

Part III. Sources of market power

Chapter 5. Product differentiation



Slides

Industrial Organization: Markets and Strategies

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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
 - ✓ *Customer poaching*

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: 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: $l_1 = 1/4, l_2 = 3/4$

Hotelling model

- Now, firms choose location **and** price.
- 2 stage model
 1. Location choice (long term decision)
 2. Price choice (short term decision)
- We already studied (in Chapter 3) the price stage with extreme locations (i.e., 0 and 1).
- We repeat the analysis for any pair of locations → 2 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 $[l_1, l_2]$

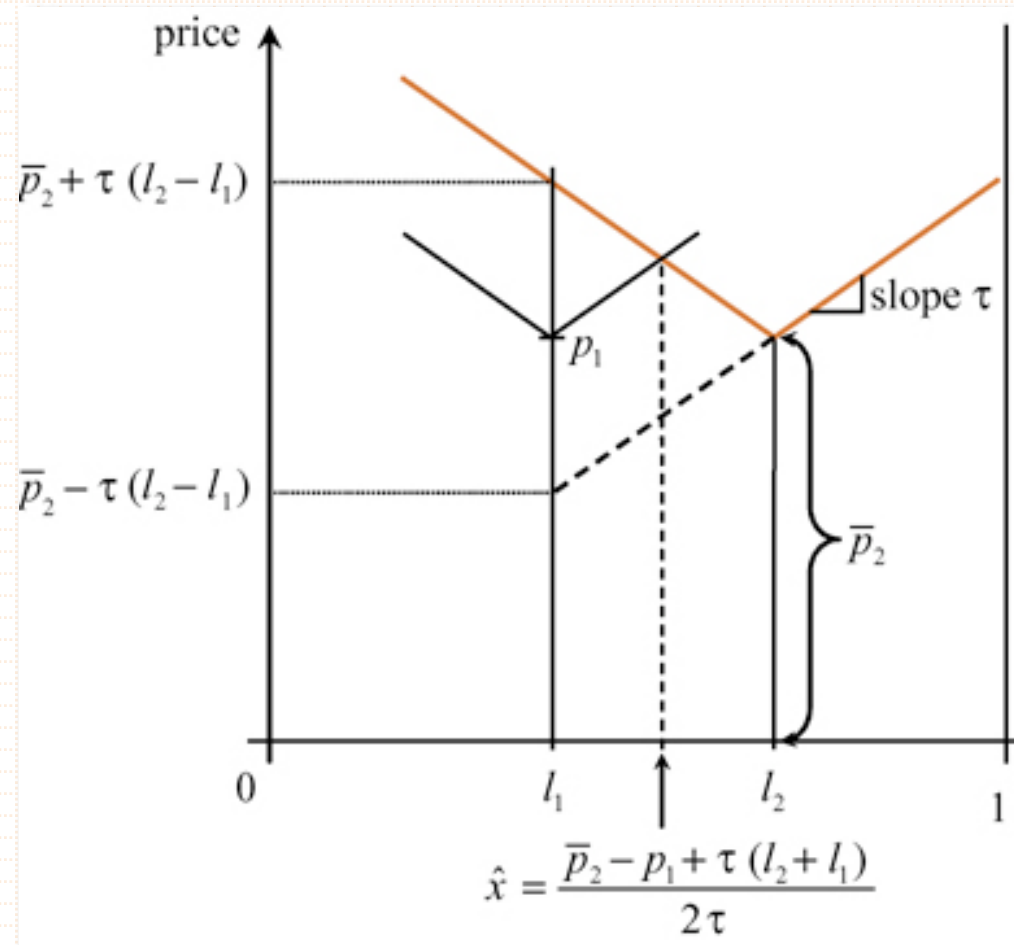
$$r - \tau(\hat{x} - l_1) - p_1 = r - \tau(l_2 - \hat{x}) - p_2 \Leftrightarrow \hat{x} = \frac{l_1 + l_2}{2} - \frac{p_1 - p_2}{2\tau}$$

- 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 price difference is “*too large*”?
 - Discontinuity in demand:

