Graduate IO: Session 1

September 12, 2016

Agenda

- course overview

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- brief Introduction to IO

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- Oligopoly Pricing in Homogenenous Products Markets

Course Description and Prerequisites

- graduate level introduction to IO
  - economic theory
  - industry and data
  - econometric tools
  - computational methods

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  - economic theory
  - industry and data
  - econometric tools
  - computational methods
- prerequisites
  - advanced microeconomics and econometrics
  - coding skills in Stata and Matlab
  - (not required) research experience in some industries

Topics

- essential topics in IO
  1. static models of oligopolistic competition
  2. product differentiation
  3. price discrimination
  4. market structure and entry

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  1. static models of oligopolistic competition
  2. product differentiation
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  4. market structure and entry
- areas of active research
  1. price dispersion and consumer search
  2. advertising
  3. vertical contracts and integration

Assignments

- attendance and ongoing readings: 15%
  - assign one or two readings at the end of each session
  - randomly call someone about the readings in the next session
    - 3-5 minutes: clearly state the research question and explain the strategy for answering it

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- two problem sets: 30%
  - micro theory: math derivation
  - empirical: programming in Stata/Matlab
- one assigned paper: 55%
  - 45 minutes group presentation: 35%
  - referee report: 20%

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- goal: transition from being consumers of research to being producers of research
  - how to: read other people's papers, evaluate your own ideas for papers, do practical stuff (e.g., coding in Stata/Matlab), construct a complete research paper

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- in particular
  - read papers carefully before coming to class
  - participate in class discussion with comments, questions, etc.
  - complete assignment carefully and on time

IO Overview: Einav and Levin (2010)

- what is IO about?
  - structure of industries in the economy
  - behaviour of firms and individuals in these industries
  - depart from perfect competition: scale economies, market frictions, strategic behavior, etc.
    - how competition plays out in different markets and how it relates to industry structure, regulation/ public policy, etc

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    - how competition plays out in different markets and how it relates to industry structure, regulation/ public policy, etc
- a brief history (since 1970s)
  - theoretical models of imperfect competition: game theory revolution (Tirole 1988)
  - empirical perspective: shift from "structure-conduct-performance" (back to Bain 1951) to "New Empirical IO" (Bresnahan 1989)

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  - cross-industry variation in industry structure could be captured by a small number of observable measures
- what were the results?
  - often $\beta_1 > 0$: more concentrated industries are more profitable
  - so what? is this causal? not really, because hard to find *exogeneous* variation to shift concentration
  - what are the policy prescriptions? reduce concentration to lower price?

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  - individual industries are taken to have important idiosyncracies: focus on a single industry/market
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- advantages
  - detailed micro data and institutional knowledge
  - clarity of economic theory
  - convincing empirical measurement/econometric identification
  - counterfactual analysis: what would happen following a merger or regulatory change

Genesove and Mullin (1998)

- in the NEIO literature, equilibrium oligopoly price P is characterized by the generalized monopolist's first-order condition

$$P + \theta Q P^{'}(Q) = mc \tag{1}$$

where Q is industry output, θ is the conduct or market power parameter, mc is the marginal cost

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- the parameter θ is called "the average collusiveness of conduct" (Bresnahan 1989)
  - perfect collusion or monopoly: $\theta = 1$
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- two major uses of (1)
  - estimate θ as a free parameter, along with cost parameters, using data on a sample of markets
  - prior choice of θ is assumed, so marginal cost can be directly inferred

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- the NEIO approach has never been "tested": requires that one have alternative measures of conduct and cost with which the NEIO estimates could be compared
- this paper: assesses the NEIO approach, using US East Coast cane sugar refining industry,1890-1941
  - production technology is simple: raw sugar is transformed to refined sugar, at a fixed and known coefficient
  - the industry underwent dramatic changes in the degree of competition

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- geographic market: cane sugar refining on East Coast of US, basis price determined in New York City
- fringe suppliers of refined sugar: domestic and European beet sugar producers; not much of a threat for most of the sample period, so not incorporated in the analysis

Industry Background

- early history:
  - American Sugar Refining Company (ASRC), formed in 1887 as a consolidation of 18 firms controlling 80% of the industry's capacity
  - the firms quickly reorganized and reduced to 10, refined prices rose 16%
  - a major entry (plant construction) happened in 1889, which led to a price war
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- entry eroded ASRC's capacity share between 1892 and 1900, precipitating a price war that ended in consolidation, cartel from 1900-11, followed by an anti-trust investigation

