Product Differentiation: Part 2

Sotiris Georganas

Royal Holloway

February 2012

Horizontal product differentiation

- Recall the distinction between vertical and horizontal product differentiation.

Definition

In a vertically differentiated product space commodities differ in quality and all consumers agree on the preference ordering of the commodities.

Definition

In a horizontally differentiated product space the consumers do not agree on the preference ordering; if all commodities are sold at the same price the optimal choice depends on the particular consumer.

- Will examine address models.

Definition

Address models are models in which consumers view each firm's product as having a particular address/location in a product space and where consumers also differ in their location; the adress of a consumer defines her most preferred product.

- Location is a *metaphor* for a one dimensional characteristic.
  - Ice cream stands on a beach, brands of cola (assuming only e.g. sweetness matters)
- The closer two products are in the product space, the *closer substitutes* they are.

- Each consumer has some version that she prefers the most – her *ideal product*. This ideal is also represented by a *location* and the consumer buys the product closest to her ideal if priced equally.
- Since consumers close to a producer are unlikely to buy from a different producer, firms have some degree of *monopoly power*.
- In address models, competition tends to be *localized*:
    - An increase in the price for one product does not impact on the demand for products that are far away (i.e. very different) but will impact on the demand for products in its neighborhood (i.e. very similar).
    - Conversely, the demand for a given product is only affected by the prices of goods in its neighborhood, not by the prices of remote products.

- Address models also require us to specify *how consumers are distributed* in the product space.
  - Are consumers particularly keen on some particular product type or are they more evenly spread in their preferences?
- We also need to specify how willing the consumers are to trade off characteristics for price.
  - How much utility does a consumer lose from buying a product that does not match her ideal?

Questions to be considered

1. Does product differentiation *create market power*?
2. *How much* will firms *choose* to differentiate their products?
3. What are the *welfare implications* of product differentiation? Does the market overprovide or underprovide variety? What determines prices in a differentiated market?

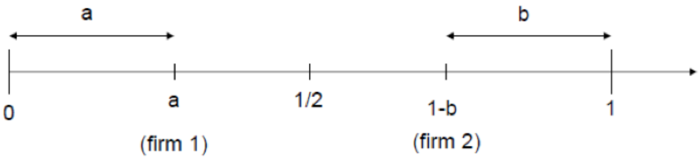
Hotelling's (1929) location model

- Best known model of horizontal product differentiation (aka "linear city model").
- Focus on the case with two given firms.
  - CW discuss cases with (i) more firms, and (ii) free entry.
- Basic features
  - Two firms at different locations in a product space (no entry).
  - Consumers also have locations and incur utility loss ("transportation costs") from consuming a product that is not their ideal.

- We will analyze:
  1. Location choice with fixed prices.
  2. Price setting with fixed locations.
  3. Location choice prior to price setting.

Model specification

- **Product space**: The unit interval.
- Two **firms**, $i = 1, 2$. Use y to denote location of firms
  - Location of firm 1 is $y_1 = a$ (i.e. a measures distance from the *left* city boundary)
  - Location of firm 2 is $y_2 = 1 - b$ (i.e. b measures distance from the *right* city boundary)
  - Label the firms so that firm 1 is the one closest to the left boundary: $a \leq 1 - b$.
  - Each firm has constant marginal cost c.



- A continuum of consumers, they all buy one unit of the good.
- Consumers characterized by preferences: Uniformly distributed on the product space.
- Let x denote the address/location of a typical consumer.
- Preferences/trade-off: Let V denote the utility from consuming the *ideal version*. Two costs to the consumer: (i) the price paid p, and (ii) a "*mismatch cost*" from not consuming the ideal version.
- Two common specifications of preferences
  - Linear mismatch cost: $V - p - k\left(|x-y|\right)$
  - Quadratic mismatch cost: $V - p - k\left(x-y\right)^2$
- The parameter $k > 0$ measures the strength of preferences; the larger is k the less consumers are willing to purchase non-ideal products.
- We will focus on the latter quadratic specification.