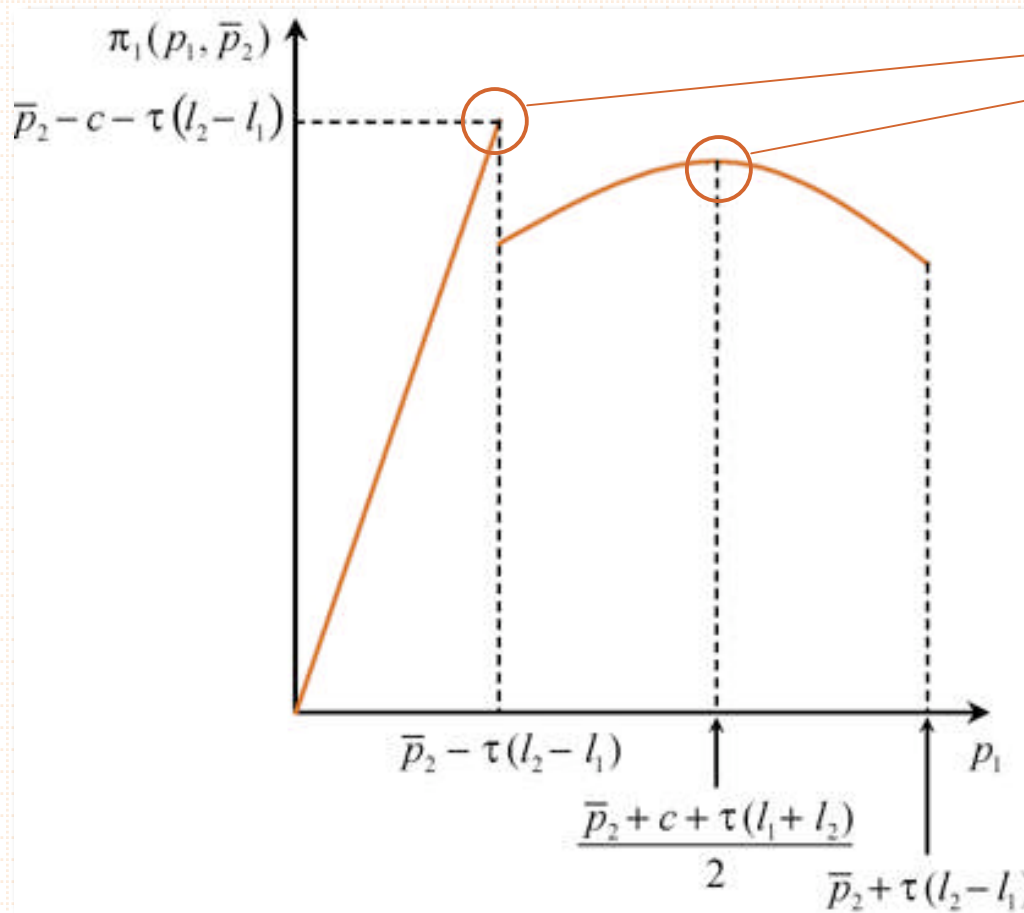
for $p_1' > p_2 + \tau(l_2 - l_1)$, no demand for firm 1

for $p_1 < p_2' + \tau(l_2 - l_1)$, no demand for firm 2

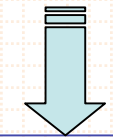
- Profits

$$\pi_1(p_1, p_2; l_1, l_2) = \begin{cases} 0 & \text{if } p_1 > p_2 + \tau(l_2 - l_1), \\ (p_1 - c) \left(\frac{l_1 + l_2}{2} + \frac{p_2 - p_1}{2\tau} \right) & \text{if } |p_1 - p_2| \leq \tau(l_2 - l_1), \\ (p_1 - c) & \text{if } p_1 < p_2 - \tau(l_2 - l_1). \end{cases}$$

Linear Hotelling model (cont'd)



2 local suprema
 → π_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
 - 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: transport costs increase with the square of distance

$$v_i(x) = r - \tau(x - l_i)^2 - p_i$$

- Indifferent consumer

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

- Price stage

$$\max_{p_1} (p_1 - c)\hat{x}(p_1, p_2) \text{ and } \max_{p_2} (p_2 - c)[1 - \hat{x}(p_1, p_2)]$$

$$\begin{aligned} \rightarrow p_1^* &= c + \frac{\tau}{3}(l_2 - l_1)(2 + l_1 + l_2) \\ p_2^* &= c + \frac{\tau}{3}(l_2 - l_1)(4 - l_1 - l_2) \end{aligned} \quad (\text{unique price equilibrium})$$

Quadratic Hotelling model (cont'd)

- Location stage

$$\begin{aligned} \hat{\pi}_1 &= \frac{1}{18} \tau (l_2 - l_1) (2 + l_1 + l_2)^2 & \rightarrow & \partial \hat{\pi}_1 / \partial l_1 < 0 \text{ for all } l_1 \in [0, l_2) \\ \hat{\pi}_2 &= \frac{1}{18} \tau (l_2 - l_1) (4 - l_1 - l_2)^2 & \rightarrow & \partial \hat{\pi}_2 / \partial l_2 > 0 \text{ for all } l_2 \in (l_1, 1] \end{aligned}$$

- Subgame perfect equilibrium: firms locate at the extreme points → maximum differentiation
- 2 forces at play
 - **Competition effect** → differentiate to enjoy market power
→ drives competitors apart
 - **Market size effect** → meet consumers preferences
→ brings competitors together
 - *Balance* depends on distribution of consumers, shape of transportation costs function and 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

$$r - p_i + \theta s_i$$

Vertical product differentiation (cont'd)

