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
Chapter 3 - Price competition

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 \( \alpha_2 = 1 - \alpha_1 \)

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

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  • firms do not enjoy any market power.

• Cost asymmetries: \( n \) firms, \( c_i < c_{i+1} \)
  • Equilibrium: any price \( p_i = p_j = p \in [c_1, c_2] \)
  • Select \( p^* = c_2 \)
Bertrand competition with uncertain costs

- Each firm has private information about its costs
  - Trade-off between margins and likelihood of winning the competition
  - See particular model in the book.

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↓;
- number of firms explodes $\rightarrow$ competitive limit.
Price competition with differentiated products

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

$$\tau(x - l_1) \quad \tau(l_2 - x)$$

Disutility from travelling

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

• Let $r$ be the reservation price.

• In the 2nd stage, consumer $x$’s utility is
  \[ r - \tau |l_i - x| - p_i \]
  if he purchase from firm $i$.

• Consumer $x$ purchases from firm 1 if
  \[ r - \tau |l_1 - \hat{x}| - p_1 > r - \tau |l_2 - \hat{x}| - p_2 \]

• Consumer $x$ purchases from firm 2 if
  \[ r - \tau |l_1 - \hat{x}| - p_1 < r - \tau |l_2 - \hat{x}| - p_2 \]

• The indifferent consumer $\hat{x}$ solves
  \[ r - \tau |l_1 - \hat{x}| - p_1 = r - \tau |l_2 - \hat{x}| - p_2 \]
Hotelling model (cont’d)

- Demand for firm 1 is
  \[ Q_1(p_1, p_2) = \hat{x} = \frac{1}{2} + \frac{p_2 - p_1}{2\tau} \]

- Demand for firm 2 is
  \[ Q_2(p_1, p_2) = 1 - \hat{x} = \frac{1}{2} + \frac{p_1 - p_2}{2\tau} \]
Hotelling model (cont’d)

• Suppose location at the extreme points

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

Indifferent consumer

\[ p_2 + \tau(1 - x) \]
\[ p_1 + \tau x \]
Hotelling model (cont’d)

- In the 1\textsuperscript{st} stage, firm \( i \) solves
  \[
  \max_{p_i} (p_i - c) Q_i(p_i, p_j)
  \]

- Plugging the demand for firm \( i \), we can rewrite the maximization problem,
  \[
  \max_{p_i} (p_i - c) \left[ \frac{1}{2} + \frac{p_j - p_i}{2\tau} \right]
  \]

- FOC: \[
  \frac{1}{2\tau} (p_j - 2p_i + c + \tau) = 0
  \]

- Solving for \( p_i \), \( p_i(p_j) = \frac{c + \tau}{2} + \frac{1}{2} p_j \)
Hotelling model (cont’d)

\[ pi = \frac{c + \tau}{2} \]

\[ pj = \frac{c + \tau}{2} \]

\[ c + \tau \]

\[ pi(pj) \]
Hotelling model (cont’d)

• Resolution
  • Firm’s problem:
    \[
    \max_{p_i} (p_i - c) \left( \frac{1}{2} + \frac{p_j - p_i}{2\tau} \right)
    \]
  • 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
  1. Localized competition with \( n \) firms: Salop (circle) model
  2. Asymmetric competition with differentiated products
Extension 1: Salop model

• Setting
  • Firms equidistantly located 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, $\tau$

\[
\begin{align*}
&\text{Firm } i \text{'s demand} \\
&\quad \hat{x}_{i,i+1} = \frac{2i + 1}{2n} + \frac{p_{i+1} - p_i}{2\tau}
\end{align*}
\]
Extension 1: Salop model (cont’d)

- Similarly, \( \hat{x}_{i-1,i} \) solves,
  \[
  r - \tau \left( \frac{i - 1}{n} - \hat{x}_{i-1,i} \right) - p_{i-1} = r - \tau \left( \hat{x}_{i-1,i} - \frac{i}{n} \right) - p_i
  \]