Model specification

Demand

- Each consumer chooses the product that maximizes her utility. The consumer located at x will buy from firm 1 if

$$V - p_1 - k\left(x - a\right)^2 \geq V - p_2 - k\left(x - \left(1 - b\right)\right)^2 \tag{1}$$

or, equivalently,

$$p_2 - p_1 \geq k\left(x - a\right)^2 - k\left(x - \left(1 - b\right)\right)^2 \tag{2}$$

and will buy from firm 2 otherwise.

- Characterize the indifferent consumer type, denoted $\bar{x}$, satisfies

$$p_2 - p_1 = k\left(\bar{x} - a\right)^2 - k\left(\bar{x} - \left(1 - b\right)\right)^2 \tag{3}$$

Benchmark case 1: Exogenously fixed prices

- Assume that the firms are required, by government regulation, to set the same price p (which exceeds the marginal cost c).

Question

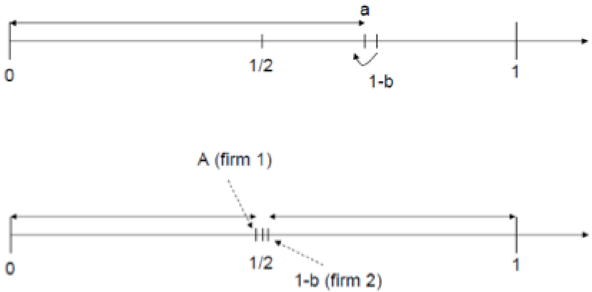
How do the firms choose locations?

Insight

Since each firm makes a profit $p - c$ on each unit sold, each firm chooses a location to maximize its demand given the location of the other firm.

- What location outcomes does this Nash competition lead to?

- Consider the best response of firm 1 to a given location of firm 2. Best response is to locate right next to firm 2, on the side with the longest interval!



Benchmark case 1: Exogenously fixed prices

Best response and equilibrium

- E.g. assume that $b < 1/2$ so that firm 2 is strictly on the right half of the city. Then firm 1's best response is to left of firm 2.
- But this cannot be an equilibrium: firm 2 would be better off locating just to the left of firm 1!
- Both firms thus gravitate to the centre of the city! The *unique Nash equilibrium* is $a = b = 1/2$.

Result

Exogenous prices generate minimal product differentiation.

Intuition

When prices are fixed, the firms have no reason to differentiate themselves in order to soften the price competition; hence they try instead simply to position themselves so as to attract the largest number of customers. This leads to "clustering" in the center.

- Minimum differentiation is not surprising given that we have shut down price competition.
- This result is known as the **principle of minimum differentiation**.
    - Which explains for example why politicians often look somehow similar
        - Also known as the cloned candidates effect
        - See Futurama, "A head in the polls"

- However, it should be noted that minimum differentiation is not a robust result.
  - E.g. if there are more than two firms it breaks down: with four firms, two firms locate at $y = 1/4$and two at $y = 3/4$(see CW), thus leading to "differentiation with bunching".
    - You get two sets of clones

Benchmark 2: Price setting with fixed location

- Need to consider how firms compete in prices!
- Will start by considering price competition with fixed locations, i.e. for a given degree of product differentiation.
- We will discuss the most interesting case later on – endogenous locations and prices.

- Assume fixed locations. Specifically assume that the firms are **at the end-points** $a = b = 0$.
- A consumer located at x buys from firm 1

$$V - p_1 - k\left(x\right)^2 \geq V - p_2 - k\left(x-1\right)^2 \tag{4}$$

and buys from firm 2 otherwise.

