Objectives for today

• Discuss course outline
• Introduction to industrial organization
• Definition of market, market power, and strategy
Course Outline

• Course objectives: cover important concepts and models of IO and learn how to apply these tools
• Learning approach: mix of formal lectures (2/3) and applications (1/3)
• Material: book, slides, weekly emails, research articles
• Pre-requisites: Calculus (optimization) and some notions of probability
• Expectations: read book chapters, review formal derivations, follow instructions in weekly emails
• Grading: pb sets (40%), midterm (30%), essay (30%)
Practitioners’ issues and debates

• Competition policy (should government interfere with firm management and market conduct?)
• Firm strategies (How to sustain competitive advantage and earn positive economic profits?)

Academia

• Theory of firm behavior and market conduct (set of abstractions, frameworks, and formal models)
• Focus on specific mechanisms that capture important and general principles

Theory Meets Practice

• Empirical research on specific markets
• Policy recommendations (to government agency or firm manager)
Course Contents

• Part I. Getting started
  • Chapter 1. What is “Markets and Strategies”?
  • Chapter 2. Firms, consumers and the market

• Part II. Market power
  • Chapter 3. Static imperfect competition
  • Chapter 4. Dynamic aspects of imperfect competition

• Part IV. Pricing and market segmentation
  • Chapter 8. Group and personalized pricing
  • Chapter 9. Menu pricing
  • Chapter 11. Bundling and tying

• Part VI. Theory of competition policy
  • Chapter 14. Cartels and collusion
  • Chapter 15. Horizontal mergers
  • Chapter 16. Strategic incumbents

• Part VII. R&D and intellectual property
  • Chapter 18. Innovation and R&D
  • Chapter 19. Intellectual property

Review of standard tools but applied to issues that interest us (IO)
Part I. Getting started

Chapter 1. What is “Markets and Strategies”? 
Introduction to Part I

Markets

- Play a central role in the allocation of goods
- Affect production decisions

Goal of “Markets and Strategies”

- *Present the role of imperfectly competitive markets for private and social decisions*

Issues related to markets and strategies

- Extremely large array!
  - Firms take thousands of strategic decisions
  - .... reacting to particular market conditions
  - .... and affecting the well-being of market participants.
Introduction to Part I

Google, Apple: Two Mobile Software Visions
Smartphone apps should be browsed, not downloaded, a Google exec says. Apple and others beg to differ

Kirin-Suntory merger to spur consolidation
By Michiko Nakamoto
Published: July 14 2009 17:40 | Last updated: July 14 2009 17:40

Kirin confirmed on Tuesday it was in early merger talks with Suntory, its local rival, in a move that is likely to trigger further consolidation in Japan’s food and drinks sector.

Barnes & Noble Plans an Extensive E-Bookstore
E-book pricing has become one of the most delicate topics in book circles. Publishers are concerned that by selling new books at such low prices, e-book retailers will undercut sales of hardcover editions, which average about $26, and eventually erode publisher margins.

“The pricing policies won’t remain static,” Mr. Lynch said in an interview. “We’re working with our publishers on various pricing models. As the pricing model evolves over time, we will adjust.”

Big pharma 'delaying' cheaper drugs
European commissioner unveils inquiry results and attacks industry for impeding generic drugs' entry to market

Horizontal merger
Product differentiation
Pricing strategies
Entry deterrence
Organization of Part I

• Chapter 1
  • Roadmap
  • Markets & strategies

• Chapter 2
  • Players in markets: firms & consumers
  • Profit maximization, utility maximization
  • Market interaction
Markets

• Allow buyers and sellers to exchange goods and services in return for a monetary payment.
• Myriad of different varieties
• **Our main focus**
  • A *small number of sellers* set price, quantity and other variables *strategically*.
  • A *large number of buyers* react *non-strategically* to supply conditions.
    • Usually, buyers = final consumers (B2C)
    • In some instances, buyers = other firms (B2B)
Market power

• How do markets operate?
  • *Perfectly competitive paradigm*: both sides of the market are price-takers
    • OK for industries with small entry barriers and large number of small firms.
  • Our focus: *markets in which firms have market power*
    • An incremental price increase does not lead to a loss of all of the demand.
    • Applies to large firms, but also to small ones.

• Market power and its sources are at the core of this course.
Number of firms in an industry

• **Natural oligopoly**
  - Supply and demand conditions are such that only a limited number of firms can enjoy positive profits.
  - Positive profits are not competed away.

• **Government-sponsored oligopolies**
  - Goal of competition policy: avoid monopolization
  - But, governments sometimes restrict entry. Why?
    - Avoid socially wasteful duplication of certain investments
      - Regulated monopolies
      - Spectrum auctions for mobile telephony
    - Patent protection to foster innovation (see Part VII)
    - Creation of national champions
Case. Alcoa’s natural monopoly

- 1886: process of smelting aluminium is patented
- A small number of firms use the patent and start to dominate the industry.
- Most successful: Alcoa (Aluminum Company of America)
- How?

  - *Large economies of scale* → Alcoa develops markets for its growing output (intermediate and final aluminium products)
  - *Production intensive in energy* → in 1893, Alcoa signs in advance for hydroelectric power produced at Niagara Falls
  - *Production intensive in bauxite* → Alcoa stakes out all the best sources of North American bauxite for itself.
  - *Efficiency gains* → Entry more difficult, even after expiration of patents
  - *Other factors* → Public policy, tariff protection, limited antitrust check before 1914.
Chapter 1 - Strategies

Strategies

• Decision theory vs. Game theory
  • Decision theory → isolated choices → monopoly
  • Game theory → strategic interaction → oligopoly

• Nash equilibrium
  • Prediction of market outcome when firms interact strategically

• Main concepts used in this course
  • Best-response function
  • Pure-, mixed-strategy Nash equilibrium
  • Subgame perfect Nash equilibrium
  • Bayesian Nash equilibrium
  • Perfect Bayesian Nash equilibrium
Review questions

• Relevance of industrial organization to practitioners
• Markets of interest to IO economists
• Definition of market power
• Relation between profits, market power, and strategy
Part I. Getting started

Chapter 2. Firms, consumers and the market
Chapter 2. **Learning objectives**

• Prepare for the rest of the course
  • By getting acquainted with useful concepts
  • By clarifying main assumptions underlying analytical frameworks

• Know better firms and consumers
  • How are they represented?
  • How are they assumed to behave?
  • How do we measure their well-being?

