Class 1: Introduction to IO

Industry structures

Efficiency and the size of the market

Welfare analysis

Structure-Conduct-Performance (SCP)

Measures of industry concentration

Issues and assumptions

- Markets and commodities: product homogeneity or product differentiation, market power of the firms
- The firm's objective function: profit maximization
  - $\pi(q) = TR(q) - TC(q)$, if there's only one price: $TR(q) = p \cdot q$
- The number of the firms
- Market entry: free entry or entry barriers
- Price and the firm's decision: price taking or price making (influencing) behavior
- Market demand and the demand facing the firm
- The strategic behavior of the firms: reaction to others' actions

Industry structures

	Perfect competition	Monopolistic competition	Oligopoly (duopoly)	Monopoly
Number of firms	many	many	a few (two)	one
Similarity of products	homogeneous products	differentiated products	homogeneous or differentiated	any
Profit in the long run	$\pi = 0$ (TC=TR)	$\pi = 0$ (TR=TC)	$\pi \geq 0$ (TR≥TC)	$\pi \geq 0$ (TR≥TC)

Differences between perfect competition and other types:

-At least some firms have market power (all 3)

-Products are not homogeneous (e.g. monopolistic competition)

-Lack of freedom of entry and exit (barriers to entry)

Industry structures

- Perfect competition, pure monopoly and in between…

	Industry output	Equilibrium price	Total profit of the industry
Monopoly, Cartel	$\frac{a-c}{2\cdot b}$	$\frac{a+c}{2}$	$\frac{(a-c)^2}{4\cdot b}$
Cournot duopoly	$\frac{2(a-c)}{3\cdot b}$	$\frac{a+2c}{3}$	$\frac{2(a-c)^2}{9\cdot b}$
Stackelberg duopoly	$\frac{3\cdot(a-c)}{4\cdot b}$	$\frac{a+3c}{4}$	$\frac{3(a-c)^2}{16\cdot b}$
Bertrand duopoly, Monopolistic competition, Perfect competition	$\frac{a-c}{b}$	c	0

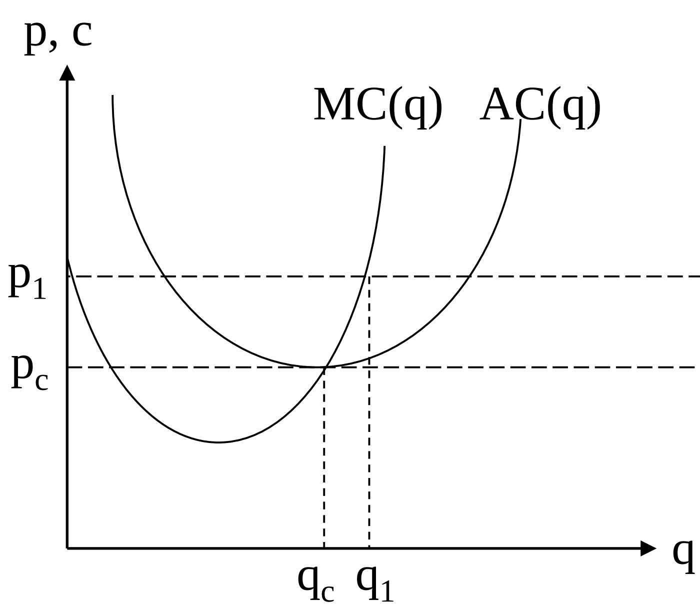
– Assuming linear inverse demand function and identical constant marginal cost

