Industrial Organization 04

Product differentiation

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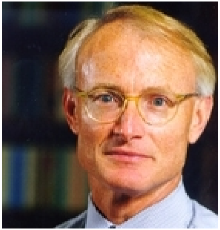
Outline

1. Introduction: forms of product differentiation
2. Models of horizontal differentiation:
   - The Hotelling model (exogenous locations, endogenous locations)
   - The Salop model (circular city, equilibrium with free entry)
3. Model of vertical differentiation

Introduction

Michael Porter (Competitive advantage, 1986)

Competitive advantage stems from the many discrete activities a firm performs in designing, producing, marketing, delivering and supporting its product. Each of these activities can contribute to a firm's relative cost position and create a basis for differentiation.



A competitive advantage should be

- Significant and rare
- Defendable

Introduction

Three forms of competitive advantage:

- Differentiation
- Costs
- A combination of the two

Two ways of acquiring a competitive advantage by differentiation :

- By creating a real difference between products
- By identifying or influencing the preferences of consumers (ex: advertising)

Forms of differentiation

Different forms of product differentiation:

"Horizontal" differentiation:

- Different varieties (different tastes)

"Vertical" differentiation:

- Different qualities (consumers agree on the ranking of the goods in terms of quality)

The Lancaster approach:

- A good as a bundle of characteristics

Forms of differentiation

Different possibilities of differentiation :

- The product (form, style, design, reliability, etc.), the service (order, delivery, installation, etc.), the personel, the point of sale, the brand image (symbols, events, etc.).
- Notion of "positioning" in marketing. Branding strategy. Consumer must be able to identify the characteristics of the product with respect to its needs.

Forms of differentiation

We will try to answer the following questions:

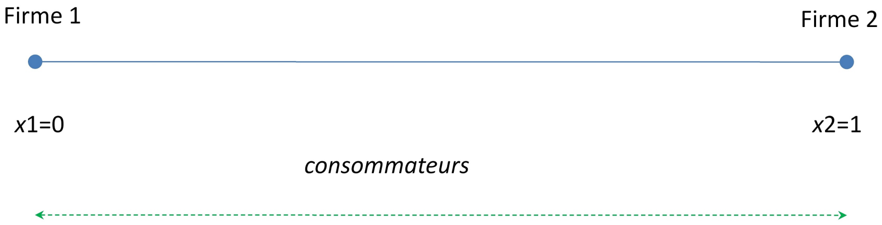
- What is the effect of differentiation on competition between firms?
- When differentiation is endogenous, what is the equilibrium? Do firms actually choose to differentiate themselves?
- Are products offered in equilibrium close to each other or distant?
- What are the effects of differentiation on new entrants?

The Hotelling model (1929)

- A "street" or a "space of tastes" represented by the interval $[0, 1]$
- Consumers are distributed uniformly along this interval. They are represented by a mass of 1.
- In this "street", two firms sell a good (the same good)
- Firms compete in prices
- Marginal cost of production c
- Consumers buy 0 or 1 unit of the good
- Utility of the good for a consumer: v
- $\rightarrow$ But there is a transportation cost the consumer pays to get the good: t per unit of distance, quadratic function
- Thus, the net utility is $v - p -$ transportation cost.

Exogenous location of firms

Firm 1 at $x_1 = 0$ and firm 2 at $x_2 = 1$



Exogenous location of firms

Method to calculate demand: determine the indifferent (marginal) consumer.

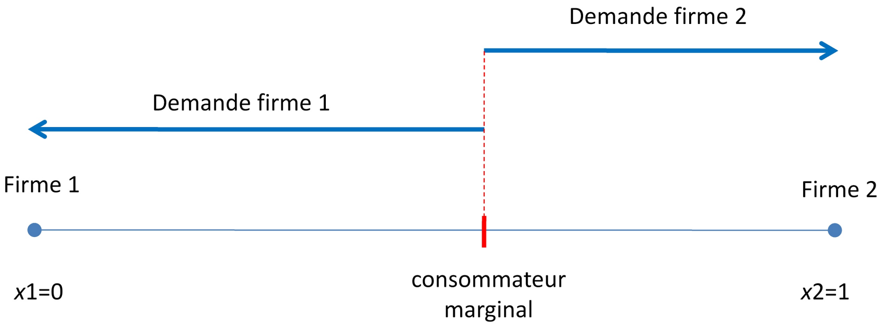
Definition of the marginal consumer

In the presence of consumers with heterogeneous tastes, it designates the consumer who is indifferent between two possible choices.

