BUSINESS ECONOMICS

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ESSEC DSBA - 2021

A few things about me

- An economist: ENSAE Paris graduate (1995), Phd in Economics at TSE (2000), University full professor in Economics (2002).
- A microeconomist: interested in individual behavior (firms and consumers), regulation, and incentives theory.
- An applied researcher: Academic research on net neutrality, termination fees, economics of privacy, data ownership (but also markets for pollution permits, economics of PPP...)
- Consulting/advising for Orange Regulatory Unit since 2007 on networks and digital issues.
- Commissioner for the Autorité Nationale des Jeux (French Gambling Commission).
- Professor at TSE between 2006 and 2020 and now full professsor at ESSEC.
- More on https://sites.google.com/view/wsandz

Course specifics

Resources

- Lecture notes (slides), readings, and exercises
- Textbooks
  - Introduction to industrial organization, Luis Cabral
  - Managerial economics (5th edition), Ivan Png
  - Microeconomics for managers, David Kreps

Organization

- 9 lectures: 1h15, then 30mn break, then 1h15
- No Midterm but a Homework after the 5^{th} session - 20% of the total grade.
- Exam: last session - 80% of the total grade.
- During the lectures we will often solve some exercises together.
- I will propose some texts to read and some exercises to solve between lectures.
- Assistantship will be done by Ayushi SARRAF (b00765892@essec.edu) every other Monday 4pm30 (starting week 2).

Introduction to the Course

- Business Economics focuses how firms make their decisions, and how those decisions are affected by the market structure they operate in.
- What types of decisions?
  1. Short run decisions: price and quantities.
  2. Medium run decisions: technical organization, internal organization
  3. Long run decisions: R&D, entry, exit
- What types of possible market structures?
  1. Monopoly
  2. Oligopoly
  3. Perfect Competition

Introduction to the Course

1. A monopoly is a firm that offers a very specific product, and is not really constrained by potential competitors.

   Ex: Electricity in many countries, infrastructures, innovative firms, platforms?

   Many firms try to make their products appear as very specific to avoid competing head-to-head with others.
2. An oligopoly is a situation where a few firms operate either on the same market or propose substitutable goods

   Ex: Supermarkets, computer manufacturers, car manufacturers, beer brewing firms.

   In this situation, firms' behaviors are interdependent.
3. Perfect competition corresponds to cases where the market conditions appear as exogenous to each (small) firm.

   Ex: Oil tanker shipping, agricultural products.

Introduction to the Course

Two main parts in this course

1. Explain firm's behavior in various competitive settings.
   How?
   Why?
2. Look more closely at issues arising in digital markets.
   We will use the main ideas developed in the first part.
   But they will be adjusted to fit digital markets..

The Road Map

1. Basics Microeconomics and Competition (Week 1).
2. Monopoly Behavior (Weeks 2 and 3).
3. A primer on Game Theory (Week 4).
4. Oligopoly Behavior (Week 5).
5. Network Effects (Week 6).
6. Platforms and Two-Sided Markets (Week 7)
7. The Economics of Privacy (Week 8)
8. Antitrust in Digital Industries (Week 9)

A brief history of industrial organization

The 1800's was a period of extensive growth and the new inventions of the Industrial Revolution. The government of the United States at first encouraged the growth of big business to benefit from economies of scale

- Emergence of powerful trusts that could fix prices and make excessive profits (the "robber barons")
- Influence over politicians which led to even greater economic benefits for the trusts in terms of tariffs (taxes), discriminatory railroad rates or rebates

At the end of the 19^{th} century, big trusts were seen as a threat and US authorities started to challenge the power acquired by big corporations organized in trusts

Senator John Sherman

> *If we will not endure a king as a political power, we should not endure a king over the production, transportation, and sale of any of the necessities of life.*

A brief history of industrial organization

Sherman Act (1890) is the oldest antitrust legislation, whose purpose was to reduce the power of the big trust and to prohibit anti-competitive practices

Legislation has been subsequently amended and completed, notably by the Clayton Act (1914) which forbids some forms of price discrimination, exclusive dealing agreements, ...

Role of economics

- Provide guidance on the practices
- Assess their impact on competition, consumers and welfare

Note that there are different ways to look at industries, with different policy implications.

A brief history of industrial organization

The Harvard Tradition (1940-1960)

- US vs US Steel (1920)
  - The Court found U.S. Steel innocent of antitrust violations . . . even though U.S. Steel's market share was around 70%!
  - "The law does not make mere size an offense or the existence of unexerted power an offense"

→ Research agenda for Harvard economists: How can we infer illegal behavior from either firm size, or other structural features?

- Structure→Conduct→Performance approach
  - Structure (number of sellers, differentiation, cost, . . .) determines Conduct (firms behavior: prices, investment decisions, . . .), which in turn determines Performance (profits, consumers' surplus, social welfare).
  - Argued that high concentration was bad for consumers and paved the way for much antitrust legislation
  - Main weaknesses: (i) assume that structure (concentration) is exogenous; (ii) assume away important differences between industries

A brief history of industrial organization

The Chicago School (1960-1980)

- Starting point
  - Firms with larger market shares tend to earn bigger profits
  - According to Harvard economists, this indicates that more concentrated markets are less competitive
  - But it could just be that firms with larger market shares are more efficient (lower costs), and therefore earn more profits

→ Monopoly is much more often alleged than confirmed. Entry (or just the threat of entry) is important. And when a monopoly does exist, it is often transitory

- Conduct→Performance→Structure approach
  - Emphasis on how (free) entry "regulates" the market
- Main weakness: lack of a convincing toolbox to establish their claims

A brief history of industrial organization

The Post-Chicago approach (or new IO, 1980-)

- Emphasis on strategic decision making: if a firm changes its actions, then this will likely lead its rivals to change their behaviors
- Modeled mathematically using game theory concepts, to provide a formal framework to go beyond the old Harvard-Chicago debate
- Produces a proliferation of models which are often very intuitive theoretically.
- However, it is difficult to know which model is the right one for a real world industry, which effects are second-order, ...

The new empirical IO (1990-)

- Combines theory and econometrics in a serious way
- Sophisticated, computationally intense, complex empirical models

Rmk: the emphasis put on prices by Post-Chicago economists has been challenged by some lawyers (as Lina Khan), in particular to control Big-Tech Giants.

Basics Microeconomics

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The Demand Curve

- I will first review the standard (and basic) concepts of microeconomics and then I will briefly talk about perfect competition in markets.
- When studying firm behavior, it is important to consider the nature of the demand function.
- This function says how much the firm(s) can sell for each level of price.
- It is a consequence of individual behavior, and its shape (it is decreasing in price), follows from the idea of decreasing marginal utilities.
- If one draws the maximum price consumers are willing to pay for an additional unit as a function of the units already consumed, we obtain the **inverse demand curve**.
- As marginal utility is decreasing, this relationship is decreasing.

The Demand Curve

- Simple example of inverse demand curve: $P = a - bq$ with P the maximum price, q the quantity and $a > 0$, $b > 0$.

Rmk 1: at the individual level, this relationship is obtained by maximizing utility with respect to quantity for given level of price.

A representative consumer with utility function $U(q) + x$, q being the units of good and x the unit of numerary, has a demand function given by $U'(q) = p \Leftrightarrow q(p) = U'^{-1}(p)$.

Rmk 2: at the aggregate level, we sum the individual demand curves to obtain the (almost continuous) aggregate demand curve.

- What can we do with such a curve?
  1. One can forecast the level of demand of each price.
  2. One can compute the consumer surplus for each level of price.

The Demand Curve

- The demand curve is useful to forecast how demand will change when prices change so it is fundamental for business economists.
- To define this change independently of the unit, it is common to define the **demand price elasticity**.

Definition

The demand price elasticity, denoted ϵ, is defined as the percent variation of quantity demanded divided by the percent variation in price. $\epsilon \equiv -\frac{dq}{dp}.\frac{p}{q}$

- For small changes in p, a reasonable approximation is given by $\epsilon \approx -\frac{\Delta q/q}{\Delta p/p}$.

The Demand Curve

- This elasticity may change with the number of goods already consumed.

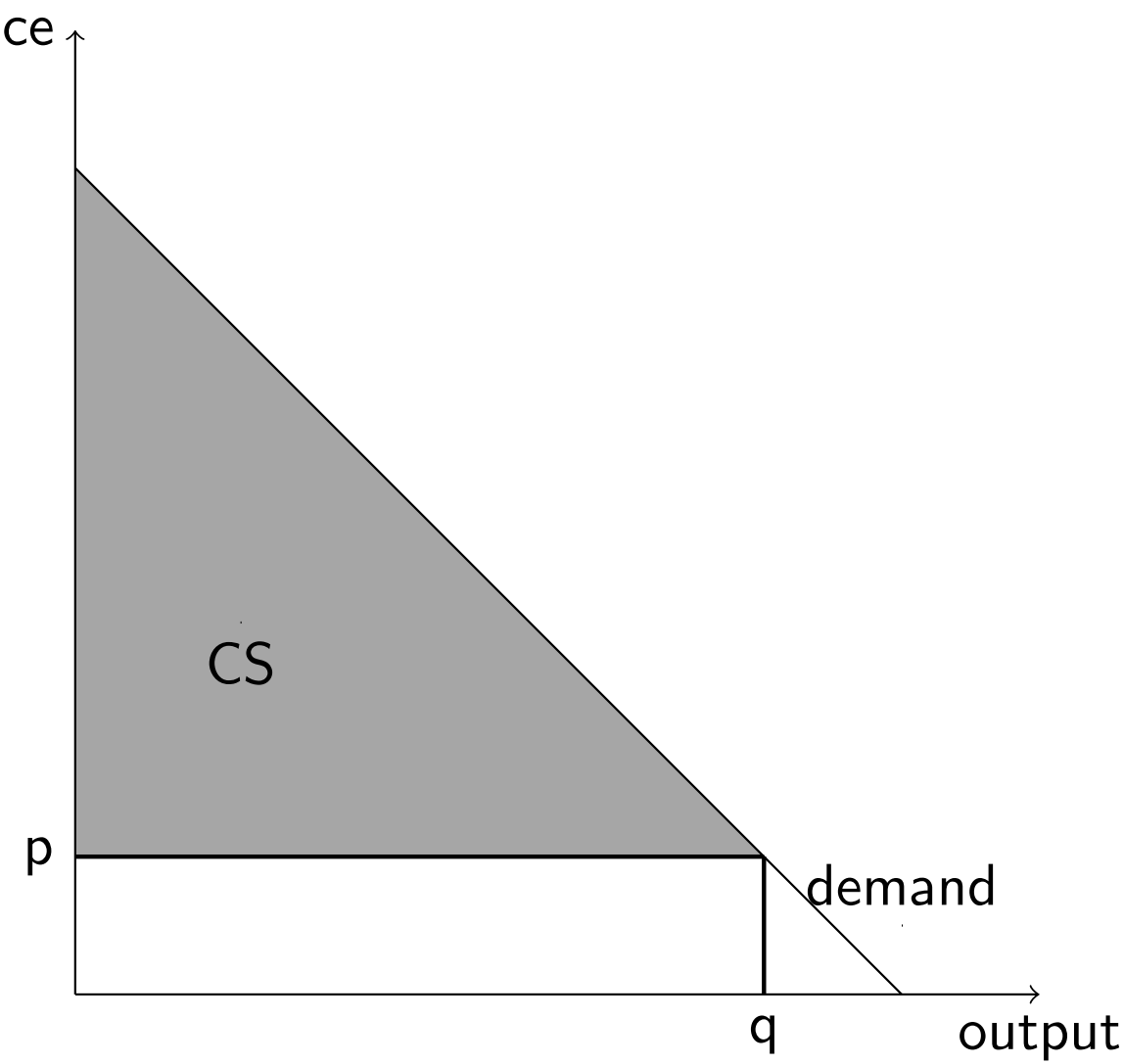
  Ex: for the linear demand case, the price elasticity is greater for small quantities and lower for large quantities.
- It is often useful to know if the elasticity is greater than 1. Indeed, it tells me if I gain from increasing marginally my price.
- When my revenues are $pQ(p)$, they increase with the price when the elasticity is between zero and 1. Indeed

$$\frac{d\big(pQ\big)}{dp} = Q + p\frac{dQ}{dp} \Rightarrow \frac{d\big(pQ\big)}{dp} > 0 \Leftrightarrow \varepsilon \in [0,1]$$

The Demand Curve and Consumer surplus

- The demand curve also provides a measure of consumers' surplus.
- This curve represents how much consumers are ready to pay (their *willingness to pay*) for each marginal unit.
- If they are ready to pay 5 € while the actual price is 2 €, the consumers' surplus associated to the trade is 3 €.
- To compute consumer surplus on a market, one has simply to sum all the surplus gained on every trade.
- Graphically, this surplus is given by the area (a triangle) between the demand curve and the price line.

