EFR summary

Microeconomics, FEB11001X
2025-2026

Lectures 1 to 16

Weeks 1 to 7

Details

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Microeconomics - IBEB
Lecture 1, week 1

What is (micro)economics

Economics is a science that studies how people, firms, and organisations behave and make choices when there is scarcity.
Microeconomics in particular is the study of individual choices and the study of group behaviour in individual markets.
Macroeconomics is the study of broader aggregations of markets.
Economists study **how** and **why** people make choices. Therefore economics is better at explaining individual markets than the entire economy.

The Cost-Benefit approach to decisions

Economists assume that choices are made based on the cost-benefit analysis.
The main question of the cost-benefit analysis is if you should do a particular activity:
Should I do activity X?
$B(x)$ = Benefit of activity X
$C(x)$ = Cost of activity X
If $B(x) > C(x)$ you **should** do activity X.
If $B(x) < C(x)$ you **shouldn't** do activity X.
If $B(x) = C(x)$ you are indifferent.

The reservation price of activity x = the price at which a person would be indifferent about doing x and not doing x.
If $B(x) - C(x) > B(y) - C(y)$:

- $B(x) - C(x) = B(y) - C(y) + r$ (reservation price)

So there is a reservation price for which you are indifferent about doing activities x and y.

The Cost-Benefit approach to decisions

Pitfall 1. Ignoring implicit costs

Implicit costs are costs that are not explicit. This is the loss of alternatives when one alternative is chosen.

An example of this is: if you spend 3 hours watching TikTok each day, you aren't able to do anything else. For example, go to work or hang out with your friends. You might have been able to earn 50€ in those 3 hours. This way something free like Tiktok will cost you money in the form of implicit costs.
Costs and benefits are reciprocal. It doesn't matter if you subtract those 50€ from the benefits or treat them as costs. Just make sure you don't count them twice!

Pitfall 2. Failing to ignore sunk costs.

Sunk costs are costs that are beyond recovery at the time a decision is made and so should be ignored. Because these costs are beyond recovery they are irrelevant.

An example of this is: Imagine you bought a concert ticket for 50€ and it isn't possible to resell this ticket. At the night of the concert you get invited to a free party which you would enjoy more than the concert. Should you go to the party or not?
In this case, you should definitely go to the party because the 50€ for the concert is beyond recovery and therefore should be ignored. This way you should go to the party.

Pitfall 3. Measuring costs and benefits as proportions rather than absolute monetary amounts

In your decision making you should only measure costs as absolute monetary amounts and not as proportions. So it shouldn't matter if you save 10€ on a TV of 500€, or 10€ on a shirt of 20€.

Pitfall 4. Failure to understand average vs. marginal distinctions

Marginal costs = Increase in total cost resulting from carrying out one additional unit of an activity.
Marginal benefit = Increase in total benefit that results from carrying out an additional unit of an activity.
You should increase your level of activity as long as **marginal B(x) >= marginal C(x)**

Average cost = Average cost of undertaking n units activity = **Total cost / n**
Average benefit undertaking n units of activity = **Total benefit / n**

The **optimal amount** of a continuously variable activity is when **MC = MB** (Marginal cost is equal to Marginal benefit).

Different approaches to choice behaviour

Positive approach: What do people choose, and how do we declare what they choose?
Normative approach: What ought or what should people choose?

The positive approach emphasizes declaring and understanding. This is used in Science, advertising, and managing people.

The normative approach helps people to make good decisions. It is important that it's good for those people.

Not all choices are good in the Cost-Benefit analysis

Economics assumes that people are rational. That doesn't mean that all the decisions are "good". People make mistakes.
The Homo-Economicus: Stereotypical decision maker in self-interest model.

Economic agent: Individual or group making choices. A group can also be a single agent. For example, if Apple increases their iPhone prices. In this case, Apple is a single agent.

Three principles of economists

1. People make choices by **optimising**: They try to make the best choices.
2. Lots of attention goes to the **equilibrium**: a situation where no one wants to change their choices.
3. **Empirical analysis**: Economists use data to test and prove their theories.

Causality: What causes what?

Observation: a statement based on something one has seen, heard or noticed.
For example: When the sun shines, there are a lot of people on the beach.

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Lecture 2, week 1

The market

Definition: A market exists of all the buyers and suppliers of a good or service.
Markets come in all forms and sizes. Place, anonymity and time are all important factors of defining the market.
Economists are among others interested in:

1. Explaining the price of a good (P)
2. Explaining the quantity traded (Q)

The **demand curve** describes the relation between the quantity of a good that demanders want to buy and the price of that good.
Law of demand: Empirical observation that if the price of a product falls, the quantity demanded increases.
$Q = f(P)$
=> $\frac{dQ}{dP} = f'(P) < 0$

Two explanations for the law of demand:

1. Increase in price: which makes people look for alternatives: substitution-effect
2. Increase in price: something has to change: income-effect

The **supply curve** describes the relation between quantity of a good that suppliers want to sell and the price.
Law of supply: empirical observation that suppliers want to sell more if the price rises.

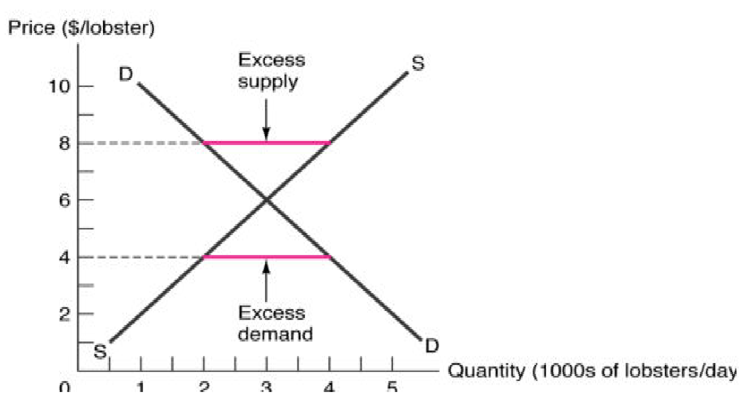
$$Q = f(P)$$
$$\frac{dQ}{dP} = f'(P) > 0$$

Two ways of reading the supply and demand curves:
Horizontal interpretation: The quantity that is offered/demanded at a certain price.
Vertical interpretation: The price that the market will move towards at a certain quantity offered/demanded.

The equilibrium

The equilibrium quantity and price is the intersection of the supply & demand curves. This is the point where all the participants are 'satisfied'. 'Satisfied' in this case means that buyers and sellers are buying/selling the amount they want to at that price.
So: $Qs(P) = Qd(P)$

If the price-quantity pair is above the equilibrium: excess supply
If the price-quantity pair is above the equilibrium: excess demand



Determinants of demand/supply

Determinants of demand:

- Incomes
  - **Normal goods**: If income increases, quantity demanded increases.
  - **Inferior goods**: if income increases, quantity demanded decreases.
- Tastes
- Price of substitutes and complements
- Expectations
- Populations

Determinants of demand:

- Technology
- Factor prices (production prices)
- Expectations
- Weather

Government intervention

Government intervention often disrupts market equilibrium and ends up doing more harm than good.

