

Oligopoly

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Introduction

So far all market power models have one firm

- Today we want to bridge monopoly and competition
- Basic problem: lots of ways to relate oligopolistically
 - Strategic interactions tougher than markets, individuals

We'll look at a range of ways thinking about oligopoly

- 1 The most classical model: Cournot's quantity choice
- 2 The Bertrand-Edgeworth critique
 - The paradox of two firms
 - Heterogeneity as the solution
- 3 Collusion: incentives, costs and comparative statics
- 4 Conjectural variations: a broader model
 - Summarizes degree of collusion
 - Also captures strategic effects: interesting in their own right
- 5 Conjectural variations and empirical measurement

Cournot's model of oligopoly

Most classic model of oligopoly is Cournot (1838)?

- 1 N firms produce a homogeneous product
 - Often we will assume same, constant MC c
- 2 Each firm takes as *the quantity of all others*
 - Sort of “competition” we talked about in Lecture 9
 - Sometimes stated as “choosing quantities” but misleading
- 3 Equilibrium is when each maximizes given others choices

Each firm earns profits $q_i [P(q_i + Q_{-i}) - c]$

- $Q_{-i} \equiv \sum_{j \neq i} q_j$, $Q \equiv \sum_j q_j$; MR? $q_i P'(Q) + P(Q)$

⇒ Marginal revenue closer to demand than with monopoly!

- $q_i < Q$ so mark-up reduced; simple with symmetric firms
- Then $q_i = \frac{Q}{n}$ which implies new Lerner?

$$\frac{P-c}{P} = \frac{1}{n\epsilon}$$

Incentives and pricing in the Cournot model

Notice a few things:

- 1 Even with many firms, prices still above cost
 - Though, as we'll explore on Tuesday, gradually fall
- 2 Prices between monopoly and perfect competition

One of the most interesting results comes from asymmetry

- Suppose different c_i , each firm sets $q_i P'(Q) + P(Q) = c_i$
- ⇒ Lower cost firms must produce more, higher mark-up
- But high cost firms still produce some; this is inefficient!
- ⇒ V. monopoly, competition, oligopoly misallocates production
- $QP'(Q) + NP(Q) = \sum_i c_i \implies \bar{q}P'(q) + P(Q) = \bar{c}$
- ⇒ Pass-through of any firm's cost like $\frac{1}{n}$
 - Only average cost matters, heterogeneity not key
 - Makes model more "robust" to heterogeneous costs
 - We'll compare this to other models shortly

Strategy spaces and game theory

Let's take a step back: how did the model we solved work?

- 1 Firms *took as given* some action of other firms
 - These are often called the *strategies* of other firms
- 2 Each firm optimized, given this

This is called a *Nash equilibrium*

Nash Equilibrium

Agents optimize, taking as given some strategy of other agents.

- Seems plausible, but devil is in what strategy we choose
- Our firms assumed other quantities stayed fixed
- But why quantities? Could be prices, mark-up, etc.
 - These problem arises *in any strategic model*
 - Oligopoly just one example; this is what makes it so tricky
- Let's consider other most common potential strategy

The Bertrand-Edgeworth paradox

How about if firm's take others' price as given?

- Profits discontinuous! If I charge a bit below, get everyone
- Suppose all have same, known cost?
 - ⇒ Positive mark-up cannot be equilibrium; undercut

Bertrand and Edgeworth's Paradox

With $N > 1$, only equilibrium is $P = c$!

- Called *Bertrand-Edgeworth paradox* or *critique*
- Two firms enough for competition? Many think absurd
- Unlikely sales change discontinuous; possible resolutions?
 - 1 Firms differ in their costs, costs may not be known
 - 2 Firms' products are not the same (inherent or search)
 - 3 Firms collude or don't take others prices as given
- Rest of the lecture will explore these

Cost heterogeneity and the Bertrand paradox

Simplest response is that firms differ in costs

- This case like first-price auction
- Each firm tries to just beat next firm
 - ⇒ $P \neq \min\{c_i\}$; rather $P = E[c_2]$, cost of 2nd lowest
- Clearly not quite the average cost, but a lot less sensitive
- As we get more firms, second lowest closer to first (?)
- ⇒ Predictions more similar to Cournot than simple Bertrand
- ⇒ Major virtue of Cournot greater robustness (and simplicity)
 - Broader: absurd conclusions indicate model problem