Demand Curve and Consumers' surplus



Cost and Supply Functions

- As a first approximation, we can think of a firm as a process of transforming inputs into outputs.
- To understand the efficiency of such a process, we must introduce the cost function which describes how many inputs are used **optimally** to produce output q.
- With a cost function, we assume that the firm has optimized over the possible production technologies.
  1. Suppose that there are 2 inputs, labor L and capital K, with prices w and r, when the firm technology is given by $F(L, K)$.
  2. The cost function $C(q)$ is the solution that minimizes the cost of inputs for a production of at least q, i.e.

$$C(q) = \min_{L,K} wL + rK \text{ s.t. } F(L, K) \geq q.$$

Cost and Supply Functions

- Let us first list a number of important cost concepts:
  - Fixed Cost: it does not depend on the output level.
  - Variable Cost: that cost would be zero it the output level were zero.
  - Total Cost: sum of the fixed cost and variable cost.
  - Average Cost: total cost divided by output level.
  - Marginal Cost: cost of one additional unit.
- If the total cost given by $C(q) = F + cq^2$, then
  - F is the fixed cost,
  - cq^2 is the variable cost,
  - $F/q + cq$ the average cost
  - $2cq$ the marginal cost.

Cost and Supply Functions

- To illustrate, let us consider an example, a small T-shirt factory (in Vietnam for example).
  1. To produce T-shirts, the manager leases one machine at a cost of 20€ per week.
  2. The machine must be operated by one worker and the hourly wage is as follows: 1€ during weekdays (up to 40 hours), 2€ on Saturdays (up to 8 hours) and 3€ on Sundays (up to 8 hours).
  3. The machine produces one T-shirt per hour and current output is 40 T-shirts per week.
- It is direct to see that
  1. The fixed cost is given by the machine weekly lease, 20€.
  2. The variable cost is given by 40 T-shirts times one hour per T-shirt, 40€.
  3. The total cost is then 60 €.
  4. Average cost is (20+40)/40=1.5€.
  5. The marginal cost is 2€ as producing an additional T-shirt implies asking the worker to work on Saturdays when the wage is higher.

Cost and Supply Functions

- How can we use this information to understand the firm behavior?
- Suppose that our small firm can sell its T-shirts for a price of 1.8 € per unit.
- Should this firm open on Saturdays and produce more than 40 T-shirts per week?
- At the current output, average cost is given by 1.5 € so, with selling price of 1.8 €, the firm is making money.
- But to know whether producing more is profitable, the manager should consider the marginal cost which is more than 1.8 €. The firm should remain closed on Saturdays.

Cost and Supply Functions

- Suppose now that the price drops to 1.3 €. What should be the optimal reaction of the manager?
- This price is greater than marginal cost so the firm gains some money at the margin...

  ... but the price is below average cost for any output level.
- The optimal decision would be to close the factory.

  Marginal cost is the appropriate concept to decide how much to produce whereas average cost is the appropriate concept to decide whether to produce at all.
- When the firm is price-taker, the supply function is given by the marginal cost function for values of price greater than the minimum of average cost.

Cost and Supply Functions

- On top on "real" costs, decision maker should consider opportunity costs.

Rmk: This is where Accounting and Economic Profits differ.

Definition

Opportunity costs are defined as the foregone benefits from not using the resource in the best alternative use.

- Example 1: if a firm owns a building and decides to open a new store, the benefit of renting the building is foregone.
- Example 2: if an investor decides to put some money in a firm, he will not be able to put this money in T-bonds.
  Those opportunity costs should be taken into account when the profitability of any investment is considered.
- Note that costs paid before the decision to produce is taken (the **sunk costs**) should not influence this decision.

Cost and Supply Functions

- Cost functions can have various shapes. Three commonly discussed cases
  1. Constant returns to scale (CRS) where the average cost does not vary with the total production.
  2. Increasing returns to scale (IRS) where the average cost decreases with the total production.
  3. Decreasing returns to scale (DRS) where the average cost increases with the total production.
- Many (most?) real-world cost functions display first increasing and then decreasing returns to scale.
- Cost functions influence the feasible market structure (imperfect competition more likely with IRS).
- Economies of scope should also be considered when a firm must decide to extend (or not) its product line.

Supply Functions in Perfect Competition

- Let us now consider the firm's choice of price and output.
- We assume that the firm is small so cannot influence the market price
- For any price p and a given cost function $C(q)$, the supply function is such that $p = C'(q)$, i.e. price equals marginal cost. Indeed,
  - For $p > C'(q)$, there are some remaining business opportunities so the firm should increase its production.
  - For $p < C'(q)$, the mark-up is negative on the marginal units sold so the firm should decrease its production.
- Formally, assuming that $C(q)$ is convex, i.e. decreasing returns to scale, the firm chooses q to maximize $\Pi(q) = pq - C(q)$, which leads to the aforementioned results.

Competition and Welfare

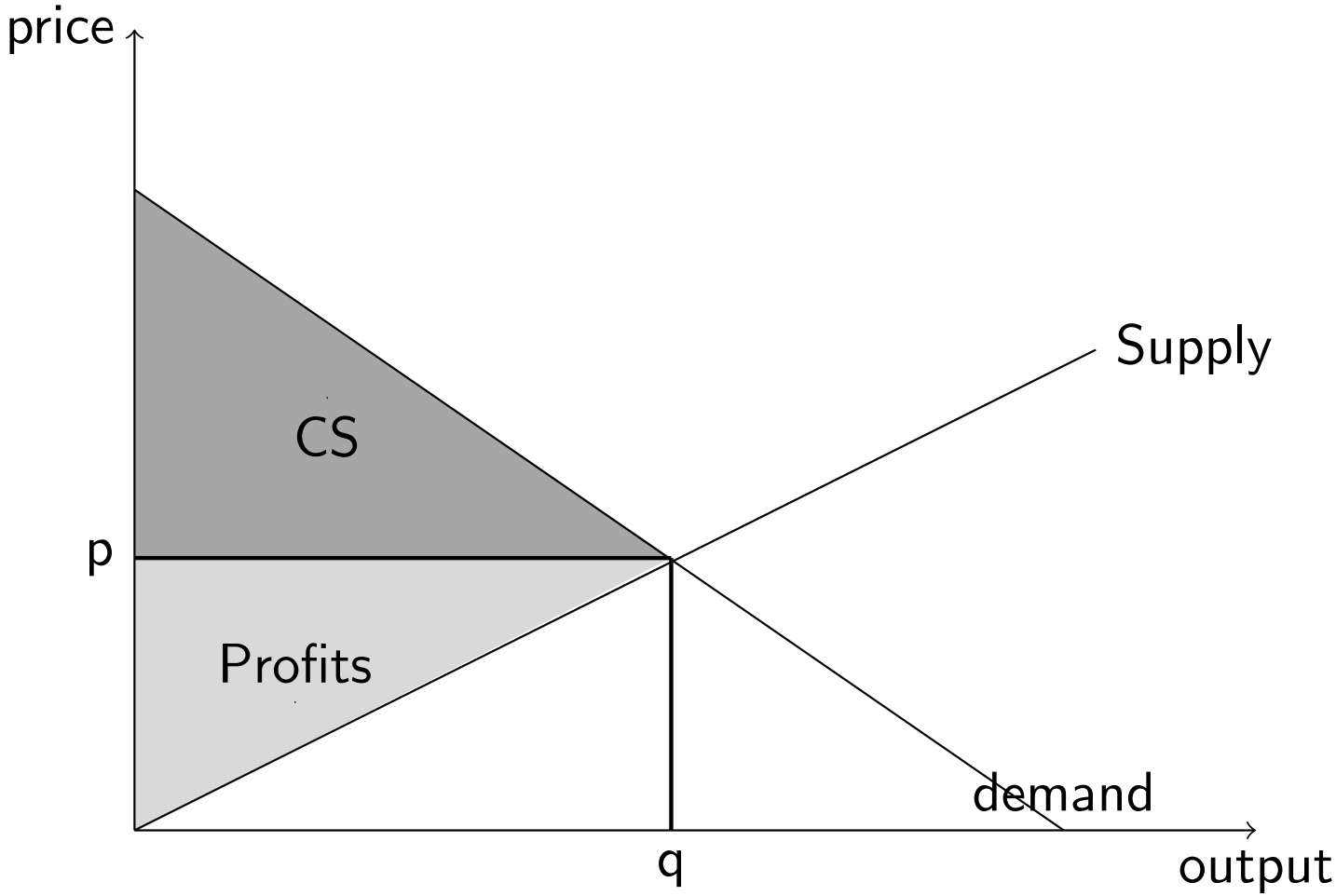
- As a benchmark case, it is interesting to look at the case of competitive markets.
- A few conditions characterizes this hypothetical situation.
  1. Firms are price-taker. This corresponds to the case where many firms participate and none is large.
  2. The products sold by the firms are homogenous, so they compete directly.
  3. There is full information on the product sold, i.e. on the price and the quality of the good sold.
  4. There is free-entry (and free exit) in (from) the market.
- Only few markets correspond to this benchmark, but many markets have some of these features.

Competition and Welfare

- We now focus on the surplus created by a trade. This surplus includes consumer surplus and firms' profit.
- The trade creates some value, as long as the item traded is worth more for the buyer than for the seller.

  If a item costs 1 to produce and has a value of 3 for a potential buyer, trading generates a surplus of 2.
- The price defines how this surplus is shared between the seller and the buyer.
- At the level of the market, the surplus can be represented in the graph (q, p) by drawing the (inverse) demand curve and the supply curve.
  1. Consumer surplus is the area between the price line and the inverse demand curve.
  2. Firms' profit is the area between the the price line and the marginal cost curve.

Competition and Welfare



Competition and Welfare

- In the above graph, the price is such that supply equals demand.
- This results from competition on both sides of the market.
- In this simple situation, such a price maximizes total surplus as any increase or decrease in price will drive the number of trades down.
- As trade is at the origin of surplus, the efficient price is the one that maximizes the number of trades.

Rmk Even if firms can make profit in the short run, assuming free entry makes the individual profit converges to zero.

A few additional remarks

- The idea that competition is socially efficient dates back to Smith (or even before for non-economists) but is not robust to the introduction of imperfect competition.
- With imperfect competition, prices are usually too high so some surplus generating trades are not realized.
- We focus in this course on situations where competition is imperfect in order to study firm's strategies.

Rmk: We do not discuss how the market is defined, even if this is important both for business and regulatory purposes.

