

Part III. Sources of market power

Chapter 5. Product differentiation



Slides

Industrial Organization: Markets and Strategies

Paul Belleflamme and Martin Peitz, 2d Edition

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Case. Competition in the banking deposit market

- There exists market power
 - Positive intermediation margins
 - Lerner index: US, 23% / Japan, 20% / EU, 15%
- Where does it come from?
 - **Consequence of firms' conduct**
 - Marketing mix: **P**rice - **P**roduct - **P**romotion
 - **P**rice → analysis of pricing strategies, see Part IV
 - **P**roduct → **Product differentiation** → Chapter 5
 - Web-banking, network of ATM, ...
 - **P**romotion → **Advertising** → Chapter 6
 - *Informative*: “Call 1-800 ING Direct. Hang up richer”
 - *Persuasive*: “Britain’s best business bank” (Allied Irish)
 - *Complementary*: “Washington Mutual. More human interest”

Case. Competition in the banking deposit market

- Where does it come from?
 - **Consequence of market environment**
 - Consumer inertia → Chapter 7
 - Because of a *lack of information*
 - It's time-consuming to compare deposit rates of competing banks (and read the small prints)
 - Source of *price dispersion*
 - Because of *switching costs*
 - Moving accounts from one bank to another takes time (and possibly money)
 - “*Bargain-then-rip-off*” pricing

Chapter 5. Learning objectives

- Understand that product differentiation involves two conflicting forces:
 - it relaxes price competition, but
 - it may reduce the demand that the firm faces.
- Be able to distinguish between horizontal and vertical product differentiation.
- Reconsider the question of entry into product market.
- Be exposed to some basic approaches to estimate differentiated product markets.

Views on product differentiation

- Product differentiation depends on consumers' preferences.
- Characteristics approach
 - Preferences are specified on the underlying characteristics space
 - Discrete choice approach
 - Consumers have heterogeneous preferences and choose one (and only one) product among the available products
 - e.g., Hotelling model
 - Representative consumer approach
 - Consumers are assumed to be identical and have a variable demand for all products
 - e.g., linear demand model with 2 goods used in Chapter 3

Views on product differentiation

- Discrete choice approach
 - Horizontal product differentiation
 - Each product would be preferred by some consumers.
 - Vertical product differentiation
 - Everybody would prefer one over the other product.
 - More formally (naïve definition): if, at equal prices,
 - consumers do not agree on which product is the preferred one → products are *horizontally* differentiated;
 - all consumers prefer one over the other product → products are *vertically* differentiated.
 - Note 1: to account for supply side characteristics, modify the definition by replacing “at equal prices” by “prices are set at marginal costs”.
 - Note 2: Not easy to draw the distinction in practice

A simple location model

- Suppose constant price (e.g., regulated price): $\bar{p}$
- Decision for firms: how to position product (where to locate) in product space (in “linear city”): $l_1, l_2 \in [0, 1]$
- Consumers
 - Mass 1 uniformly distributed on $[0, 1]$; location = ideal point in product space; linear transportation cost
 - Consumers buy at most one unit from one of the firms
 - From product i , consumer x derives utility

$$v_i(x) = r - \tau|x - l_i| - \bar{p}$$
 - Indifferent consumer ($l_1 < l_2$): $\hat{x} = (l_1 + l_2) / 2$
 - Firms' demands:

$$Q_1(l_1, l_2) = (l_1 + l_2) / 2, Q_2(l_1, l_2) = 1 - (l_1 + l_2) / 2$$

A simple location model

- Firms maximize profits w.r.t. their product location given the location of the competitor

$$\pi_i(l_i, l_j) = \begin{cases} (\bar{p} - c)(l_i + l_j) / 2 & \text{if } l_i < l_j \\ (\bar{p} - c) / 2 & \text{if } l_i = l_j \\ (\bar{p} - c)[1 - (l_i + l_j) / 2] & \text{if } l_i > l_j \end{cases}$$

- Unique Nash equilibrium: $l_1 = l_2 = 1/2$
- Lesson:** If duopolists choose product locations (but do not set prices), they offer the same product (no differentiation).
- Insufficient differentiation from social viewpoint
 - To minimize total transport: $l_1 = 1/4, l_2 = 3/4$

A simple location model (cont'd)

- **Why do both firms locate at the center?** Suppose $l_j < \frac{1}{2}$.
 - If firm i locates just to the right of l_j , it serves all consumers to its right: a demand close to $1 - l_j > \frac{1}{2}$.
 - Any location further right loses consumers in between to firm j .
- Hence, each firm wants to locate next to its rival, on the side of the larger market. The only locations where neither firm wants to move are

$$l_1 = l_2 = \frac{1}{2}, \quad \text{with demands} \quad Q_1 = Q_2 = \frac{1}{2}$$

- **Social optimum.** Total transportation costs are minimized when each firm is at the center of the half it serves, $l_1 = \frac{1}{4}$ and $l_2 = \frac{3}{4}$: the longest trip falls from $\frac{1}{2}$ to $\frac{1}{4}$.