An example is rental policy. In lots of cities the rent prices are too high for the poor. A reaction from politicians on this is the point system. The renting price is based on objective criteria instead of supply and demand. This results in excess demand. Another problem with this is that the poor people might prefer to use the extra money on something else, so the government would be better off giving the money to the people instead of cheaper houses.

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Lecture 2/3, week 1

Rational choice model

A **model** is a simplified description of reality.

Structure of an economic model:
1. Description of possibilities of economic agent
2. Description of his goals.

A combination of both leads to an explanation of his behaviour.

A few assumptions need to be made for now to decide:
1. Complete information
2. One period
3. Other people don't matter

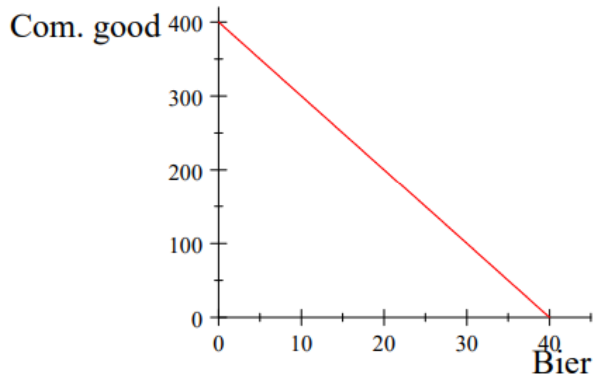
The budget curve (opportunity set)

The options of Charlie are depending on the price of beer, the price of pizza and his **monthly income**. Which makes: $M = PbB + PzZ$
Which can be rewritten as a line by writing $B = \frac{M-PzZ}{Pb}$
It's slope coëfficiënt = -(Pp/Pb) and can be interpreted as that if Charly wants to buy one extra pizza he should sacrifice Pp/Pb beers.

In reality instead of the choice being between two goods the choice might be between millions of goods. This can be written as:

$$M = \sum_{i=1}^{N} PiGi$$

Imagine instead of wanting to be looking at all goods we want to look at one good, and another good which consists of all other goods. This is the '**Composite good**'. The price of the composite good = 1.



Description of his goals

We describe what an agent wants with help of preference orders: A scheme by which a person organises alternatives based on desirability.
For the preference orders there are a few assumptions:

1. **Completeness:**
   For any two bundles A and B, the consumer can compare them:
   A is preferred to B, or B is preferred to A, or the consumer is indifferent.
2. **More is Better (Monotonicity):**
   If a bundle A has *more of at least one good* and *no less of the other*, then A is preferred to C.
3. **Transitivity:**
   If A is preferred to C and C is preferred to D, then A is preferred to D.
4. **Continuity:**
   If a bundle A is only slightly different from B, preferences don't jump suddenly. Meaning: if A is preferred to B, then bundles *very close to A* are also preferred to B. (This ensures smooth indifference curves.)
5. **Convexity:**
   If the consumer is indifferent between A and C, then any mixture (combination) of A and C is at least as good as A or C.
   This is why indifference curves are **bowed inward** (people like **variety**).

A few exceptions on transitivity:

- Football games: if Feyenoord wins from Ajax, And Ajax wins from PSV it doesn't necessarily mean Feyenoord will win from PSV.
- Collective preference orders based on majority (votes)

The indifference curve

An indifference curve is a set of bundles between which a consumer is indifferent.

Marginal rate of substitution (MRS) is the slope coëfficient of the indifference curve: Which means how much of product A you are willing to give up for an extra product B.

Indifference map:

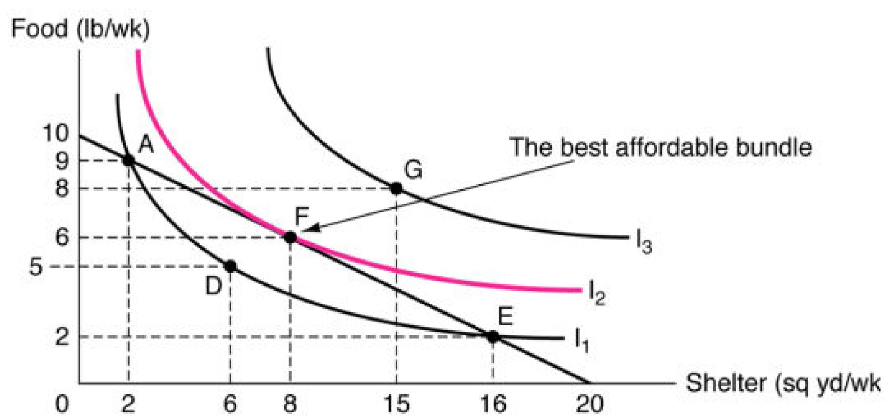
- Unlimited amounts of indifference curve
- The higher the curve, the higher the utility
- Different persons have different indifference curves and therefore also different indifference maps
- Indifference curves cannot cross each other.

Two ways to learn about indifference curves:

1. Asking questions about all sorts of bundles.
2. Statistics (How do income & prizes affect a choice)

How to maximise utility

The goal of the consumer is to maximise its utility (trying to reach the highest indifference curve)
The highest indifference curve is reached when the MRS (slope coëfficient of indifference curve) is equal to the slope coëfficient of the budget constraint.
So when: $MRS = \frac{Px}{Py}$



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Lecture 4, week 2

Rational choice model into mathematics

The structure of the economic model can be written as:
max. U (x, y) s. t. y = f(x)
U (x, y) describes the indifference map (all the indifference curves)
y = f(x) describes the budget constraint.
Maximising this will make sure all the resources are used optimally.

The utility function is described as U = U(x, y) where U stands for utility.
Utility is something positive, so therefore we want to maximise our utility.
More-is-better implies:
$\frac{\partial U}{\partial Y} = UY > 0; \frac{\partial U}{\partial F} = UF > 0$
Which makes sure the marginal utility is greater than zero.

If you write the differential of U(F, S) it can be written as: $MRS = \frac{dF}{dS} = -\frac{Us}{Uf}$

Ordinal vs. marginal utility

Ordinal utility: People can say bundle A is better than bundle B but the number U (utility) has no meaning in itself.
Cardinal utility: The number in itself has meaning because you can compare people's utility number against each other.

Economics of happiness makes use of cardinal utility:
People from different countries were asked how happy they are on a scale of 4. An interpretation of this scale of 4 is that they were asking on which utility scale people are.
The answers got used to decide how happy people were, and it concluded that richer countries reported a higher utility than poorer countries.