- Things we do not do: nonprofit organizations, mixed oligopolies, CSR ....
- Our description of the world is more descriptive than prescriptive or normative.

Exercise

We consider the milk market where the supply curve is given by $Q = 40P$ and the demand curve by $Q = 30 - 20P$ with Q the quantity (in millions of liters) and P the price per liter. We will assume that this market is competitive.

a Compute explicitly the equilibrium price and quantity.

b Analyze the price-elasticities of supply and demand at this equilibrium point.

We now assume that the government wants to support prices in this industry, through a policy of public purchase.

c How many units the government must buy to increase the price by 20%?

d What is the cost of such a policy for the government?

e What do you think of the global impact on efficiency of this public policy?

Monopoly Behavior

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Monopoly behavior: Presentation

- We consider here the case where only one firm operates on the market.
- The reasons for the existence of such a monopoly can be quite diverse: technological, regulatory or strategic.
- Monopoly is more likely to prevail in sectors where fixed costs are important and/or innovations are of primary importance.
- We will first present the main ideas behind monopoly power and then discuss some simple extensions.
- In the first part of the lesson, we restrict the presentation to the case of linear pricing and then we will discuss more advanced pricing strategies.

Monopoly

- We assume that there is a well-defined market with a single supplier.
- The monopoly sets price p and consumers demand is $D(p)$ with $D'(p) < 0$.
  It is equivalent to assume that the monopoly chooses a quantity q with $q = D(p)$. In this case, the price is $p = P(q)$ the inverse demand function.
- By producing q, the monopolist incurs a cost $C(q)$, with $C(.)$ increasing and convex.
- The objective function of the monopoly then writes as

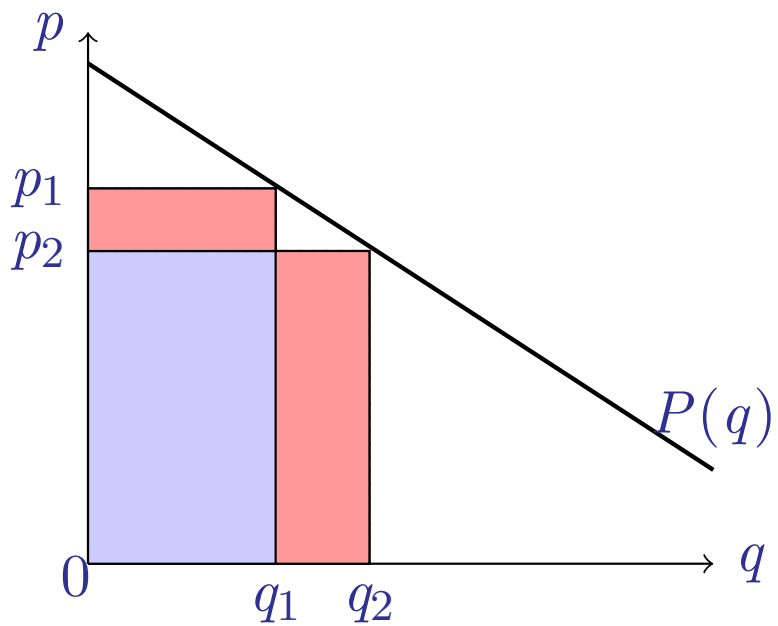
$$\max_q qP(q) - C(q)$$

- Profit maximization occurs when marginal revenue equals marginal cost, i.e.

$$P(q) + qP'(q) - C'(q) = 0 \tag{1}$$

Monopoly and Monopoly Power

- The first term is the additional revenue for the marginal unit, the second term represents the loss on all infra-marginal units, while the third one is the marginal cost.
- The marginal revenue effect (the first two terms in Equation (1)) is represented below.



Increasing production from q_1 to q_2 leads to more sales but a lower price ($p_2 < p_1$); the net effect on revenue is a priori ambiguous.

Monopoly and Monopoly Power

- Let p^m and q^m be the monopoly price and quantity respectively. As $q^m = D(p^m)$, Equation (1) can be written as

$$\frac{p^m - C'}{p^m} = \frac{1}{\epsilon} \tag{2}$$

  with ϵ the demand elasticity at price p^m.
- The above equation characterizes the mark-up the monopoly can gain for its marginal production.
- Optimally, the LHS called the **Lerner Index** should be inversely proportional to the demand elasticity.

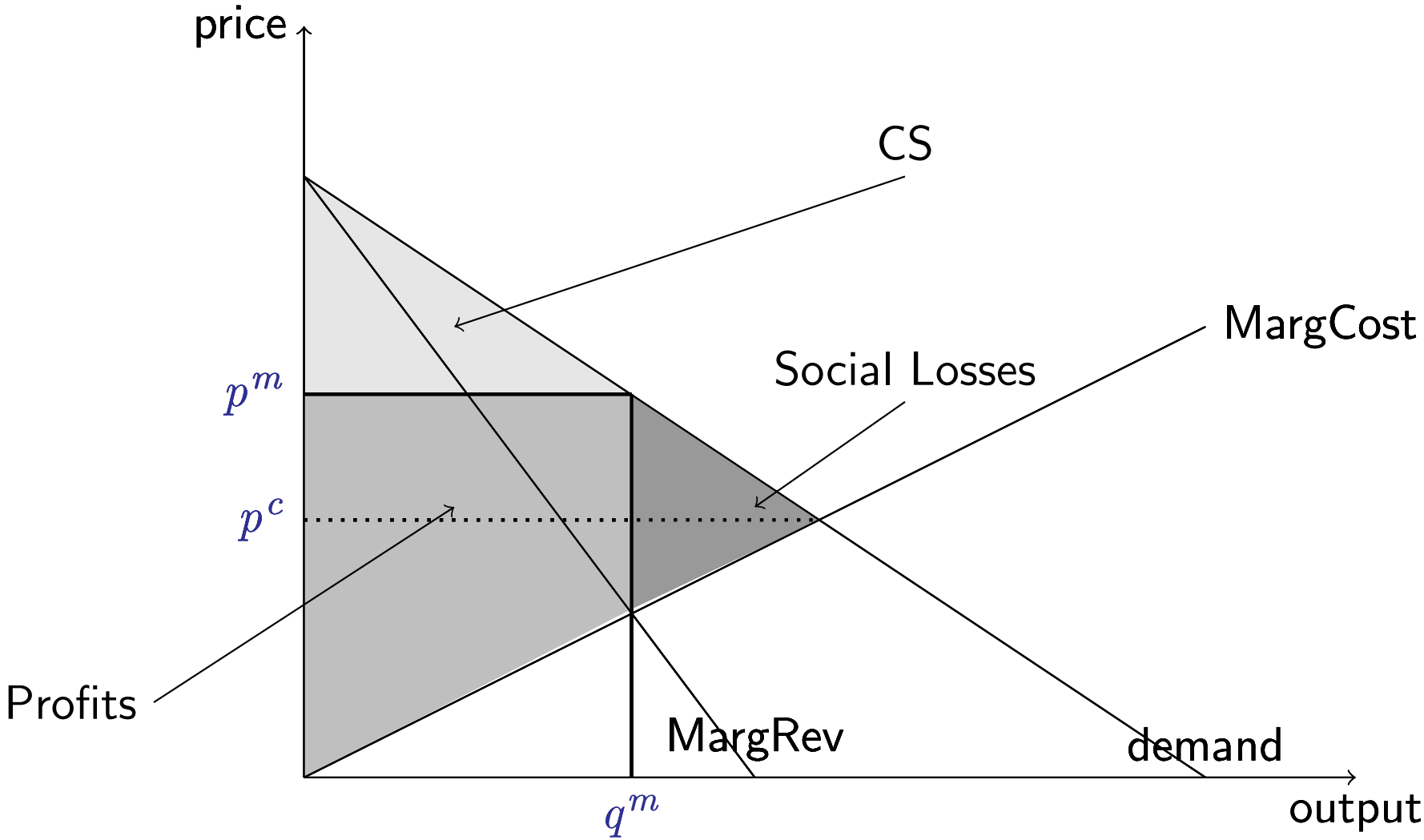
Result

A monopoly should set a price-cost margin that is greater the lower the price elasticity of demand is.

Monopoly and Monopoly Power

- What are the welfare effects of monopoly power?
  1. As prices are higher, the surplus from trade shifts from consumers to firms. This first effect is purely redistributive but does not affect efficiency.
  2. As the price is above marginal cost, some surplus generating trades are not realized.
- So a monopoly has some redistributive effects as well as some efficiency effects.
- This can be represented graphically as follows

Monopoly and Monopoly Power



Restraining monopoly power: Regulation

- Because monopolies entail some inefficiencies, public authorities take action to reduce these distortions
  - Facilitate entry (for instance, through removal of legal entry barriers)
  - "Control" the behavior of the monopoly (Sherman Act and Clayton Act in the US, Article 102 of the TFEU in Europe).
- Many markets, which were seen as natural monopolies, have been progressively opened up to competition since the 1980s. How to introduce competition?
  - **Divestiture of the historical operator as in the US Telecom Industry.**
  - **Competition in the market as in the electricity generation and distribution markets in Europe.**
  - **Competition for the market when there is room for only one firm, but firms have to compete through an auction (railroads, waste management,water...).**

Restraining monopoly power: Regulation

- While the last 40 years have shown that introducing competition (for or in the market) promotes consumers interest, it is not always a feasible option
  - The historical operator controls an input which is essential to competitors: rail tracks, electricity transmission network, local loop in broadband, ...
  - The fixed cost of production is socially too high to be duplicated
- In both cases, there is a need for regulating the firm... not an easy task in practice!

Restraining monopoly power: Regulation

Consider a natural monopoly, with cost $C(q) = F + cq$, F "large".
Suppose the regulator imposes the firm to price at a certain level

Regulations	Description	Pros	Cons
Marginal cost	$p = MC$	Efficiency	Negative profit $\pi = -F$ $\Rightarrow$ Subsidy from taxpayers $\Rightarrow$ Regulatory capture
Average cost	$p = AC$	No subsidy	- $p > MC$ - Weak incentives to $\searrow$ cost
Price cap	$p \leq \bar{p}$	Strong incentives to $\searrow$ cost	- Weak incentives to $\nearrow$ quality - High risk for the firm

Multi-product Monopoly

- We can extend this basic framework by considering the case of a firm being the sole provider of two goods $i = 1, 2$, selling quantities $q = (q_1, q_2)$ for a price $p = (p_1, p_2)$.
- We assume that the demands write as $q_i = D_i(p)$ and the production costs are independent so can be represented as

$$C(q_1, q_2) = \sum_{i=1}^{2} C_i(q_i)$$

- The objective of the monopoly is then

$$\max \sum_{i=1}^{2} \left(p_i D_i(p) - C_i(D_i(p)) \right)$$

- What are the optimal quantities the monopoly chooses to produce when demands are interdependent?

Multi-product Monopoly

- Using the FOC and simplifying leads to

$$\frac{p_i - C_i'}{p_i} = \frac{1}{\epsilon_{ii}} - \frac{(p_j - C_j')D_j\epsilon_{ij}}{p_i D_i \epsilon_{ii}}$$

with ϵ_{ii} the (positive) price-demand elasticity and ϵ_{ij} the cross-price demand elasticity of good j with respect to price i.

(1) If the goods are substitutable, i.e. $\partial D_j/\partial p_i > 0$ or equivalently $\epsilon_{ij} < 0$, the multi-product firm will choose a higher price than the mono-product firm.

Idea: part of the lost demand on one good will consume the other good.

(2) If the goods are complements, i.e. $\partial D_j/\partial p_i < 0$ or equivalently $\epsilon_{ij} > 0$, the multi-product firm will choose a price lower than the mono-product firm.