Here: the marginal consumer is indifferent between *buying from the firm 1* and *buying from the firm 2*.

Where does the marginal consumer is approximately located?

Exogenous location of firms



Exogenous location of firms

- The marginal consumer $\widetilde{x}$ is defined by

$$v - \left(p_1 + \left(\widetilde{x} - 0\right)^2 t\right) = v - \left(p_2 + \left(1 - \widetilde{x}\right)^2 t\right),$$

that is,

$$\widetilde{x} = \frac{1}{2} + \frac{p_2 - p_1}{2t}.$$

- From this, we derive the demand of firm 1 (if prices are not too different)

$$D_1\left(p_1, p_2\right) = \frac{1}{2} + \frac{p_2 - p_1}{2t},$$

- The demand of firm 2 is then $D_2 = 1 - D_1$.

Exogenous location of firms

We start by defining the:

Profit functions

$$\pi_i = (p_i - c)\left(\frac{1}{2} + \frac{p_j - p_i}{2t}\right)$$

- Firm i maximizes its profit π_i by taking the price p_j as given.
- The first order condition gives the optimal price for firm i as a function of the price p_j.

→ It is the reaction function of firm i (or the best-response function).

Reaction function of firm i

$$p_i = R_i(p_j) = \frac{c + t + p_j}{2},$$

Exogenous location of firms

The Nash equilibrium corresponds to the intersection of the reaction curves.

We have

$$p_i = R_i(R_j(p_i)),$$

where

$$p_i = R_i(p_j) = \frac{c + t + p_j}{2}.$$

What is the equilibrium price?

Equilibrium price

$$p^\star = c + t$$

Exogenous location of firms

Equilibrium price

$$p^\star = c + t$$

→ The equilibrium price increases with t

Conclusion

When firms' locations are fixed, an increase of the differentiation level (t) increases firms' market power.

When firms choose locations

→ We say that location decisions are endogenous (≠ exogenous).

We study a **two-stage game**:

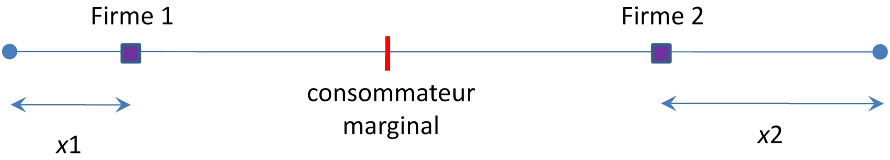
1. Firms choose location
2. Then, they set prices given their locations

We search for the subgame perfect equilibrium. We use backward induction:

- We first find the equilibrium of the price competition (last) stage
- Next, we solve for the equilibrium in the first stage,
- Assuming that firms anticipate that the price competition equilibrium will prevail in the second stage.

When firms choose locations

We assume that firm 1 is located at x_1 of the left end and firm 2 at x_2 of the right end.



Stage 2: price competition

We first determine the demand for given prices.

- The marginal consumer x is given by:

$$v - \left(p_1 + \left(\widetilde{x} - x_1\right)^2 t\right) = v - \left(p_2 + \left(1 - x_2 - \widetilde{x}\right)^2 t\right),$$

that is,

$$\widetilde{x} = x_1 + \frac{1 - x_1 - x_2}{2} + \frac{p_2 - p_1}{2t\left(1 - x_1 - x_2\right)}.$$

- If $0 \leq \widetilde{x} \leq 1$, demands for firm 1 and firm 2 are respectively $D_1 = \widetilde{x}$ and $D_2 = 1 - \widetilde{x}$

Stage 2: price competition

Next, we determine the reaction functions :

- The profit function of firm i ($i = 1, 2$) is:

$$\pi_i = (p_i - c)\left(x_i + \frac{1 - x_1 - x_2}{2} + \frac{p_j - p_i}{2t\,(1 - x_1 - x_2)}\right)$$

- Firm i maximizes its profit with respect to p_i taking its rival price p_j as given
- We find the first order conditions, which gives the reaction functions.