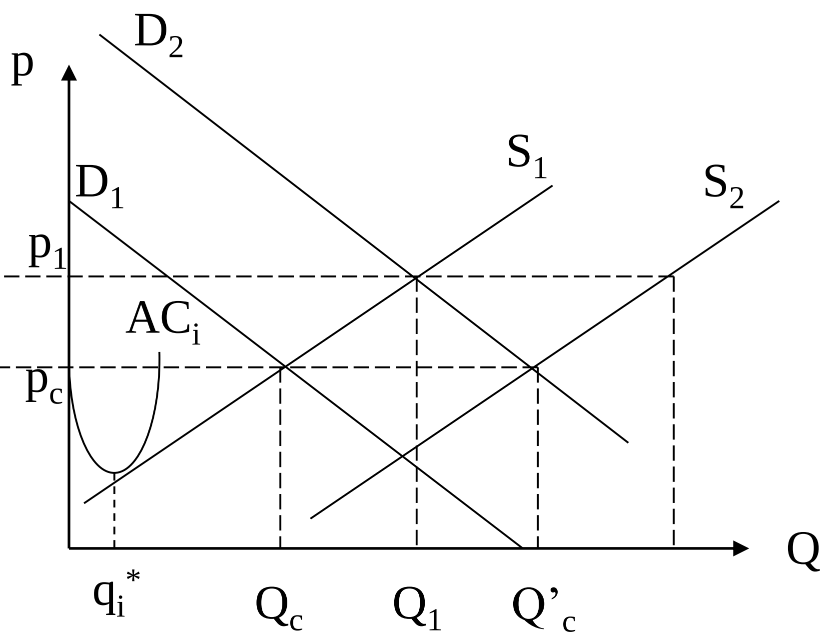
$P = a - bQ$ $\qquad$ $TC(qi) = cqi$

Perfect competition

- Why is there perfect competition among firms? $\boxed{\min_q AC(q^*) \Rightarrow q^* << Q}$
- The first order condition of profit maximization: MR(q) = MC(q)

$$\boxed{\max_q \{pq - c(q)\} \Rightarrow p = MC(q) \quad : p \geq AVC(q)}$$





$$\boxed{\pi(q_1) = p_1 q_1 - AC(q_1)q_1 > 0}$$

$$\boxed{\pi(q_c) = p_c q_c - AC(q_c)q_c = 0}$$

Example: how many firms can operate in a market? (1)

- The market demand curve for cellular phones, and the firms' individual cost curves are, respectively:

$$Q^D = \frac{2000}{3} - \frac{50}{9}P \Rightarrow P = 120 - \frac{9}{50}Q^D$$

$$TC(q_i) = 100 + q^2 + 10q$$

(a) What is the first order condition of the profit maximum for each firm?

(b) (c) How much will they produce and what will be the equilibrium price of the cellular phones?

(c) How many firms can operate in this market in the long run? (n = ?)

(d) How can the industry supply curve be derived?

Example: how many firms can operate in a market? (2)

(a) P = MC(q) → P = 2q + 10 → q^* = (P – 10)/2

(b) Since competitive firms earn zero economic profit in the long run,
P = AC(q^*) = MC(q^*)

$$AC(q) = \frac{100}{q} + q + 10 = 2q + 10 = MC(q) \Rightarrow$$

$$\Rightarrow 100 = q^2 \Rightarrow q = 10 \Rightarrow p = MC(q) = 30 \Rightarrow$$

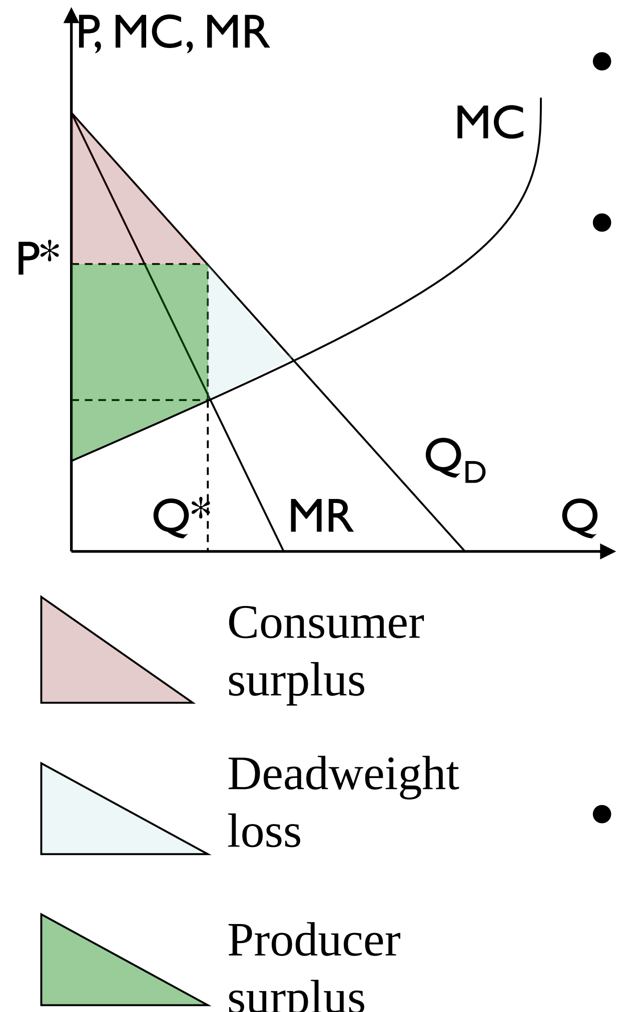
$$\Rightarrow Q^D = \frac{2000}{3} - \frac{50}{9}P = \frac{4500}{9} = 500$$