Idea: too high a price has an depressing effect on all goods.

Monopoly and price discrimination

- In many circumstances, the same good is sold at very different prices to different classes of customers: movie tickets, plane tickets, haircuts, retail and wholesale products...
- This behavior is usually called price discrimination.
- Price discrimination can be constrained by the law, but it is mainly constrained by the possibility of resale.
- Even when resale is possible, it is often difficult either because of transaction costs or informational problems.
- For some goods, resale is not technically possible (haircut, electricity,...)

Multi-market monopoly

- The most common form of discrimination consists of dividing the market using some general and observable characteristics.
- The same good can have very different values in different places (or time).

  Example: for cars, most European countries exhibit a home bias (French cars more expensive in France, Italian cars more expensive in Italy...)
- This type of discrimination, called third-degree price discrimination, consists in using public information (place, time, occupation, age) to propose different prices to different groups of agents.
  Note that in this case, there is no discrimination within groups.

Multi-market monopoly

- Let us suppose that the whole population can be divided into two groups, 1 and 2.
- Each group has a specific demand function, $D_i(p_i)$.
- We still assume that the monopoly has a variable cost function $C(q)$.
- If the firm can set different prices to those two groups, p_1 et p_2, the monopoly program writes as

$$\max_{p_1,p_2} p_1 D_1(p_1) + p_2 D_2(p_2) - C\left(D_1(p_1) + D_2(p_2)\right)$$

- This leads to

$$\frac{p_i - C'}{p_i} = \frac{1}{\epsilon_i}$$

Multi-market monopoly

- As in the simple monopoly case, we see that the price will depend on the price-elasticity of each group.
- **Under third-degree price discrimination, a seller should charge a lower price in the market segments with greater elasticity.**
- What are the most relevant examples?
  1. Rebates for students or seniors for some services (haircut, travel...)
  2. Heterogeneity in prices for cars or vines according to the location.
  3. Temporary rebates for new subscribers to TV channels or newspapers.
- The monopoly always benefits from price discrimination and the consumers may win or loose (it depends on their price-elasticity).

Exercise

You own a private parking lot near ESSEC with a capacity of 600 cars. The demand for parking at this lot is estimated to be $D(p) = 1000 - 2p$, where $D(p)$ is the number of customers with monthly parking passes and p is the monthly parking fee per car.

(a) Derive your marginal revenue schedule.

(b) What price generates the greatest revenue?

Your fixed costs of operating the parking lot, such as the monthly lease paid to the landlord and the cost of hiring an attendant, are \$25,000 per month. In addition, your insurance company charges you \$20 per car per month for liability coverage, and the City charges you \$30 per car per month as part of its policy to discourage the use of private automobiles.

(c) What is your profit-maximizing price?

(d) Is it a profitable business?

Monopoly Behavior (cont'd)

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MONOPOLY BEHAVIOR II

- Implicit assumption made so far: monopolist uses a linear price, or the price paid by buyers depends neither on the quantity nor on the variety of goods purchased (in the case of a monopolist offering several goods to consumers)
- In practice, discounts are ubiquitous and can take different forms
- Firms may also use information about consumers to fine-tune their offers

$\rightarrow$ a firm price discriminates as soon as it doesn't use a linear price to sell its products: price discrimination exists when two "similar" products which have the same marginal cost are sold by a firm at different prices

  - if differences in prices between buyers exactly reflect differences in the costs of serving these buyers, then there is no discrimination

You will realize that price discrimination is everywhere around us. Let us fix ideas with a few examples

Examples of price discrimination

Airline travel and time of departure

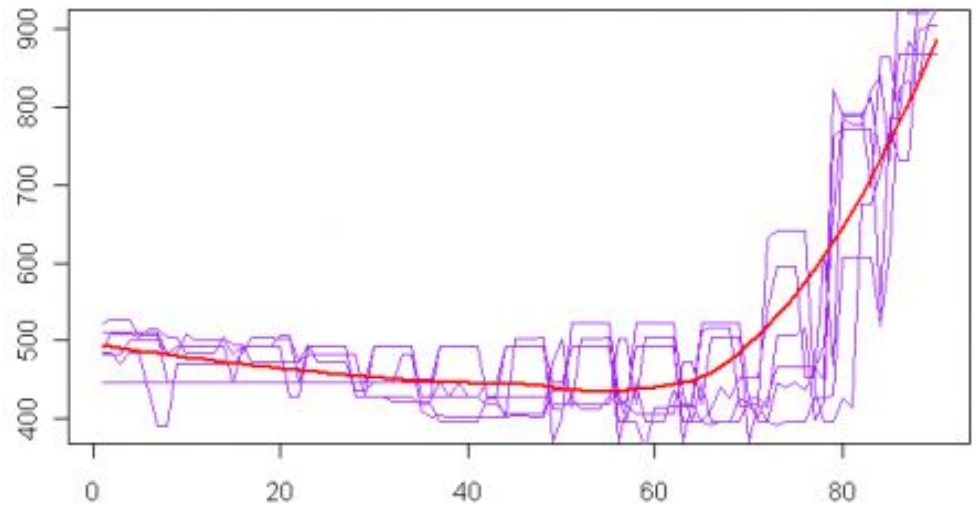
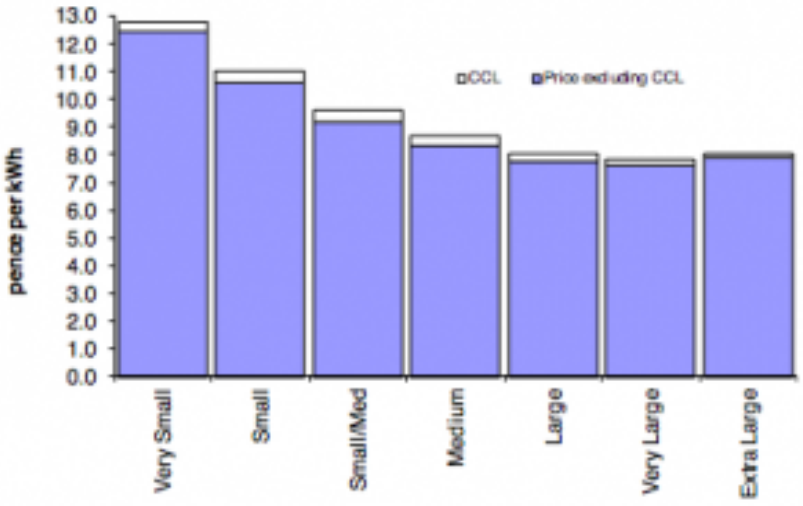


Figure: Evolution of the price of an airline ticket over a 3-month period before departure

Examples of price discrimination

Quantity purchased

Chart 3.4.1: Average UK non-domestic electricity prices Q3 2012

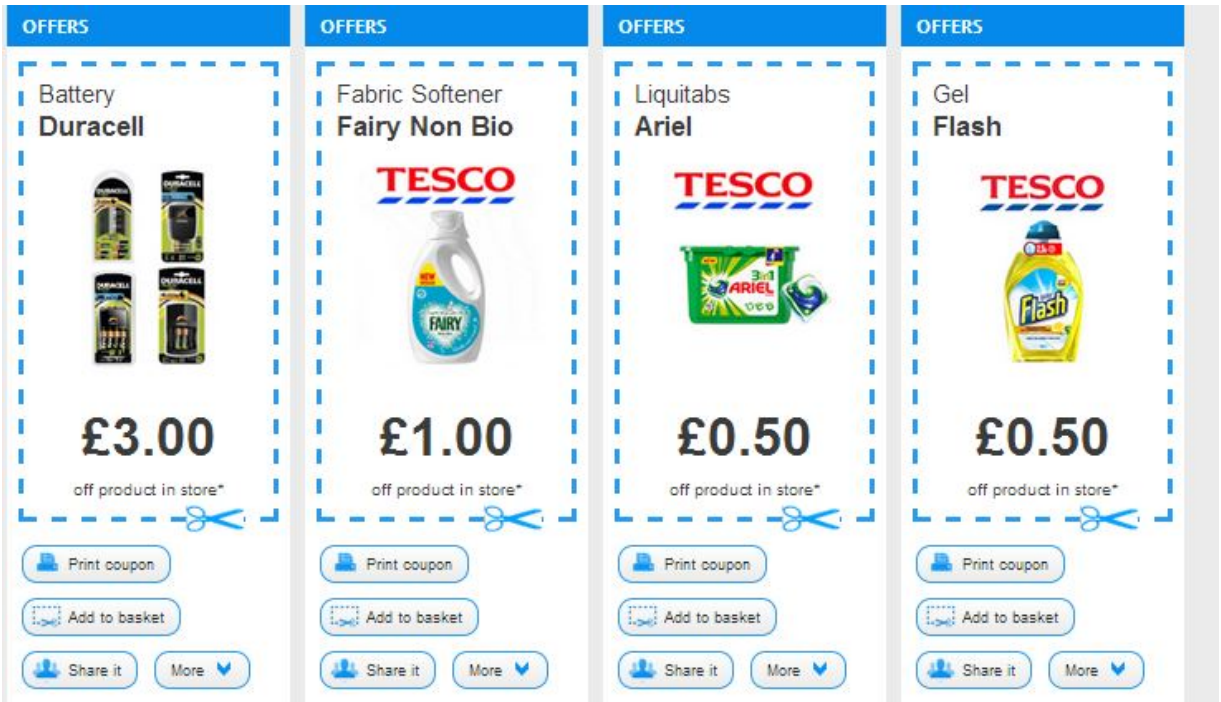


- Average electricity prices, excluding CCL, have risen in cash terms between Q3 2011 and Q3 2012 by an average of 9 per cent.
- Price changes have varied by sizeband, rising by between 5 and 9 per cent for smaller consumers, and by between 10 and 14 per cent for all other consumers.
- Average prices in Q3 2012 are 9 per cent lower than the high reached in Q1 2009.
- The inclusion of CCL increases the average price of electricity by between 2 and 4 per cent.

Figure: Average price of electricity falls, as firms get bigger and consume more

Examples of price discrimination

Coupons



Examples of price discrimination

Age discounts

Examples of price discrimination

Loyalty cards

Examples of price discrimination

Bundling

Two-part tariffs

- The purchase of some products and services can be separated into two decisions, and therefore, two prices: decision to enter market and decision about how much to buy

  Some examples
  - Amusement park: pay to enter, pay for rides and food within the park
  - Tennis club: pay to join, pay to play
  - Rental of Mainframe Computers: flat fee, processing time
  - Taxi: service fee, price-per-km
- Why do firms use such pricing strategies? To extract surplus the buyers.

  Reminder: under **linear pricing**, consumers earn some surplus but some mutually profitable transactions are not realized.
- We will discuss some rationales for using a particular nonlinear pricing strategy; focus on the case of a monopoly, keeping in mind that some insights may be different under competition

Forms of price discrimination

- **A first typology**: In static situations, if tariffs (i) are anonymous, (ii) do not involve quantity discounts for a specific product, (iii) do not involve discounts for buying a range of products, then no price discrimination.
- **Personalized pricing**: a firm offers a different tariff to identifiably different consumers
- **Quantity discounts**: the per-unit price for a specific product decreases as the number of purchased units increases; nonlinear tariffs may be used to sort different types of consumers endogenously.
  - We will focus on this form of price-discrimination
- **Bundling discounts**: (i) pure bundling when a consumer can only purchase the products as bundle, (ii) mixed bundling when individual items can also be bought

Personalized Pricing

- As a benchmark, let us look at the case where the firm knows what the willingness to pay of consumers is
- Ex: a shop you already bought from; your school that has some information on your financial means.
- The standard strategy, if the consumer only buys one unit of good, is to price at the value of this good for the consumer.
- When consumers consume more than one unit, one can either set a different price for each unit or, equivalently, propose non-linear tariffs.