Differentiated products: the most popular solution

Another, more popular, response is product differentiation

- If one firm increases price, demand only falls continuously
 - ① Consumers view products as *differentiated*
 - Non-price characteristics as last week
 - ② Identical, but consumers have to search
 - Prices are not transparent, costly to go to store
 - ⇒ Once in store, monopolist competing against cost of 2nd visit
- Either way we can write for firm i , $Q^i(p_1, \dots, p_i, \dots, p_N)$
 - So long as nice, smooth, no Bertrand-style discontinuities
- Each monopolist on own product, but others substitute
 - $\frac{\partial Q^i}{\partial p_j} > 0$ for $i \neq j$
- Very broad model, could quantities as strategies
 - However “Nash-in-prices” or “Bertrand” has become central
 - Called “Differentiated Products Nash-in-Prices” or (DPNiP)

Pricing with differentiated products

Same basic principles hold for pricing in this case

- We can define *residual demand elasticity*:
 - Elasticity of demand *holding fixed other prices?*

$$\epsilon_i^r = \frac{\partial Q^i p_i}{\partial p_i Q^i}$$

- Then just follow Lerner rule: $\frac{p_i - MC_i}{p_i} = \frac{1}{\epsilon_i^r}$

- Nothing special about prices as strategies

① Just as easily defines firm's optimal quantity

- Key is *holding fixed other firms' prices*

② Could also do à la Cournot/Nash-in-quantities

- Then residual elasticity is *holding fixed other quantities*
- Less common so we won't get into math, but very similar

⇒ No reason differentiated products needs price strategies

- This is used extremely broadly in industrial economics

How oligopolists benefit from a cartel

Oligopolists create (pecuniary) externalities on one another?

① Purely pecuniary under Cournot; why?

- Believe all other firms' quantities are given

② Purely real under DPNiP; why?

- Believe other firms' prices are fixed, quantities change

⇒ Quantities always too high under Cournot but...?

- May be too high under DPNiP if other mark-ups larger

Regardless of social benefits or costs, firms benefit by avoiding

- Because substitutes, $q \downarrow / p \uparrow$ always benefits competitor
 - In fact, let's *define* two firms competing by being substitutes
- If they act to internalize this (pecuniary) externality we say?
 - They are "colluding" or "forming a cartel" or my favorite:
 - "Combination in the restraint of trade"
- Denounced since Adam Smith, illegal under Sherman Act

Classical theories of oligopoly

Stigler's theory of collusion

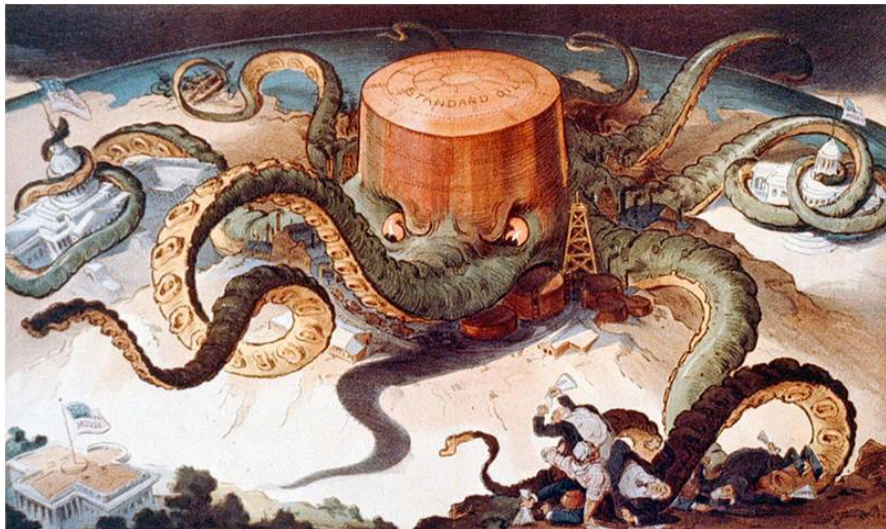
Conjectural variations as a unifying framework

Benefits to a cartel

Problems in maintaining a cartel

Factors facilitating collusion

A cartoon that help catalyze the antitrust act



Legal restrictions on cartel formation

Once upon a time, cartel agreements were legally enforceable

- ① In the US prior to the Sherman Act
- ② In Continental Europe prior to the EU reforms
- ③ Hardly illegal in many developing countries (like Perú)
- ④ Britain all the way back to 18th century made illegal

Luckily the United States now leads the world on enforcement

- ① Explicit agreement about prices/service illegal
 - Only competitors; complements are different as we'll see
- ② Even without communication ("tacit") can be prosecuted
 - In practice much less because hard to prove
- ③ Criminal (jail time) and civil penalties
 - Usually "treble damages": probability of detection $\approx \frac{1}{3}$

⇒ Many practical challenges in running a cartel today

⇒ Collusion difficult, only possible in limited settings

Incentives to defect from a cartel

The basic problem is that cartel benefits all but...