• Delineate the scope of market interaction
  • 2 extremes: perfect competition and monopoly
  • How to define a market?
  • How to measure its performance?
Firms

• Firm seen as a program of profit maximization
  • Profit = Revenues - Costs
    • Revenues → depend on consumers preferences and on type of market interaction
    • Costs → depend on firm’s technology
  • Puts relationships within the firm into a “black box”

• What we do:
  • Examine costs, discuss profit maximization
  • Open the “back box”: principal/agent
  • Determinants of firm’s boundaries: make or buy?
Costs

- Economic costs refer to opportunity costs
- Cost function: $C(q)$
  - Minimal cost to produce output $q$ given the input prices and the production technology
- Economies of scale: average costs are decreasing
  - Favour a concentrated industry (see Chapter 1)
- Diseconomies of scale: average costs are increasing
- Marginal cost: $C'(q)$
  - We will often take it as constant.
  - Fixed cost + constant marginal cost $\rightarrow$ economies of scale
- Economies of scope: average costs of a particular product decrease if product range is increased
Costs (cont’d)

• Fixed costs
  • Independent of current output levels
  • Affect profit level but not decisions such as pricing

• Sunk costs
  • Part of the fixed costs which cannot be recovered
  • Often exogenous to the firm but may be determined by decisions of firms already active in the market
  • Important to explain the formation of imperfectly competitive markets
    • See Chapter 4
    • Can be abstracted away in short-run analyses
The profit-maximization hypothesis

- **Profit** of single-product firm: \( \pi(q) = qP(q) - C(q) \)
  - \( P(q) \): inverse demand of the firm
  - \( C(q) \): firm’s economic costs
  - Focuses on firm’s own quantity and ignores other variables (e.g., advertising, R&D efforts)
  - In market context, also affected by other firms’ choices
- **Firms are assumed to be profit maximizers**
  - Natural objective of owners of the firm
  - Yet, most large companies are not owner-managed...
    - We need to ‘open the black box’
Inside the black-box of a firm

• Owners vs. manager
  • Managers may have different objectives than profit-maximization.
  • How to align objectives?
  • See ‘principal/agent model’ in companion slides

• **Lesson**: In a principal-agent relationship between owner and manager with hidden effort,
  • manager bears the full risk ⇔ he/she is risk neutral;
  • otherwise, owner bears part of the risk & incentives are not perfectly aligned.
Boundaries of the firm

• **Compare costs of internal and external provision**
  - OK if easy to allocate opportunity costs to internal provision and if markets exist with established prices
  - But, external provision may result from bilateral trade
    - Additional concern: incompleteness of contracts

• Most firms are **multi-product**. Why?
  - Economies of scope
  - Price and non-price strategies
  - Use of essential facility

• **Limits** to the scope of the firm
  - Limited managerial span
  - Organizational costs accelerate with organization size
Consumers as decision makers

• Consumers are assumed to be rational
  • They choose what they like best.
    • Yet, they may make errors (as long as errors are non-systematic, we can deal with them; see Chapter 5).
  • They are forward-looking.
    • They form expectations about the future.
  • Under uncertainty, they maximize expected utility.
    • Assumption: they have the same prior beliefs.
• Consumers may act as strategic players.
  • E.g.: adoption of network goods (see Chapter 20)
Utility and demand

• Consumer’s decision problem of under certainty
  • Choose
    • quantities $q = (q_1, q_2, \ldots, q_n)$
    • and quantity $q_0$ of the Hicksian composite commodity
  • to maximize utility $u(q_0, q)$
  • subject to budget constraint $p \cdot q + q_0 \delta y$
  • Equivalent to $\max_q u(q) + y - p \cdot q$
  • Solution to F.O.C. $\rightarrow$ individual demand functions

• From individual to aggregate demand
  • Either any consumer is representative of all others
  • Or account for taste differences among consumers
Welfare analysis of market outcomes

- Partial equilibrium approach
  - Focus on one market at a time
  - Abstract away cross-market effects
- Welfare measures
  - Firms: sum of firms’ profits
  - Consumers: consumer surplus
    - Net benefit from being able to purchase a good or service
    - Difference between willingness to pay and price actually paid
- Potential problems
  - Income effects
  - Extension to several consumers
  - Extension to several goods
Consumer surplus

\[ CS(\bar{q}) = \frac{1}{2} b \bar{q}^2 \]
Perfectly competitive paradigm

- Firms take the market price as given.
- Market price results from combined action of all firms and all consumers.
- Firms face a horizontal demand curve
  - Marginal revenue = price (1)
- Profit maximization
  - marginal revenue = marginal cost (2)
  - (1) & (2)  → price = marginal cost

**Lesson**: A perfectly competitive firm produces at marginal cost equal to the market price.
Strategies in a constant environment ("monopoly")

- Monopoly pricing formula
  - Monopoly’s problem: $\max_q \pi(q) = qP(q) - C(q)$
  - FOC gives: $P(q) - C'(q) = -qP'(q)$ (1)
  - Inverse elasticity price of demand: $1/\eta = -qP'(q)/P(q)$
  - Divide both sides of (1) by $P(q)$ yields

\[
\frac{P(q) - C'(q)}{P(q)} = \frac{1}{\eta}
\]

- **Lesson**: A profit-maximizing monopolist increases its markup as demand becomes less price elastic.
Chapter 2  Market interaction

Strategies in a constant environment (cont’d)

• **Monopoly pricing: two goods**

\[
\max_{p_1,p_2} p_1 Q_1(p_1, p_2) + p_2 Q_2(p_1, p_2) - C(Q_1(p_1, p_2), Q_2(p_1, p_2))
\]

• Linked demands, unlinked costs
  • Products are substitutes / complements
• Linked costs, unlinked demands
  • Economies / diseconomies of scope

• **Lesson**: A multi-product monopolist sets lower (higher) prices than separate monopolists when the products are complements (substitutes) or when there are (dis-) economies of scope.
Dominant firm model

- Large firm + ‘competitive fringe’
  - Example: Market for generics (pharmaceuticals)
  - See particular model in the book

Imperfect competition

- So far, decisions could be made in isolation
  - Because negligible firms (perfect competition)
  - Because single or dominant firm (“monopoloy”)
- Outside these extremes
  - Restricted number of firms on the market
  - Market outcomes depend on the combination of all firms’ decisions.
  - Decisions must incorporate this reality → game theory
How to define a market?