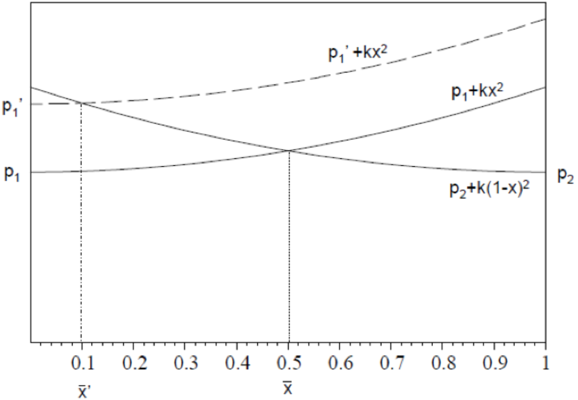
- What is the address of the consumer who is indifferent?

$$p_1 + k\bar{x}^2 = p_2 + k\left(\bar{x}-1\right)^2 \tag{5}$$

which has a very simple unique solution

$$\bar{x} = \frac{1}{2} + \frac{p_2 - p_1}{2k} \tag{6}$$

Hence, if prices are equal, $\bar{x} = 1/2$. If $p_1 < p_2$, then $\bar{x} > 1/2$ (i.e. more consumers buy from firm 1 than from firm 2)



- The larger k is the less $\bar{x}$ moves in response to prices. Hence, the stronger preferences are for product type, the less mobile are consumers across the two producs in response to relative prices.

- From the identity of the critical consumer, we obtain the demands
  - Demand facing firm 1 (consumers below $\bar{x}$)

$$D_1(p_1, p_2) = \bar{x} = \frac{1}{2} + \frac{p_2 - p_1}{2k}. \tag{7}$$

  - Demand facing firm 2 (consumers above $\bar{x}$)

$$D_2(p_1, p_2) = 1 - \bar{x} = \frac{1}{2} + \frac{p_1 - p_2}{2k}. \tag{8}$$

- From the demands we obtain the firms' profits
  - Profit for firm 1

$$\pi_1(p_1, p_2) = (p_1 - c) D_1(p_1, p_2) = (p_1 - c)\left[\frac{1}{2} + \frac{p_2 - p_1}{2k}\right] \quad (9)$$

  - Profit for firm 1

$$\pi_2(p_1, p_2) = (p_2 - c) D_2(p_1, p_2) = (p_2 - c)\left(\frac{1}{2} + \frac{p_1 - p_2}{2k}\right) \quad (10)$$

- Consider now the Bertrand-Nash price-setting equilibrium.
- Firm 1's *best response* to firm 2 setting price p_2 the price p_1 which maximizes π_1 given p_2

$$\frac{\partial \pi_1 (p_1, p_2)}{\partial p_1} = \left(\frac{1}{2} + \frac{p_2 - p_1}{2k} \right) - (p_1 - c) \frac{1}{2k} = 0 \qquad (11)$$

- Note that the idea here is the same as in the quality differentiation game: increasing p_1 has two effects (i) it increases the markup $(p_1 - c)$ which increases the profit from each sold unit, and (ii) it decreases the demand. Hence the first term is the demand, and the second is the markup factor multiplied by the change in demand.

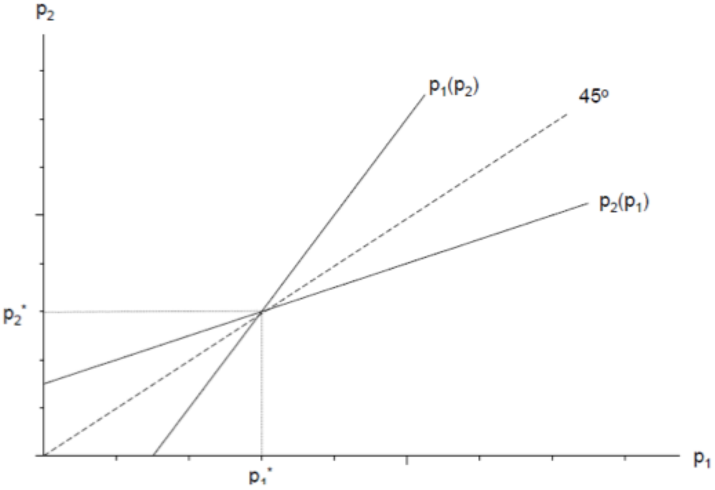
- Solving for the **best response** (i.e. the choice of p_1 as a function of p_2) yields