- Solving for \( \hat{x}_{i-1,i} \),
  \[
  \hat{x}_{i-1,i} = \frac{2i-1}{2n} + \frac{p_i - p_{i-1}}{2\tau}
  \]

- Assume \( p_{i-1} = p_{i+1} = p \), the demand for firm \( i \) is
  \[
  Q_i(p_i) = \hat{x}_{i,i+1} - \hat{x}_{i-1,i} = \frac{1}{n} - \frac{p - p_i}{\tau}
  \]
Extension 1: Salop model (cont’d)

• Focus on symmetric equilibrium

• Firm $i$’s problem:

$$\max_{p_i} (p_i - c)Q(p_i, p) = (p_i - c) \left( \frac{1}{n} + \frac{p - p_i}{\tau} \right)$$

• FOC: \[1/n + (p - 2p_i + c)/\tau = 0\]

• Setting $p_i = p$ yields:

\[p^* = c + \tau/n\]

• $n \uparrow \rightarrow$ closer substitutes on the circle
  \[\rightarrow\text{competitive pressure} \uparrow \rightarrow p^* \downarrow\]

• If $nn \rightarrow \infty$, then $p^* \rightarrow c$ (perfect competition)
Extension 2: Asymmetric competition with differentiated products

• Same setting as Hotelling model
• Only difference: product 1 is of superior quality
  • Consumer’s indirect utility:
    \[
    \begin{cases}
    r_1 - \tau x - p_1 & \text{if buy 1} \\
    r_2 - \tau(1-x) - p_2 & \text{if buy 2}
    \end{cases}
    \]
    with \( r_1 > r_2 \)

• Assume: \( r_2 + \tau > r_1 \) \( \rightarrow \) product 2 more attractive for some consumers

• Indifferent consumer
  \[
  \hat{x} = \frac{1}{2} + \frac{(r_1 - r_2) - (p_1 - p_2)}{2\tau} = Q_1(p_1, p_2)
  \]
Extension 2: Asymmetric competition with differentiated products (cont’d)

• Firm 1 chooses \( p_1 \) to maximize \( (p_1 - c) Q_1(p_1, p_2) \)
• Similarly for firm 2.
• Solving for the two FOCs:

\[
\begin{align*}
    p_1^* &= c + \tau + \frac{1}{3}(r_1 - r_2) \\
    p_2^* &= c + \tau - \frac{1}{3}(r_1 - r_2)
\end{align*}
\]

\[
Q_1(p_1^*, p_2^*) = \frac{1}{2} + \frac{r_1 - r_2}{6\tau}
\]

• High-quality firm sets a higher price and sells more.
Extension 2: Asymmetric competition with differentiated products (cont’d)

- Firm $i$ chooses $p_i$ to solve
  \[
  \max_{p_i} (p_i - c)Q_i(p_i, p_j)
  \]

- FOC:
  \[
  \frac{1}{2\tau} [p_j - 2p_i + c + \tau + (r_i - r_j)] = 0
  \]

- Solving for $p_i(p_j)$,
  \[
  p_i(p_j) = \frac{c + \tau + (r_i - r_j)}{2} + \frac{1}{2} p_j
  \]
Extension 2: Asymmetric competition with differentiated products (cont’d)

• Welfare maximization → sell at marginal cost

\[ Q_1(c, c) = \frac{1}{2} + \frac{r_1 - r_2}{2\tau} > Q_1(p_1^*, p_2^*) = \frac{1}{2} + \frac{r_1 - r_2}{6\tau} \]

• Firm 1’s equilibrium demand is too low from a social point of view.