So what is **important for utility**:

- Relative income position
- Marital status: A divorce is compensated by 100.000 Euros higher income.
- Work versus no work
- Security: Risk aversion
- Children makes you deeply unhappy

Solving the optimisation problem

We solve the optimisation problem with two methods:

1. The **Lagrange method**
2. The **substitution method**

The lagrange method:

1. Set up the lagrange function: $L(x, y) = U(x, y) - \lambda(ax + by - m)$
2. Set up the first order conditions:
   a. $Ux(x, y) - \lambda a = 0$
   b. $Uy(x, y) - \lambda b = 0$
   c. $ax + by = m$
3. Divide 2a and 2b: $\frac{Ux(x,y)}{Uy(x,y)} = \frac{a}{b}$
4. Solve the rest of the variables with this answer.

The substitution method:

1. Rewrite: $ax + by = m$ into for example: $y = \frac{m-ax}{b}$
2. Substitute y into U(x, y) so that makes $U(x, \frac{m-ax}{b})$
3. Take the derivative of U.
4. Optimise the derivative of U.

You can also solve problems with even more variables by setting up the first-order derivatives by putting all the first partial derivatives and the budget constraint together.

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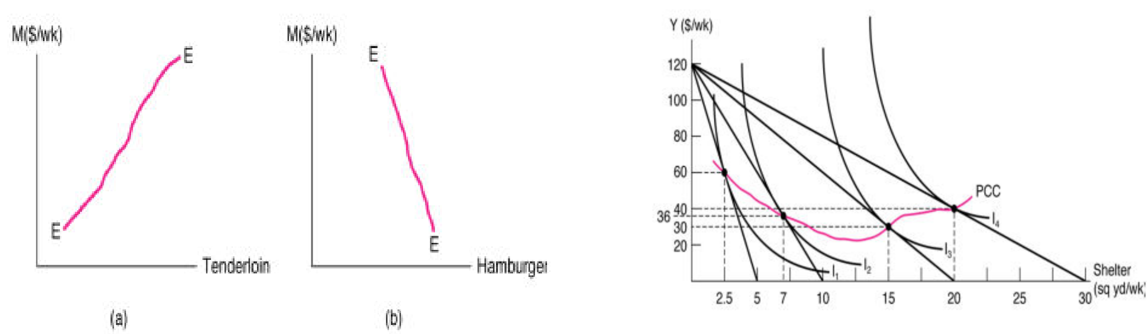
Lecture 5&6, week 2

Analysing the demand curve

Individual demand curve: how does the quantity demanded of a person change when prices differ?
Another name for the individual demand curve is the **price-consumption curve**(PCC). It shows for every price the best bundle (in relation to the different budget constraints and the indifference map).
A price increase will always make a person worse off, because he will reach a lower indifference curve.

Engel curve, Q = f(M), shows the relation between income and the quantity demanded.
With normal goods: f'(M) > 0
With inferior goods: f'(M) < 0

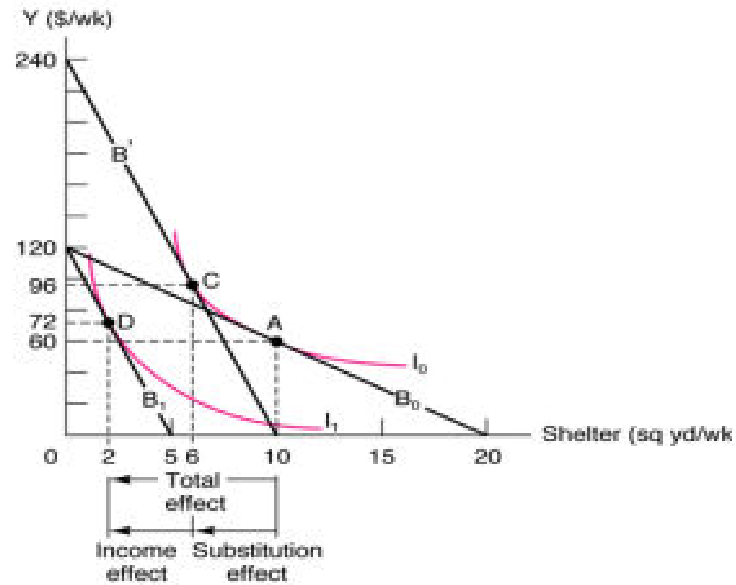


Effect when the price changes

There are two reasons why the quantity demanded changes when the price increases:

1. The **income-effect**: Lower real income (Engel curve)
2. **Substitution-effect**: Looking for alternatives.

To distinguish substitution effect and income effect: shift new budget equation to the point where the initial utility can be achieved.

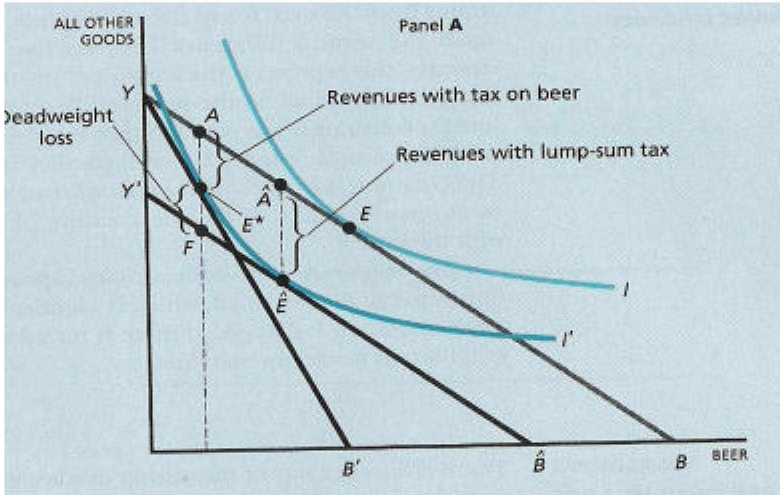


The difference between C and D in shelter is the income effect.
The difference between A and C in shelter is the substitution effect.

Government taxing

When the government set a tax on a product there will be changes in the budget curve of the consumer and will therefore change the utility the consumer is reaching. We want to make the tax as efficient as possible:
A situation is inefficient if it is possible for the government to achieve higher returns while the consumer receives the same utility.

When putting a tax on a product the budget curve will change:
$PxX + PyY = M \rightarrow (Px + t) + PyY = M$
When putting a tax on income the budget curve will change:
$PxX + PyY = M \rightarrow PxX + PyY = M - T$



Income tax will reach higher returns while the consumer receives the same utility. Therefore not changing the VAT rate on a product and taxing income is more efficient. The tax on for example alcohol can be justified for other reasons, like health.

Individual curve to market curve

The market demand curve is the sum of the individual demand curves.
Summing the individual demand curves will give the market demand curve.
An example:
$P = 16 - 2Qa \ -> \ Qa = 8 - \frac{1}{2}p$
$P = 8 - 2Qb \ -> \ Qb = 4 - \frac{1}{2}p$
$P <= 8 \ -> \ \Sigma Qi = Q = 12 - P \ -> P = 12 - Q$
$P > 8 \ -> \ P = 16 - 2Q$

Price Elasticity (ε)

Managers would like to know how strong the demand reacts to the price.
Price elasticity = the resulting percentage change in quantity of a percent change in price.
$\varepsilon = \frac{dQ}{dP} * \frac{P}{Q}$
There are three possibilities for **price elasticity**:
$\varepsilon < -1$: **Elastic demand**, demand decreases more than one percent when price increases one percent.
$\varepsilon = -1$: **Unit-Elastic demand**, demand decreases one percent when price increases one percent.