• A market is the set of suppliers and demanders whose trading establishes the price of a good (G. Stigler)

A market is a product and its substitutes

- Cross-elasticity of demand: $(\% \Delta Q_y)/(\% \Delta P_x)$
- Product characteristics

A market is constrained by geography

- Where do consumers buy?
- The law of one price and trade flows
"A relevant product market comprises all those products and/or services which are regarded as interchangeable or substitutable by the consumer, by reason of the products' characteristics, their prices and their intended use."

"The relevant geographic market comprises the area in which the undertakings concerned are involved in the supply and demand of products or services, in which the conditions of competition are sufficiently homogeneous and which can be distinguished from neighbouring areas because the conditions of competition are appreciably different in those areas".
SSNIP Test

• Identify the closest substitutes to the product under review.
• How? Hypothetical monopoly test
  - Relevant market = smallest product group such that a hypothetical monopolist controlling that product group could profitably sustain a Small and Significant Non-transitory Increase in Prices (SSNIP)

Start with narrowest definition (A)

*Can a hypothetical monopoly on A sustain a SSNIP?*
  - **Yes?** STOP THERE: A is relevant market
  - **NO?** INCLUDE CLOSE SUBSTITUTES → B

*Can a hypothetical monopoly on B sustain a SSNIP?*
  - **Yes?** STOP THERE: B is relevant market
  - **NO?** INCLUDE MORE SUBSTITUTES → C, etc.
How to assess market power?

• Market power = ability to raise price above the perfectly competitive level
  \[ \frac{p - C'}{p} \]

• Measure 1: Lerner index →
  • Markup: difference between price and marginal costs as a percentage of the price
  • How to measure it empirically? See Chapter 3

• Measure 2: Concentration indices
  • Define firm i’s market as \( \alpha_i = \frac{q_i}{Q} \)
  • Order \( n \) firms by decreasing market share
  • \( m \)-firm concentration ratio:
  \[ I_m = \sum_{i=1}^{m} \alpha_i \]
  • Herfindahl index:
  \[ I_H = \sum_{i=1}^{n} \alpha_i^2 \]
Review questions

• Under which assumptions is the consumer surplus a reasonable measure of the consumer welfare in a particular market?

• Derive the following (a) prices in perfectly competitive markets (price equals marginal cost-Lemma 2.2), (b) the monopoly-pricing formula with one good (inverse elasticity rule-Lemma 2.3) and with two goods (Lemma 2.4)

• Describe the hypothetical monopoly test (or SSNIP test) that is used to define a market.

• Give the definition of the Lerner index and Herfindahl indices. What are these measures used for?
Part II. Market power

Chapter 3. Static imperfect competition
Oligopolies

• Industries in which a few firms compete
• Market power is collectively shared.
• Firms can’t ignore their competitors’ behaviour.
• **Strategic interaction** → Game theory

Oligopoly theories

• *Cournot* (1838) → quantity competition
• *Bertrand* (1883) → price competition
• Not competing but **complementary theories**
  • Relevant for different industries or circumstances
Organization of Part II

• **Chapter 3**
  - Simple settings: unique decision at single point in time
  - How does the nature of strategic variable (price or quantity) affect
    - strategic interaction?
    - extent of market power?

• **Chapter 4**
  - Incorporates time dimension: sequential decisions
  - Effects on strategic interaction?
  - What happens before and after strategic interaction takes place?
Case. DVD-by-mail industry

• **Facts**
  - < 2004: Netflix almost only active firm
  - 2004: entry by Wal-Mart and Blockbuster (and later Amazon), not correctly foreseen by Netflix

• **Sequential decisions**
  - Leader: Netflix
  - Followers: Wal-Mart, Blockbuster, Amazon

• **Price competition**
  - Wal-Mart and Blockbuster undercut Netflix
  - Netflix reacts by reducing its prices too.

• **Quantity competition?**
  - Need to store more copies of latest movies
Chapter 3. **Learning objectives**

- Get (re)acquainted with basic models of oligopoly theory
  - Price competition: Bertrand model
  - Quantity competition: Cournot model
- Be able to compare the two models
  - Quantity competition may be mimicked by a two-stage model (capacity-then-price competition)
  - Unified model to analyze price & quantity competition
- Understand the notions of strategic complements and strategic substitutes
- See how to measure market power empirically
The standard Bertrand model

• 2 firms
  • Homogeneous products
  • Identical constant marginal cost: $c$
  • Set price simultaneously to maximize profits

• Consumers
  • Firm with lower price attracts all demand, $Q(p)$
  • At equal prices, market splits at $\alpha_1$ and $\alpha_2 = 1 - \alpha_1$

• → Firm $i$ faces demand

$$Q_i(p_i) = \begin{cases} Q(p_i) & \text{if } p_i < p_j \\ \alpha_i Q(p_i) & \text{if } p_i = p_j \\ 0 & \text{if } p_i > p_j \end{cases}$$
The standard Bertrand model (cont’d)

• Unique Nash equilibrium
  • Both firms set price = marginal cost: \( p_1 = p_2 = c \)
  • Proof
    • For any other \((p_1, p_2)\), a profitable deviation exists.
    • Or: unique intersection of firms’ best-response functions
The standard Bertrand model (cont’d)

• ‘Bertrand Paradox’
  • Only 2 firms but perfectly competitive outcome
  • Message: there exist circumstances under which duopoly competitive pressure can be very strong

• Lesson: In a homogeneous product Bertrand duopoly with identical and constant marginal costs, the equilibrium is such that
  • firms set price equal to marginal costs;
  • firms do not enjoy any market power.