Stage 2: price competition

The intersection of the reaction curves gives the equilibrium prices.

Equilibrium prices at stage 2 are

$$p_1^* = c + t\,(1 - x_1 - x_2)\left(1 + \frac{x_1 - x_2}{3}\right),$$
$$p_2^* = c + t\,(1 - x_1 - x_2)\left(1 + \frac{x_2 - x_1}{3}\right).$$

Stage 1: choice of location

- At stage 1, firm 1 (for instance) chooses her location taking firm 2's location as given
- She anticipates the equilibrium price of stage 2
- Therefore, her profit maximization problem is:

$$\max_{x_1} \left(p_1^*(x_1, x_2) - c\right) D_1\left(x_1, x_2, p_1^*(x_1, x_2), p_2^*(x_1, x_2)\right).$$

- We solve the first order condition $\rightarrow$ it is the **total derivative** of profit π_1 with respect to x_1
- Indeed, the location choice affects profit in two different ways:
  1. Direct effect: π_1 depends on x_1
  2. Indirect effects: π_1 depends on p_1 and p_2, which in turn depend on x_1

Stage 1: choice of location

- We can ignore the effect of x_1 to π_1 because (it is the "envelop theorem")

$$\left.\frac{\partial \pi_1}{\partial p_1}\frac{\partial p_1^*}{\partial x_1}\right|_{p_1=p_1^\star, p_2=p_2^\star} = 0,$$

- Therefore,

$$\frac{d\pi_1}{dx_1} = \left(p_1^*\left(x_1, x_2\right) - c\right)\left(\underbrace{\frac{\partial D_1}{\partial x_1}}_{\text{direct effect }(+)} + \underbrace{\frac{\partial D_1}{\partial p_2}\frac{\partial p_2^*}{\partial x_1}}_{\text{indirect effect }(-)}\right).$$

Stage 1: choice of location

In a game with several stages, we potentially have

- Direct effects: when variables chosen in the first stages directly affect the profit functions,
- Indirect effects (or strategic effects): when variables chosen in the first stages affect the strategies defined in later stages, that in turn affect the profit functions.

Here:

- The direct effect (+) is a market share effect
- The indirect or strategic effect (-) is the intensification of competition

Stage 1: choice of location

We find that the strategic effect (-) always dominates the direct effect of the market share (+)

What are the firms' differentiation strategies in equilibrium?

Perfect equilibrium of the game

In equilibrium, firms choose maximum differentiation.

Within a context of price competition, firms have strong incentives to differentiate themselves in order to soften the competition intensity.

Even though they also have an incentive to "mimetism" in order to capture their rival's market share.

Comparison of social optimum

How the location choices of the firms compare to the social optimum?

Do firms differentiate themselves *too much* or *too little*?

Socially optimal locations are those that minimize production and transportation costs. They are minimized when firms are located at 1/4 and at 3/4.

Therefore, there is too much differentiation.

If prices are exogenous

Let's assume that prices are exogenous (fixed).

What are the firms' locations in equilibrium?

In equilibrium, the two firms produce the same (average) variety $\rightarrow$ there is minimal differentiation.

The example of television

If we apply these results to competition between TV channels on the audience market...

... we find that channels (purely) financed by subscription fees are more differentiated than channels (purely) financed by advertising.

And differentiation is minimum for TV channels financed by advertising.

Are there other dimensions of competition that could modify this result?