Hotelling model

- Now, firms choose location **and** price.
- Two-stage game:
 1. Location choice (long term decision)
 2. Price choice (short term decision)
- Two scenarios:
 - Linear transportation costs
 - Quadratic transportation costs

Linear Hotelling model

- Consumers
 - Mass 1 uniformly distributed on $[0,1]$; location = ideal point in product space; linear transportation cost
 - Consumers buy at most one unit from one of the firms
 - From product i , consumer x derives utility

$$v_i(x) = r - \tau|x - l_i| - p_i$$

- Firms
 - Choose first l_i in $[0,1]$ and then p_i
 - Constant marginal cost of production, c
- We look for subgame perfect equilibria.

Linear Hotelling model (cont'd)

- Price stage
 - Label firms such that $l_1 \leq l_2$
 - If price difference “*not too large*”, there exists an indifferent consumer located in $[l_1, l_2]$

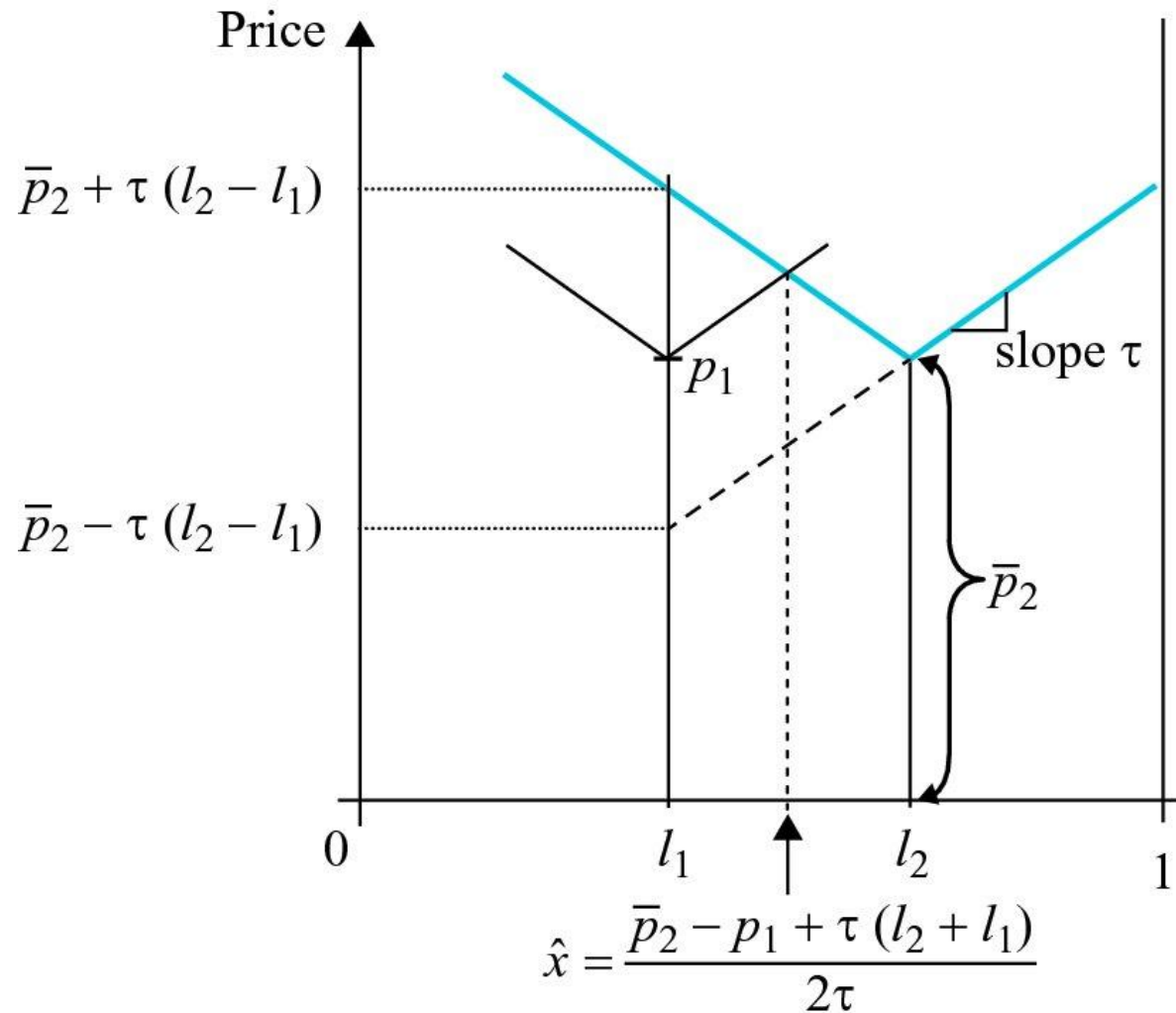
$$r - \tau(\hat{x} - l_1) - p_1 = r - \tau(l_2 - \hat{x}) - p_2 \Leftrightarrow \hat{x} = \frac{l_1 + l_2}{2} - \frac{p_1 - p_2}{2\tau}$$

