Before there was “New” Empirical IO

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Grad IO

Early Stuff

This lecture is a bit different from all of the others

- Focus is primarily on theory rather than empirics
- History of approaches (some of which have fallen out of fashion).
- Should be familiar to most of you
    - Brush up on first few chapters of Tirole (1988) (somewhat dated) but still the best reference for oligopoly theory.
    - Vives (2000) is a more modern (and focused) review of oligopoly theory.
    - I assume familiarity with an undergrad text like Carlton and Perloff (1999), Cabral (2000) or Shy (1996).

History of IO: Part 0

Early 20th century Agricultural Economics

- How can we estimate supply and demand from data?
- Mostly homogenous agricultural products.
- Early discussion of simultaneity/endogeneity econometrics

Complaint: everything still perfectly competitive.

History of IO: Part I

Structure-Conduct-Performance (1940-1960) Harvard

- Associated with the work of Joe Bain.
- Structure (number of firms, market shares, etc.). Barriers to entry are key.
- Structure $\rightarrow$ conduct (ie: how firms behave)
- Conduct $\rightarrow$ performance (ie: prices, markups, efficiency)
- Use accounting data to get performance (profits, price-cost margins, etc.)
- OLS regression across industries to see whether profits are higher in more concentrated industries.
- Empirics were somewhat atheoretic.

Complaint: the direction of causality is assumed. (Don't profits determine number of entrants too?).

History of IO: Part II

Chicago School (1960-1980)

- Most associated with the work of George Stigler and later Robert Bork "Antitrust Paradox"
- Monopoly is more often alleged than confirmed
- Even when monopoly does exist -often only temporary (did MSFT take over the world?)
- Entry and threat of entry is crucial.
- Emphasis on price theory (markets work) and better econometrics
- Still quite persuasive for practice of antitrust (judges and lawyers).

History of IO: Part III

Game Theory (1980-1990s)

- For most of the 1980s, IO was dominated by game theorists.
- Strategic decision making, Nash Equilibrium
- Lots of intuitive (and sometimes counter-intuitive) clean theoretical models
- Hard to know which model is the right model for the industry we are looking at.

History of IO: Part IV

The not so "new" anymore empirical IO (NEIO) (1989-)

- Back to one industry at a time.
- Careful game-theoretical model of industry behavior
- Joined with modern econometrics, data, and computation.

Some preliminaries

- FOC and profit maximization

The FOC for profit maximization is derived from the principle of marginal analysis. Marginal analysis is the process of comparing the additional costs and benefits of producing one more unit of output.
When a firm seeks to maximize profit, it will produce the quantity of output at which marginal revenue (the additional revenue from selling one more unit of output) equals marginal cost (the additional cost of producing one more unit of output). This can be represented as:

$MR = MC$

Taking the derivative of the firm's profit function with respect to output yields the marginal revenue function. The FOC for profit maximization is derived by setting the marginal cost equal to the marginal revenue and solving for the optimal level of output. This can be represented as:

$d\pi/dQ = MR - MC = 0$

Where π is the profit function and Q is the quantity of output produced.

The FOC tells us that at the profit-maximizing level of output, the additional revenue gained from selling one more unit of output is exactly equal to the additional cost of producing one more unit of output. This condition ensures that the firm is producing the optimal quantity of output to maximize its profits.

The Monopoly Problem

Start with a quantity-setting monopolist facing a known inverse demand curve $P(Q)$ and costs $C(Q)$.

$$\pi(Q) = P(Q) \cdot Q - C(Q) - F$$

monopoly is going to choose quantity to max profits (FOC)

Take the FOC and derive the Lerner Index:

The Lerner Index is a measure of a firm's market power, defined as the difference between the price it charges for its product and its marginal cost, divided by the price.
It provides a measure of a firm's pricing power, which is the ability of the firm to charge higher prices than its costs would suggest.

change the market clearing price (P'(Q)) and it's going to be applied to all of my infra marginal units (Q)