• Cost asymmetries
  • $n$ firms, $c_i < c_{i+1}$
  • Equilibrium: any price $p \in [c_1, c_2]$
Bertrand competition with uncertain costs

• Each firm has private information about its costs
  • Trade-off between margins and likelihood of winning the competition

• **Lesson**: In the price competition model with homogeneous products and private information about marginal costs, at equilibrium,
  • firms set price above marginal costs;
  • firms make strictly positive expected profits;
  • more firms $\rightarrow$ price-cost margins↓, output↑, profits↓;
  • Infinite number of firms $\rightarrow$ competitive limit.
Price competition with differentiated products

- Firms may avoid intense competition by offering products that are imperfect substitutes.
- **Hotelling model** (1929)

![Diagram](attachment:diagram.png)

Mass 1 of consumers, uniformly distributed
Hotelling model (cont’d)

• Suppose location at the extreme points

\[ \hat{x} = \frac{1}{2} + \frac{p_2 - p_1}{2\tau} \]

Indifferent consumer
Hotelling model (cont’d)

• Resolution
  • Firm’s problem: \[
  \max_{p_i} \left( p_i - c \right) \left( \frac{1}{2} + \frac{p_j - p_i}{2 \tau} \right)
  \]
  • From FOC, best-response function: \[p_i = \frac{1}{2} (p_j + c + \tau)\]
  • Equilibrium prices: \[p_i = p_j = c + \tau\]

• Lesson: If products are more differentiated, firms enjoy more market power.

• Extensions
  • Localized competition with \(n\) firms: Salop (circle) model
  • Asymmetric competition with differentiated products
The linear Cournot model

• Model
  • Homogeneous product market with $n$ firms
  • Firm $i$ sets quantity $q_i$
  • Total output: $q = q_1 + q_2 + \ldots + q_n$
  • Market price given by $P(q) = a - bq$
  • Linear cost functions: $C_i(q_i) = c_i q_i$
  • Notation: $q_{-i} = q - q_i$

• Residual demand

\[
P(q_i, q_{-i}) = (a - bq_{-i}) - bq_i \\
\equiv d_i(q_{-i})
\]
The linear Cournot model (cont’d)

- Firm’s problem
  - **Cournot conjecture**: rivals don’t modify their quantity
  - Firm $i$ acts as a monopolist on its residual demand:
  - FOC: $a - c_i - 2bq_i - bq_{-i} = 0$
  - Best-response function: $q_i(q_{-i}) = \frac{1}{2b}(a - c_i - bq_{-i})$

- Nash equilibrium in the duopoly case
  - Assume: $c_1 \leq c_2$ and $c_2 \leq (a + c_1) / 2$
  - Then, $q_1^* = \frac{1}{3b}(a - 2c_1 + c_2)$ and $q_2^* = \frac{1}{3b}(a - 2c_2 + c_1)$

$q_1^* \geq q_2^* \Rightarrow \pi_1^* \geq \pi_2^*$
The linear Cournot model (cont’d)

• Duopoly

**Lesson**: In the linear Cournot model with homogeneous products, a firm’s equilibrium profits increases when the firm becomes relatively more efficient than its rivals.
Symmetric Cournot oligopoly

- Assume \( c_i = c \) for all \( i = 1 \ldots n \)
- Then

\[
q^*(n) = \frac{a - c}{b(n + 1)} \rightarrow L(n) = \frac{p^*(n) - c}{p^*(n)} = \frac{a - c}{a + nc}
\]

- If \( n \uparrow \rightarrow \) individual quantity \( \downarrow \), total quantity \( \uparrow \), market price \( \downarrow \), markup \( \downarrow \)
- If \( n \rightarrow \infty \), then markup \( \rightarrow 0 \)

**Lesson**: The (symmetric linear) Cournot model converges to perfect competition as the number of firms increases.
Implications of Cournot competition

• General demand and cost functions

• Cournot pricing formula

\[
\frac{P(q) - C'_i(q_i)}{P(q)} = \frac{\alpha_i}{\eta} \quad \text{with} \quad \alpha_i = q_i / q
\]

• Lesson: In the Cournot model, the markup of firm \( i \) is larger the larger is the market share of firm \( i \) and the less elastic is market demand.

• If constant marginal costs

\[
\frac{p - \sum_{i=1}^{n} \alpha_i c_i}{p} = \frac{I_H}{\eta} \quad \text{with} \quad I_H = \sum_{i=1}^{n} \alpha_i^2, \text{ Herfindahl index}
\]

Average Lerner index
Price versus quantity competition

• Comparison of previous results
  • Let $Q(p) = a - p$, $c_1 = c_2 = c$
  • Bertrand: $p_1 = p_2 = c$, $q_1 = q_2 = (a - c)/2$, $\pi_1 = \pi_2 = 0$
  • Cournot: $q_1 = q_2 = (a - c)/3$, $p = (a + 2c)/3$, $\pi_1 = \pi_2 = (a - c)^2/9$

• **Lesson**: Homogeneous product case $\rightarrow$ higher price, lower quantity, higher profits under quantity than under price competition.

• To refine the comparison
  • Limited capacities of production
  • Direct comparison within a unified model
  • Identify characteristics of price or quantity competition
Limited capacity and price competition

- Edgeworth’s critique (1897)
  - Bertrand model: no capacity constraint
  - But capacity may be limited in the short run.

- Examples
  - Retailers order supplies well in advance
  - DVD-by-mail industry
    - Larger demand for latest movies → need to hold extra stock of copies → higher costs and stock may well be insufficient
  - Flights more expensive around Xmas

- To account for this: two-stage model
  1. Firms precommit to capacity of production
  2. Price competition
Capacity-then-price model (Kreps & Scheinkman)

• Setting
  • **Stage 1**: firms set capacities $\bar{q}_i$ and incur cost of capacity, $c$
  • **Stage 2**: firms set prices $p_i$; cost of production is 0 up to capacity (and infinite beyond capacity); demand is $Q(p) = a - p$.

• **Subgame-perfect equilibrium**: firms know that capacity choices may affect equilibrium prices

• Rationing
  • If quantity demanded to firm $i$ exceeds its supply...
  • ... some consumers have to be rationed...
  • ... and possibly buy from more expensive firm $j$.