- Each firm has incentive to betray; why?
 - This is what it means to be an (pecuniary) *externality*
 - By reducing price/increasing quantity each benefits
 - Can steal business, from others, benefit from higher prices

⇒ The more ambitious cartel is, the less stable?

- Higher is the price, more incentive to steal the sales
- Near competitive level, little or no incentive to cheat

⇒ Extent of collusion is ability to deter cheating

- Every cartel needs to create expectations of punishment

⇒ Policy related to cartels all about this interplay

- 1 Goal of cartel is to ensure credible punishment of cheaters
- 2 Goal of agency, customers is to catch and prevent

- Stigler bases oligopoly theory on this back-and-forth

Detection, punishment and cartel enforcement

In order for the cartel to deter cheating it must?

- 1 Be able to determine what the optimal agreement is
 - Diffuse information, as in other externality problems
 - Hindered further here by government breathing down neck
- 2 Have clear what does and does not constitute cheating
 - Firms should be given some flexibility (private information)
 - But if too much flexibility then cartel does not function
- 3 Be able to detect cheating, distinguish from background
 - Many things might look like cheating but be innocent
- 4 Have cost-effective means of punishment
 - If you could tax and redistribute ideal
 - Shifting market share across firms works well
 - Price wars harm everyone so less effective
- 5 Be able to do this quickly (patience and frequency)

Stigler's factors facilitating/detering collusion

Stigler's theory is based on these necessities; factors?

- He emphasizes factors facilitating/hindering these
 - 1 Large, heterogeneous buyers hurt, small homo help
 - Hard to track, easy to extract undermining concession
 - 2 Heterogeneity of product/firms hurts
 - Harder to define optimum, more incentive for one defect
 - 3 Price transparency helps track defections
 - Ability to offer secret price cuts key
 - Case against collecting industry, offering info to consumers
 - 4 Industry concentration helps reduce tracking, temptation
 - 5 Variability of demand hurts monitoring
 - 6 Frequency of interaction helps detect soon
 - 7 Growing demand helps, declining hurts
 - If declining, grab what you can while you can

Summarizing collusion through conjectures

All of these determine the extent of deterrence

- Most deterrence happens through price cuts/wars
- So simple way to summarize is firms' *conjectures*
 - If I lower price, how much will rival lower (or raise?) hers?
 - Also works with quantity...how do they respond?
- This varies depending on Stigler's factors
 - ⇒ Models incorporating called *Conjectural Variations* (CV)
- Usually capture by "parameter" of conjectured adjustment
 - Note this idea is useful to change price v. quantity models
 - Cournot is price model with conjectured "accommodation"
 - Price is quantity with conjectured "aggression"
- ⇒ Thus CV is broad framework incorporating all theories
 - Good because it can be used to talk about all them
 - But to be useful requires more structure

Cournot pricing with conjectural variations

Let's consider simplest Cournot model

- Again profits $[P(Q_{-i} + q_i) - c] q_i$
- But now extra term, as other quantities not fixed: $\frac{dQ_{-i}}{dq_i}$
- Optimal pricing given by?

$$P + P' q_i \left(1 + \frac{dQ_{-i}}{dq_i} \right) = c$$

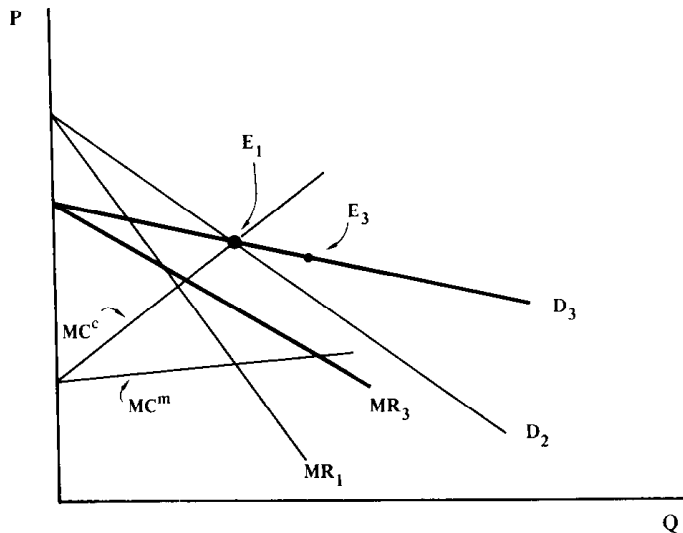
- If $\frac{dQ_{-i}}{dq_i} > 0$ then *MR* further below *P*
 - Therefore called a “conjectured accommodating reaction”
 - If you are nice and reduce quantity, others follow you
 - This is how collusion is facilitated
- On the other hand, if aggressive, $\frac{dQ_{-i}}{dq_i} < 0$, lower prices
 - This case was on your exam; if $\frac{dQ_{-i}}{dq_i} = -1$ then Bertrand
- Also starting from Bertrand, DPNiP