  Ex: telephone package; energy package; sports clubs...
- We now discuss two forms of non-linear pricing: two-part pricing and block pricing.

Personalized Two-Part Pricing

- A two-part pricing consists of (1) a fixed fee (2) a usage fee charged for each unit the consumer actually buys.
- To understand, we consider a shop that faces two types of customers, old and young.
- The inverse demand function of a typical member of each group is $P = V_o - Q_o$ for the old and $P = V_y - Q_y$ for the young.
- We assume that old customers are ready to pay more than young ones, i.e. $V_o > V_y$.
- The cost function of the firm is given by $C(Q) = cQ$.
- If the firm can only use linear pricing, but can discriminate between groups, the price chosen will be $P_o = \frac{V_o+c}{2}$ for the old and $P_y = \frac{V_y+c}{2}$ for the young.

Personalized Two-Part Pricing

- The profit on each group i is given by

$$\Pi_i = Q_i(P_i - c) = \frac{(V_i - c)^2}{4}$$

- Each consumer consumes $Q_i = V_i - P_i = \frac{V_i - c}{2}$ and makes a surplus given by

$$CS_i = \frac{1}{2} Q_i(V_i - P_i) = \frac{1}{8}(V_i - c)^2$$

- For example, if $V_0 = 16$ €, $V_y = 12$ € and $c = 4$,
  1. the optimal prices are $P_o = 10$ € and $P_y = 8$ €,
  2. the quantities are 6 units for the y and 4 units for the o,
  3. the profits are 36 € on the o market, 16 € on the y market;
  4. the surplus of each consumer is 18 on the o market and 8 on the y market.

Personalized Two-Part Pricing

- To avoid leaving some surplus to the consumers, the firm may switch to non-linear tariffs.
- A first solution would be to charge as a fixed fee the surplus gained by each type of consumer, i.e. in the numerical example 18 for the old and 8 for the young.
- There is an even better solution which consists in
  1. Setting the usage price (the price per unit) equal to the marginal cost,
  2. Setting the fixed fee for each type of consumer equal to that consumer's valuation
- Note that the usage price decreases in order to maximize the number of trades as surplus is generated by trades.

Two-Part Pricing

- Each consumer of type i will then be priced $p_i = c$, $F_i = CS_i = \frac{1}{2}(V_i - c)^2$ for a consumption $Q_i = V_i - c$.
- Using the numerical example, the usage price will be 4 € for each group while the fixed fees will be $F_o = 72 = \Pi_o$ and $F_y = 32 = \Pi_y$.
- Each old consumer will buy 12 units while young ones will get 8 units.
- This pricing strategy has two impacts
  1. It increases the firm's profit.
  2. It increases the total number of trades which is now equal to the one in the competitive case.
- When the firm can perfectly discriminate between consumers, personalized pricing is efficient.

Block Pricing

- The firm can achieve the same outcome by bundling the quantity with the total charge it wishes to set for that quantity.
- Indeed, the firm can propose to a consumer of type i ($i \in \{o, y\}$) to consume $V_i - c$ units for a total price

$$TP_i = \frac{1}{2}(V_i - c)^2 + (V_i - c)c = \frac{1}{2}(V_i^2 - c^2)$$

- Considering again our example, it amounts to proposing 12 units for $72 + 4 \times 12 = 120$ € to the old and 8 units for $32 + 4 \times 8 = 64$ € to the young

Remarks on Personalized Pricing

- Note that the average price paid by each consumer is 10 € for the old ones and 8 € for young ones.
- The average price is the same than the one found in the case of linear pricing, but the profit (and the total surplus) is much higher with non-linear pricing.
- With non-linear pricing, it is as if the firm could adjust its unit price to the real willingness to pay of each consumer.
- There is no trade-off anymore between margin and quantity.
- But this assumes not only that resale is not possible but also that the firm can identify who is young and old.
- What can the firm do when the relevant characteristics are not easily observable?

Menu Pricing

- When the firm does not know the characteristics of the customers (income, taste), personalized pricing is not feasible
- In the above example, the firm could decide to make only one offer, the one designed for the old, and gain 72 € per old costumers.
- If there is a vast majority of old consumers, this strategy is not too costly.
- If there is a majority of young customers, it may be optimal on the contrary to propose the other contract, i.e. charge the low price.
- There is in fact a better solution that consists of proposing different options (*menus*) in a way that allows to screen the different types of consumers.
- In the real-world, these options correspond to different qualities, quantities, or versions of the same good.

Menu Pricing

- In this problem, some types of consumers (the h, for high demand) are ready to pay more than others (the l, for low demand) but would like to hide this to the firm.
- As a h consumer can always take the option proposed to the l, it will be very difficult for the firm to extract all the surplus from trade.
- What should then be the optimal strategy of the firm?
- As we will see, the firm will offer a variant of the block strategy that we discussed before.
- Let us consider the same function as before (with different names), and assume that the inverse demand functions are $P_h = 16 - Q_h$ and $P_l = 12 - Q_l$.
- Therefore, the maximum surplus that can be generated is 72 € for the high-demand consumers and 32 € for the low-demand ones.

Menu Pricing

- Suppose first that the firm decides to use the same block strategy as in the case of full information.
- The high demand consumers get zero surplus if they take the offer designed for them.
- If they choose instead the low demand offer, they will consume less units (8 instead of 12) BUT their net surplus will be greater.
- Indeed, the gross surplus is 96 € (the area between the inverse demand curve and the x-axis, for $Q \in [0, 8]$) while the total price is 64 € $\Rightarrow$ Net Surplus of 32 €.
- If the firm wants the high demand consumer to choose the offer with 12 units, it must lower the price from 120 € to 88 €.
- The money gained by the high demand consumers is called the informational rent.

Menu Pricing

- With this strategy, the owner sells its product to all types of consumers but offers quantity discounts.
- Indeed, the price per unit for low-demand consumers is 8 € $(64/8)$ while the price per unit for high-demand consumers is 7.33 € $(88/12)$.
- This is a first reason why a 12-pack of beer is cheaper than 12 individual bottles of beer or why it is cheaper to buy a season's subscription to the opera/theater/stadium than to buy tickets to each event individually.
- The profit of the firm is here $64 - 8 \times 4 = 32$ € for the low-demand and $88 - 12 \times 4 = 40$ € for the high-demand.
- But the firm can in fact use a better strategy.

Menu Pricing

- Suppose that the firm changes the offer designed for the low-demand consumers and proposes now 7 units for a price of 59.5 €.
- The price is just equal to the gross surplus of the low-demand consumers so their net surplus remains equal to zero.
- The gross surplus of the high demand consumers when they choose this offer is now 87.5 € so the net surplus is 28 €.
- Since the money high-demand consumers can gain by choosing the offer designed for the low-demand ones is reduced, the firm can increase the price it charges for consuming 12 units.
- More precisely, the firm can now propose a package with 12 units at a price of 92 €.
- Is it a good strategy for the firm?

Menu Pricing

- For each high-demand consumer, the firm gains 4 € more with this new strategy.
- For each low-demand consumer, the firm loses the surplus generated by the 8th unit.
  1. The revenue decreases from 64 to 59.5 €.
  2. The cost of production is reduced by 4 €
  3. Therefore, the total loss on a low-demand consumer is 0.5 €
- As long as the share of high-demand consumers is not too small (larger than $1/9$), this is a profitable strategy.
- But it may be even more profitable to reduce again the number of units included in the low-demand package.

  Exercise: when there are the same numbers (shares) of high-demand and low demand customers, show that the firm should propose only 4 units in the low-demand package.

Menu Pricing

- The example illustrates the importance of incentive compatibility constraints.

  This problem applies to pricing problem but also to insurance, taxation or regulatory issues.
- The firm may find therefore more profitable to reduce the number of units offered to some customers in order to extract more from others customers.
- In the example, we focus on quantity distortions but it could also apply to quality distortions.
- And this is not new.

Menu Pricing

- One of the first French "ingénieurs economistes" (XIXth century), Jules Dupuit, made some related remarks on the train pricing system.

  "*It is clear that by multiplying the classes, we could charge the traveler all the utility that he or she derives [from the transport]. But for this, it is necessary to be able to distinguish between travelers who derive different utilities from their transport and force them to choose voluntarily this or that tariff category. However, it is the great difficulty which gives rise to the implementation of many measures that are generally very poorly understood by the public.*"

MONOPOLY BEHAVIOR II

- Dupuit then explains the different forms quality/price discrimination can take.

  " *Thus, as the people when they see the passengers in the third-class carriages sometimes uncovered, sometimes poorly suspended, always poorly seated, have shouted at the barbarity of the companies. It would cost so little, they say, to put there a few meters of leather and a few kilograms of horsehair that there's more than greed in refusing it...*
  It is not because of the few thousand francs which would have to be spent to put a roof over the third-class carriages or to upholster the third-class seats that some company or other has open carriages with wooden benches. ... What the company is trying to do is to prevent the passengers who can pay the second-class fare from traveling third class; it hits the poor, not because it wants to hurt them, but to frighten the rich..."

Second degree price discrimination: Menu pricing

Another illustration (from NY Time, Oct. 27, 2017)

Tesla originally offered its Model S sedan in two variants. The difference was a few lines of software code that restricted the energy available from one version's battery.

A simple, over-the-air change in that code could instantly render the two cars' battery output identical. Yet the price for the unrestricted model was thousands of dollars higher.

Tesla was engaging in what economists call price discrimination, the practice of charging different prices for essentially the same good or service.

Second degree price discrimination: Menu pricing

Had the company not priced its offerings as it did, it would not have been able to offer the features that have made its cars so attractive to buyers. Tesla has also had to invest in the extensive network of fast-charging stations without which electric cars would simply be impractical.

Those features were costly to develop. This year's Model S starts at $68,000, but fully optioned models sell for almost $160,000. If Tesla priced every vehicle at $160,000, its sales would be far too small to cover its formidable development costs. To succeed, it must achieve greater scale, a goal that its new Model 3 sedan promises to promote. But that same goal is also served by its current pricing practices.

Second degree price discrimination: Menu pricing

If Tesla had charged the same price to every buyer, smaller sales volumes would have required that price to have been even higher than for the premium models. Uniform pricing would have resulted in a worse outcome not only for the company but also for its customers.

In fact, companies like Tesla are practicing what might better be called the hurdle method of differential pricing. Under this method, sellers offer buyers a choice: They can buy the product at list price without further ado, or they can jump over some hurdle to be eligible for a significant discount.

From the seller's perspective, the ideal hurdle is one that only price-sensitive buyers are willing to jump. Such hurdles enable sellers to expand their sales by offering significant discounts without having to cut prices for everyone.

Second degree price discrimination: Versioning

Firm can offer different versions of its product, with different attributes, at different prices

Example: selling products whose quality is voluntarily deteriorated (it is often easier to degrade a high-quality product than to improve the quality of a low-quality one)

- Late 1990s, Intel was selling two versions of the 486 processor, 486DX ($588) and 486SX ($333). Only difference: the mathematical co-processor was deactivated on 486SX.
- Missing functionalities in the student-version of some softwares
- Hourly restriction in some gyms

Inter-Temporal Pricing

- At last, it may be interesting to look at the optimal pricing scheme when the good can be used for a long time, the case of durable good.

  Ex: Land, house, cars,...
- As the monopoly has different periods to sell the good, he may practice some inter-temporal price discrimination.
- To look at this (complex) problem, we assume that there are only 2 periods, and the whole market inverse demand function is given by $P = 100 - Q$.
- We take the simplifying assumption that the marginal cost is 0.
- With a durable good, each consumer buys at most one unit, either at the first or at the second period.