• **Crucial question**: Who will be served at the low price?
Capacity-then-price model (cont’d)

- Efficient rationing
  - First served: consumers with higher willingness to pay.
  - Justification: queuing system, secondary markets

Consumers with unit demand, ranked by decreasing willingness to pay

There is a positive residual demand for firm 2

Excess demand for firm 1

Consumers with highest willingness to pay are served at firm 1’s low price

Consumers with unit demand, ranked by decreasing willingness to pay
Chapter 3 - Price vs. quantity

Capacity-then-price model (cont’d)

• Equilibrium (sketch)
  • **Stage 2.** If \( p_1 < p_2 \) and excess demand for firm 1, then demand for 2 is:
    \[
    \hat{Q}(p_2) = \begin{cases} 
    Q(p_2) - \overline{q}_1 & \text{if } Q(p_2) - \overline{q}_1 \geq 0 \\
    0 & \text{else}
    \end{cases}
    \]

  Claim: if \( c < a < (4/3)c \), then both firms set the market-clearing price: \( p_1 = p_2 = p^* = a - \overline{q}_1 - \overline{q}_2 \)

  • **Stage 1.** Same reduced profit functions as in Cournot:
    \[
    \overline{\pi}_1(\overline{q}_1, \overline{q}_2) = \left( a - \overline{q}_1 - \overline{q}_2 \right)\overline{q}_1 - c\overline{q}_1
    \]

• **Lesson:** In the capacity-then-price game with efficient consumer rationing (and with linear demand and constant marginal costs), the chosen capacities are equal to those in a standard Cournot market.
Differentiated products: Cournot vs. Bertrand

• Setting
  • Duopoly, differentiated products \((b>d, b>0)\)
  • Consumers maximize linear-quadratic utility function

\[
U(q_0, q_1, q_2) = aq_1 + aq_2 + \frac{bq_1^2 + 2dq_1q_2 + bq_2^2}{2} + q_0
\]

under budget constraint \(y = q_0 + p_1q_1 + p_2q_2\)

• Inverse demand functions

\[
\begin{align*}
P_1(q_1, q_2) &= a - bq_1 - dq_2 \\
P_2(q_1, q_2) &= a - bq_2 - dq_1
\end{align*}
\]

• Demand functions

\[
\begin{align*}
Q_1(p_1, p_2) &= \bar{a} - \bar{b}p_1 + \bar{d}p_2 \\
Q_2(p_1, p_2) &= \bar{a} - \bar{b}p_2 + \bar{d}p_1
\end{align*}
\]

with \(\bar{a} = a / (b + d), \bar{b} = b / (b^2 - d^2), \bar{d} = d / (b^2 - d^2)\)
Differentiated products (cont’d)

• Maximization program
  • Cournot: \( \max_{q_i} (a - bq_i - dq_j - c_i)q_i \)
  • Bertrand: \( \max_{p_i} (p_i - c_i)(\bar{a} - bp_i + dp_j) \)

• Best-response functions
  • Cournot: \( q_i(q_j) = (a - dq_j - c_i) / (2b) \)
    Downward-sloping \( \rightarrow \) Strategic substitutes
  • Bertrand: \( p_i(p_j) = (\bar{a} + dp_j + \bar{b}c_i) / (2\bar{b}) \)
    Upward-sloping \( \rightarrow \) Strategic complements

• Comparison of equilibria

• Lesson: Price as the strategic variable gives rise to a more competitive outcome than quantity as the strategic variable.
Appropriate modelling choice: price or quantity?

- **Monopoly**: it doesn’t matter.
- **Oligopoly**: price and quantity competitions lead to different residual demands
  - **Price competition**
    - $p_j$ fixed $\rightarrow$ rival willing to serve any demand at $p_j$
    - $i$’s residual demand: market demand at $p_i < p_j$; zero at $p_i > p_j$
    - So, residual demand is very sensitive to price changes.
  - **Quantity competition**
    - $q_j$ fixed $\rightarrow$ irrespective of price obtained, rival sells $q_j$
    - $i$’s residual demand: “what’s left” (i.e., market demand $– q_j$)
    - So, residual demand is less sensitive to price changes.
Appropriate modelling choice (cont’d)

• How do firms behave in the market place?
  
  • Stick to a price and sell any quantity at this price?  
    → price competition  
    → appropriate choice when
    • Unlimited capacity  
    • Prices more difficult to adjust in the short run than quantities  
    • Example: mail-order business  
  
  • Stick to a quantity and sell this quantity at any price?  
    → quantity competition  
    → appropriate choice when
    • Limited capacity (even if firms are price-setters)  
    • Quantities more difficult to adjust in the short run than prices  
    • Example: package holiday industry  

• Influence of technology (e.g. Print-on-demand vs. batch printing)
Strategic substitutes and complements

• How does a firm react to the rivals’ actions?
• Look at the slope of reaction functions.
  • **Upward** sloping: competitor ↑ its action → marginal profitability of my own action ↑
    → variables are **strategic complements**
      • Example: price competition (with substitutable products); see Bertrand and Hotelling models
  • **Downward** sloping: competitor ↑ its action → marginal profitability of my own action ↓
    → variables are **strategic substitutes**
      • Example: quantity competition (with substitutable products); see Cournot model
Strategic substitutes and complements (cont’d)

- Linear demand model of product differentiation
  (with \( d \) measuring the degree of product substitutability)
Estimating market power

• Setting
  • Symmetric firms producing homogeneous product
  • Demand equation: \( p = P(q,x) \) \( (1) \)
    • \( q \): total quantity in the market
    • \( x \): vector of exogenous variables affecting demand (not cost)
  • Marginal costs: \( c(q,w) \)
    • \( w \): vector of exogenous variables affecting (variable) costs

• **Approach 1.** Nest various market structures in a single model

\[
MR(\lambda) = p + \lambda \frac{\partial P(q,x)}{\partial q} q
\]

\( \lambda = 0 \) competitive market
\( \lambda = 1 \) monopoly
\( \lambda = 1/n \) \( n \)-firm Cournot

**Firm’s conjecture** as to how strongly price reacts to its change in output
• **Approach 1** (cont’d)
  - Basic model to be estimated non-parametrically: demand equation (1) + equilibrium condition (2)

\[
MR(\lambda) = p + \lambda \frac{\partial P(q,x)}{\partial q} q = c(q,w)
\]

• **Approach 2.** Be agnostic about precise game being played
  - From equilibrium condition (2), Lerner index is

\[
L = \frac{p - c(q,w)}{p} = -\lambda \frac{\partial P(q,x)}{\partial q} \frac{q}{p} = \frac{\lambda}{\eta}
\]

• (2) is identified if single \(c(q,w)\) and single \(\lambda\) satisfy it
Review questions

• How does product differentiation relax price competition? Illustrate with examples.