(c) n = Q^*/q^* = 500/10 = 50

(d) The market supply curve is the horizontal summation of the individual supply curves:

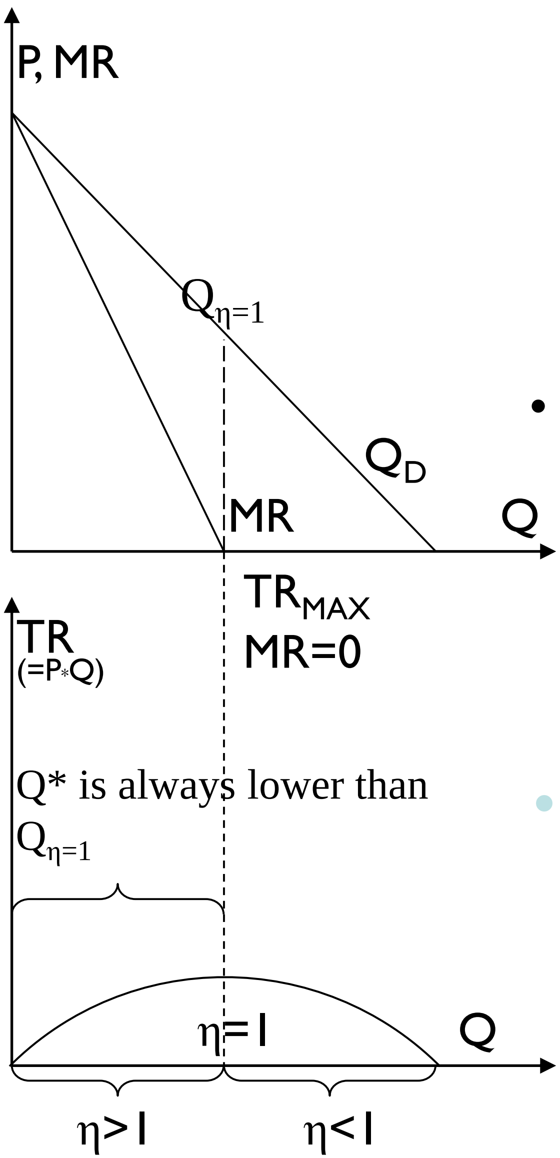
$$q = \frac{P-10}{2} \Rightarrow Q^S = 50 \cdot \frac{P-10}{2} = 25P - 250$$

Monopoly



- Price is always higher than the marginal cost (p > MR = MC)
- From a societal viewpoint, monopoly is less efficient (Pareto efficiency) than perfect competition, as the sum of the consumer surplus and producer surplus is lower. The output is also lower:
  (q*: MR(q*)=MC(q*))
- The quantity supplied by the firm depends on the market demand → no independent market supply curve

Marginal revenue, markup pricing



- The marginal revenue of the firm:

$$MR(q) = \frac{\partial TR(q)}{\partial q} = \frac{\partial (pq)}{\partial q} = p + q\frac{\partial p}{\partial q} =$$

$$= p\left(1 + \frac{q\partial p}{p\partial q}\right) = p\left(1 + \frac{1}{\eta}\right) \qquad \eta = \frac{p\partial q}{q\partial p}$$