Inter-Temporal Pricing

- Let us first assume that consumers are short-sighted, i.e. they do not realize at the first period that the good will/can be proposed by the firm at the second period.
- At the first period, the firm maximizes its profit and chooses P maximizing $PQ = P(100 - P)$ so the monopoly price is 50.
- At the second period, only the consumers with a willingness to pay less than 50 are still on the market. The new inverse demand curve is thus given by $P = 50 - Q$.

  It is then optimal for the firm to propose a new monopoly price on this sub-market, and this price is now 25.
- Inter-temporal price discrimination allows the monopoly to set different prices, $P = 50$ for early buyers and $P = 25$ for late buyers, at different periods of time.
- What could be the problem with this pricing strategy?

Inter-Temporal Pricing

- Suppose now that potential customers anticipate the firm's strategy.
- If they are not "too impatient", the early buyers may decide to wait until the second period to benefit from the reduced price.
- Then, at the second period, all the customers are still on the market and the optimal pricing strategy for the firm is then the standard monopoly price $P = 50$.
- So the effect is to delay the sales.
- But suppose now that there is an infinity of periods, and that the customers are still patient.
- Then customers will refrain from buying as long as they expect a lower price tomorrow.
- At the limit, the only way for the monopoly to deter this behavior is to propose at once a price equal to the marginal cost.

Inter-Temporal Pricing

- This result is called the "Coase Conjecture".
- It expresses the idea that a monopoly may be its own competitor and therefore, at the limit, is driven to price at marginal cost, exactly as in the competitive case.
- How can the monopolist escape from this situation?
  1. It can commit to keep its price high, or having developed a reputation for not lowering price.
  2. It can have a buy-back policy (the "most-favored nation" clause) and pay to the consumers the difference between the price they paid and any lower price later consumers could pay.
  3. He can decide to lease instead of selling the goods. By leasing, the firm commits to its high price as every period is the same as the initial one.

Inter-Temporal Pricing

- The durable good case illustrates the more general problem, the difficulty for any market participant to commit to its future behavior.
- If customers believe that their current action (for example, what shop they visit or what they buy) will backfire on them, they are less likely to do so.
- This problem can be linked to the privacy debate on Internet and explains the codes (or charters) companies tend to develop on the way they use the information collected on customers.
- For some companies whose main business model is to collect and sell information (Yahoo, Facebook, Google), there is a complex trade-off.
- This shows that, even when a firm is a monopoly, it is constrained on its actions and may not have the incentives to use all the information it can collect about its clients (except when consumers are not fully aware of the consequence of their current actions . . .)

Exercise

Suppose that the typical buyer of a vacuum cleaner has a straight-line (that is linear) individual demand curve for cleaner bags. At a price of $11 per bag, he would buy zero, while at a price of $1 per bag, he would buy 50 per year. He plans to use the vacuum cleaner for only one year. The costs of production are $50 for the vacuum cleaner and $1 per bag.

1. Derive the formula for the demand curve.
2. Suppose that the manufacturer sells the vacuum cleaner bundled with 50 bags. What is the maximum that the manufacturer can charge for the bundle? What would be the manufacturer's profit per consumer?
3. Suppose that manufacturers sets a uniform price for bags. What would be the profit-maximizing price and the corresponding profit for the bundle?
4. Suppose that the manufacturer sets a two-part pricing policy, comprising a price for the vacuum cleaner and a price of $3 per bag. What is the maximum, $X, that the manufacturer can charge for the vacuum cleaner? What would be the manufacturer's profit per consumer?

Additional Material: Bundling

An example of bundling

Software	Price
Word	135€
Excel	135€
PowerPoint	135€
OneNote	69€
Outlook	135€
Total	609€
Pack Office	269€

Additional Material: Bundling

Bundling: selling together two distinct products

- Microsoft Office
- Movies distributors ask theaters to buy both 'good' and 'bad' movies
- Think of goods like professional copiers/printers and their maintenance
- Menus at restaurants
- ...

When is such a bundling strategy profitable?

Additional Material: Bundling

Two products, A and B; two types of buyers, 1 and 2; buyers buy at most one unit of each product; no complementarity between A and B; marginal cost 0

Example 1: buyers willingnesses to pay

	Type 1	Type 2
A	90	100
B	30	20
AB	120	120

- A and B sold separately: $p_A = 90$, $p_B = 20$, $\pi_A + \pi_B = 2 \cdot 90 + 2 \cdot 20 = 220$
- A and B sold as a bundle : $p_{AB} = 120$, $\pi_{AB} = 2 \cdot 120 = 240$

Example 2 : buyers willingnesses to pay

	Type 1	Type 2
A	90	100
B	5	20
AB	95	120

- A and B sold separately: $p_A = 90$, $p_B = 20$, $\pi_A + \pi_B = 2 \cdot 90 + 20 = 200$
- A and B sold as a bundle : $p_{AB} = 95$, $\pi_{AB} = 2 \cdot 95 = 190$

Additional Material: Bundling

Differences between the two examples?

- In example 1, a type 1 has a high demand for product A, a type 2 has a higher demand for product B
- In example 2, a type 2 has a higher demand for both products

$\rightarrow$ Intuition: bundling is profitable is there is some asymmetry ("negative correlation") in the buyers demand.

A primer in Game Theory

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ESSEC DSBA - 2021

Games and Strategy

- Method to analyze situations with strategic behavior. A few examples
  1. Two newspapers choosing the headlines for tomorrow.
  2. Two music companies choosing the time for releasing the album of their major artists.
  3. Two competing firms choosing the price at which their products are sold.
- With these (simple) examples, the gains of one side depend both on its decisions and on the decision taken by the other side.
- Each side must therefore try to conjecture what the others will do, knowing that the others will do the same.

Games and Strategy

- Those situations are called games, and the active agents are called players.
- What differs from classical microeconomics is the fact that the optimal choice of an agent depends on the actions of the other one.
- Note also that today's actions have an impact of the set of future feasible actions - the strategy set.

Definition

A game consists of a set of players, a set of rules (who can do what and when) and a set of payoff functions defined as the utility each player gets as a result of each combination of strategies.

Games and Strategy

- The objective of game theory is to provide concepts to forecast the outcome of situations (games) where agents have strategic interactions.
- We can distinguish games according two main criteria.
  1. The gains of each player for any outcome are common knowledge or not: the game is then either a game of complete information or a game of incomplete information.
  2. Players play in a simultaneous way or they play sequentially. Formally, a game is said simultaneous if agents do not know the actions chosen by the others when making their own choice.
- In this introductory chapter, we will only consider games of complete information.

Dominant and Dominated Strategies

- Let us consider first a simple set-up with two players, 1 and 2, interacting in a simultaneous way.
- Each player has a finite number of options and the gains depend on the choice made by both players.
- The strategy set for 1 is $S_1 = \{H, M, L\}$ while the strategy set for 2 is $S_2 = \{L, R\}$.
- We assume that both players choose their action simultaneously.
- Games with a small number of possible actions for each player can be represented as a matrix. This matrix is such that each cell contains the gains of both players as a function of the choice of actions.

Dominant and Dominated Strategies

		Player 2	
		L	R
Player 1	H	$1, 2$	$2, -2$
	M	$-1, -1$	$1, 2$
	L	$0, 1$	$-1, 1$

Dominant and Dominated Strategy

- In this game, player 1 has a **dominant strategy**, i.e. a choice yielding a higher payoff, for any action chosen by player 2.

  It is therefore reasonable (rational?) to predict that player 1 will play H.
- Player 2 has no dominant strategy (always winning) or dominated strategy (always losing).
- But if we think that player 2 knows that player 1 is rational and will therefore choose H, what should be player 2's optimal choice?

  Player 2 should choose to play L.
- Using dominant strategies or eliminating dominated strategy is a first step to predict the behavior of rational players.

Nash Equilibria

- Consider now the following example (called the stag hunt, inspired by J.J. Rousseau).
- The two players are hunters and can try to catch either stags or hares.
  1. To catch a stag, they must cooperate and it gives them each 5 days of food.
  2. Each player can catch a hare alone, which gives him 1 day of food.
  3. If one player tries to catch a hare while the other decides to hunt stags, the latter hunter will get nothing.
- There is no dominant (or dominated) strategy and it is clearly better for each player to cooperate.
- But if one player believes that the other will try to catch a hare, he must do the same.
- How can we predict the outcome of this game?

Nash Equilibria

- The main idea is to find a group of strategies (one choice per player) such that no player would like to change his mind if the other player does not change either.
- When no one regrets his choice, given the actions chosen by the other(s), we have reached a **Nash Equilibrium.**
- Let us consider a n-player game, where $s_i \in S_i$ denotes player's i strategy and $u_i(s)$ his gains, with $s = (s_1, s_2, ..., s_n)$. Let us also note $s_{-i} = (s_1, ..., s_{i-1}, s_{i+1}, ..., s_n)$.

Definition

A vector of strategies $s^* = (s_1^*, ..., s_n^*)$ *is a Nash equilibrium if, for all* $i = 1, ..., n$,

$$u_i(s_i^*, s_{-i}^*) \geq u_i(s_i', s_{-i}^*), \quad \forall s_i' \in S_i.$$

Nash Equilibria

- Nash equilibria can also be defined using the notion of best-response function (BRF), or reaction function.
- $\forall s_{-i} \in S_{-i}$, we define the set of best-actions agent i can choose by $R_i(s_{-i}) = \{s_i \in S_i : u_i(s_i, s_{-i}) \geq u_i(s_i', s_{-i}) \text{ for all } s_i' \in S_i\}$

Proposition

A Nash Equilibrium (NE) is a vector of strategies s^* such that, for all $i \in \mathbb{N}$, $s_i^* \in R_i(s^*_{-i})$. Equivalently, a Nash Equilibrium is where all BRF cross.

- Therefore, looking for a NE amounts to finding a situation where all the BRF are compatible.

  Question: what is the Nash equilibrium in the stag hunt game?

The prisoner's dilemma

- After a crime, two suspects are arrested together and put into separate rooms. The prosecutor lacks evidence so he would like the suspects to confess. His proposal is the following.

  If both suspects confess, they will get 3 years in prison. If neither confess, they will only be charged with lesser offenses and spend only 1 year in prison. If only one suspect confesses, he will be released while the other one will spend 5 years in jail.
- The formal analysis of the situation is as follows
  1. There are 2 players, $i = 1, 2$.
  2. The possible strategies are Confess of Deny: $S_i = \{C, D\}$.
  3. The gains are given by the following matrix:

The prisoner's dilemma

		Player 2	
		D	C
Player 1	D	$-1, -1$	$-5, 0$
	C	$0, -5$	$-3, -3$

The prisoner's dilemma

- What will be the behavior of the agents?
- From a global point of view, the players should deny as they will only be charged with small offenses. But is it a reasonable prediction?
- Denial is not a reasonable prediction as Confess is here a dominant strategy for both players.
- Even when pre-play communication is possible, the only reasonable prediction is that both players confess.
- The equilibrium is here (C, C) which is a dominant strategy for both players and therefore it is also the unique Nash Equilibrium.

A modified prisoner's dilemma

- Let us modify slightly the above game by assuming that if one player confesses while the other one denies, the former is sentenced to 2 years in prison.
- In this new game, confess is not anymore a dominant strategy.
- But there are two Nash Equilibria.
  1. Both players confess.
  2. Both players deny.
- As it is clear from this example, there may exist many Nash Equilibria which have no reason to be Pareto-optimal.
- There are also two equilibria in the stag hunt game.
- Note also that, when complex strategies are considered (as mixed strategies which involve introducing random elements in the strategy), there is always at least one Nash Equilibrium.