• How does the number of firms in the industry affect the equilibrium of quantity competition?

• When firms choose first their capacity of production and next, the price of their product, this two-stage competition sometimes looks like (one-stage) Cournot competition. Under which conditions?

• Using a unified model of horizontal product differentiation, one comes to the conclusion that price competition is fiercer than quantity competition. Explain the intuition behind this result.
Review questions (cont’d)

• Define the concepts of strategic complements and strategic substitutes. Illustrate with examples.

• What characteristics of a specific industry will you look for to determine whether this industry is better represented by price competition or by quantity competition? Discuss.
Part II. Market power

Chapter 4. Dynamic aspects of imperfect competition
Chapter 4. Learning objectives

• Understand how competition is affected when decisions are taken sequentially rather than simultaneously.

• Analyze entry decisions into an industry and compare the number of firms that freely enter with the number that a social planner would choose.

• Distinguish endogenous from exogenous sunk cost industries and analyze how market size affects market concentration.
Sequential choice: Stackelberg

- **Chapter 3: ‘simultaneous’ decisions**
  - Firms aren’t able to observe each other’s decision before making their own.

- **Here: sequential decisions**
  - Possibility for some firm(s) to act before competitors, who can thus observe past choices.
    - E.g.: pharma. firm with patent acts before generic producers
  - Better to be leader or follower?
    - Depends on nature of strategic variables & on number of firms moving at different stages.
  - First mover must have some form of commitment.
    - When and how is such commitment available?
One leader / One follower

• **First-mover advantage?**
  • Firm gets higher payoff in game in which it is a leader than in symmetric game in which it is a follower.
  • Otherwise, **second-mover advantage**.

• **Quantity competition: Stackelberg model**
  • Similar to Cournot duopoly
  • But, one firm chooses its quantity before the other.
  • Look for subgame-perfect equilibrium
  • **Setting**
    • \( P(q_1,q_2) = a - q_1 - q_2 \); \( c_1 = c_2 = 0 \)
    • Firm 1 = leader; firm 2 = follower
One leader / One follower (cont’d)

- Solve by backward induction
  - **Follower’s decision**
    - Observes $q_1$, chooses $q_2$ to $\max \pi_2 = (a - q_1 - q_2)q_2$
    - Reaction: $q_2(q_1) = (a - q_1)/2$
  - **Leader’s decision**
    - Anticipates follower’s reaction:
      $\max \pi_1 = (a - q_1 - q_2(q_1))q_1 = (1/2)(a - q_1)q_1$

- Equilibrium

\[
q_1^L = a/2, \quad q_2^F = q_2(q_1^L) = a/4, \quad P(q_1^L, q_2^F) = a/4
\]
\[
\pi_1^L = a^2/8, \quad \pi_2^F = a^2/16
\]
One leader / One follower (cont’d)

• Results
  • Leader makes higher profit than follower. As firms are symmetric → First-mover advantage
  • Comparison with simultaneous Cournot
    • \( q^C = \frac{a}{3} \) & \( \pi^C = \frac{a^2}{9} \)
    • Larger (lower) quantity and profits for leader (follower) w.r.t. Cournot
    • Intuition: leader has stronger incentives to increase quantity when follower observes and reacts to this quantity, than when follower does not.
One leader / One follower (cont’d)

**Lesson**: In a duopoly producing substitutable products with one firm (the leader) choosing its quantity before the other firm (the follower), the subgame perfect equilibrium is such that

- firms enjoy a first-mover advantage;
- the leader is better off and the follower is worse off than at the Nash equilibrium of the Cournot game.
One leader / One follower (cont’d)

- **Price competition**
  - Previous result hinges on strategic substitutability
    - Follower reacts to ↑ in leader’s quantity by ↓ its own quantity → leader finds it profitable to commit to a larger quantity.
  - Reverse applies under strategic complementarity
    - If leader acts aggressively, follower reacts aggressively.
    - Preferable to be the follower and be able to undercut.

- **Lesson:** In a duopoly producing substitutable products under constant unit costs, with one firm choosing its price before the other firm, the subgame-perfect equilibrium is such that at least one firm has a second-mover advantage.
One leader / Endogenous number of followers

- E.g.: market for a drug whose patent expired
  - Leader: patent holder / Followers: generic producers
  - Observation: leader cuts its price, possibly to keep the number of entrants low

- Theoretical prediction
  - Leader always acts more aggressively (i.e., sets larger quantity or lower price) than followers.
  - Intuition: leader is also concerned about the effect of its own choices on the number of firms that enter; nature of strategic variables is less important.
  - Confirms the observations.
Commitment

• Implicit assumption so far:
  • Leader can commit to her choice.

• Schelling’s analysis of conflicts
  • **Threat**: punishment inflicted to a rival if he takes a certain action. **Goal**: prevent this action
  • **Promise**: reward granted to a rival if he takes a certain action. **Goal**: encourage this action
  • But, threats and promises must be credible to be effective → they must be transformed into a commitment: *inflict the punishment or grant the reward must be in the best interest of the agent who made the threat or the promise.*
  
• **How?** Make the action irreversible.
Commitment (cont’d)

• **Paradox of commitment**
  • It is by limiting my own options that I can manage to influence the rival’s course of actions in my interest.

• **Case**: When Spanish Conquistador Hernando Cortez landed in Mexico in 1519, one of his first orders to his men was to burn the ships. Cortez was committed to his mission and did not want to allow himself or his men the option of going back to Spain.

• How to achieve irreversibility?
  • Quantities: install production capacity (+ sunk costs)
  • Prices: ‘most-favoured customer clause’, print catalogues
Free entry: endogenous number of firms

- So far, limited number of firms
  - Implicit assumption: entry prohibitively costly
- Here, opposite view
  - No entry and exit barriers other than entry costs.
  - Firms enter as long as profits can be reaped.
- Two-stage game
  1. Decision to enter the industry or not
  2. Price or quantity competition
- 3 models
  - Free entry in Cournot model
  - Free entry in Salop model
  - Monopolistic competition
Properties of free entry equilibria

• Setting
  • Industry with symmetric firms; entry cost $e > 0$
  • If $n$ active firms, profit is $\pi(n)$, with $\pi(n) > \pi(n+1)$
  • Number of firms under free entry, $n^e$ such that $\pi(n^e) - e > 0$ and $\pi(n^e+1) - e < 0$
  • $e \uparrow \rightarrow n^e \downarrow$

Case. Entry in small cities in the U.S.