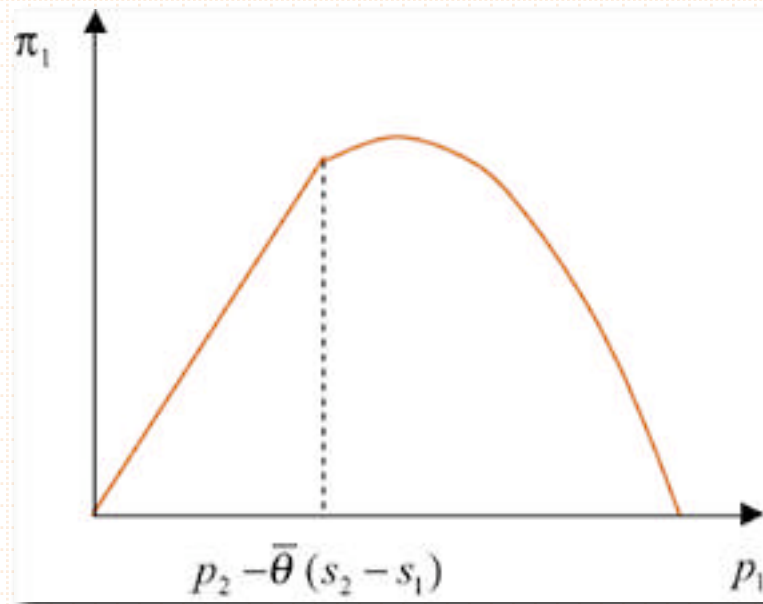
- Firms
 - Duopolists
 1. Choose quality: s_1, s_2
 2. Choose price: p_1, p_2
 - Constant marginal cost, $c = 0$
- Price stage
 - Suppose $s_1 < s_2$
 - Indifferent consumer is determined by the ratio of price and quality differences:

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

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)

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

$$\tilde{\pi}_1(s_1, s_2) = \frac{1}{9}(\bar{\theta} - 2\underline{\theta})^2(s_2 - s_1)$$

$$\tilde{\pi}_2(s_1, s_2) = \frac{1}{9}(2\bar{\theta} - \underline{\theta})^2(s_2 - s_1)$$
 - 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.

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



VS



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

Ed Iacobucci,
CEO of DayJet Corp.

Adam Aircraft A700

More expensive
Has a lavatory

Eclipse 500

Less expensive
No lavatory

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.
 - Intuition from previous model
 - Recall equilibrium prices:

$$p_1^* = \frac{1}{3}(\bar{\theta} - 2\underline{\theta})(s_2 - s_1), p_2^* = \frac{1}{3}(2\bar{\theta} - \underline{\theta})(s_2 - s_1)$$
 - Does not hold if

$$\bar{\theta} \leq 2\underline{\theta}$$
 - In that case, if entry cost (however small), low-quality firm does not enter → natural monopoly
 - Can be generalized to an n -firm oligopoly (see book)

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
 - Indirect utility function for a homogeneous good

$$v_i = r - p_i + \varepsilon_i = \bar{v}_i + \varepsilon_i \text{ where } E\varepsilon_i = 0$$

'Observable' or
'measured' utility

Reflects the preferences of
a subpopulation for good i
in expectation

- Binary discrete choice model
 - Consumers face 2 alternatives, 1 and 2
 - Denote e_i the realization of ε_i
 - Choose alternative i if

$$\bar{v}_i - \bar{v}_j > e \text{ with } e = \text{realization of } \varepsilon = \varepsilon_1 - \varepsilon_2, \text{ and } E\varepsilon = 0$$

Probabilistic choice and the logit model (cont'd)

- **Binomial logit**
 - Assume that $\varepsilon = \varepsilon_1 - \varepsilon_2$ is logistically distributed

$$F(e) = 1 / [1 + \exp\{-e / \mu\}]$$

- Probabilistic demand is then of the form

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

- **Multinomial logit**
 - Extension to n products

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

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:

$$c_i = \kappa w_i + \omega_i$$

Relevant observable product characteristics on the cost side

mean cost derived from unobserved characteristics

Empirical analysis of horizontal differentiation

- Estimation of the model

- Firm i 's profits: $\pi_i = (p_i - c_i)M\alpha_i$

- From F.O.C.:

$$p_i = c_i + \frac{\alpha_i}{|\partial\alpha_i / \partial p_i|} = \kappa w_i + \frac{\alpha_i}{|\partial\alpha_i / \partial p_i|} + \omega_i = \kappa w_i + \frac{1}{\gamma} \frac{\alpha_i}{\partial\alpha_i / \partial \bar{v}_i} + \omega_i$$

- Using multinomial logit:

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

- Can be jointly estimated with

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

Extension: the nested logit model

- Limitations of the logit model
 - Restrictions are imposed on substitution patterns.
 - May be unrealistic
 - Example: product introduction in the family van segment has different effects on the market share of a car in that segment or on an SUV.
- Possible answer: **nested logit model**
 - Group different products together in different nests.
 - Consumers select first among nests and then within the selected nest.

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.)