{P - c}{-q_i \frac{\partial P(Q)}{\partial Q}}
\end{aligned}
$$

Where the key conjecture is:

$$
\theta \equiv \frac{\partial Q}{\partial q_i} = \frac{\partial \sum_j q_j}{\partial q_i} = 1 + \frac{\partial \sum_{j \neq i} q_j}{\partial q_i}
$$

How much would change the competitors' quantity if I increased my production by one unit?

Conjectural Variations in the Cournot case

More general, conjectural variations can refer to the change of all the other player's action due to a marginal change of a given player's action.

$$\theta \equiv \frac{\partial Q}{\partial q_i} = 1 + \frac{\partial \sum_{j \neq i} q_j}{\partial q_i}$$

- If $\theta = 0$ then perfect competition $\Leftrightarrow$ Price=Mg Cost.
- If $\theta = 1$ then Cournot outcome $\Leftrightarrow$ Price $>$ Mg Cost.
- If $\theta = N$ then Perfect collusion $\Leftrightarrow$ Monopoly Price $>>$ Mg Cost.

Cournot Competition

Demand Equation:

$$P_t = \alpha_0 + \alpha_1 x_t + \alpha_2 Q_t + \varepsilon_t$$

where x_t are the vector of demand shifters.

From FOC of Cournot competition ($P = MC - q_i \frac{\partial P(Q)}{\partial q_i}$).

Firm Specific Supply Equation:

$$P_t = MC_t - q_{it} \frac{\partial P(Q)}{\partial q_i} + \epsilon_t = MC_t - q_{it} \times \underbrace{\alpha_2}_{\frac{\partial P(Q)}{\partial Q}} \times \underbrace{\theta}_{\frac{\partial Q}{\partial q_i}} + \epsilon_t$$

where unobservable marginal cost, MC_t, is a function observable cost shifters ,w_t.

Estimating Marginal Cost

In Cournot competition, the supply side takes quantities into account because of the imperfect competition.
If marginal costs also include quantities because of economics of scale, then we have a problem of identification.
Suppose $MC_t = c_0 + c_1 w_t + c_2 q_{it}$ then:

$$\begin{aligned} P_t &= \underbrace{(c_0 + c_1 w_t + c_2 q_{it})}_{MC_t} - \alpha_2 \theta q_{it} + \epsilon_t \\ &= c_0 + c_1 w_t + \underbrace{(c_2 - \alpha_2 \theta)}_{problem!} q_{it} + \epsilon_t \end{aligned}$$

Infinite combinations of c_2 and θ, so called identification problem!
Quantity matters for two reasons in the supply side: a) Because economics of scale ($c_2 \neq 0$); and b) Because there is no perfect competition ($\theta \neq 0$).

One possible solution

One solution: the demand is not just linear in quantities but also has a demand shifter interaction.

If $P_t = \alpha_0 + \alpha_1 x_t + \alpha_2 Q_t + \alpha_3 Q_t x_t + \varepsilon_t$ then

$$\begin{aligned} P_t &= MC_t - q_{it}\frac{\partial P(Q)}{\partial Q}\frac{\partial Q}{\partial q_i} + \epsilon_t \\ &= [c_0 + c_1 w_t + c_2 q_{it}] - q_{it}(\alpha_2 + \alpha_3 x_t)\theta + \epsilon_t \\ &= c_0 + c_1 w_t + \underbrace{(c_2 - \alpha_2\theta)}_{estimate1} q_{it} - \underbrace{\alpha_3\theta}_{estimate2} x_t q_{it} + \epsilon_t \end{aligned}$$

Now, two estimates for two parameters (2 equations and 2 unknowns), there is a unique (c_2, θ) combination.

Another serious problem: **Endogeneity**

Suppose constant marginal costs, so quantity only appears in the supply side because of the lack of perfect competition.

Demand Equation + demand shifters x_t

$$P_t = \alpha_0 + \alpha_1 x_t + \alpha_2 Q_t + \varepsilon_t$$

Firm Specific Supply equation + cost shifters w_t

$$P_t = \beta_0 + \beta_1 w_t + \beta_2 q_{it} + \epsilon_t$$

Still you have endogeneity problem since it is likely that q_{it} would be correlated with $(\varepsilon_t, \epsilon_t) \Rightarrow$ Biased and inconsistent estimators.

IV solution

Instrumental variables can solve the endogeneity problem (correlation between q_{it} and $(\varepsilon_t, \epsilon_t)$). We know that Z_t must meet: $E(Z_t q_{it}) \neq 0$ and $E(Z_t \epsilon_{it}) = 0$

- In the supply side, we look for good predictors of the firm specific quantities q_i that are uncorrelated with supply shocks
  - General demand shocks (such as those in x_t).
  - firm specific demand shocks.
- In the demand side, we look for good predictors of the total quantities Q_t that are uncorrelated with demand shocks
  - cost shocks (such as those in w_t).
  - retail prices in other markets if markets face uncorrelated shocks.