$\varepsilon > \ -1$: **Elastic demand**, demand decreases less than one percent when price increases one percent.

Income elasticity = the resulting percentage change in quantity of a percent change in income.

$\eta = \frac{dQ}{dM} * \frac{M}{Q}$

Three possibilities for income elasticity:

$\eta < 0$ -> **inferior goods**

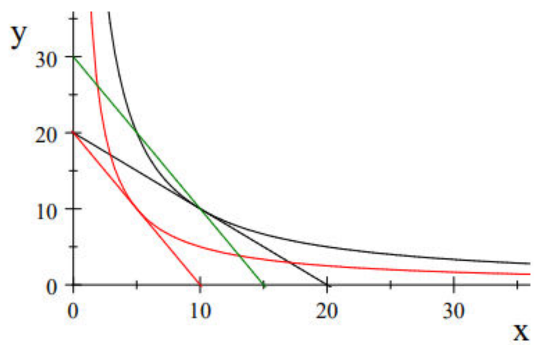
$0 <= \eta <= 1$ -> **Normal goods**

$\eta > 0$ -> **Luxury goods**

Price compensation

Price compensation means that you have so much more income that you can buy the same bundle you used to buy when prices were lower.

Price compensation will lead into higher utility, because the budget curve will go over the old indifference curve you used to reach. -> See illustration



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Lecture 6, week 2

Uncertainty in economics

In the previous notations we assumed that the consumer knows all prices, his income and the features of all products. In reality, people are uncertain about prices, their taste, the quality of products and much more.

Uncertainty will raises two questions:
1. How and to what extent do people collect information
2. How do people decide under uncertainty.

When people collect information they look at what is known, what isn't known and after this they start collecting. That raises the question how much information needs to be collected. Therefore we always use the cost-benefit analysis:
- Benefit: The amount of information raises your changes of making a good decision.
- Cost: Collecting information doesn't come without a cost.

B = Benefit of a good decision (instead of a bad one)
P(I) = Change of a good decision as a function of the amount of information.
C(I)= The cost of collecting information
Therefore we want to:
Max: P(I)B-C(I) -> $\frac{\partial P(I)}{\partial I}B = \frac{\partial C(I)}{\partial I}$

Rational ignorance

Research shows however that voters are "dumb" (ignorant)
Economics call that "**rational ignorance**"
Take for example collecting information for the American elections:
- Benefit: Increases your vote the chance that the best candidate wins
  - B = Difference in utility per candidat = 0(U(Trump)-U(Clinton))
  - P(I) = The chance that your vote will be decisive = 0

- Cost: C = Collecting information about all sorts of political issues.

A way of winning information is “**Communication”**
The amount of information depends on:
- The sender of information
- The message
- Circumstances

“Communication”

A way of collecting information is “**Communication**”
The degree in which statements contain information depends on:
- The sender of the information
- The message
- The circumstances

Every producer will say they have the best product if there is no way for the consumer to find out which is the best.
That’s when **balance thinking** comes into play.
For example: Producer A offers a 10 year warranty because he makes amazing products. Producer A will be able to demand a higher price. Although there will be no balance yet, because all the other producers will all be seen on the same level. That’s why producer B also offers a warranty of 5 years, even though it is worse than the warranty of producer A. This will continue until everyone offers a warranty of different duration and so will the consumer find out about all the products which are best

- **Relevation principle:** some information is given voluntarily, because if no information is given, people fear the worst.

Decision-making under uncertainty

The two main questions about uncertainty are:
- Collecting information
- How to decide under uncertainty

Economists see decision making under uncertainty just like a lottery.

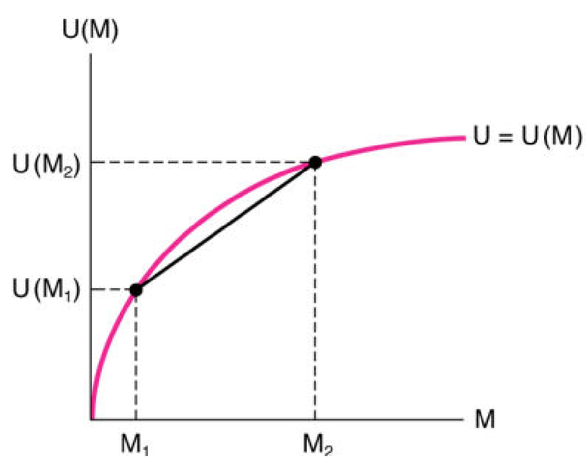
The expected value = The sum of all possible outcomes weighted by its respective probability of occurrence.
For example: If i can invest 100 euros and i have a 50% chance of tripling my money and a 50% chance of losing all my money, the EV = ½ * (300-100) + ½ * (0-100)=50

In economics people make decisions based on expected utility (and not expected money)! This is very important to keep in mind. (This is called the Von Neumann-Morgenstern expected utility model)
That's why people make choices based on the expected utility.
The expected utility = The sum of all possible outcomes measured in utility weighted by its respective probability of occurrence.

A **fair gamble** = A lottery with an expected value = 0.
A **risk-averse person** prefers security above a fair gamble. His preferences are described by a utility function with declining marginal utility.

Declining marginal utility is seen in the illustration below. You can see that the line of expected utility is always below the utility function and therefore a risk-averse person prefers security above a fair gamble.

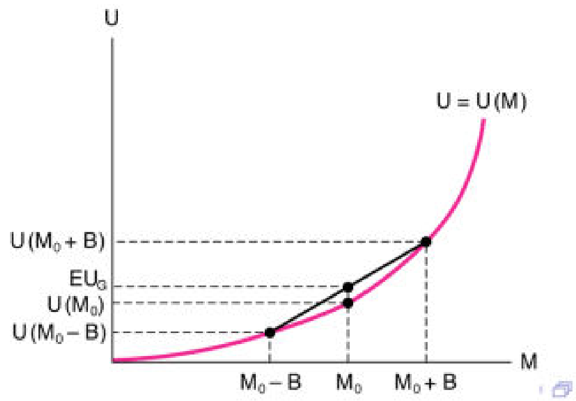
$$U'(M) > 0; U'' < 0.$$



A **risk-seeking person** prefers a fair gamble above security. The preferences of a risk-seeking person will be described by a utility function with a declining marginal utility.