Estimating conjectures

Natural question is *how much* Stigler's factors impact

- Factors are all qualitative; CV parameter quantitative
- Natural question is how much these change
 - Determines impact on *amount* of collusion
- Natural approach: regress CV parameter on factors
 - Astonishingly, I don't think anyone has ever done this!
- To do this, though, we need to measure the CV parameter
- This is difficult, but two approaches have been taken
 - 1 Measure c , P' and solve for CV parameter
 - Works pretty well, but sometimes cost data difficult
 - "New empirical IO" (NEIO) tries to avoid using cost data...
 - 2 Measure by comparing different types of demand shifts
 - If demand curve rotates, affects price \propto *market power*
 - Thus size of impact measures CV parameter

Twisters v. shifters (Bresnahan 1981)



Strategic effects: why conjectures are so natural

Conjectures are very natural not just to summarize collusion...

- When others' quantity increases, \tilde{q} for me
 - I allow total to market to rise by ρ_q
 - This requires me to reduce (increase) by $1 - \rho_q = 1 - \rho$

⇒ Quantity *strategic substitute (complement)* if $\rho < (>)1$
- When others' change price, shifts my demand
 - I move price by $\rho_d = 1 - \rho$

⇒ Price is strategic complement (substitute) if $\rho < (>)1$
- Firms may, to some extent, anticipate this impact
 - Their prices/quantities may be fixed for some time
 - Others may react so even if not fixed
 - Almost every company, even non-collusive, asks this

⇒ Firms may have conjectures for many reasons

 - All of these impact degree of "performance"/prices

Leadership, Stackelberg and strategic effects

A simple example of this is “Stackelberg model”

- Simplest version is two firms in duopoly
- Firm 1 chooses quantity q_1 , then firm 2 chooses
- Firm 2's profit is $q_2 [P(q_1 + q_2) - c] = [Q - q_1] [P(Q) - c]$
 $\implies q_1$ is the same as \tilde{q} so $\frac{dQ}{dq_1} = \rho$
- Firm 1's profit is $q_1 [P(Q(q_1)) - c]$; optimal quantity?
 - $P + P' q_1 \rho = c$
- We can then analyze how this affects things:
 - ① Does the leader benefit from leadership?
 - Obviously: could always choose same quantity as before
 - ② Does follower benefit from the leader?
 - Only if $\rho > 1$ as in this case raise mark-up
 - ③ Better to be follower? $\iff \rho > 1$
 - ④ Consumers/society benefit from leadership? $\iff \rho < 1$

A hypothesis for measuring conjectures

This suggests another natural way to measure conjectures

- Presumably, firm forms conjectures based on experience
- In past, when $c \uparrow \implies p \uparrow$, what happened?
 - Did my rival's price rise or fall? By how much?
- This seems a reasonable way to determine conjecture
 - This is called *consistent conjecture* hypothesis
 - Due to work by Bresnahan (1981) and others
- If you think about it, other models a bit strange
 - In Cournot, if I change quantity, so does rival...
 - But I don't take this into account!?
- Also very convenient from empirical perspective
 - \implies If we observe shocks, we can measure conjecture
 - Similar: shock to firm cost shows relevant demand
 - For positive purposes, shocks to firm don't move demand

Consistent conjectures: estimating residual demand

This lets us isolate the part of the market we want to consider

- 1 Residual demand facing a single firm
 - Measured by Baker and Bresnahan (1988)
 - Use firm-specific cost shocks (changes in factor prices)
 - Apply to brewing industry; breweries in different locations
 - Changes in transport costs, simple, easy methodology
- 2 Merger between two rival firms
 - Next class we'll talk more about mergers
 - But key here is the effect of two firms merging
 - Useful to separate from rest of the industry...
 - Under consistent conjectures, you can do exactly this!
- 3 Could be applied more broadly (quality, antitrust)
 - This approach, for historical reasons, largely go lost
 - Great opportunity for a senior thesis!