• Same analysis if \( r_1 = r_2 = r \), but \( c_1 < c_2 \)

• **Lesson:** Under imperfect competition, the firm with higher quality or lower marginal cost sells too few units from a welfare perspective.
The linear Cournot model

- **Model**
  - Homogeneous product market with *n* firms
  - Firm *i* sets quantity *q*<sub>i</sub>
  - Total output: *q* = *q*<sub>1</sub> + *q*<sub>2</sub> + … + *q*<sub>n</sub>
  - Market price given by *P*(*q*) = *a* − *bq*
  - Linear cost functions: *C*<sub>i</sub>(*q*<sub>i</sub>) = *c*<sub>i</sub> *q*<sub>i</sub>
  - Notation: *q*<sub>-i</sub> = *q* − *q*<sub>i</sub>

- **Residual demand**

\[
P(q) = (a - bq_{-i}) - bq_i
\equiv d(q_i; q_{-i})
\]
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:
  
  \[
  \max_{q_i} (P(q) - c_i)q_i
  \]

  \[
  a - c_i - 2bq_i - bq_{-i} = 0
  \]

  • 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,
    
    \[
    q_1^* = \frac{1}{3b} (a - 2c_1 + c_2) \quad \text{and} \quad q_2^* = \frac{1}{3b} (a - 2c_2 + c_1)
    \]

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

\[ q_i \]

\[ \frac{a - c_i}{2} \]

\[ BRF_i \]

\[ -\frac{1}{2} \]
The linear Cournot model (cont’d)

• Duopoly

\[ q_1(q_2) = \frac{a - c_2}{b} \]
\[ q_2(q_1) = \frac{a - c'_2}{b} \]
\[ q_1(q_2) = \frac{a - c_1}{2b} \]

\[ c'_2 > c_2 > c_1 \]

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

• Suppose that \[ c_i = c \] for all \( i = 1 \leq n \)

• 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 (details see next slide)

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

**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 marginal costs are constant

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

Average Lerner index
Details: Cournot pricing formula

• Firm i chooses $q_i$ to solve
  \[
  \max_{q_i} \pi_i = P(q)q_i - C_i(q_i)
  \]

• FOC:
  \[
P'(q)q_i + P(q) - C'_i(q_i) = 0
  \]

\[
\Rightarrow \frac{P(q) - C'_i(q_i)}{P(q)} = -\frac{P'(q)q_i}{P(q)} \frac{q}{q}
\]

Inverse of elasticity

Market share
Details: Cournot pricing formula

• F.O.C. of profit maximization for Cournot firm

\[ P'(q)q_i + P(q) - C'_i(q_i) = 0 \iff P(q) - C'_i(q_i) = -P'(q)q_i \iff \]
\[ \frac{P(q) - C'_i(q_i)}{P(q)} = \frac{-P'(q)q_i}{P(q)q} = \frac{1}{\eta} \alpha_i \]

• Suppose constant marginal costs: \( C_i(q_i) = c_i q_i \)

\[ \frac{p - c_i}{p} = \frac{\alpha_i}{\eta} \to \sum_{i=1}^{n} \pi_i = \sum_{i=1}^{n} (p - c_i) \alpha_i q = \begin{cases} (p - \sum_{i=1}^{n} \alpha_i c_i)q \\ \frac{pq}{\eta} \sum_{i=1}^{n} \alpha_i^2 \end{cases} \]

\[ \Rightarrow \frac{p - \sum_{i=1}^{n} \alpha_i c_i}{p} = \frac{\sum_{i=1}^{n} \alpha_i^2}{\eta} = \frac{I_H}{\eta} \]

→ Lerner index (weighted by market shares) is proportional to Herfindahl 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 highest willingness to pay are served at firm 1’s low price

Consumers with unit demand, ranked by decreasing willingness to pay

There is a positive residual demand for firm 2

Excess demand for firm 1
Capacity-then-price model (cont’d)

• **Equilibrium** (details next slides)

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

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

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

• **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.
Details: Capacity-then-price model