Road Map to find Nash equilibrium

- To conduct a best response analysis and solve for the Nash equilibria of a game, just do the following
  1. For each player i, look for best-response function $BR_i(\cdot)$
  2. Then, look for the intersection of these best-responses. This gives you all the Nash equilibria
- When the strategy space is continuous (price, quantities,...), this means writing the optimality conditions for each agent and find the actions compatible with all the conditions.
- Example: find the Nash Equilibrium when two firms compete in price assuming that $D_1(p_1, p_2) = 1 - 2p_1 + p_2$, $D_2(p_1, p_2) = 1 - 2p_2 + p_1$ and $c_1 = c_2 = 0$.

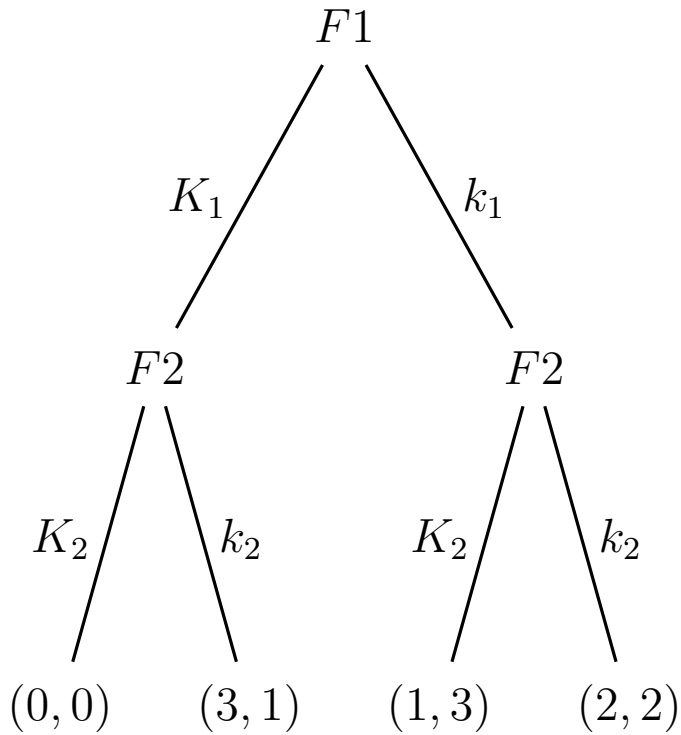
Sequential games

- Most of the economic situations are more accurately depicted as sequential games.
- Those sequential models are often represented by a game tree with decision nodes, i.e. places where agents must make a choice.
- For this sort of game, one should specify: the set of players, the timing of actions, the feasible set of actions at each decision node, the information available at each node and the gains associated with each sequence of choice.
- In the context of dynamic games, the notion of strategy is broader than simply stating the equilibrium actions. Indeed, one should determine the actions of all players in any possible circumstances, even those that will never occur in equilibrium.

Sequential games

- Let us take the example of two firms (F1 and F2), where each one should decide either to produce a large quantity (K_i), or a small quantity (k_i), with $K_i > k_i$ for all $i = 1, 2$.
- Each firm would like to produce a large amount and that the other firm does not produce much -to avoid too low a price.
- We assume that F1 chooses first and F2 makes his choice after observing F1's decision
- The gains of both firms are represented by the following tree.

Sequential games



Sequential games

What are the possible strategies for both players?

- F1 must simply choose between K_1 and k_1.
- As for F2, it is necessary to state his choice if F1 produces K_1 and his choice if F1 chooses k_1. The firm has in fact 4 possible strategies

1. $(K_2 K_2)$, i.e. F2 plays K_2 for any initial choice of F1;
2. $(K_2 k_2)$, i.e. F2 plays K_2 if F1 chooses K_1 but plays k_2 if F1 chooses k_1;
3. $(k_2 K_2)$, i.e. F2 plays k_2 if F1 chooses K_1 but plays K_2 if F1 chooses k_1;
4. $(k_2 k_2)$, i.e. F2 plays k_2 for any initial choice of F1.

Sequential games

		Player 2			
		K_2K_2	K_2k_2	k_2K_2	k_2k_2
Player 1	K_1	$0,0$	$0,0$	$3,1$	$3,1$
	k_1	$1,3$	$2,2$	$1,3$	$2,2$

Sequential games

- Looking at the matrix representation of the game allows to exhibit 3 Nash Equilibria, (k_1, K_2K_2), (K_1, k_2K_2) and (K_1, k_2k_2). But some equilibria are more reasonable than others.
- Let us consider for the example the equilibrium (k_1, K_2K_2).
  1. F2 commits to produce K_2 for any choice made by F1.
  2. F1, fearing that prices would be too low if he choosing himself a large quantity, chooses (k_1).
  3. This allows F2 to benefit from large sales at (relatively) high prices.
- But one may question the credibility of this threat, i.e. the fact that F2 will choose to produce a large quantity whatever the quantity initially chosen by F1.

Sequential games

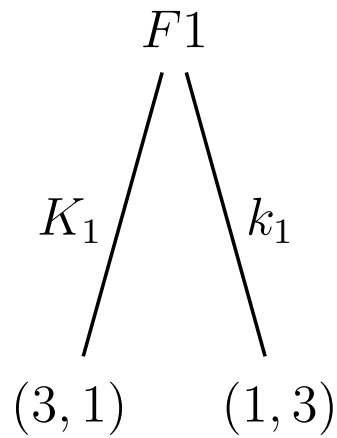
- Suppose now that F1 challenge F2's threat and chooses K_1. Then F2 has no incentive to produce a large quantity K_2.

  Sequential rationality should make us predict that, with the current payoff, if F1 chooses K_1 then F2 will choose k_2.
- F2's threat should not influence F1 as the threat goes against F2's interest.
- Nevertheless, using the standard definition of Nash equilibria does not allow to discard such an equilibrium.
- In sequential games, there is therefore the need adding a new element to ensure that equilibria are "reasonable".

Sequential games

- A way of getting rid of this sort of unreasonable equilibria is to apply the principle of **backward induction**.
- This method consists in starting by the last stage of the game, to see what the optimal choice of the player acting at this node is, to substitute the node with the corresponding gains, and to move backward applying the same method at the previous node.
- In our game,
  1. There are two stages so we first solve the second.
  2. If F1 chooses K_1, it is optimal for F2 to choose k_2.
  3. Inversely, if F1 chooses k_1, F2 will choose K_2.
- For the two nodes where firm 2 must choose, we substitute the nodes by the consequence of F2's optimal decision.

Sequential games



Sequential games

What will the be F1's decision?

- It is direct to see that F1 will choose to produce a large quantity, i.e., K_1.
- The outcome of the game is characterized by the choices (K_1, k_2) but this is not enough to define an equilibrium as an equilibrium must define the choice of the player's for any possible decision node.
- Formally, the equilibrium is defined by $(K_1, k_2 K_2)$, i.e. F1 chooses K_1 and 1) F2 choose k_2 if F1 chooses K_1, 2) F2 choose K_2 if F1 chooses k_1.

Sequential games

- The use of backward induction is simple and allows to select reasonable equilibria but this method is only valid when information is perfect.
- Sometimes, the last period is itself a game where agents play simultaneously.
- One has then to solve the last game, and then to move backward until the first decision node is reached.
- Equilibria derived in this way are called **Subgame Perfect Nash Equilibria**.

  When a method is used to eliminate some Nash equilibria, we use the term of "refinement".

Sequential games

- When the strategy spaces of continuous, the method consists in using best-reply functions derived from the first order conditions of the maximization program.
- Taking as given the actions chosen by the other players, one compute the best response of the last playing agent.
- Then, this best-reply function is incorporated into the objective function of the agent playing the previous stage and his optimal strategy is derived from a first order condition.

Exercise

Peter and Mary must meet to go to a show. They must choose between either going to the stadium or going to the Opera, but they cannot coordinate (it was a long time ago, before the development of mobile telephony). Peter gets a utility of 2 if he goes to the stadium with Mary, while Mary has only a utility of 1 in this case. Conversely, if Peter and Mary meet at the Opera, Mary has a utility of 4 while Peter gets only 1. At last, if Peter and Mary choose different places, they both get 0 utility.

1. Write down the payoff matrix.
2. What is (are) the Nash Equilibrium (equilibria)?
3. When there are more than one equilibrium, which one is the more likely? Why?

Suppose Mary has claimed she would never go the stadium. If Peter chooses to go to the stadium, he can send a message to Mary "I am at the stadium" with no way to get any answer.

4. What is then the most likely Nash equilibrium? Explain.

Oligopoly Behavior

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ESSEC DSBA - 2021

Presentation

- This chapter deals with market structures where only a small number of firms compete.
- This is the case when there are increasing returns to scale, large fixed costs, of that an essential input is only available to a limited number of firms.
- In the case of an oligopoly, each firm must consider the impact of its own decision on the price, but must also try to anticipate the behavior of its competitors.

  So, it can be modeled as a game.
- We will study oligopoly in the short run - where sellers compete mainly in price - and then in the long run - when the main strategic variable is to decide on production capacity.

Price Competition

- The first form of competition, and the most common, is when the firms choose their price to attract consumers.
- To make the analysis as simple as possible, we first assume that the goods sold by the firms are perfectly homogenous.
- In this case, the only feature of interest for the consumers is the price.
- Consider then a situation where two firms compete in price, and such that their marginal cost of production is constant and equal to 10 €.
- Assuming that the demand function writes as $D = 50 - P$, what is the price chosen by the firms?

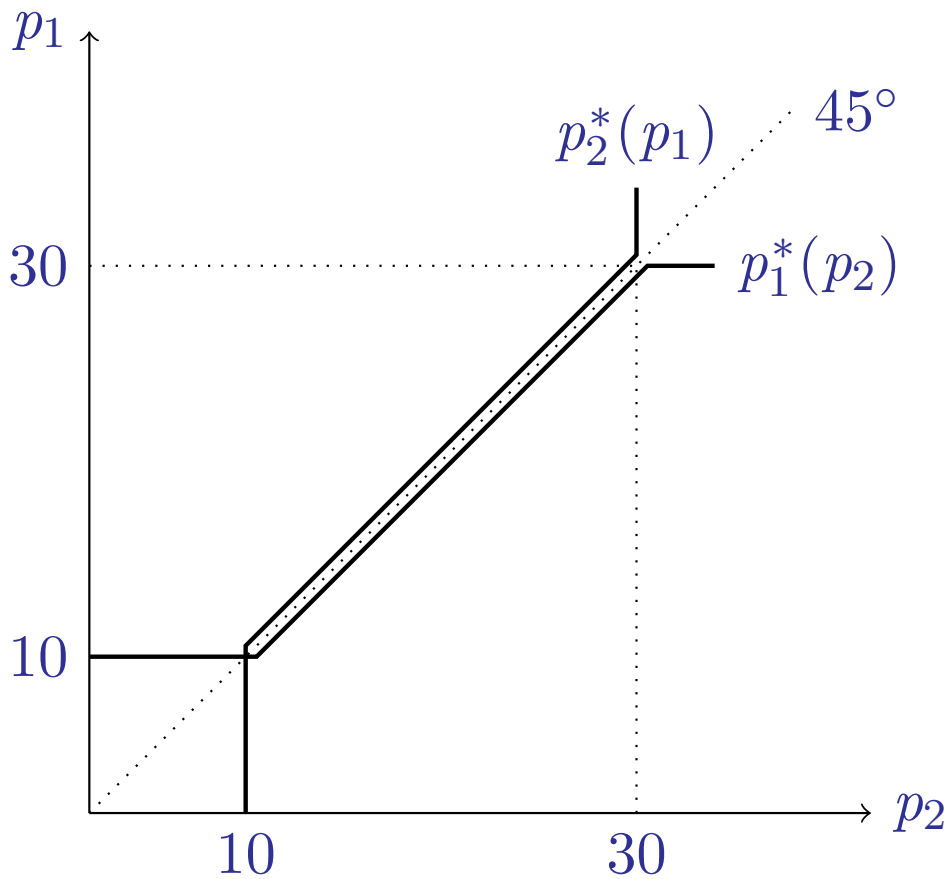
Price Competition

- Note first that a monopoly would choose a price to maximize $(P-10)(50-P)$, which leads to a price equal 30.
- When there are two firms, each firm must choose its price taking into account the choice of the other.
- This situation can be described as a game in which the players are the firms, the set of strategy any price above 0, and the payoff for each firm given by its profit function.
- Note here that the demand addressed to each firm is a function of the prices p_1 and p_2. Indeed,
  1. if $p_1 < p_2$, then firm 1's demand is $D(p_1) = 50 - p_1$ whereas firm 2's demand is zero;
  2. if $p_1 > p_2$, then firm 2's demand is $D(p_2) = 50 - p_2$ whereas firm 1's demand is zero;
  3. if both firms set the same price, $p_1 = p_2 = p$, each firm receives one half of the market demand $\frac{1}{2}D(p) = \frac{1}{2}(50-p)$.