없었다면 *P(Q)=C'(Q)* 라서

$$\pi'(Q) = 0$$

$$\underbrace{\overbrace{P'(Q) \cdot Q}^{\text{monopoly distortion}} + P(Q)}_{MR} = \underbrace{C'(Q)}_{MC}$$

Lerner markup:
(a number between zero and 1)

$$\frac{P(Q) - C'(Q)}{P(Q)} = -\frac{P'(Q) \cdot Q}{P(Q)} = \frac{1}{|\epsilon_d|}$$

The Lerner Index ranges from 0 to 1. A Lerner Index of 0 indicates that the firm has no market power, and the price it charges is equal to its marginal cost. An index of 1 means that the firm has complete market power, and the price it charges is infinitely higher than its marginal cost.

The Lerner Index and the elasticity of demand are related because both measures provide information about a firm's market power.

The elasticity of demand is a measure of the responsiveness of quantity demanded to changes in price. If demand for a product is relatively elastic, a small change in price will result in a larger change in quantity demand.

The Lerner Index, on the other hand, measures the difference between the price a firm charges and its marginal cost, as a proportion of the price. It provides a measure of a firm's market power, with a higher Lerner Index indicating greater market power and the ability to charge higher prices.

The relationship of Lerner Index and the elasticity of demand is inverse.
The higher the elasticity of demand for a product, the lower the Lerner Index will be. This is because when demand is more elastic, firms have less pricing power and must price closer to the marginal cost to maintain market share.

The Monopoly Problem

We could have rewritten it as

$$P\left(1+\frac{1}{\epsilon_d}\right) = MC$$

- This is helpful because it shows us the important result that the monopolist never produces in the inelastic portion of the demand curve. $\epsilon_d \in (-1, 0]$.
- Why? MR is negative! Reduce Quantity!
- Often data report: $\frac{P}{MC} = \mu$. But we usually work with the Lerner formula in IO.
- For the monopolist firm level elasticity ϵ_d is the same as ϵ_D the market elasticity.

Cournot Model (1838) / Nash in Quantities

- Assume constant marginal cost $c_i = c$ and n equal sized firms to make life easy.
- We let $Q = \sum_{i=1}^{N} q_i$ the total output of the industry.

We consider profits and FOC's:

how much does the aggregate quantity in the market respond when person i produces a single more unit

$$\begin{aligned} \pi_i(q_i) &= (P(Q) - C_i'(q_i)) \cdot q_i \\ \frac{\partial \pi_i(q_i)}{\partial q_i} &= (P(Q) - C_i'(q_i)) + q_i \cdot P'(Q) \cdot \frac{\partial Q}{\partial q_i} = 0 \end{aligned}$$

Cournot competition implies that $\frac{\partial Q}{\partial q_i} = 1$ and $\frac{\partial q_j}{\partial q_i} = 0$ for $i \neq j$ (this is because it is a simultaneous move game).

In the Cournot competition, this is 1, that is when a player produces one more unit the market q also goes up by exactly one unit; because people simultaneously choose quantities and i don't know that my opponent was going to produce one more unit and there's nothing i can do about it;

$$P(Q) + P'(Q) \cdot q_i = \underbrace{P(Q) + \overbrace{P'(Q) \cdot \frac{Q}{n}}^{\text{Cournot Distortion}}}_{MR} = mc$$

Take everybody's FOC; again i get the same setup, MR=MC in monopoly, n=1 (이전 페이지 참고)

The Cournot model is a model of imperfect competition in which firms compete by choosing the quantity of output they will produce, given the output produced by their competitors.

In the Cournot model, firms simultaneously choose the quantity of output they will produce, taking into account the quantity produced by their competitors. Each firm assumes that its competitors will hold their output constant, and sets its own output level to maximize its profit given this assumption.

The model assumes that firms have identical costs of production, and that the market demand for the product is known and fixed. The equilibrium outcome of the model is the Nash equilibrium, in which each firm's output level is the best response to the output levels of its competitors.

The Cournot model is often used to analyze industries in which firms produce differentiated products or have some degree of market power, but not enough to be considered monopolies. The model provides insights into the strategic interactions between firms and can help to explain the pricing and output decisions made by oligopolistic markets.