• Bresnahan & Reiss (1990, 1991) estimate an entry model
  • Data from rural retail and professional markets in small U.S. cities.

• Results
  • Firms enter if profit margins are sufficient to cover fixed costs of operating.
  • Profit margins $\downarrow$ with additional entry.
Cournot model with free entry

- **Linear model** (more general approach in the book)
  - \( P(q) = a - bq, \ C_i(q) = cq, \ c < a \)
  - Equilibrium: \( q(n) = (a-c)/[b(n+1)] \)
  - "Business-stealing effect": \( q(n+1) < q(n) \)

- Free-entry equilibrium

\[
\pi(n^e) = \frac{1}{b} \left( \frac{a - c}{n^e + 1} \right)^2 - e = 0 \iff \left( n^e + 1 \right)^2 = \frac{(a - c)^2}{be}
\]

- Social optimum (second best)

\[
W(n) = n\pi(n) + SC(n) = \frac{n(n+2)}{2b} \left( \frac{a - c}{n+1} \right)^2 - ne
\]

\[
W'(n^*) = 0 \iff \left( n^* + 1 \right)^3 = \frac{(a - c)^2}{be}
\]
Lesson: Because of the business-stealing effect, the symmetric Cournot model with free entry exhibits socially excessive entry.
Price competition with free entry

• **Salop (circle) model** of Chapter 3
  - Firms enter and locate equidistantly on circle with circumference 1
  - Consumers uniformly distributed on circle
  - They buy at most one unit, from firm with lowest ‘generalized price’ (unit transportation cost, $\tau$)
  - If $n$ firms enter, equilibrium price: $p(n) = c + \tau / n$

• Free-entry equilibrium

\[
\pi(n^e) = 0 \iff (p - c) \frac{1}{n^e} - e = 0 \iff \frac{\tau}{(n^e)^2} = e \iff n^e = \sqrt{\frac{\tau}{e}}
\]
Price competition with free entry (cont’d)

- Social optimum (second best)
  - Planner selects $n^*$ to minimize total costs

\[
\min_n TC(n) = ne + \tau \left(2n \int_0^{1/(2n)} s \, ds\right) = ne + \frac{\tau}{4n}
\]

\[
TC'(n^*) = 0 \iff e - \frac{\tau}{4(n^*)^2} = 0 \iff n^* = \frac{1}{2} \sqrt{\frac{\tau}{e}} = \frac{1}{2} n^e
\]

- **Lesson**: In the Salop circle model, the market generates socially excessive entry.
  - Intuition: dominance of business-stealing effect
  - **Case**: Socially excessive entry of radio stations in the U.S.
Monopolistic competition

• 4 features
  • Large number of firms producing different varieties
  • Each firm is negligible
  • No entry or exit barriers → economic profits = 0
  • Each firm enjoys market power

• S-D-S model (Spence, 1976; Dixit & Stiglitz, 1977)
  • Rather technical → see the book

• **Lesson:** In models of monopolistic competition, the market may generate excessive or insufficient entry, depending on how much an entrant can appropriate of the surplus generated by the introduction of an additional differentiated variety.
Industry concentration and firm turnover

• So far, **exogenous** sunk costs
  • \( e = \) sunk cost, exogenous (i.e., not affected by decisions in the model); if \( e \uparrow \rightarrow n^e \downarrow \)
  • If market size \( \uparrow \rightarrow n^e \uparrow \) & industry concentration \( \downarrow \)

• **Lesson**: In industries with exogenous sunk costs, industry concentration decreases and approaches zero as market size increases.

• Not verified empirically in all industries
  • \( \exists \) industries with large increase of market demand over time **and** persistently high concentration
  • To reconcile theory with facts: **endogenous** sunk costs
Industry concentration and firm turnover (cont’d)

- **A model with endogenous sunk costs**
  - Quality-augmented Cournot model
  - 3-stage game (see companion slides to Chapter 4)
    1. Firms decide to enter
    2. Firms decide which quality to develop
    3. Firms decide which quantity to produce
  - Endogenous sunk costs arise from strategic investments that increase the price-cost margin
    - Improvements in quality, advertising, process innovations
    - **Intuition:** Market size $\uparrow \rightarrow$ market more valuable $\rightarrow$ active firms invest more $\rightarrow$ some of extra profits are competed away $\rightarrow$ upper bound on entry (lower bound on concentration)
Chapter 4 - Sunk costs

Industry concentration and firm turnover (cont’d)

- **Lesson:** In markets with endogenous sunk costs, even as the size of the market grows without bounds, there is a strictly positive upper bound on the equilibrium number of firms.

**Case. Supermarkets in the U.S.**

  - Identifies 51 distribution markets
  - All are highly concentrated (dominated by 4 to 6 chains), *independently of the size of the particular distribution market*.

- Due to endogenous sunk costs?
  - Quality dimension: available number of products
  - Can be increased by more shelf space and/or improved logistics
  - Average number or products has indeed increased
  - Investments are incurred within each distribution market.
Quality-augmented Cournot model

- Effect of endogenous sunk costs on entry?
- 3-stage game
  - Firms decide to enter
  - Firms decide which quality to develop ($s_i$)
  - Firms decide which quantity to produce ($q_i$)
- Consumers
  - Measure $M$, with Cobb-Douglas utility function
    \[ u(q_0, q) = q_0^{1-\gamma} (sq)^\gamma \]
  - Consumers spend a fraction $\gamma$ of their income $y$ on the good offered by Cournot competitors
  - Total consumer expenditure = $M\gamma y$
Quality-augmented Cournot model (cont’d)