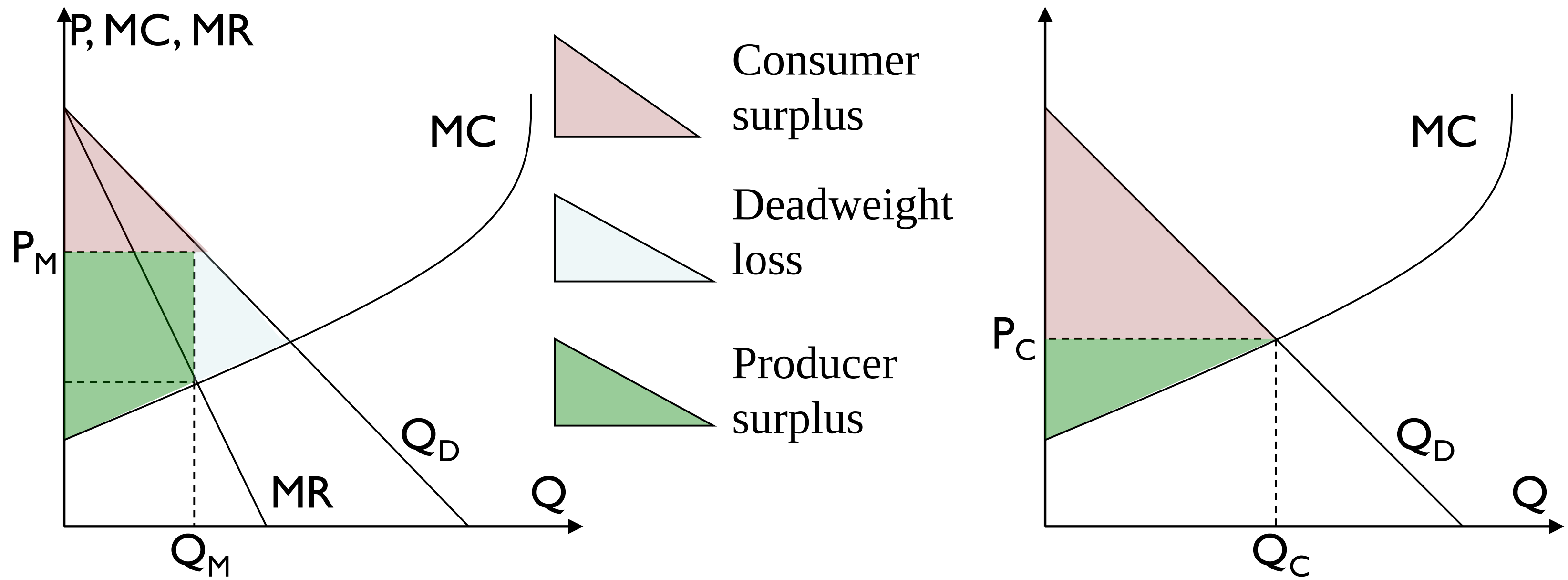
- As (MR=MC) is a necessary condition for optimality, this formula can be used to determine the optimal price:

$$p* = \frac{MC(Q)}{\left(1 + \frac{1}{\eta}\right)} \quad \textit{and as } \eta < 0: \quad p = \frac{MC(Q)}{\left(1 - \frac{1}{|\eta|}\right)}$$

- The rational firm would never produce a higher quantity of output than $Q_{\eta=1}$, as the total revenue decreases for higher quantities. As for all positive q-s, the profit would also decrease as revenue decreases.

$$\frac{\partial TC(q)}{\partial q} > 0$$

Comparison of monopoly and perfect competition, deadweight loss



- The deadweight loss is the economic benefit forgone by the society as the result of the lower quantity of output supplied by the firm with market power.
- In theory, both the consumers and the firm could increase their surplus if the firm could sell (Q_C-Q_M) units of the output at price (P_C) *after* selling Q_M goods at the monopoly price (P_M). If the monopolist were permitted to charge individualised prices, the deadweight loss could be reduced (or in an extreme case, eliminated).