- What does “*not too large*” price difference mean?

$$\hat{x} \geq l_1 \Leftrightarrow p_1 \leq p_2 + \tau(l_2 - l_1)$$

$$\hat{x} \leq l_2 \Leftrightarrow p_1 \geq p_2 - \tau(l_2 - l_1)$$

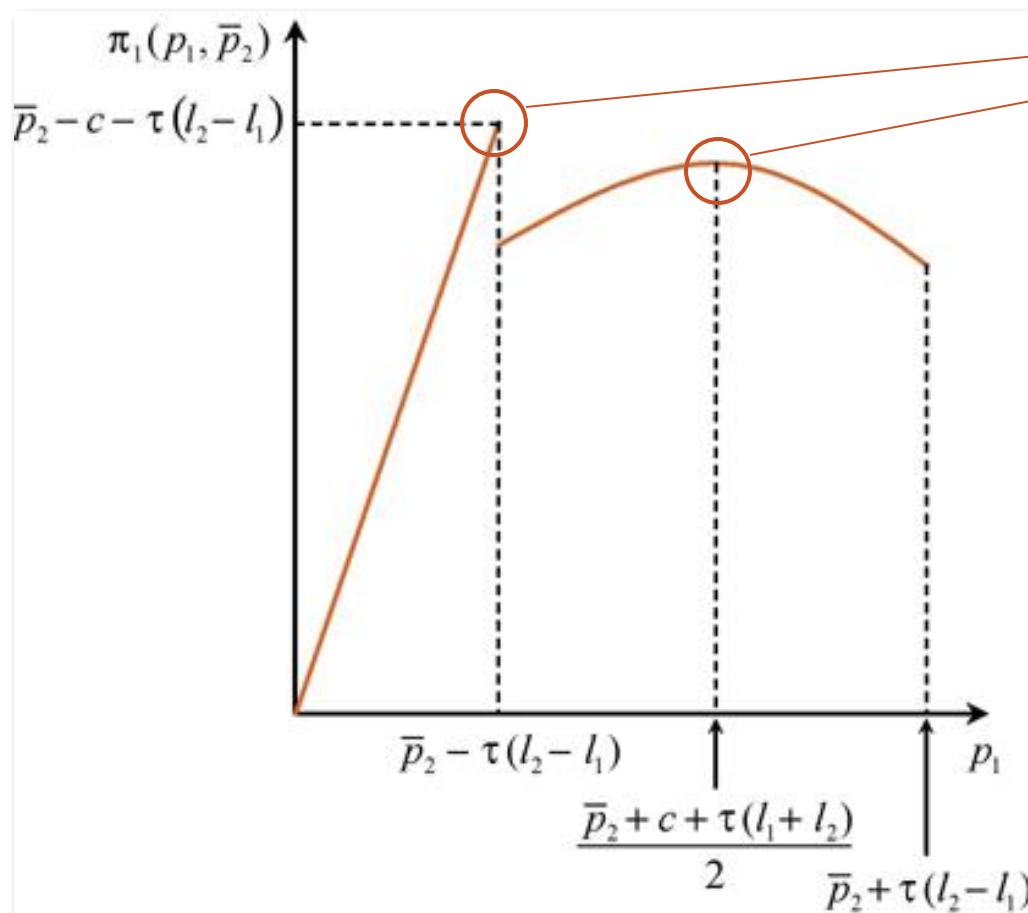
Linear Hotelling model (cont'd)



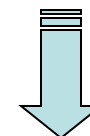
Linear Hotelling model (cont'd)

- **Price stage (cont'd).** What if the price difference is “too large”? Demand is then discontinuous:
 - If $p_1 > p_2 + \tau(l_2 - l_1)$, even the consumer at l_1 prefers firm 2: firm 1 has no demand.
 - If $p_1 < p_2 - \tau(l_2 - l_1)$, even the consumer at l_2 prefers firm 1: firm 2 has no demand.
- **Firm 1's profit** is therefore
 - 0 if $p_1 > p_2 + \tau(l_2 - l_1)$;
 - $(p_1 - c) \left(\frac{l_1 + l_2}{2} + \frac{p_2 - p_1}{2\tau} \right)$ if $|p_1 - p_2| \leq \tau(l_2 - l_1)$;
 - $p_1 - c$ (the whole market) if $p_1 < p_2 - \tau(l_2 - l_1)$.
- The jumps in demand make profit non-concave in p_1 (next slide).