$$p_1(p_2) = \frac{1}{2}(k + c + p_2) \tag{12}$$

- Similarly, firm 2's best response can be shown to be

$$p_2(p_1) = \frac{1}{2}(k + c + p_1) \tag{13}$$

- Note that the two best response functions are upward sloping. The price choices are *strategic complements*. The higher is the price set by firm 2, the higher is the price that firm 1 will want to set!



p2
p1(p2)
45o
p2(p1)
p2*
p1*
p1

Benchmark 2

Equilibrium prices with fixed locations

- Having derived the best response functions, we can now characterize the Bertrand-Nash price setting equilibrium.
- What are the equilibrium prices? A pair $\left(p_1^*, p_2^*\right)$ such that $p_1^* = p_1\left(p_2^*\right)$ and $p_2^* = p_2\left(p_1^*\right)$.
- Note that this model (unlike the quality model) is symmetric. Hence we can expect to find a symmetric equilibrium.

- Indeed, solving yields

$$p_1^* = p_2^* = k + c \tag{14}$$

- Hence
  - Each firm serves *half the market*; in equilibrium the critical consumer is $\bar{x}^* = 1/2$.
  - Each firm sets a price larger than c; the markup $p_i^* - c$ is hence positive and each firm makes *positive profits*.
  - The profits for each firm is

$$\pi_i^* = (p_i^* - c)\, D_i\left(p_1^*, p_2^*\right) = (p_i^* - c)/2 = k/2 \tag{15}$$

- The markup $p_i^* - c$ is equal to k; hence the stronger are the consumers' preferences, the larger is the markup and, hence, also each firm's profits.
- Intuitively, product differentiation yields more "local" monopoly power and hence more profit opportunities to the firms the less willing are the consumers to substitute among the products.

- What would have happened if the two firms where not at the boundaries of the city?
    - Suppose each firm is at an equal distance from "its" boundary: $0 < a = b < 1/2$.
    - Then prices are still symmetric, but they are lower. Similarly, profits are lower.
    - Indeed, in the limit as $a, b \to 1/2$ (so that there is no differentiation), $p_i^* \to c$ and profits disappear. (standard Bertrand equilibrium with homogenous products).
- Is locating at the boundaries an equilibrium?

Main model: Choosing location and price

- Model with endogenous locations and Bertrand-Nash price competition.
- Timing
  - Firms choose locations;
  - Firms choose prices;
  - Consumer choose whom to buy from.

- Consider again the model with two firms.
- We will not solve this model explicity (neither does CW). We will draw on the intuition from the two above benchmark cases.
- Consider arbitrary locations a and $1 - b$ such that $a < 1 - b$ (i.e. firm 1 is to the left of firm 2).
- What would be the effect of firm 1 moving slightly further to the right (i.e. close to firm 2)?

- The two above benchmark cases suggest that there will two effects
  1. At given prices moving to the right *increases firm 1's demand* since it can capture some of firm 2's consumers. This is a *demand effect.*
  2. However, moving to the right also reduces the differences between the products and *intensifies the price competition*, with both firms lowering their prices as a result. This is a *strategic effect*. Since prices are strategic complements, firm 1's price will also fall.
- With the quadratic specification, the strategic effect dominates. Hence in equilibrium there is *maximal product differentiation*.
- Thus we once again arrive at the *principle of differentiation*: the firms want to differentiate their products in order to soften the price competition.