- Differentiation in order to reduce competition in quality of TV programs
- Differentiation in order to avoid that the audience switches to the TV channel that places the least ads

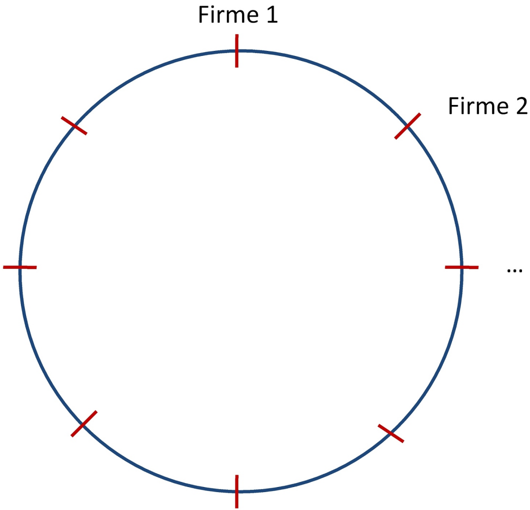
The Salop model (1979)

The Salop model (1979) or circular city model.

- A differentiation cercle of perimeter equal to 1 (a "circular city")
- Consumers are a mass of 1 and are located uniformly around the cercle
- n identical firms on the cercle
- We assume that firms are also located uniformly around the circle
- Marginal cost c
- Firms compete in prices
- We assume a "free entry" condition and we note f the fixed cost of entry

How many firms enter in equilibrium? Are there enough entries or on the contrary too few/too many entries?

The Salop model (1979)



The Salop model (1979)

- We consider a firm i among the n firms
- Firm i has two "rivals" which propose the same price p (symmetry assumption)
- The two rivals are both located at a distance of $1/n$ from firm i
- We start by determining the identity of the indifferent consumer between firm i and its rival located $1/n$ further away:

$$p_1 + t\tilde{x} = p + t(\frac{1}{n} - \tilde{x}),$$

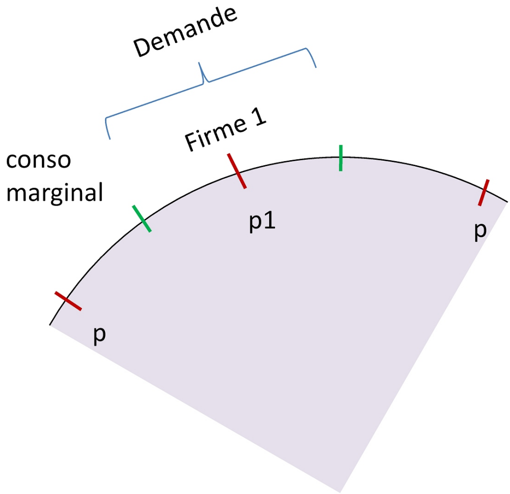
that is,

$$\tilde{x} = \frac{1}{2n} + \frac{p - p_1}{2t}.$$

Therefore, we have

$$D_1(p, p_1) = 2\tilde{x}$$

The Salop model (1979)



Price equilibrium

Firm 1's profit is:

$$\pi_1 = (p_1 - c)\left(\frac{1}{n} + \frac{p - p_1}{t}\right)$$

We solve for the best response function:

$$p_1^\star(p) = \frac{c + p + t/n}{2}$$

We assume a symmetric equilibrium where $p_1 = p$, thus

$$p^\star = c + \frac{t}{n}$$

The equilibrium profit is (with a fixed cost f):

$$\pi^\star(n) = \frac{t}{n^2} - f$$

Equilibrium with free entry

How to find the number of entrant firms in equilibrium?

$\rightarrow$ There are entries as long as the profit of a new entrant is strictly positive.

We find the number of firms n which satisfies the zero-profit condition in order to obtain the number of entrants in equilibrium :

$$n^\star = \sqrt{\frac{t}{f}}$$

Thus, the long-term equilibrium price is

$$p^\star = c + \sqrt{tf}$$

Effect of f ? Effect of t?

Equilibrium with free entry

It can be shown that from the point of view of social welfare there is too much entry.

How can we explain this result?

- Private and social incentives do not match
- Firms may enter and increase the demand but they also steal the rivals' clients (business stealing)

Brand proliferation

Let's take a circular city model.