The Cournot distortion is a concept that refers to the inefficiency that arises in a Cournot oligopoly due to the fact that each firm does not take into account the effect of its own output on the price of the product.

In other words, each firm assumes that its competitor's output will remain constant, even though its own output affects the market price and therefore the quantity demanded by consumers.

The Cournot distortion arises because each firm produces a quantity that is larger than the quantity that would be produced in a perfectly competitive market.

The magnitude of the Cournot distortion depends on the number of firms in the market and the degree of product differentiation. As the number of firms increases or the degree of product differentiation decreases, the Cournot distortion becomes smaller, approaching the efficient outcome of a perfectly competitive market.

Cournot Model (1838) / Nash in Quantities

Rearrange to form the Lerner Index:

$$\frac{P - mc}{P} = -\frac{1}{n}\frac{Q}{P}P'(Q) = -\frac{1}{n \cdot \epsilon_D}$$

e_D is the elasticity of demand for the entire market

Some notes

because there's going to be substitutes readily available; if i raise the price of beer altogether, we're going to slowly reduce consumption of beer slowly

- In general market demand is much less elastic than firm level demand.
- When things are symmetric then we can relate aggregate to firm level elasticity: $\epsilon_d = n \cdot \epsilon_D$.
- For beer market demand $\epsilon_D \approx -0.8$. If $n = 5$ then a typical firm faces an elasticity of -4.0.
- We can back out implied markups pretty easily: $P = \frac{MC}{1-(1/\epsilon_d)} = \frac{4}{3}MC$.
- Market demand can be at inelastic part of curve – but firm level demand cannot.

When we look for demand in a category, it can be at inelastic part of curve, unlike firm demand

Betrand Paradox (1883)/ Nash in Prices

Briefly contrast with Bertrand

- Two firms with symmetric marginal costs $c_i = c$.
- Nash in prices means that $p = c$.
- ***Text***
- This is not very interesting or helpful. Also firms make profits!
- Solutions
  - Add capacity constraints (starts to behave like Cournot again (Kreps Scheinkman)).
  - Add other frictions (search costs?)
  - Add product differentiation (mostly we focus on this).

The Bertrand model is used to analyze competition between two firms that produce identical products and compete on price.

In the Bertrand model, each firm chooses a price for its product simultaneously and consumers will buy from the firm that charges the lowest price. If both firms charge the same price, consumers will split their purchases between the firms equally. The objective of each firm is to maximize its profits by setting a price that will attract the largest share of customers.

The traditional assumption of the Bertrand model is that firms set their price equal to their marginal cost, leading to a perfectly competitive outcome where both firms earn zero economic profits. However, the Bertrand paradox shows that this assumption does not always hold, and that firms can earn positive profits by setting their prices just below the price of their competitor.

The Bertrand paradox is a phenomenon that challenges the traditional assumption of the Bertrand model, which suggests that in a two-firm industry, perfect competition will lead to price equal to marginal cost.

The traditional assumption is that firms will set their price equal to their marginal cost, leading to a perfectly competitive outcome where both firms earn zero economic profits. The paradox shows that this assumption does not always hold. If the two firms have identical marginal costs but differentiate their products in some other way, such as through advertising or location, they can be differentiated in the eyes of consumers. This can lead to price competition between the two firms, with each firm settings its price just below the competitor's price to capture all of the demand.

In this case, the equilibrium outcome is not perfectly competitive, and the firms will earn positive economic profits. This is because the price of the product is set just below the price of the competitor, rather than at marginal cost, resulting in a Bertrand equilibrium in which both firms earn positive economic profits.

The Bertrand paradox highlights the importance of product differentiation in determining the pricing behavior of firms, and suggests that perfect competition may not always be the outcome in a two-firm industry.