Linear Hotelling model (cont'd)



2 local suprema
 $\rightarrow \pi_1$ not quasi-concave in p_1



Price equilibrium
 may fail to exist
**Happens when
 locations are too
 close.**

Linear Hotelling model (cont'd)

- Location stage
 - Price equilibrium fails to exist for some pairs of location → no subgame perfect equilibrium
 - But it does when firms are located in the extremes (see Chapter 3, or Example 12.C.2 in MWG).
 - Where price equilibrium exists, firms want to move towards zone where price equilibrium does not exist.
 - **Instability in competition**
- **Lesson:** Although product differentiation relaxes price competition, firms may have an incentive to offer better substitutes to generate more demand, which may lead to instability in competition.

Quadratic Hotelling model

- **Only difference:** transportation costs increase with the square of the distance, $v_i(x) = r - \tau(x - l_i)^2 - p_i$.
- **Step 1. Indifferent consumer.** Setting $v_1(\hat{x}) = v_2(\hat{x})$, with $l_1 < l_2$, the quadratic terms in $\hat{x}$ cancel:

$$\hat{x} = \frac{l_1 + l_2}{2} + \frac{p_2 - p_1}{2\tau(l_2 - l_1)}$$

- Demand is now continuous in prices, so a price equilibrium always exists.
- **Step 2. Price stage.** Firm 1 maximizes $(p_1 - c)\hat{x}$ and firm 2 maximizes $(p_2 - c)(1 - \hat{x})$. Solving both first-order conditions,

$$p_1^* = c + \frac{\tau}{3}(l_2 - l_1)(2 + l_1 + l_2) \quad \text{and} \quad p_2^* = c + \frac{\tau}{3}(l_2 - l_1)(4 - l_1 - l_2)$$

Quadratic Hotelling model (cont'd)

- **Step 3. Location stage.** Substituting the equilibrium prices, firm 1's profit is

$$\hat{\pi}_1(l_1, l_2) = \frac{\tau}{18} (l_2 - l_1)(2 + l_1 + l_2)^2$$

- Differentiating with respect to l_1 ,

$$\frac{\partial \hat{\pi}_1}{\partial l_1} = -\frac{\tau}{18} \underbrace{(2 + l_1 + l_2)}_{>0} \underbrace{(2 + 3l_1 - l_2)}_{>0 \text{ since } l_2 \leq 1} < 0$$

- Firm 1 always wants to move left, to $l_1 = 0$; by symmetry, firm 2 moves to $l_2 = 1$: **maximum differentiation**.
 - At $l_1 = 0$ and $l_2 = 1$: $p_1^* = p_2^* = c + \tau$ and $\hat{x} = \frac{1}{2}$, as in the Hotelling model of Chapter 3.

Quadratic Hotelling model (cont'd)

- Two forces determine the locations:
 - **Competition effect**: moving away from the rival softens price competition, which drives firms apart.
 - **Market size effect**: moving toward the rival captures more consumers at given prices, which brings firms together.
- With quadratic costs, the competition effect dominates everywhere, so firms locate at the extremes.
- The balance depends on the distribution of consumers, the shape of transportation costs, and the feasible product range.

Quadratic Hotelling model (cont'd)

- **Lesson:** With endogenous product differentiation, the degree of differentiation is determined by balancing
 - the competition effect (drives firm to $\uparrow$ differentiation)
 - the market size effect (drives firm to $\downarrow$ differentiation).