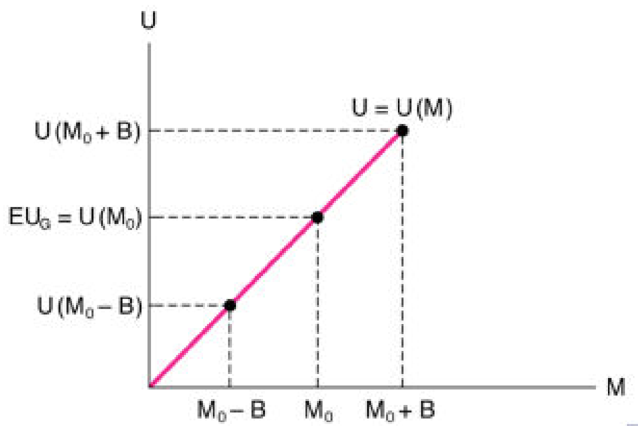
See the illustration below for the utility function of a risk-seeking person:

$$U'(M) > 0; U''(M) > 0$$



A **risk-neutral person** is indifferent between accepting and rejecting a fair gamble. He has a utility function with a constant marginal utility.
See the illustration below for the utility function of a risk-seeking person:

$$U'(M) > 0; U''(M) = 0$$



People are willing to pay a lot for insurance!

A **full insurance**, is an insurance where income, M, is independent of the factor you are insuring.
An example of what you could be insuring is your health. Let's say there's a ⅔ Change you stay healthy and a ⅓ change you get sick. Your expected utility will be EU=⅔ x 600+ ⅓ x 150 = 500. We are also assuming you are risk averse. The amount you are willing to pay for insurance = M, if you stay healthy, - M corresponding to the expected utility which lies on the same indifference curve.

Moral hazard is the incentive to take greater risk because the cost of that risk is borne by others. So if you're insured of something you might take greater risk, for example not putting your bike on a lock.

Example of a question of decision making under uncertainty

Imagine that Sarah has two options. One option is becoming a teacher where she is certain of M=5. The other option is becoming an actrice with a 1% chance to earn M=400 and a 99% change to earn M=2.
Her utility function is described as U(M)=1 - 1/M
^Side note on the utility function: U'(M)= 1/M^2 -> U"(M)=-2/M^2. Because U'(M)>0^&U"(M)<0 is she risk averse.

Her expected utility for becoming a teacher is $1 - \frac{1}{5} = 0.8$
Her expected utility for becoming an actress is $\frac{1}{100}(1 - \frac{1}{400}) + \frac{99}{100}(1 - \frac{1}{2}) = 0.505$
Therefore she will become a teacher because EVteaching>EVacting

Now imagine sarah can buy advice. Someone can predict perfectly if she will become a topactress. How much will Sarah at most pay for this advice.
$U(T)\ without\ advice\ = U(t - p)\ with\ advice$
$0.99(1 - \frac{1}{5-p}) + 0.01(1 - \frac{1}{400-p}) = \frac{4}{5}$from which will follow p=0.05. So sarah will pay at most p=0.05 for the advice.

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Lecture 7, week 3

The Intertemporal Consumption Choice Model

Up till now we made the assumption that the consumer spends his entire income. In reality consumers also save money and get loans. Therefore the question rises: how does a consumer distribute his consumption over time?

Therefore we make use of two periods: today and the future.

We also assume that there are no initial assets and no inheritances.

Intertemporal Choice

- Trade-off between consuming today (C_1) and consuming tomorrow (C_2).
- Consumer has income M_1 today and M_2 tomorrow (no inflation ⇒ prices constant).
- Consumption decisions involve saving or borrowing.
- Normalise $pC_2 = 1$.

Intertemporal Opportunity Cost

In chapter 4, the opportunity cost between goods x and y was $-Px/Py$.
Here, the cost of consuming today vs tomorrow is the interest rate **r**.

The gross opportunity cost of consuming today is $(1 + r)$, and thus, the slope of the budget line = $-(1 + r)$.

For $r \geq 0$, the line is steep → borrowing is costly.
To transform tomorrow's M euros in today's euros: $M \rightarrow M / (1 + r)$
To transform today's M euros in tomorrow's euros: $M \rightarrow M \times (1 + r)$

Intertemporal Budget Constraint

If today's consumption C_1 is on x-axis and C_2 on y-axis:

- If all income is consumed tomorrow: $C_2 = M_2 + M_1(1 + r)$
- If all income is consumed today: $C_1 = M_1 + M_2 / (1 + r)$
- Slope of budget constraint: $-(1 + r)$

We can read the budget constraint from either today's or tomorrow's perspective.

The intertemporal budget constraint in today's euros: $C_1 + C_2 / (1 + r) \leq M_1 + M_2 / (1 + r)$
The intertemporal budget constraint in tomorrow's euros: $(1 + r)C_1 + C_2 \leq (1 + r)M_1 + M_2$

Note: If the borrowing rate > lending rate, the constraint has a kink at the endowment (M_1, M_2).

Intertemporal Indifference Curves

Preferences over (C_1, C_2) are written as $U(C_1, C_2) = \bar{U}$.
The slope (MRS) is known as the Marginal Rate of Time Preference (MRTP):

$$MRTP = -U_{C_1}/U_{C_2}$$

Consumer maximises: $$\max_{C_1, C_2} U(C_1, C_2) - \lambda \left(C_1 + \frac{C_2}{1+r} - M_1 - \frac{M_2}{1+r} \right)$$

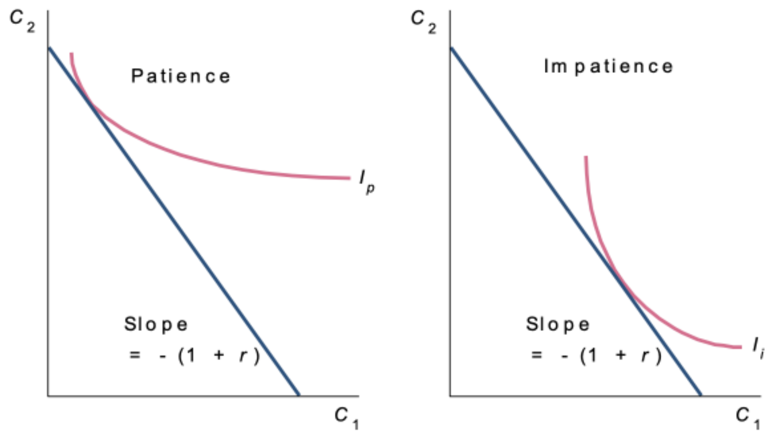
Optimum condition: $$MRTP(C_1^*, C_2^*) = -(1+r)$$

This condition is also known in macroeconomics as the Euler equation

Patience and Saving

If $C_1^* < M_1$ → consumer is not spending all his present income; He saves: $S_1 = M_1 - C_1$
Tomorrow, he can consume: $C_2 = M_2 + (1 + r)(M_1 - C_1)$.

- Patient if: $MRTP < (1 + r)$.
- Impatient if: $MRTP > (1 + r)$.



Modelling Patience in Utility

- Utility function with time-preference parameter β: $U(C_1, C_2) = u(C_1) + \beta u(C_2)$.
- $u(\cdot)$ increasing and concave
- β = gross rate of time preference = $1 / (1 + \delta)$; δ = net rate of time preference.
- Rewriting the Euler equation: $UC_1/UC_2 = \beta\,(1 + r) = (1 + r)/(1 + \delta)$.