Cost Structure

- technology is simple and common to all the firms: marginal cost can be summarized by

$$MC = c_0 + k \times P_{\text{raw}}$$

  - MC: the marginal cost of producing 100 lbs of refined sugar
  - c_0: variable cost: \$0.26 for producing 100 lbs of refined sugar
  - k: conversion ratio: 1.041 (1 lb of raw sugar = .96 lb of refined sugar)
  - P_{raw}: price of 100 lbs of raw sugar

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- ASRC retained substantial excess capacity for entire sample period

Demand Model

- a simple linear demand model

$$Q(P) = \beta(\alpha - P) + \epsilon$$

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  - β: measure of size of market
  - α: maximum willingness to pay
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- sugar is an input into fruit canning which occurs in the third quarter: demand parameters can differ in high season from other quarters (basically two demand curves)

$$Q(P) = \begin{cases} \beta_H(\alpha_H - P) + \epsilon & \text{high season} \\ \beta_L(\alpha_L - P) + \epsilon & \text{low season} \end{cases}$$

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- need to find a variable that is correlated with P but not with demand shock (known as an instrument)
- usually use input prices that shift supply: helps determine P but typically independent of demand shocks

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- the "natural" instrument is P_{raw}, but
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- the "natural" instrument is P_{raw}, but
  - P_{raw} is probably not exogenous because US consumption is 25% of world market: likely to be correlated with US demand shocks
- Cuban imports as an instrument: a proxy for Cuban production of raw sugar
  - Cuban raw sugar represents a substantial share of total U.S. imports of raw sugar: variation in Cuban imports affects price of raw sugar and hence price of refined sugar
  - but variation in Cuban imports is due to supply factors such as weather: independent of U.S. demand shocks
  - bottom line: regardless of the level of production, almost always 100% of Cuban production were shipped to US, during the sample period

Demand Estimates

TABLE 3 **Demand for Refined Sugar, Separately by Season**

		(1) Quadratic ($\gamma = 2$)		(2) Linear ($\gamma = 1$)		(3) Log-Linear ($\alpha = 0$)		(4) Exponential ($\gamma, \alpha \to \infty$)
Low season [N = 73]								
Refined Price	α_L	7.72	β_L	−2.30	γ_L	−2.03	$\left(\frac{\gamma}{\alpha}\right)_L$	−.53
		(.86)		(.48)		(.48)		(.12)
Intercept		−1.20	$\beta\alpha_L$	13.37		4.19		3.52
		(.47)		(1.90)		(.65)		(.48)
High season [N = 24]								
Refined Price	α_H	11.88	β_H	−1.36	γ_H	−1.10	$\left(\frac{\gamma}{\alpha}\right)_H$	−.26
		(2.03)		(.36)		(.28)		(.07)
Intercept		−2.48	$\beta\alpha_H$	10.74		3.17		2.70
		(.54)		(1.57)		(.40)		(.29)
$\chi^2_{(2)}$ test		6.90		28.18		29.17		25.96

Notes: Standard errors are in parentheses. They are heteroskedasticity-robust and corrected for serial correlation with four lags, by the method of Newey and West (1987). *Refined Price* is instrumented by the log of *Cuban Imports*. The reported $\chi^2_{(2)}$ statistic is for the joint test of equality of the coefficients on price and the intercept across seasons.

- demand is larger and less elastic in high season

"Guessing" the Conduct Parameter

TABLE 2 **Sample Statistics**

	Full Sample		Low Season		High Season	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Refined Price (P)	4.03	.62	3.99	.63	4.14	.58
Raw Price (P_{RAW})	3.30	.59	3.28	.61	3.36	.53

- price is only slightly higher in high season: the market power is quite weak
- thus, θ should be small, though positive

Pricing Rule

- basic markup equation

$$\frac{P - MC}{P} = \frac{\theta}{\eta(P)}$$

  - LHS is known as the Lerner index
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  - special cases: $\theta = 1$ if monopoly; $\theta = 0$ if competitive; $\theta = s_i$ if Cournot

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- in this case, $\eta(P) = P/(\alpha - P)$, so pricing rule is

$$P = \frac{\theta\alpha + c_0 + kP_{\text{raw}}}{1 + \theta}$$

Estimation

- suppose P_{raw} is exogenous, we could run this regression

$$P = \beta_0 + \beta_1 \times 1\,(\text{high season}) + \beta_2 \times P_{\text{raw}}$$