• 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
• Efficient rationing

• Upper bound on capacity at stage 1

\[
c\bar{q}_i \leq \max_q (a - q)q = a^2 / 4 \Leftrightarrow \bar{q}_i \leq a^2 / (4c)
\]
Details: Capacity-then-price model (cont’d)

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

• Proof
  • Let \( p_1 = p^* \) and show that 2’s best-response is \( p_2 = p^* \).
  • \( p_2 < p^* \) doesn’t pay: same quantity (because firm 2 sells all its capacity) sold at lower price
  • \( p_2 > p^* \) could pay as firm 1 is capacity constrained...
    For this, revenues should be increasing at \( p^* \) ...
  • Firm 2’s revenues:
    \[
    p_2 Q(p_2) = \begin{cases} 
    p_2 (a - p_2 - \bar{q}_1) & \text{if } a - p_2 \geq \bar{q}_1, \\
    0 & \text{else}
    \end{cases}
    \]
Details: Capacity-then-price model (cont’d)

• Proof (cont’d)

  • Max reached at \( \bar{p}_2 = \frac{(a - \bar{q}_1)}{2} \)

  • Revenues are decreasing at \( p^* \) if

\[
p^* > \bar{p}_2 \iff a - \bar{q}_1 - \bar{q}_2 > \frac{a - \bar{q}_1}{2} \iff a > \bar{q}_1 + 2\bar{q}_2
\]

Since \( \bar{q}_1, \bar{q}_2 \leq \frac{a^2}{4c} \), \( \bar{q}_1 + 2\bar{q}_2 \leq (3/4)(a^2/c) \)

Assumption \( a < (4/3)c \) \( \iff (3/4)(a/c) < 1 \)

• Hence, not profitable to set \( p_2 > p^* \). QED
Capacity Constraints
• Go to EconS 503’s website, Chapter 8, slides 178-192

Cournot Model of Quantity Competition
• Go to EconS 503’s website, Chapter 8, slides 102-141

Product Differentiation
• Go to EconS 503’s website, Chapter 8, slides 142-153
Differentiated products: Cournot vs. Bertrand

Setting

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

\[
U(q_0, q_1, q_2) = aq_1 + aq_2 - (bq_1^2 + 2dq_1q_2 + bq_2^2) / 2 + q_0
\]

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

\[
\bar{a} = a / (b + d), \quad \bar{b} = b / (b^2 - d^2), \quad \bar{d} = d / (b^2 - d^2)
\]
Chapter 3 - Price vs. quantity

Differentiated products

- Maximization program
  - Cournot: \( \max_{q_i} (a - bq_i + dq_j - c_i)q_i \)
  - Bertrand: \( \max_{p_i} (p_i - c_i)(\bar{a} - \bar{b}p_i + \bar{d}p_j) \)

- Best-response functions
  - Cournot: \( q_i(q_j) = (a - dp_j - c_i)/(2\bar{b}) \)
  - Bertrand: \( p_i(p_j) = (\bar{a} + \bar{d}p_j + \bar{b}c_i)/(2\bar{b}) \)

Downward-sloping \( \rightarrow \) Strategic substitutes
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 \( \uparrow \) its action \( \rightarrow \) marginal profitability of my own action \( \uparrow \)
    \( \rightarrow \) variables are strategic **complements**
    
    • **Example:** price competition (with substitutable products);
      See Bertrand and Hotelling models

  • **Downward sloping:** competitor \( \uparrow \) its action \( \rightarrow \) marginal profitability of my own action \( \downarrow \)
    \( \rightarrow \) 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)

![Diagram showing price vs. quantity competition with $d$ and $\Delta^{-d}$](image)
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

• Interpretation 1. Nest various market structures in a single model

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

\( \lambda = 0 \) 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
Estimating market power (cont’d)

• Interpretation 1 (cont’d)
  • Basic model to be estimated non-parametrically: demand equation (1) + equilibrium condition (2)

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

• Interpretation 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.