→ Discriminating monopolist, price discrimination

Example

- The 50 cellular phone companies were acquired by one investor and the result was a 50 plant monopoly. The overall cost function of the monopoly and the market demand function are, respectively:

$$TC(Q) = 5000 + \frac{Q^2}{50} + 10Q \text{ and } Q^D = \frac{2000}{3} - \frac{50}{9}P \Rightarrow P = 120 - \frac{9}{50}Q^D$$

- The profit maximizing output level of the monopoly can be calculated by equating MR(Q) with MC(Q):

$$MR(Q) = 120 - \frac{9}{25}Q = \frac{Q}{25} + 10 = MC(Q) \Rightarrow$$

$$\Rightarrow Q^* = 11 \cdot 25 = 275; \quad P^* = 120 - \frac{9}{50} \cdot 275 = 70.5;$$

$$\pi\left(Q^*\right) = 70.5 \cdot 275 - (5000 + 275^2 / 50 + 2750) = 10125$$

Industrial Organization – basic models

1) SCP model (Structure-Conduct-Performance)
2) Anti-competitive conduct – an example: price fixing (cartel)

"People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices."

(Adam Smith)

The Structure-Conduct-Performance model

Basic foundation

demand

price elasticity, substitution

consumer characteristics, econ. growth

supply

raw materials, technology,

supply of skilled labour

Market structure

Number and size of firms, types of products, product differentiation, barriers to entry

Conduct

Price setting, R&D, marketing activities, investments

Performance

Efficiency (Pareto and X-inefficiency), profitability quality of products, innovation, technological development

Reminder

Oligopoly

- The market is dominated by a few sellers
- At least some firms have market power
- There are barriers to entry – firms might be able to make long-run profits
- The strategic behavior of firms is important
- Some basic types:
  - Cournot competition
  - Stackelberg competition
  - Bertrand competition

Cournot competition

- A basic oligopoly model
- Cournot (🡐 Antoine Augustin Cournot) competition: the market is dominated by a few firms that compete on the basis of quantity rather than price and each firm makes an output decision assuming that the other firms' behavior is fixed.
- Characteristics:
  - The number of firms is fixed
  - Each firm has market power
  - Firms choose quantities simultaneously
  - Homogenous (identical) products
  - No cooperation between the firms

Cournot duopoly (two firms)

- The managers of both firms will try to obtain q_i^* that maximizes their profits (π_i), provided that the [expected] output of the other firm (q^e_j) is fixed:

$$\pi_1 = q_1 \cdot p(q_1 + q_2^e) - c(q_1)$$

$$\pi_2 = q_2 \cdot p(q_1^e + q_2) - c(q_2)$$

- If the marginal cost curves of the two firms and the demand curve are linear ($MC_i = dc(q_i)/q_i = c_i$; $p(Q) = a–bQ$):

$$\pi_1 = q_1 \cdot (a - b(q_1 + q_2^e)) - c_1 q_1 = aq_1 - bq_1^2 - bq_1 q_2^e - c_1 q_1$$

$$\pi_2 = q_2 \cdot (a - b(q_2 + q_1^e)) - c_2 q_2 = aq_2 - bq_2^2 - bq_2 q_1^e - c_2 q_2$$

Cournot duopoly (two firms)

- The partial derivatives of the profit functions with respect to q_1 and q_2 are:

$$\frac{\partial \pi_1}{\partial q_1} = a - 2bq_1 - bq_2^e - c_1 \qquad \frac{\partial \pi_2}{\partial q_2} = a - 2bq_2 - bq_1^e - c_2$$

- The profit maximizing outputs (first order condition: the partial derivatives are equal to zero):

$$q_1(q_2) = \frac{a - bq_2^e - c_1}{2b} \qquad q_2(q_1) = \frac{a - bq_1^e - c_2}{2b}$$

- If the two firms are identical (their marginal costs are equal: c_1=c_2=c), the equilibrium outputs are:

$$q_1 = q_2 = \frac{a - c}{3b} \qquad Q = q_1 + q_2 = \frac{2(a - c)}{3b}$$

Cournot competition (n firms)