Vertical product differentiation

- All consumers agree that one product is preferable to another, i.e., has a higher *quality*
- Consumers
 - Quality is described by $s_i \in [\underline{s}, \bar{s}] \subset \mathbb{R}_+$
 - Preference parameter for quality: $\theta \in [\underline{\theta}, \bar{\theta}] \subset \mathbb{R}_+$
 - larger $\theta \rightarrow$ consumer more sensitive to quality changes
 - Each consumer chooses 1 unit of 1 of the products
 - Uniform distribution on $[\underline{\theta}, \bar{\theta}]$, mass $M = \bar{\theta} - \underline{\theta}$
 - Utility for consumer θ from one unit of product i

$$r + \theta s_i - p_i$$

Vertical product differentiation (cont'd)

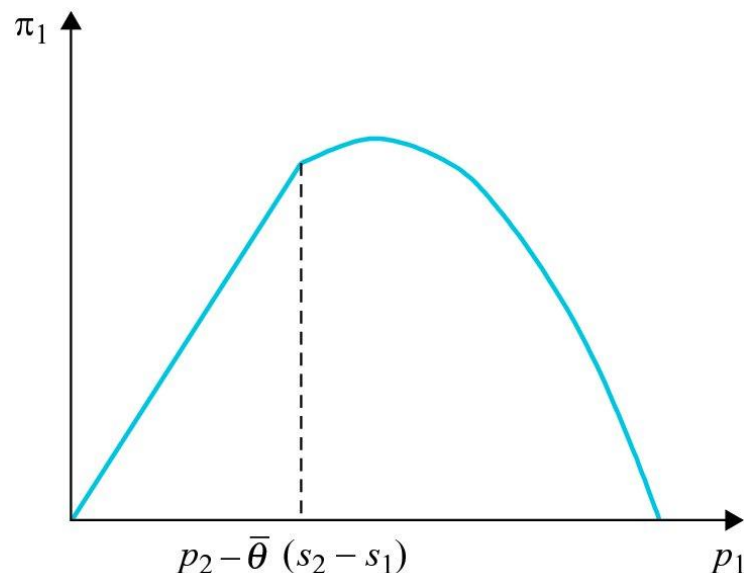
- Time structure:
 1. Choose quality: s_1, s_2
 2. Choose price: p_1, p_2
- Constant marginal cost, $c = 0$
- Price stage
 - Suppose $s_1 < s_2$
 - Indifferent consumer is determined by the ratio of price and quality differences:

$$r - p_1 + \hat{\theta}s_1 = r - p_2 + \hat{\theta}s_2 \Leftrightarrow \hat{\theta} = \frac{p_2 - p_1}{s_2 - s_1} \text{ for } \hat{\theta} \in [\underline{\theta}, \bar{\theta}]$$

Vertical product differentiation (cont'd)

- Price stage (cont'd)

$$\pi_1(p_1, p_2; s_1, s_2) = \begin{cases} 0 & \text{if } p_1 > p_2 - \underline{\theta}(s_2 - s_1), \\ p_1 \left(\frac{p_2 - p_1}{s_2 - s_1} - \underline{\theta} \right) & \text{if } \underline{\theta}(s_2 - s_1) \leq p_2 - p_1 \leq \bar{\theta}(s_2 - s_1), \\ p_1(\bar{\theta} - \underline{\theta}) & \text{if } p_1 < p_2 - \bar{\theta}(s_2 - s_1). \end{cases}$$



Solving the system of F.O.C.:

$$p_1^* = \frac{1}{3}(\bar{\theta} - 2\underline{\theta})(s_2 - s_1)$$

$$p_2^* = \frac{1}{3}(2\bar{\theta} - \underline{\theta})(s_2 - s_1)$$

(parameter restriction: $\bar{\theta} > 2\underline{\theta}$)

→ Even the price of the low-quality firm increases with the quality difference!

Vertical product differentiation (cont'd)

- **Step 1. First-order conditions.** In the interior case, firm 1 sells to $[\underline{\theta}, \hat{\theta}]$ and firm 2 to $[\hat{\theta}, \bar{\theta}]$, with $\hat{\theta} = \frac{p_2 - p_1}{s_2 - s_1}$:

$$\max_{p_1} p_1 \left(\frac{p_2 - p_1}{s_2 - s_1} - \underline{\theta} \right) \quad \text{and} \quad \max_{p_2} p_2 \left(\bar{\theta} - \frac{p_2 - p_1}{s_2 - s_1} \right)$$

- Solving both first-order conditions simultaneously,

$$p_1^* = \frac{1}{3} (\bar{\theta} - 2\underline{\theta})(s_2 - s_1) \quad \text{and} \quad p_2^* = \frac{1}{3} (2\bar{\theta} - \underline{\theta})(s_2 - s_1)$$

- **Step 2. Indifferent consumer and profits.** $\hat{\theta} = \frac{\bar{\theta} + \underline{\theta}}{3}$, so

$$\hat{\pi}_1 = \frac{1}{9} (\bar{\theta} - 2\underline{\theta})^2 (s_2 - s_1) \quad \text{and} \quad \hat{\pi}_2 = \frac{1}{9} (2\bar{\theta} - \underline{\theta})^2 (s_2 - s_1)$$