Cases:

- 1. $r = \delta \Rightarrow C_1^* = C_2^*$ (equal consumption)
- 2. $r > \delta \Rightarrow C_1^* < C_2^*$ (patient consumer)
- 3. $r < \delta \Rightarrow C_1^* > C_2^*$ (impatient consumer)

Effects of Changes in r, M_1 and M_2

If r increases the opportunity cost of present consumption increases
If r decreases the opportunity cost of present consumption decreases
Substitution effect: C_1 ↓ (both borrowers and lenders).
Income effect: Borrower C_1 ↓, Lender C_1 ↑.

Therefore, the total effect is ambiguous.

Change in M_1 or M_2:

1. Change in current income (M_1) → C_1 and C_2 rise less than 1-for-1.
2. Change in future income (M_2) → C_2 and C_1 rise less than 1-for-1.
3. Permanent change ($\Delta M_1 = \Delta M_2$) → C_1 and C_2 increase almost equally (if $\delta \approx r$).

Friedman's Permanent Income Hypothesis

- Permanent income: total income in present value, Y[illegible] $= M_1 + M_2/(1 + r)$.
- Permanent income changes → reflected one-for-one in consumption.
- Temporary income changes → mostly saved.
- We consume permanent income but save temporary income.

Microeconomics - IBEB
Lecture 8, week 3

Probability Theory

Deterministic and Random Variables

- Deterministic variable: has a fixed, certain value (e.g. income = €1000).
- Random variable: value not known ex-ante; represents a lottery or gamble.

Examples:

- Coin flip → Heads/Tails (p = ½ each)
- Dice roll → 1 to 6 (p = 1/6 each)
- Lottery draw → 1 to N (p = 1/N each)

Events and Support

Event: specific outcome of a random variable.
Support: all possible outcomes.

Discrete: finite set (e.g. dice, coin).
Continuous: infinite set within an interval (e.g. GDP, income).

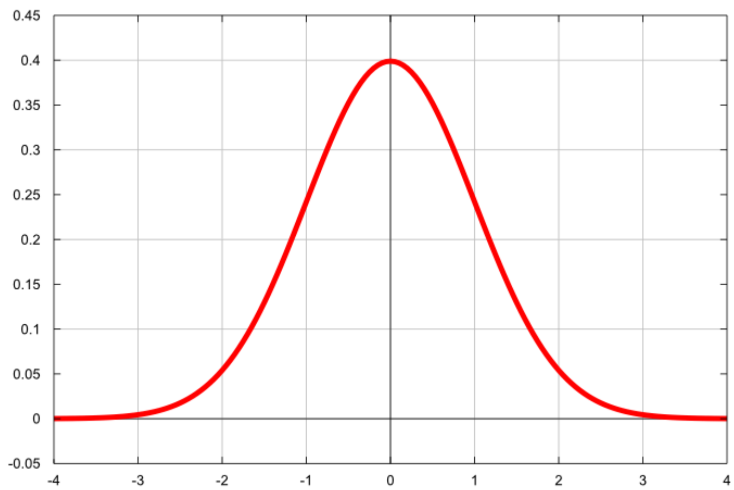
Probabilities and Probability Distributions

- Probability $p = Pr(X = x)$ lies between 0 and 1.
- The sum of all probabilities = 1 ($\Sigma p_i = 1$).
- For a continuous variable, $Pr(X = x)=0$ because there are infinite outcomes.
- Use a Probability Density Function (PDF) to describe likelihoods.

Probability Density Function (PDF)

- Describes how likely each value of X is.
- For continuous X: $\int f(x)dx = 1$.

Standard Normal Distribution: Bell-shaped, symmetric around 0

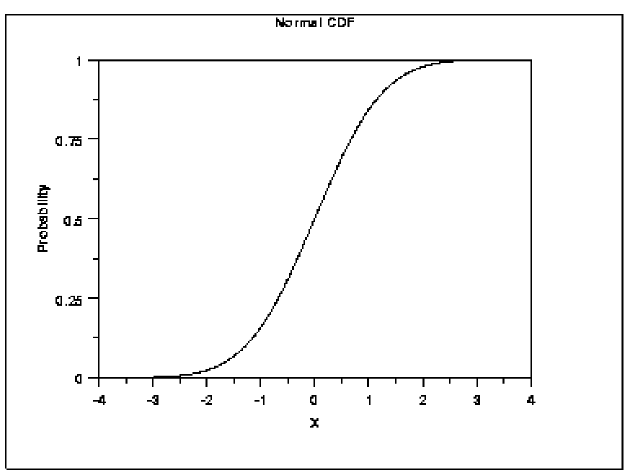


Discrete Distributions

- Represented by frequency histograms showing how often each value occurs.
- Height of each bar = probability or frequency

Cumulative Distribution Function (CDF)

- Gives probability that $X \leq x$: $F(x) = Pr(X \leq x)$.
- Always increasing; $F(-\infty)=0$, $F(+\infty)=1$.
- Example (dice): $Pr(X<3)=1/3$.
- Standard Normal CDF = S-shaped curve from 0 to 1



Expected Value (Mean)

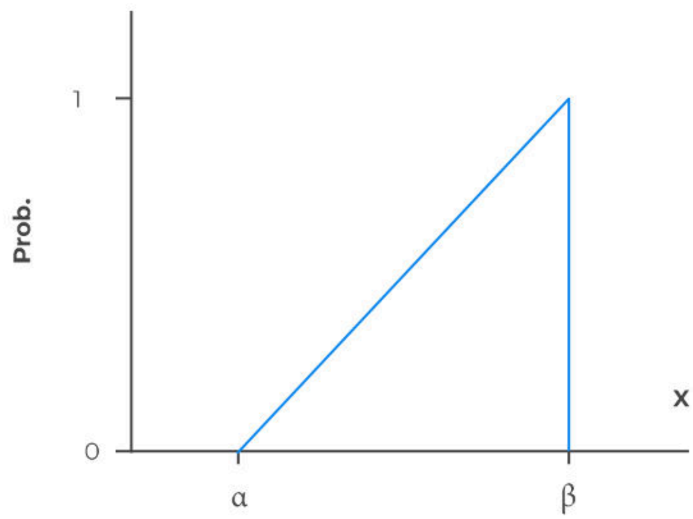
- Weighted average of all possible outcomes.
- For discrete X: $E(X)=\Sigma\, p_i\, x_i$
- For continuous X: $E(X) = \int x\, f(x)dx$

Examples:

- Dice → $E(X)=3.5$

Uniform Distribution

A uniform distribution is a continuous distribution where all outcomes are equally likely.