- If there are more than two firms (the number of firms is n), the output of the industry: $$Q = \sum_{j=1}^{n} q_j$$
- The optimum condition for the i-th firm:

$$p(Q) + \frac{\Delta p}{\Delta Q} q_i = MC(q_i)$$

$$p(Q)\left[1 + \frac{\Delta p}{\Delta Q}\frac{Q}{p(Q)}\frac{q_i}{Q}\right] = MC(q_i)$$

Market share of the i-th firm in the numerator

Price elasticity of demand in the denominator

$$p(Q)\left[1 + \frac{s_i}{\eta}\right] = MC(q_i) \quad \text{or} \quad p(Q)\left[1 - \frac{s_i}{|\eta|}\right] = MC(q_i)$$

Determinants of market power (Market structure)

- Concentration (Number and similarity of firms; extreme cases: monopoly, competition)
- Homogeneity (substitutability) of products (If consumers regard the goods as essentially identical [perfectly substitutable] they always buy at the lowest price).
- … ?

- **How to measure concentration?**

Firms\Markets	A	B	C	D
1	20	60	33.3	45
2	20	10	33.3	45
3	20	5	33.3	1.25
4	20	5		1.25
5	20	5		1.25
6		5		1.25
7		5		1.25
8		5		1.25
9				1.25
10				1.25

Measuring concentration

- Observable dimensions of market structure:
  - The number of firms
  - Inequality (differences in market share)
- Main indicators:
  - Concentration ratio is a measure of the total output produced in an industry by a given number of firms in the industry. It can be calculated as the sum of market shares held by the *m* largest firms.

$$CR_m = \sum_{i=1}^{m} s_i \qquad (CR_4^B = 80; CR_4^D = 92.5)$$

(Most frequently used: $m = 4$)

The Herfindahl index

- Formula : $H = \sum_{i=1}^{n} s_i^2$

where $s_i = \frac{q_i}{Q} \cdot 100$ or $s_i = \frac{q_i}{Q}$

- range: $0 < H < 10000$ (or 1)
- Depends on:
  - number of firms (if $n\downarrow \rightarrow H\uparrow$)
  - inequality (if inequality $\uparrow \rightarrow H\uparrow$)

(for our 4 markets:
$H_A = 5\times20^2 = 2000$; $H_B = 60^2+10^2+6\times5^2 = 3850$
$H_C = 3\times33{,}3^2 = 3326{,}67$; $H_D = 2\times45^2+8\times1{,}25^2 = 4062{,}5$

The Herfindahl index (also known as Herfindahl–Hirschman Index, or HHI) is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them

Decomposition and interpretation

- $d_i = s_i - 1/n$ (deviation from the average market share in the industry)

$$H = \underbrace{\sum_{i=1}^{n} d_i^2}_{\text{inequality}} + \underbrace{\frac{1}{n}}_{\text{number of firms}}$$

Mearsuring Market Concentration in the Hungarian Chemical Industry (Source: Hungarian Competition Authority, 2006)

	Number of firms	CR3 based on the turnover of firms	CR5 based on the turnover of firms	CR10 based on the turnover of firms	HHI based on the turnover of firms
Basic chemicals	165	73,18	82,32	89,67	2 463
Agrochemicals	32	76,73	83,97	92,12	2 404
Paints, dyes, inks and coatings etc.	50	62,63	71,25	82,83	1 629
Soaps, detergents, bathing foams etc.	121	76,23	87,48	91,77	2 668
Other chemicals	91	26,19	39,19	63,21	493
Chemical fibres	5	96,06	100,00	100,00	5 319

CR_m – the sum of market shares of the m largest firms

Measuring performance (efficiency): Lerner index

- **Market power** is the ability of a firm to alter the market price of a good or service (hike the price above marginal costs)
- **Formula**: Lerner index (m_i)

For one firm: $$m_i = \frac{p - MC_i}{p}$$

For an industry: $$M = \sum_{i=1}^{n} s_i m_i$$

In a perfectly competitive market, the Lerner index is equal to zero (perfect competition is used as a benchmark)