Vertical product differentiation (cont'd)

- **Step 3. Quality stage.** Qualities are chosen in $[\underline{s}, \bar{s}]$, with $s_1 < s_2$. The derivatives of the profits in Step 2 have a constant sign:

$$\frac{\partial \hat{\pi}_1}{\partial s_1} = -\frac{(\bar{\theta} - 2\underline{\theta})^2}{9} < 0 \quad \Rightarrow \quad s_1^* = \underline{s}$$

$$\frac{\partial \hat{\pi}_2}{\partial s_2} = \frac{(2\bar{\theta} - \underline{\theta})^2}{9} > 0 \quad \Rightarrow \quad s_2^* = \bar{s}$$

- Both solutions are corners: the low-quality firm chooses the lowest quality and the high-quality firm the highest, which maximizes the quality gap and softens price competition.

Vertical product differentiation (cont'd)

- Quality stage
 - Substitute for second-stage equilibrium prices in profit function:

$$\begin{aligned}\tilde{\pi}_1(s_1, s_2) &= \frac{1}{9}(\bar{\theta} - 2\underline{\theta})^2(s_2 - s_1) \\ \tilde{\pi}_2(s_1, s_2) &= \frac{1}{9}(2\bar{\theta} - \underline{\theta})^2(s_2 - s_1)\end{aligned}$$
 - Both profits $\uparrow$ in the quality difference $\rightarrow$ equilibrium quality choices:
 - Simultaneous: $(s_1, s_2) = (\underline{s}, \bar{s})$ or $(\bar{s}, \underline{s})$
 - Sequential: 1st (2nd) chooses highest (lowest) quality

- **Lesson:** In markets in which products can be vertically differentiated, firms offer different qualities in equilibrium so as to relax price competition.

Worked example: vertical differentiation

- **Parameters.** $\underline{\theta} = 1$, $\bar{\theta} = 4$, $\underline{s} = 1$, $\bar{s} = 3$, and $c = 0$. From Step 3, $s_1 = 1$ and $s_2 = 3$, so $s_2 - s_1 = 2$.

- **Prices.**

$$p_1^* = \frac{(4 - 2) \times 2}{3} = \frac{4}{3} \quad \text{and} \quad p_2^* = \frac{(8 - 1) \times 2}{3} = \frac{14}{3}$$

- **Indifferent consumer.** $\hat{\theta} = \frac{14/3 - 4/3}{2} = \frac{5}{3}$, so firm 1 sells $\frac{5}{3} - 1 = \frac{2}{3}$ and firm 2 sells $4 - \frac{5}{3} = \frac{7}{3}$.

- **Profits.**

$$\pi_1^* = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9} \quad \text{and} \quad \pi_2^* = \frac{14}{3} \times \frac{7}{3} = \frac{98}{9}$$

- The high-quality firm charges more, sells more, and earns more than 10 times as much.

Case. VLJ industry: “Battle of bathrooms”

- Very Light Jets
 - 4 to 8 passengers, city-to-city, 60 to 90-minute trips

You are not going to have women on a plane unless it has a lavatory.

Jim Burns,
Founder of Magnum Air

Vertical differentiation



Adam Aircraft A700
More expensive
Has a lavatory

VS



Eclipse 500
Less expensive
No lavatory

Having a bathroom on board is not an issue for short trips.

Ed Iacobucci,
CEO of DayJet Corp.

Vertical differentiation and natural oligopolies

- Analysis of Chapter 4
 - Natural bounds to number of firms in oligopolistic markets → main source: scale economies
 - Number of firms determined by entry process
- In the presence of vertical differentiation
 - There may be a limited number of firms even for negligible amount of scale economies.

Vertical differentiation and natural oligopolies

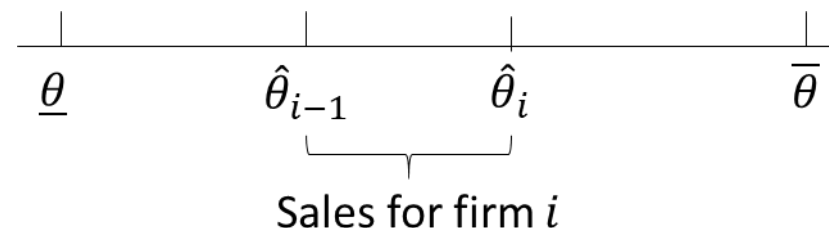
- Intuition from previous model
 - Recall equilibrium prices:

$$p_1^* = \frac{1}{3}(\bar{\theta} - 2\underline{\theta})(s_2 - s_1), \quad p_2^* = \frac{1}{3}(2\bar{\theta} - \underline{\theta})(s_2 - s_1)$$