We'll have $\widehat{q}_{it}$ and $\widehat{Q}_t$ that are uncorrelated with $(\varepsilon_t, \epsilon_t)$

IV solution

Suppose constant marginal costs, so quantity only appears in the supply side because of the lack of perfect competition.

Demand Equation: Demand Shifters x_t, where $\widehat{Q}_t = \sum_i \widehat{q}_{it}$

$$P_t = \alpha_0 + \alpha_1 x_t + \alpha_2 \widehat{Q}_t + \varepsilon_t$$

Firm Specific Supply Equation: Cost Shifters w_t

$$P_t = \beta_0 + \beta_1 w_t + \underbrace{\beta_2}_{=-\theta\alpha_2} \widehat{q}_{it} + \epsilon_t$$

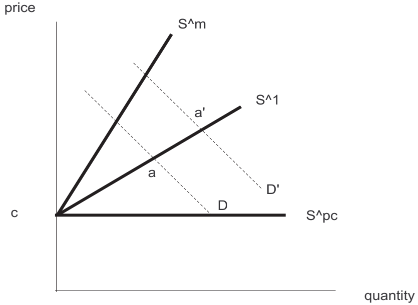
Now you have consistent estimates $(\widehat{\alpha}_2, \widehat{\beta}_2)$

NEIO Approach

Estimate conjectural variations to test the degree of competition:

$$\widehat{\theta} = \frac{\partial Q}{\partial q_i} = \frac{\frac{\partial P}{\partial q_i}}{\frac{\partial P}{\partial Q}} = -\frac{\widehat{\beta}_2}{\widehat{\alpha}_2}$$

More competitive markets if β_2 is close to zero (under constant marginal costs) or very negative α_2 (elastic demand)



Any equilibrium less competitive than Cournot?

So far, we have seen Bertrand and Cournot. Anything worse for consumers?

How we can have collusion as an equilibrium?

That lead us to dynamic models of homogeneous goods.

Supergame Basic Model

Now, let's move towards repeated interactions. Let $0 < \delta < 1$ be the discount factor (money today is better than money tomorrow: impatience). Now we have a sequence of actions: $(a_{i0}, a_{i1}, a_{i2}, a_{i3}, a_{i4}, .., a_{iT})$

$$V_i = \sum_{t=0}^{T} \delta^t \pi_i(a_{i,t}, a_{-i,t})$$

Can we sustain cooperation/collusion under repeated interactions? As long as the number of periods T is fixed and known: NO. Backward induction kills any cooperation. We have repeated static interactions, so back to Cournot or Bertrand outcomes...

Infinite Periods and Grim Strategies

If $T \to +\infty$ or there is uncertainty about T, then:

$$V_i = \sum_{t=0}^{+\infty} \delta^t \pi_i(a_{i,t}, a_{-i,t})$$

Can we sustain cooperation/collusion under repeated interactions?
YES. We can rely on the Folk Theorem (first version in Friedman 1971)

Infinite Periods and Grim Strategies

Suppose a symmetric game for both players and the following strategies:

$$a_i = \begin{cases} a_i^* \text{ (cooperation)}, & \text{if observe cooperation } a_j^* \\ a_i^0 \text{ (punishment)}, & \text{otherwise} \end{cases}$$

Grim Strategy Payoffs

Suppose symmetric cooperation payoff for each player, splitting the monopoly profit π^m equally.

Therefore, $\pi_i(coop, coop) = \pi_j(coop, coop) = \frac{\pi^m}{2}$

If agent i deviates, then the payoffs are: $\pi_i(dev, coop) = \pi^m$ and $\pi_j(coop, dev) = 0$

but then punishment regime is forever:
$\pi_i(dev, dev) = \pi_j(dev, dev) = \pi^0$.

Obviously $\pi^m \geq \frac{\pi^m}{2} \geq \pi^0$.

Comparing payoffs

In general if $1 > \delta > 0$ and π_x constant over time.:

$$\sum_{t=0}^{+\infty} \delta^t \pi_x = \frac{\pi_x}{1-\delta} \Leftrightarrow V = \pi_x + \delta V \Rightarrow V = \frac{\pi_x}{1-\delta}$$

If the cooperation equilibrium is always played, then

$$V_i(coop) \;=\; \sum_{t=0}^{+\infty} \delta^t \left(\frac{\pi^m}{2}\right) = \frac{1}{1-\delta}\left(\frac{\pi^m}{2}\right)$$

If i deviates, she gets the one-time benefits and then a lifetime punishment...