  - then use $(\beta_0, \beta_1, \beta_2)$ and (α_L, α_H) to recover (θ, c_0, k)

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- P_{raw} is endogenous and but we can use the moment condition restriction

$$E\left[\left\{P\,(1+\theta) - \theta\alpha - c_0 - kP_{\text{raw}}\right\} Z\right] = 0$$

  - instruments:
    $Z = (\text{constant}, 1(\text{high season}), \log(\textit{Cuban Imports}))$

Results

TABLE 7 NLIV Estimates of Pricing Rule Parameters

	Linear		Direct Measure
	(1)	(2)	(3)
$\hat{\theta}$	.038 (.024)	.037 (.024)	.10
$\hat{c}_o$	.466 (.285)	.39 (.061)	.26
$\hat{k}$	1.052 (.085)		1.075

- market is a lot more competitive than monopoly or even Cournot (with nine firms or fewer firms)
- the NEIO approach performs reasonably well although variable cost is overestimated
- column (2) imposes the value of k: does not improve the estimate of θ, but raises the precision

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- firms' price-cost margins are not taken to be observables: marginal cost is inferred from firm behavior (i.e., FOC)
- individual industries have important idiosyncracies: firm's conduct is likely to vary across industries based on these unobserved industry-specific factors so little can be learned from cross-sectional studies of industries
- the behavioral equations by which firms set prices and quantities are estimated and the structural parameters identified

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- monopoly models: agent optimizes against a fixed environment
- oligopoly models: agent has to consider what actions its competitors will take (i.e., beliefs) and how they may react to its actions (i.e., dynamics)
- focus initially on static models: they will give us some insights into more complicated dynamic models

Cournot Model

- normal form representation
  - player: $i = 1, 2, ..., N$
  - strategy for firm i: $q_i \in [0, \infty)$
  - payoff: $\pi(q_i, q_{-i}) = P\left(\sum_i q_i\right) q_i - C(q_i)$

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- examples: commodity markets (e.g., spring water, sugar)

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- problem: not very useful, typically not the case in reality

Alternative Formulation: Best-Reply Response

- let $R_i(q_{-i})$ denote firm i's best replies to its rivals' output choices, then a Nash equilibrium is a profile $\{q_1^*, ..., q_N^*\}$ such that

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- in other words, the Nash equilibrium is a fixed point of the mapping $\mathbf{R}$, where $\mathbf{R}$ is the Cartesian product of R_i
- existence reduces to checking that $\mathbf{R}$ meets conditions of some fixed point theorem, this also provides algorithm for finding Nash equilibria

Symmetric Case with Linear Demand

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- solve the N equations for N unknown

$$q_i^* = \frac{a - c}{b(N+1)}$$

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- solution (equilibrium)

$$q_i^* = \frac{a - 2c_i + c_j}{3b}$$

  - interpretation: the more efficient (lower cost) firm produces more output

Markups

- evaluated at the equilibrium, the FOC can be written as

$$\frac{P(Q^*) - c_i}{P(Q^*)} = \frac{s_i^*}{\eta^*}$$

where $s_i^* = \frac{q_i^*}{Q^*}$ is firm i's market share and η^* is the the elasticity of market demand

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- firms have market power (price is above marginal cost)
- the more elastic is demand, the lower are the markups
- firms with lower marginal costs have higher market shares
- more firms $\Rightarrow$ smaller shares $\Rightarrow$ lower markups
- solution lies between competition and monopoly

Bertrand Model

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- players: two firms indexed by $i = 1, 2$
- stragety of firm i: $p_i \in [0, \infty)$
- payoffs

$$\pi_i (p_i, p_j) = \begin{cases} p_i D(p_i) - C(D(p_i)) & \text{if } p_i < p_j \\ \frac{1}{2}[p_i D(p_i) - C(D(p_i))] & \text{if } p_i = p_j \\ 0 & \text{if } p_i > p_j \end{cases}$$

Solution

- Nash Equilibrium: a pair of prices $\{p_1^*, p_2^*\}$ such that

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- unique NE: $p_1^* = p_2^* = c$
  - can $p_1 > p_2 > c$ be an equilibrium?
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  - no, because it is profitable to undercut rival

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  - perfect information: in reality consumers may have to engage in costly search to determine which firm has the lowest price
- relaxing any one of these assumptions yields a richer model with more realistic predictions

Readings for Next Session

- D. Kreps and J. Scheinkman, "Quantity Precommittment and Bertrand Competition Yield Cournot Outcomes," *Bell Journal of Economics*, 1983.