Asymmetric Cournot and HHI

- Symmetry doesn't seem like a particularly realistic assumption.
- We can extend this to the asymmetric case pretty easily by modifying the Cournot distortion: $q_i \cdot P'(Q) \cdot \frac{\partial Q}{\partial q_i}$.
- Instead we have that $\frac{q_i}{Q} \cdot \frac{\partial Q}{\partial q_i} = \frac{q_i}{\sum_{j=1}^{n} q_j} \equiv s_i$ or market share.
- Obviously this nests symmetric case where $q_i = \frac{Q}{n}$ or $s_i = \frac{1}{n}$.
- The Cournot markup / Lerner Index is just

$$\frac{P - mc_i}{P} = \frac{s_i}{|\epsilon_D|}$$

- Cournot: markups are proportional to market-share.
- Nests perfect competition $n \to \infty$ or $s_i \to 0$.
- Semi-joke: IO economists say something is intuitive if it follows Cournot predictions.

The asymmetric Cournot model is an extension of the standard Cournot model of oligopoly in which firms have different production costs. In the standard model, it is assumed that all firms have identical production costs, which may not reflect the real-world conditions.

In the asymmetric model, each firm faces a different marginal cost of production, which affects its optimal level of output and pricing decisions. The model assumes that firms choose their output levels simultaneously, based on their assumptions about the output levels chosen by their competitors.

The model can help to explain why some firms are able to charge higher prices and earn higher profits than their competitors, and how market structure and entry barriers affect the behavior of firms in different industries.

Asymmetric Cournot and HHI

Now consider the market share weighted Lerner index:

$$HHI = \sum_{i=1}^{N} \frac{P - mc_i}{P} s_i = \sum_{i=1}^{n} \frac{s_i^2}{\epsilon_D}$$

- For $\epsilon_D = 1$, this is known as the Hirschman-Herfindal Index.
- This gives us a measure of market concentration that varies from 0 to 10,000 (units of s_i are in percentages).
- DOJ/FTC describe markets as:
  - Highly Concentrated: $HHI \geq 2500$.
  - Moderately Concentrated: $HHI \in [1500, 2500]$. $\Delta HHI \geq 250$ merits scrutiny.
  - Un-Concentrated: $HHI \leq 1500$.

Asymmetric Cournot and HHI

- Can also work backwards form HHI to get effective "number of firms".
- Here HHI is in units of $[0,1]$ instead of $[0,10000]$.

$$HHI = \sum_{i=1}^{N} s_i^2 = \frac{1}{n^*} \to n^* = \frac{1}{HHI}.$$

- ex. Four firms with shares $40\%, 30\%, 15\%, 15\%$. So the $HHI = .295$. Thus $n^* = 1/.295 = 3.39$ and $\epsilon_d = \epsilon_D \cdot 3.39$.
- Alternatively (under Cournot only!) can write:

$$\frac{P - MC}{P} = \frac{HHI}{\epsilon_D}$$

HHI and Welfare

Under Cournot (and only Cournot) with constant MC, we can relate HHI to particular measures of welfare:

- Cowling Waterson (1976) relate HHI to producer share of revenue:

$$HHI = \epsilon_d \cdot \frac{PS}{R}$$

- Spiegel (2020) relates HHI to producer share of surplus:

$$HHI = \frac{1}{\epsilon_d\left(Q^*\right)} \cdot \frac{PS}{CS}$$
$$\frac{CS}{TS} = \frac{1}{1 + \epsilon_d\left(Q^*\right) \cdot HHI}$$

Alternatives to HHI

- Another alternative is the k firm concentration ratio $CR_k = \sum_{i=1}^{N} s_i$.
- This can be useful as an additional descriptive statistic.
- It shows up in some older work
- 4 firms is a popular measure.

Complaints about HHI

- HHI only relates to market power under the Cournot assumptions
  - Holding competitor's output responses fixed so that $\frac{\partial Q}{\partial q_i} = 1$.
  - Competition is about setting quantity rather than price: strong restrictions on cross-price elasticities.
  - Is quantity (instead of price) the relevant strategic variable? (Sometimes...).
- Assumes that products are homogenous so that all firms/products are equally good competitors.
- More concentrated markets have higher markups, but not always lower welfare (allocating production from low to high cost firms might improve welfare).

Also, how do we define markets in the first place?