Could firms decide to increase the number of products to prevent the entry of competitors? (We call it brand proliferation strategy)

For instance, in 1972, the six major firms in the US breakfast cereal market were holding 95% of the market share.

Between 1950 and 1972, they launched more than 80 different brands.

The FTC accused the 4 companies of abuse of dominant position (but lost the case).

Vertical differentiation model

In the horizontal differentiation model, firms produce different types of product but offer the same quality.

Vertical differentiation necessarily implies asymmetries: there are high quality providers and low quality providers.

Does the maximal differentiation principle remain valid?

Vertical differentiation model

- Two firms, 1 and 2, produce goods with different qualities: s_1 and s_2
- Marginal cost of production c
- Production cost of quality is 0
- The firms first choose their product quality then simultaneously choose their prices (two-stage game)
- All consumers value quality but at different levels

$$U_\theta = \begin{cases} \theta s_i - p_i & \text{if it buys from the firm } i \\ 0 & \text{otherwise} \end{cases}$$

- Consumers are uniformly distributed on $\left[\underline{\theta}, \overline{\theta}\right]$, with

$$\underline{\theta} \geq 0 \text{ and } \underline{\theta} + 1 = \overline{\theta}.$$

Vertical differentiation model

Other assumptions:

- $s_2 > s_1$
- We define $\Delta s = s_2 - s_1$
- Enough heterogeneity between consumers: $\overline{\theta} \geq 2\underline{\theta}$ (otherwise the low quality firm is excluded)
- Market covered in equilibrium:

$$c + \frac{\overline{\theta} - 2\underline{\theta}}{3}(s_2 - s_1) \leq s_1\underline{\theta}$$

Vertical differentiation model

This model is solved in the same way as the Hotelling model.

We start by solving the price competition equilibrium in the second stage.

1. We first determine the marginal consumer
2. Which gives the demand functions for each firm
3. We then find the best response functions
4. The intersection of the reaction curves gives the equilibrium prices

Next, we determine the equilibrium quality choices in the first stage.

Vertical differentiation model

The equilibrium prices at the second stage are:

$$p_1^\star = c + \left(\frac{\overline{\theta} - 2\underline{\theta}}{3}\right)\Delta s$$

$$p_2^\star = c + \left(\frac{2\overline{\theta} - \underline{\theta}}{3}\right)\Delta s$$

Vertical differentiation (alike horizontal differentiation) gives market power to firms: $p_1^\star > c$ and $p_2^\star > c$

The price of the firm with high quality (firm 2) is higher than the price of the low quality firm (firm 1) : $p_2^\star > p_1^\star$

The price gap is equal to $p_2^\star - p_1^\star = \Delta s/3$. It increases with the degree of differentiation between firms.

Vertical differentiation model

Let's assume that $s \in \left[\underline{s}, \bar{s}\right]$.

Quality choice?

Equilibrium of the game of vertical differentiation

There are two Nash equilibria such as that one firm proposes the lowest quality and the other proposes the highest quality.

If the game is played sequentially, the firm that plays first chooses the high quality.

We find the same principle of maximal differentiation than in the Hotelling model.

Take-Aways (1)

- Firms seek to stand out from their competitors by elaborating differentiation strategies, which allow them to make higher profits.
- In the Hotelling model with quadratic transportation costs and exogenous locations, firms charge a price equal to the marginal cost plus the transportation cost.
- In the Hotelling model with quadratic transportation costs, if firms choose their locations, then they choose to differentiate themselves as much as possible. This is excessive compared to the social optimum.

Take-Aways (2)

- In the Salop model, the long term equilibrium price (with free entry) is equal to the marginal cost plus the square root of the transportation cost multiplied by the fixed entry cost. Therefore, the more there is differentiation and the higher the entry costs, the higher the price the firms can charge to consumers. There are too much entry compared to the social optimum (brand proliferation strategy).
- Vertical differentiation (differentiation in quality for instance) gives also possibilities to firms to charge higher prices.