Historical note

- The original model in 1929 had linear costs and Hotelling claimed it leads to minimum differentiation. Big mistake. Consider the subgame after locations are chosen...
- D'Aspremont, Gabszewicz and Thisse showed in 1979 (50 years later) that actually, only when the firms are located in exactly the same location is existence of an equilibrium guaranteed (with Bertrand prices!)
    - ...if they are close, but not in the same spot, **there is no equilibrium.** Intuition: the profits and the best response functions are not continuous.
        - continuity of BR is a condition that guarantees existence of Nash equilibrium

Efficiency

- What is the socially optimal outcome in the simple Hotelling model with two firms/products?
- We can ignore
  - profits (since they are simply transfers from consumers).
  - Production costs (since they are independent of location/prices)
- Hence, what remains are the mismatch costs.
- Given that two brands are produced, what locations would minimize total mismatch costs?

Efficiency

- The answer is simple: $a = b = 1/4$.

Result

With competition in locations and prices, there is excessive product differentiation.

Strategic Product Differentiation

- Consider a monopolist facing the threat of entry from a rival. A rival may consider introducing a differentiated product.
- What can the incumbent do to prevent entry?
  - If the incumbent can introduce multiple brands/products, then the incumbent may introduce suffiently many different products so that no further niches or locations are available that will support profitable entry.
- Such a strategy is known as strategic *brand proliferation* or *("spatial preemption")*

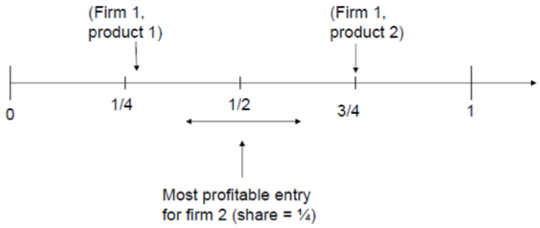
Strategic Product Differentiation
Example (from Cabral)

- Between 1950 and 1970, no entry in breakfast cereal industry despite significant profits.
- Four incumbents (Kelloggs, General Foods, General Mills, Quaker Oats).
- The number of brands increased from 25 to 80 (and still increasing).
- Suggests strategic brand proliferation.

- In equilibrium, the incumbent places more varieties on the market than it would have done, had it not been threatened by entry.
- Requirement for the strategy to work:
  - Relies on *commitment not to withdraw* brands should entry occur.
  - More plausible is there are fixed/sunk costs associated with introducing a new variety.

- Analyze in terms of Hotelling model with fixed prices $p_i = \bar{p}$.
- Assume one firm (the "incumbent") moves first; firm 2 moves second.
- Let F be the fixed cost of creating a variety and assume that $F < \bar{p}/2$. Ignore variable costs, $c = 0$.
- What if either firm can only produce one variety?
  - Firm 1 will choose to locate at the centre of the city $(a = 1/2)$. That way, it can guarantee to serve half the city (at least).
  - Firm 2 will also enter and locate next to firm 1.
  - Since $\bar{p}/2 > F$ both firms make positive profits.

- Suppose now that a firm can introduce *more than one variety*. And suppose that firm 1 introduces two varieties: one at $y = 1/4$ and one at $y = 3/4$.
- Then no matter where firm 2 enters, a new variety cannot capture more than $1/4$ of the market (e.g. by locating at the centre $1/2$).



- If $F > \bar{p}/4$ firm 2 cannot enter and make positive profits.
- Entry has been deterred by brand proliferation.
- If firm 1 had not faced threat of entry it would only have produced one variety.

What to remember from the two lectures on product differentiation

- What is product differentiation
- Taxonomy of product differentiation.
- Upward sloping reaction functions in Bertrand competition with differentiated products.
- The interaction between vertical product differentiation and market structure.
- Horizontal product differentiation
- Location model representation of product characteristics and tastes.
- The effect of price regulation (minimum product differentiation).
- Strategic location choice (excessive product differentiation).
- The notion of strategic product differentiation