$$V_i(dev) \;=\; \underbrace{\pi^m}_{\text{one-time gains}} + \underbrace{\sum_{t=1}^{+\infty} \delta^t \pi^0}_{\text{lifetime punishment}} = \pi^m + \frac{\delta}{1-\delta}\pi^0$$

Comparing payoffs

Cooperative equilibrium only persists if:

$$V_i(coop) \geq V_i(dev) \quad \Leftrightarrow \quad \frac{1}{1-\delta}\left(\frac{\pi^m}{2}\right) \geq \pi^m + \frac{\delta}{1-\delta}\pi^0$$
$$\Leftrightarrow \quad \delta \geq \left(\frac{1}{2}\right)\left[\frac{\pi^m}{\pi^m - \pi^0}\right]$$

Ceteris paribus: Cooperation is more likely if

- δ is higher (more patient players).
- π^m is higher (larger benefits of cooperation).
- π^0 is lower (bigger punishment).

Dynamic Bertrand Competion

Suppose N symmetric firms, if cooperation then the payoff is $\frac{\pi^m}{N}$, instead if deviation, then punishment is Bertrand competition, $\pi^0 = 0$. Therefore the comparison is straightforward:

$$V_i(coop) \geq V_i(dev) \Leftrightarrow \frac{1}{1-\delta}\left(\frac{\pi^m}{N}\right) \geq \pi^m + \sum_{t=1}^{+\infty} \delta^t \times 0$$

$$\Leftrightarrow \delta \geq 1 - \frac{1}{N}$$

Ceteris paribus: Cooperation is more likely with a small number of firms. We recover Bain's intuition of implicit collusion.

Critique to Conjectural Variations

If $\frac{\partial Q}{\partial q_i} = \theta = 0$ then perfect competition; if $\theta = 1$ then Cournot competition, if $\theta = N$ then Joint profit maximization (perfect collusion).

Theoretical critique: What is $\theta = 0.5$?

There is no game that yields this result.

Corts JOE 1999

Suppose the most favorable case for NEIO, so you can estimate demand and supply using instruments to solve endogeneity problems and there is constant marginal costs.

$$P = \alpha_0 + \alpha_1 x_t + \alpha_2 Q_t + \varepsilon_t$$
$$P = \beta_0 + \beta_1 w_t + \beta_2 q_{it} + \epsilon_t$$

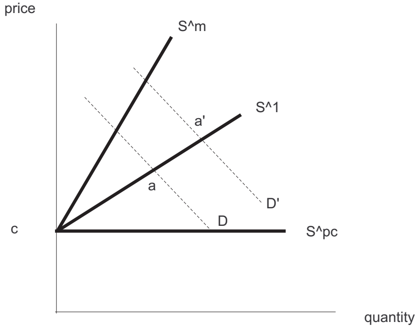
Marginal Cost Equation:

$$c_i = c_0 + c_1 w_t$$

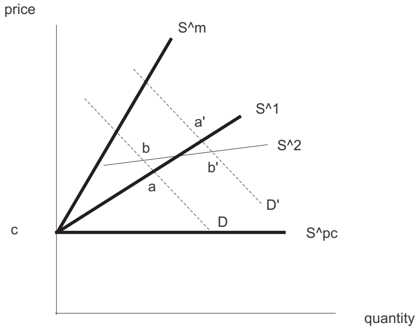
As we saw, the estimate of θ would be:

$$\theta = \frac{\partial Q}{\partial q_i} = \frac{\frac{\partial P}{\partial q_i}}{\frac{\partial P}{\partial Q}} = -\frac{\beta_2}{\alpha_2}$$

Notice that average and slope are the same, when supply is a ray...



Not the general case....



What if we have supply S^2. **Do we care about the level or the slope?**

The problem is that the Lerner index requires levels and econometrics provides variations..

$$\theta = \frac{1}{-\frac{\partial P}{\partial Q}} \frac{\frac{P-c}{x}}{\frac{q}{x}} \neq \widehat{\theta} = \frac{1}{-\frac{\partial P}{\partial Q}} \frac{\frac{dP-c}{dx}}{\frac{dq}{dx}}$$

Killing Conjectural Variations

Corts illustrates the severity of the mismeasurement of market power by simulating data generated by a symmetric duopoly playing a fully collusive supergame equilibrium when considering iid shocks, linear demand and constant marginal costs.

This discrepancy was very serious when:

- discount factor is small, so collusion cannot be sustained in all the demand states.
- given a small discount factor, the demand shocks are i.i.d.
- given a small discount factor, the demand shocks are negatively correlated.

Summary of Lecture 2

- We saw how to estimate supply and demand for homogenous products. Cost shifters and demand shifters are key.
- NEIO improve the discipline through assuming non-observable marginal costs (ie, non-observable profits), studying one industry at the time.
- Still only works in static framework and for homogenous goods since it is based on Cournot analysis.