Price Competition

- What is each firm's best strategy in this context?
  1. F1's optimal choice depends on what it conjectures F2 will choose.
  2. Note first that no firm will ever propose a price less than 10 or greater than the monopoly price $p^M = 30$.
  3. If F1 conjectures that F2 will set a price $p > 10$, F1 has some incentives to set a price slightly below p. And the same for F2.
  4. Therefore, each firm's best-response is to set a price slightly below the price chosen by the other firm, as long as this price is in $[10, 30]$
- We can depict each firm's reaction function in the graph (p_2, p_1).

Price Competition



Price Competition

- A pair of strategies is a Nash Equilibrium if no firm can increase its profits by deviating unilaterally from this strategy.
- Equivalently, the reaction functions must be consistent.
  1. $p_1^* = p_1^*(p_2^*)$
  2. $p_2^* = p_2^*(p_1^*)$
- Graphically, it corresponds to the intersection of the reaction functions.
- Therefore, the unique equilibrium of the game is such that both firms set prices at marginal cost, here 10€ - just like in the case of perfect competition.

Price Competition

- This model of price competition has been proposed by Joseph Bertrand, at the end of the XIXth century, so this form of competition in price is called Bertrand competition.
- It generates this intriguing result (called the "Bertrand Paradox") that two firms are enough to replicate the outcome reached in the case of perfectly competitive market.
- It relies on some strong assumptions: homogenous product, no capacity constraint, no collusion between firms.
- But it tells something interesting: when it is easy to adjust production, that is when the elasticity of supply is high, competition is tough, prices are likely to be close to costs and economic profit converges to zero.
- What if the competing sellers offer differentiated products?

Price Competition

- With differentiated products, if one seller undercuts its competitor's price, it would only be able to obtain a part of the competitor demand.
- To model this situation, H. Hotelling has proposed to describe the situation as one where two firms (we keep this simplification) are located at the two ends of a segment, Firm 1 at point 0 and Firm 2 at point 1.
- Consumers have unit demands and a consumer's gross surplus from consuming the product is $\overline{s}$.
- We assume that a consumer always buys from Firm 1 or Firm 2.
- In deciding which product to buy, consumers take into account two elements, the price and the "distance" to the store or to the product.

Price Competition

- A buyer located at x will choose Firm 1 rather than Firm 2 iff $p_1 + tx^2 \leq p_2 + t(1-x)^2$.

  Here, t represents how the product differentiation matters (relative to the price) in the way consumers make their choice.
- The market share of each firm is found by looking at the buyer $\tilde{x}$ indifferent between Firm 1 and Firm 2. This leads to

$$p_1 + t\tilde{x}^2 = p_2 + t(\tilde{x}-1)^2 \Leftrightarrow \tilde{x} = \frac{1}{2} + \frac{(p_2 - p_1)}{2t}$$

- Therefore,
  1. $D_1(p_1, p_2) = \frac{1}{2} + \frac{(p_2 - p_1)}{2t}$
  2. $D_2(p_1, p_2) = 1 - D_1(p_1, p_2) = \frac{1}{2} - \frac{(p_2 - p_1)}{2t}$

Price Competition

- F1's profit is $\Pi_1 = D_1(p_1, p_2)\,(p_1 - c)$, so the effect of a price increase is given by $d\Pi_1/dp_1$, i.e.

$$-\frac{1}{2t}(p_1 - c) + \frac{1}{2} + \frac{(p_2 - p_1)}{2t} = \frac{1}{2} + \frac{(p_2 + c - 2p_1)}{2t}$$

- A price increase by F1 decreases its demand but increases its margin on the residual demand, which is not zero in contrast with the Bertrand model.
- Maximizing each firm's profit, we can derive the firms' best response function
  1. $p_1 = R_1(p_2) = \frac{t}{2} + \frac{c+p_2}{2}$.
  2. $p_2 = R_2(p_1) = \frac{t}{2} + \frac{c+p_1}{2}$
- Note that the prices are *strategic complements* since a price adjustment (upward or downward) by a firm leads the other firm to adjust its own price in the same direction.

Price Competition

- The Nash equilibrium consists in choosing a common price $p = t + c$.
- The higher the taste intensity t, the more firms are in monopoly w.r.t. the consumers located close to them and therefore the higher the price.

  This means that the more consumers differ in their taste, the higher the price the firms are able to set.
- In the Hotelling model, it is assumed that both firms are located at the two ends of the line.
  1. If one firm could choose to relocate its activity, it would certainly choose to be nearer to the center of the line, to propose a good closer to the average taste.
  2. But if both firms can locate in the product space wherever they want, they may choose to locate at the two ends to escape competition.

Limit Pricing

- What happens when one firm can set its price before the other?
- The leader can try to deter the other firms from entering the market.
- This is done by setting a price low enough so that no entrant could make some positive profit.
- This can only happen when 1) there are some economies of scale, 2) the products differentiated (so an entrant cannot conquer the whole market) 3) the old firm is better off with this new price than with an price that accommodates entry.
- This strategy of limit pricing is also used sometimes temporarily to test the financial resources of the entrant.

Capacity Competition

- In the long run, the strategic variable for oligopolistic sellers is production capacity.
- We then describe the market by assuming that sellers compete by setting simultaneously production capacity.

  In this model, first proposed by A.A. Cournot, the price is set by a market-maker such that demand equates total capacity.
- To simplify the analysis, we take the simple case with only two sellers (F1 and F2) assuming that they produce at a constant marginal cost c. We also assume that the demand inverse demand function is given by $P = D - q_1 - q_2$ where q_i is the capacity/production of firm i and $D > 0$.
- Here again, the capacity choice can be analyzed by looking at the Nash equilibrium.

Capacity Competition

- Let us first define firm 1's residual demand as the demand that addresses to firm 1, taking as given the capacity chosen by the other firm.
- In our case, for a given level q_2, firm 1's residual demand curve is given by $P = D - q_2 - q_1$ for $q_1 \in [0, D - q_2]$.
- Since firm 1's profit is given by $Pq_1 - cq_1$, we can obtain firm 1's optimal capacity choice either by equating marginal revenue and marginal cost or equivalently by differentiating the profit w.r.t. q_1.
- This leads to an optimal capacity choice such that $D - q_1 - q_2 - q_1 = c$, that is $q_1 = \frac{D-q_2-c}{2}$.
- The last equality is firm 1's reaction function. Deriving the same for firm 2, we obtain the Nash equilibrium choice of production $q_1^* = q_2^* = \frac{D-c}{3}$.

Capacity Competition

- Suppose that the demand parameter D increases by 1. This is equivalent to saying that each potential consumer is willing to pay 1€ more for each unit of good.
- Will the price rise by 1€?
  1. This would be the case if the firms were not able to increase their production.
  2. But each firm wants to produce more because the marginal revenue on its residual curve is now greater than the marginal cost.
  3. So the price will increase but by less than 1.
  4. Formally, for a given level D, the market price is given by $P = D - q_1 - q_2 = D - \frac{2}{3}(D + c)$. So a shift of 1€ in the demand curve only leads to an increase of 1/3€ of the final price.

Capacity Competition

- What will happen with more than 2 firms?
  1. Each firm still chooses its optimal capacity to equate marginal benefit and marginal cost.
  2. But the more firms on the market, the lower the price and therefore the marginal revenue.
  3. The individual production will then decrease with the number of firms on a market.

Food for thought: show that the price with the Cournot duopoly is lower than the price that would be chosen by a monopoly on the same market. Show also that the industry profit is lower with a duopoly than with a monopoly.

Capacity Leadership

- In the case of Cournot competition, the capacity choices are strategic substitutes.
- Indeed, if one firm increases its capacity, then the other firm will decrease its capacity.
- This implies that if a firm could choose first a high capacity, it will induce the other one to choose a low capacity.
- And because both firms sell at the same price, the leader will make a larger profit than the follower.
- Therefore, in the case of capacity competition, there is a first-mover advantage as long as this capacity choice cannot be changed ex-post.

  Rmk: this first-mover advantage is not always true. In the case of price competition with homogenous products, there is a last-mover advantage.

Restraining Competition

- A monopoly is more profitable than an oligopoly, so oligopolists have some incentive to restrict competition.
- This can be done either by coordinating their choice, either keeping separate entities or merging the firms.
- The first idea to restrain competition consists for the firms in signing an agreement and forming a cartel.
- These agreements amount quite often to set to each firm a maximum level of production, to avoid a drop in price.
    1. In the case of capacity competition, the firms could decide to produce jointly the same level as a monopoly.
    2. They would be able to reach jointly the monopoly profit, which is the maximum profit the industry can gain.
    3. Since each firm has individually some incentives to produce more than its quota, it is important to check compliance with the agreement.

Restraining Competition

- Most developed countries do not allow cartels and agreements between firms designed to restrain competition.
- As firm cartels are usually illegal, they must rely on informal enforcement whose effectiveness depends on
  1. The number of sellers: it is easier with fewer firms;
  2. Excess capacity: with excess capacity, the incentive to exceed its quota is higher for the firms;
  3. Barriers to entry: when it is easy for new firms to enter, it is harder to sustain high prices;
  4. Transparency: when all firms sell identical products and markets are transparent, it is easier to enforce the cartel.

  Food for though: some people claim that promotion campaigns such as "get twice the difference back if you find cheaper elsewhere" is a way to sustain high prices. Explain why.

Restraining Competition

- Another way to restrain competition is for the competing sellers to merge.
- In this case, the industry will be monopolized as in the case of cartel.
- This integration is said to be horizontal when the firms are in the same business (even if the product may not be perfect substitutes), and is different from vertical integration that concerns firms operating at different stages of production.
- Horizontal integration (and sometimes also vertical integration) of large firms is also potentially anti-competitive so it requires the approval of competition authorities.

Exercise

We consider a market where two firms, F1 and F2, compete *à la* Cournot. Both firms have the same marginal cost c (with $c < 1/2$), with respective output q_1 and q_2, and the inverse demand function is given by $P = 1 - q_1 - q_2$.

1. Find the equilibrium quantities chosen by both firms, and the corresponding profits.

We assume that F1 can use a new technology that allows to reach the same production at a marginal cost of 0.

2. What are the new equilibrium quantities in this case?
3. Compute the profits and compare with the one obtained in the first question.
4. What price F1 will be ready to pay to benefit from this new technology? Discuss the case where only F1 can bid for the technology and the case where both firms can bid.