Support = [a, b]

- PDF: $f(x)=1/(b-a)$
- CDF: $F(x)=(x-a)/(b-a)$
- Mean: $E(X)=(a+b)/2$

Conditional Expectations (Uniform Distribution)

If X ~ Uniform[a, b]:

- $E(X \mid X < x)=(a+x)/2$
- $E(X \mid X > x)=(x+b)/2$

Key Notes

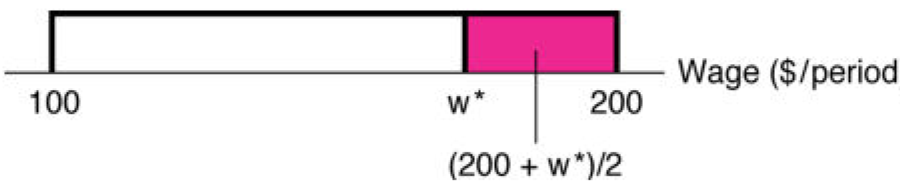
- Uncertainty is represented by random variables.
- PDFs and CDFs describe distributions of possible outcomes.
- Expected value summarises average outcome.
- The uniform and normal distributions are foundations for analysing expected utility and decision-making under risk in upcoming lectures.

Microeconomics - IBEB
Lecture 8, week 3

Search Theory

A crucial question in search theory is when do you stop looking and when do you go into action.

Imagine you are looking for a job and every job pays between 100 and 200 euros. Looking for another job costs you 10 euros each time, and the salary is uniform divided. So 1 euro extra from 100 euros is worth as much as 1 euro extra from 199 euros.



The benefit of looking for a new job is: $Pr(W > W^*)[E(W|W > W^*) - W^*]$. Where Pr(W>W*) stands for the chance that W* > W, so the chance that you find a higher result by searching.

The expected gain in the case if W* > W is: [E(W|W > W*)-W*).
If you are looking for the amount where you should stop searching is: $\frac{200-W^*}{2} * \frac{200-W^*}{200-100} = 10(price\ of\ looking)$. A more general formula can be written as $\frac{max-W^*}{2} * \frac{max-W^*}{max-min} = price$

Hawk and dove model

Hawk and doves are fighting for food (12 calories)
There are three possibilities:

- Two hawks: fight for food. Both lose for (-)4 calories.
- Two doves: Coöperate together. Both gain 6 calories

- Hawk and a dove: Dove flies away. The hawk gains 12 calories.

Let the percentage of hawks be 'h', then the percentage of doves is '1-h'.
The equilibrium will be reached when Ch=Cd
$Cd = (1 - h)6 + 0h = 6 - 6h$
$Ch = (1 - h)12 - 4h = 12 - 16h$
The equilibrium can be calculated which will equal to $h = \frac{3}{5}$and $d = 1 - \frac{3}{5} = \frac{2}{5}$
The equilibrium doesn't have to be a 'social optimum'.

Intemporal choice model

Up till now we made the assumption that the consumer spends his entire income. In reality consumers also save money and get loans. Therefore the question rises: how does a consumer distribute his consumption over time?

Therefore we make use of two periods: today and the future.
We also assume that there are no initial assets and no inheritances.

Notation:

- Ct is the consumption in period t.
- Mt is the income in period t.
- $St = Mt - Ct$ are the savings in period t
- i is the interest to which you can save and loan

How much you can spend at most in period 2: (1+i)M1+M2
How much you can spend at most in period 1: M1+$\frac{M2}{1+i}$
If you spend in period 2 x amount of money you have to pay back x(1+i). Therefore the maximum amount you can loan is: M2=x(1+i) => $x = \frac{M2}{1+i}$
Discounted value of M2 in period 1 = $\frac{M2}{1+i}$

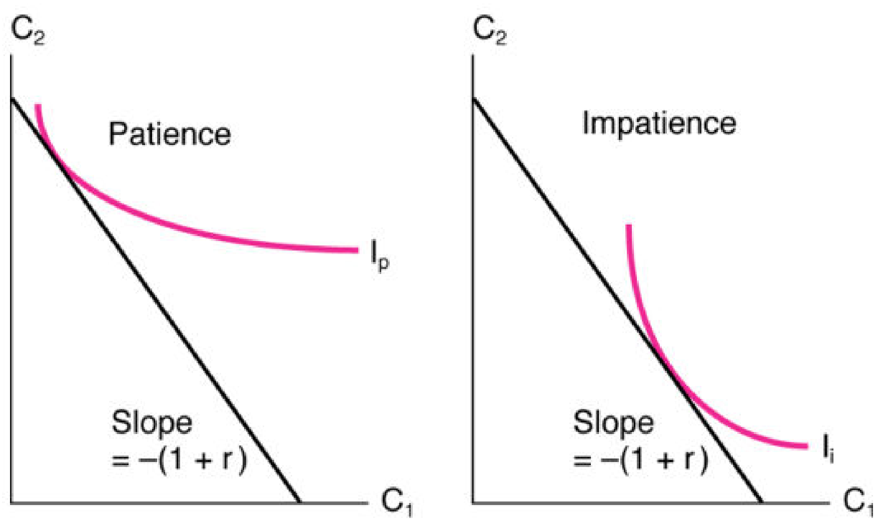
The **temporal budget comparison** shows the opportunity set of the consumer.
The budget comparison in period 1: $M1 = C1 + S1 \ -> \ S1 = M1 - C1$
The budget comparison in period 2: $C2 = (1 + i)(M1 - C1) + M2$
The price of one extra unit of C1 is C1(1+i)
The slope of the budget comparison therefore is -(1+i)

The **endowment point** (M1, M2) is the point that the consumer, regardless of i can always choose. That's spending all your income now and all your future income in the future.

Intemporal indifference map

The indifference curves have the same properties as before: completeness, more-is-better, transivity, continuity, convexity.
The Marginal rate of time preference (MRTP) = $\frac{dC2}{dC1}$= The slope coefficient of the indifference curve.

The shape of the indifference curve says something about the patience of a person. If someone is patient they will trade a lot of money right now for a bit more money in the future, and if someone is impatient they will trade a lot of money in the future for a bit of money now.



Deciding on the optimal choice is the same as with the normal rational choice model. You gotta find the point where the temporal budget comparison hits the indifference curve => $mrtp = -(1 + r)$

Who should pay for taxes?

A big question in economics is who should pay for taxes: Consumers or suppliers. Jurists have a different opinion on who pays taxes as the economist. If a jurists put a tax on a supplier the economist asks the question who really pays for the tax. If all the costs of the tax get transferred to the consumer by the supplier the consumer really pays for the tax.

There are **two ways to levy taxes**. Via:

- The **consumer** (**changes** the **demand curve**).
  Initial demand curve: P = Qd, after taxes P + T = Qd (In the case of a subsidy -> P - S = Qd)
- The **supplier** (**changes** the **supply curve**)
  Initial supply curve: P = Qs, after taxes P - T = Qd (In the case of a subsidy -> P + S = Qs)

If the tax gets put on the consumer, and you want to calculate how much the consumer is actually paying you should fill in P = Qd and if you want to calculate how much suppliers receive of that price you should fill in P = Qd - T.