The relationship between market power and concentration

- Cournot oligopoly with n firms (s_i: market share of the i-th firm)

$$m_i = \frac{p - MC_i}{p} = \frac{s_i}{|\eta|}$$

- Lerner index for the industry:

$$M = \sum_{i=1}^{n} s_i m_i = \sum_{i=1}^{n} s_i \frac{s_i}{|\eta|} = \frac{HHI}{|\eta|}$$

(Competitive market = $0 < M < 1/|\eta|$ = Monopoly)

The weakness of the SCP model: it disregards the strategic interaction of the firms → Game theoretical approach to IO

A useful tool for explaining the strategic behaviour of firms (competition versus cooperation) =

GAME THEORY

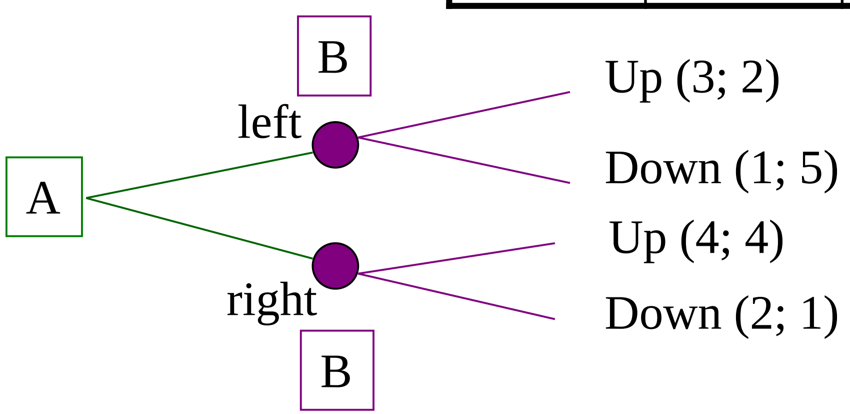
About game theory

- Strategic behavior: reaction to known or assumed actions of the competitors
- Strategies: optional moves of the players as a reaction to the other players' actual or assumed moves
- Pay-offs: the gain or loss of a player resulting from his different moves
- Simultaneous decisions and sequential moves
- Finite and infinite number of possible moves
- The normal form of a game

	A		
B		Left	Right
	Up	3; 2	4; 4
	Down	1; 5	2; 1

Equilibrium

- The extensive form of the game



THE PRISONER'S DILEMMA

Two men are arrested, but the police do not possess enough information for a conviction. Following the separation of the two men, the police offer both a similar deal—if one testifies against his partner (defects/betrays), and the other remains silent (cooperates/assists), the betrayer goes free and the cooperator receives the full 15-year sentence.

F_1 \ F_2	Stay silent (coop.)	Confess (no coop.)
Stay silent (coop.)	1 year, 1 year	15 years, Goes free
Confess (no coop.)	Goes free 15 years	10 years, 10 years

Nash Equilibrium

Collusion or competition?

S_2 / S_1	$q_1=15$ (coop.)	$q_2=20$ (no coop.)
$q_1=15$ (coop.)	450, 450	375, 500
$q_2=20$ (no coop.)	500, 375	400, 400

Market demand:
p=100-Q
Costs:
MC=AC=40
Quantity (monopoly): Q=30
Price (monopoly): p=70
Profit (monopoly):900,
as $\Pi=(p-AC)\times Q$

Firms compete on the basis of quantity (Cournot duopoly):
No cooperation = higher output = higher profit, but lower price

Collusion or competition?

S_1 \ S_2	$p_1=60$ (coop.)	$p_2= 50$ (no coop.)
$p_1=60$ (coop.)	800, 800	0, 1500
$p_2=50$ (no coop.)	1500, 0	750, 750

Market demand:
p=100-Q
Costs:
MC=AC=20
Price (monopoly): p=60
Profit (monopoly):
Π=1600

Firms compete on the basis of price (Bertrand competition): Consumers will buy from the firm that offers a lower price (final result after consecutive price cuts: P=MC=20)