- Does not hold if $\bar{\theta} \leq 2\underline{\theta}$
- In that case, with positive (but possibly small) entry cost, low-quality firm does not enter → natural monopoly
- Can be generalized to an n -firm oligopoly (next slides)

Natural oligopolies

- Suppose there are n firms.
- The utility function is $\theta s_i - p_i$.
- The marginal cost $c = 0$
- $s_{i+1} > s_i$



- Profit for firm i is

$$\pi_i(p_i, s_i) = p_i(\hat{\theta}_i - \hat{\theta}_{i-1})$$

where $\hat{\theta}_0 = \underline{\theta}$, $\hat{\theta}_i = \frac{p_{i+1} - p_i}{s_{i+1} - s_i}$ for all $i = 1, \dots, n - 1$, $\hat{\theta}_n = \overline{\theta}$

Natural oligopolies (cont'd)

- **Step 1. First-order conditions.** Firm i maximizes $\pi_i = p_i(\hat{\theta}_i - \hat{\theta}_{i-1})$. Raising p_i lowers $\hat{\theta}_i$ and raises $\hat{\theta}_{i-1}$, so $\frac{\partial \pi_i}{\partial p_i} = 0$ becomes

$$\hat{\theta}_i - \hat{\theta}_{i-1} = \frac{p_i^*}{s_{i+1} - s_i} + \frac{p_i^*}{s_i - s_{i-1}} \quad \text{for } 1 < i < n$$

- Firms 1 and n have a single neighbor, so

$$\hat{\theta}_1 - \underline{\theta} = \frac{p_1^*}{s_2 - s_1} \quad \text{and} \quad \bar{\theta} - \hat{\theta}_{n-1} = \frac{p_n^*}{s_n - s_{n-1}}$$

Natural oligopolies (cont'd)

- **Step 2. A lower bound on sales.** For $1 < i < n$, rewrite Step 1 by adding and subtracting $\frac{p_{i-1}^*}{s_i - s_{i-1}}$:

$$\hat{\theta}_i - \hat{\theta}_{i-1} = \underbrace{\frac{p_i^*}{s_{i+1} - s_i} + \frac{p_{i-1}^*}{s_i - s_{i-1}}}_{>0} + \underbrace{\frac{p_i^* - p_{i-1}^*}{s_i - s_{i-1}}}_{=\hat{\theta}_{i-1}} > \hat{\theta}_{i-1}$$

- Hence, $\hat{\theta}_i > 2\hat{\theta}_{i-1}$: each threshold is more than twice the previous one.
- The same argument for firm n gives $\bar{\theta} > 2\hat{\theta}_{n-1}$, and firm 1 needs positive sales, $\hat{\theta}_1 > \underline{\theta}$.

Natural oligopolies (cont'd)

- **Step 3. At most a few firms.** Chaining the inequalities from Step 2,

$$\bar{\theta} > 2\hat{\theta}_{n-1} > 2^2\hat{\theta}_{n-2} > \dots > 2^{n-1}\hat{\theta}_1 > 2^{n-1}\underline{\theta}$$

- If all n firms are active, then $\bar{\theta} > 2^{n-1}\underline{\theta}$. This bound does not depend on entry costs, which can be arbitrarily small.
 - $n = 2$ requires $\bar{\theta} > 2\underline{\theta}$ (as in the duopoly model); $n = 3$ requires $\bar{\theta} > 4\underline{\theta}$; $n = 10$ requires $\bar{\theta} > 2^9\underline{\theta} = 512\underline{\theta}$.
- **Example.** $\underline{\theta} = 1$ and $\bar{\theta} = 10$: since $2^3 = 8 < 10 < 2^4 = 16$, at most four firms can be active: a **natural oligopoly**.

Probabilistic choice and the logit model

- Discrete choice models
 - Important to have consumers choosing differently to have a 'smooth' aggregate demand.
 - How to formalize this?
 - Consumers are heterogeneous by nature.
→ assumption made in this chapter (& in most of the book)
 - Alternative: **probabilistic choice theory**
 - Ex ante (before some random variable is realized): customers are the same.
 - Ex post (after this realization): customers are different
→ *heterogeneity results from randomness*.
 - Modelling customer behaviour as probabilistic is motivated by experimental evidence from the psychology literature.