• **3rd stage**
  • Price-quality ratio must be the same for all n firms:
    \[ p_i / s_i = p_j / s_j \equiv \lambda \text{ for all } i, j \text{ active} \]
  • Hence, industry revenues are such that
    \[ R = \sum p_i q_i = \lambda \sum s_i q_i \iff \lambda = R / \left( \sum s_i q_i \right) \]
    with
    \[ \frac{d\lambda}{dq_i} = -\frac{Rs_i}{\left( \sum s_i q_i \right)^2} = -\frac{s_i}{R} \lambda^2 \]
  • Firm maximizes
    \[ M\pi = (p_i - c)q_i = (\lambda s_i - c)q_i \]
Quality-augmented Cournot model (cont’d)

3rd stage (cont’d)

• FOC:

\[
\frac{d\pi_i}{dq_i} = (\lambda s_i - c) + s_i q_i \frac{d\lambda}{dq_i} = 0 \iff s_i q_i = \frac{R}{\lambda} - \frac{cR}{\lambda^2 s_i}
\]

• Summing over \( n \) firms:

\[
\sum_i s_i q_i = \frac{nR}{\lambda} - \frac{cR}{\lambda^2} \sum_i \frac{1}{s_i}
\]

• As total revenues = total expenditure

\[
\sum_i s_i q_i = \frac{R}{\lambda} \iff \lambda = \frac{c}{n - 1} \sum_i \frac{1}{s_i}
\]

• Plugging this value in FOC:

\[
q_i = \frac{R}{c} \frac{n - 1}{s_i} \left( 1 - \frac{n - 1}{s_i \sum_i \frac{1}{s_i}} \right)
\]
Quality-augmented Cournot model (cont’d)

• 3rd stage (cont’d)

• Positive sales for all firms ⇔ qualities not too different

\[
\frac{1}{n-1} \sum_i \frac{1}{s_i} > \frac{1}{s_i}
\]

• Combine previous results to get

\[
p_i - c = \left( \frac{s_i}{n-1} \sum_i \frac{1}{s_i} - 1 \right) c
\]

\[\Rightarrow (p_i - c)q_i = \left( 1 - \frac{n-1}{s_i \sum_i \frac{1}{s_i}} \right)^2 R\]
Quality-augmented Cournot model (cont’d)

• Exogenous quality
  • Include entry costs, $e$, and fixed costs for producing quality, $C(s)$.
  • Symmetric equilibrium: $s_i = s$.
  • Firm’s net profit:

$$
(p^*(n) - c)q^*(n) - e - C(s) = \frac{R}{n^2} - e - C(s) = \frac{M \gamma y}{n^2} - e - C(s)
$$

• If market size $M$ explodes, $n \rightarrow \infty$
• Confirmation of result in 2-stage (entry-then-quantity-competition) model: no lower bound on concentration
Quality-augmented Cournot model (cont’d)

• Endogenous quality: 2 \textsuperscript{nd} stage
  • If all other firms set quality $\hat{s}$, firm $i$’s profit is

$$R - C(s_i) = \left(1 - \frac{1}{n-1 + \frac{s_i}{\hat{s}}}ight)^2 R - C(s_i)$$

• Take $C(s_i) = \alpha s_i^\beta$

• Symmetric equilibrium: $s_i = \hat{s} \equiv s^*$

$$2 \left(1 - \frac{1}{n-1 + 1}\right) \frac{s_i^*}{\left(\frac{1}{n-1} + 1\right)^2} R = \alpha \beta (s_i^*)^{\beta - 1} \iff s^* = \sqrt[\beta]{\frac{2R (n-1)^2}{\alpha \beta n^3}}$$

• Increases with $R = M\gamma$

$\Rightarrow$ market size $\uparrow \rightarrow$ firms compete more fiercely in quality
Quality-augmented Cournot model (cont’d)

• Endogenous quality: 1st stage
  • Firm’s net profit becomes
    \[
    \frac{M \gamma y}{n^2} - e - \frac{2}{\beta} \frac{(n-1)^2}{n^3} M \gamma y = \frac{M \gamma y}{n^3} \left( n - \frac{2}{\beta} (n-1)^2 \right) - e
    \]
  • Positive as long as
    \[
    n - \frac{2}{\beta} (n-1)^2 > 0 \iff n \leq \bar{n} \equiv 1 + \frac{1}{4} \left( \beta + \sqrt{\beta(\beta + 8)} \right)
    \]

• Upper bound (independent of \( M \)) on number of firms
• Example: \( \beta = 5 \Rightarrow \bar{n} = 4.27 \)
• Natural oligopoly because only a small number of firms can be sustained, independently of market size
Quality-augmented Cournot model (cont’d)

• **Lesson:** In markets with endogenous sunk costs, even as the size of the market grows without bounds, there is a strictly positive upper bound on the equilibrium number of firms.
Industry concentration and firm turnover (cont’d)

- **Dynamic firm entry and exit**
  - So far, static models
    - OK to predict number of active firms in industries
    - But, unable to generate entry and exit dynamics
  - What do we **expect**?
    - Market entry (exit) in growing (declining) industries
  - What do we **observe**?
    - Simultaneous entry and exit in many industries
  - **Explanation**?
    - Firms are heterogeneous (e.g., different marginal costs)
    - Their prospects change over time (idiosyncratic shocks)
  - **Model**
    - More technical; to be read in the book
Industry concentration and firm turnover (cont’d)

- **Lesson**: In monopolistically competitive markets, market size $\uparrow$
  $\rightarrow$ total number of firms in the market $\uparrow$
  $\rightarrow$ only particularly efficient firms stay
  $\rightarrow$ turnover rate $\uparrow$
  $\Rightarrow$ firms tend to be younger in larger markets.

**Case. Hair salons in Sweden**

- **Hypothesis**: estimated age distribution function of firms with large market size lies above estimated age distribution of firms with small market size.
- Confirmed by the data.
Review questions

• Why is there generally a first-mover advantage under sequential quantity competition (with one leader and one follower) and a second-mover advantage under sequential price competition? Explain by referring to the concepts of strategic complements and strategic substitutes.

• When firms only face a fixed set-up costs when entering an industry, how is the equilibrium number of firms in the industry determined? Is regulation possibly desirable (to encourage or discourage entry)? Discuss.
Review questions (cont’d)

• What is the difference between endogenous and exogenous sunk costs? What are the implications for market structure?

• Which market environments lead to simultaneous entry and exit in an industry?