Probabilistic choice and the logit model (cont'd)

- **Random utility.** Consumer utility from good i is

$$v_i = \underbrace{r - p_i}_{\bar{v}_i} + \varepsilon_i, \quad \text{with } E\varepsilon_i = 0$$

- $\bar{v}_i$ is the 'observable' or 'measured' utility; it reflects the preferences of the population for good i in expectation.
- **Binary choice.** With two alternatives, a consumer chooses 1 if $\bar{v}_1 + \varepsilon_1 > \bar{v}_2 + \varepsilon_2$, that is, if

$$\varepsilon < \bar{v}_1 - \bar{v}_2, \quad \text{where } \varepsilon \equiv \varepsilon_2 - \varepsilon_1$$

- The share of consumers choosing 1 is the probability $F(\bar{v}_1 - \bar{v}_2)$, where F is the distribution of ε .

Probabilistic choice and the logit model (cont'd)

- **Binomial logit.** If ε is logistically distributed, $F(e) = \frac{1}{1+\exp(-e/\mu)}$, then

$$Q_1 = \frac{1}{1 + \exp(-(\bar{v}_1 - \bar{v}_2)/\mu)} = \frac{\exp(\bar{v}_1/\mu)}{\exp(\bar{v}_1/\mu) + \exp(\bar{v}_2/\mu)}$$

- A larger μ means more randomness: shares become less sensitive to utility differences.
- **Multinomial logit.** With n products,

$$Q_i = \frac{\exp(\bar{v}_i/\mu)}{\sum_{j=1}^n \exp(\bar{v}_j/\mu)}$$

- Example: $\mu = 1$, $\bar{v}_1 = 1$, and $\bar{v}_2 = 0$. Then $Q_1 = \frac{e}{e+1} \approx 0.73$.

Empirical analysis of horizontal differentiation

- Demand side
 - Consumers can choose among n products (+ an outside good, noted 0, with utility = 0)
 - Market shares using multinomial logit (with $\mu = 1$)

$$\alpha_i = \frac{\exp\{\bar{v}_i\}}{1 + \sum_{j=1}^n \exp\{\bar{v}_j\}}$$

- All consumers have the same mean utility level

$$\bar{v}_i = \beta x_i + \xi_i - \gamma p_i$$

Vector of observed
characteristics

mean utility derived from
unobserved characteristics

Empirical analysis of horizontal differentiation

- Demand side (cont'd)
 - Linear market shares in unobserved characteristics:

$$\log \alpha_i - \log \alpha_0 = \beta x_i + \xi_i - \gamma p_i$$

- If we consider ξ_i as an error term, we can estimate demand parameters (β, γ) from this structural model.

- Supply side

- Nash equilibrium in prices
- Costs:

$$c_i = K w_i + \omega_i$$

Relevant observable product characteristics on the cost side

mean cost derived from unobserved characteristics

Empirical analysis of horizontal differentiation

(cont'd)

- **Step 1. Firm i 's first-order condition.** Firm i maximizes $(p_i - c_i)M\alpha_i$, so

$$p_i = c_i + \frac{\alpha_i}{|\partial \alpha_i / \partial p_i|}$$

- **Step 2. Logit derivative.** Since $\bar{v}_i$ decreases in p_i at rate γ , $\frac{\partial \alpha_i}{\partial p_i} = -\gamma \alpha_i (1 - \alpha_i)$. Substituting, with $c_i = \kappa w_i + \omega_i$,

$$p_i = \kappa w_i + \frac{1}{\gamma} \frac{1}{1 - \alpha_i} + \omega_i$$

- Firms with larger market shares charge higher markups.
- **Step 3. Estimation.** This pricing equation can be estimated jointly with the demand equation, $\log \alpha_i - \log \alpha_0 = \beta x_i + \xi_i - \gamma p_i$.

Extension: the nested logit model

- Limitations of the logit model
 - Severe restrictions imposed on substitution patterns.
 - Often unrealistic
 - Example: product introduction in the subcompact car segment has different effects on the market share of a car in that segment or on a luxury car.
- Possible answers:
 - nested logit model
 - Group different products together in different nests.
 - Consumers select first among nests and then within the selected nest.
 - may still be too restrictive because of symmetry of price elasticities of products outside a nest
 - random coefficient logit

Review questions

- In which industries is product differentiation important? Provide two examples.
- What makes firms locate close to each other in the product space? And what does it make them to differentiate themselves from their competitors?
- When is vertical product differentiation present in an industry? Discuss demand and cost characteristics.

Review questions (cont'd)

- Does the number of firms in an industry with constant marginal costs necessarily converge to infinity as the entry cost turns to zero? Explain.
- Why are we interested in empirically estimating models of product differentiation? (After all, to understand the intensity of competition in the short run, we only need to know the Lerner index.)