Shortly said, if you want to calculate how much the consumer is actually paying you should fill in the Q calculated with the new functions in the original demand function.

The group (consumers or suppliers) who pay economically for the tax is independent of who legally pays.

The **transfer rate** is the percentage of how much consumers or suppliers pay of the tax. For example, if the old price used to be 16 and is now increased to 17 and the tax is 3 the consumers have a transfer rate of the tax of ⅓ ((17-16)/3).

Microeconomics - IBEB

Lecture 9, week 4

Producer theory

The definition of **products** is anything which supplies utility, now or in the future. (not only physical goods).

Definitions of **production** are: a process that creates utility, now or in the future. Or a process that production factors (**inputs**) turns into products (**outputs**)

Examples of inputs are: labor, capital, land, energy, raw materials, entrepreneurship, and knowledge. Output is anything that supplies utility, now or in the future.

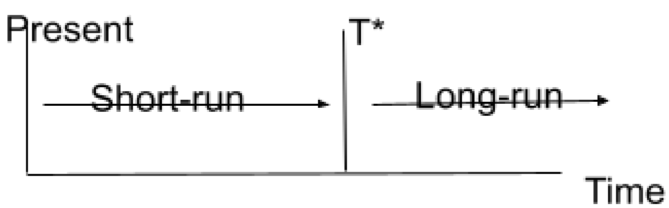
The **production function:** Input -> Business/production function -> output
In this course the only inputs (production factors) we are gonna use are **labour**, which we describe as **L**, and **capital**, which we describe as **K**.

We can write the production function as **Q = F(K, L)**, where Q is the amount of products we produce. Function F is the production technology.
An example of a production function is the Cobb-Douglas production function: $Q = mK^{a}L^{b}$ with $a, b \in [0, 1)$ and $m > 0$

Long vs. short run

The producer chooses the production factors (inputs). Some choices are able to be changed quickly, these are **variable inputs**, other choices aren't possible to change quickly, these are **fixed inputs**.

T* is the time it takes to change all production factors (see illustration)

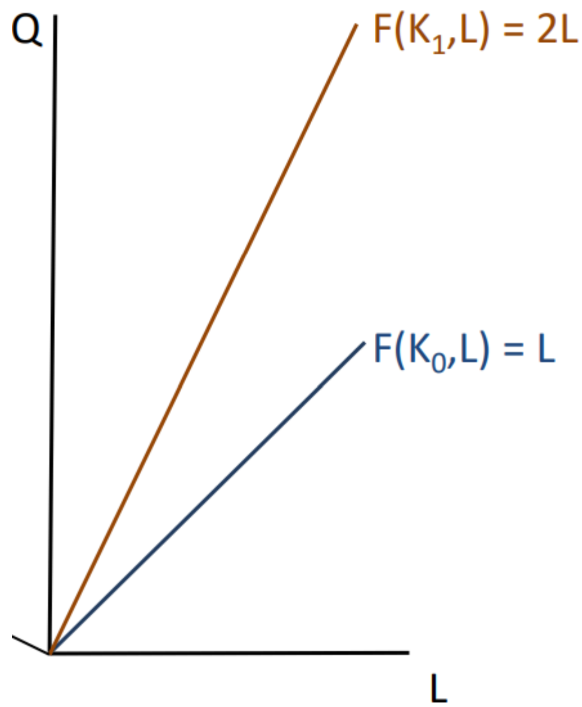


In the **short-run** there is at least 1 productionfactor 'fixed'.
In the **long-run** are all production factors 'variable'.

In this course Labor 'L' is always variable and Capital 'K' is fixed.

Production in the short-run

If we have a production function F(K, L)=KL and capital is fixed in the short run to K = K_0 = 1 we can illustrate that (see illustration). Later we change K = K_1 = 2, therefore the production function also changes.



The short-run production function always goes through the origin.

Total, average and marginal product

Total product (TP):

- How much gets produced: Q (production function)

Average product (AP):

- Output per unit variable input
- The average product of labour: $AP_L = \frac{Q}{L} = \frac{F(K,L)}{L}$

Marginal product (MP):

- How much changes the output with the change of 1 unit of an input.
- The marginal product of labour: $MP_L = \frac{dQ}{dL} = \frac{\partial F(K,L)}{\partial L}$

Effects of labour in the short-run:
If there is one person he will do everything. If there are multiple people there will be specialisation (Adam Smith), and if there are too many people they get in each other's way. This effect is called the **law of diminishing returns**.

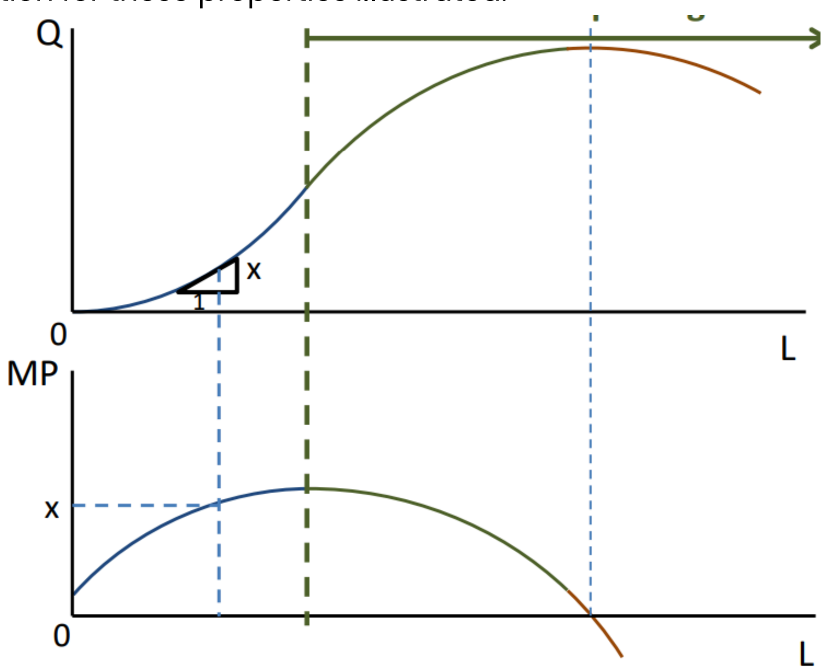
A more formal definition of the **law of diminishing returns** is: a principle stating that profits or benefits gained from something will represent a proportionally smaller gain as more money or energy is invested in it.

The law of diminishing returns, works for every short-run input although it doesn't work in the long-run. For example if we multiply our restaurant (long-run because it also affects fixed costs) and place it on the other side of town it won't necessarily give less returns than the first restaurant.

Properties of the marginal product of labour (MP_L):

- Slope coefficient of the total product (TP)
- Rises for L if L is small (specialisation)
- Decreases if L is bigger (law of diminishing returns)
- TP: The inflection point is at the start of diminishing returns
- The MP can be negative for L if L is big (people get in each other's way)
- The start of negative returns is when $MP_L = 0$

See the illustration for these properties illustrated.



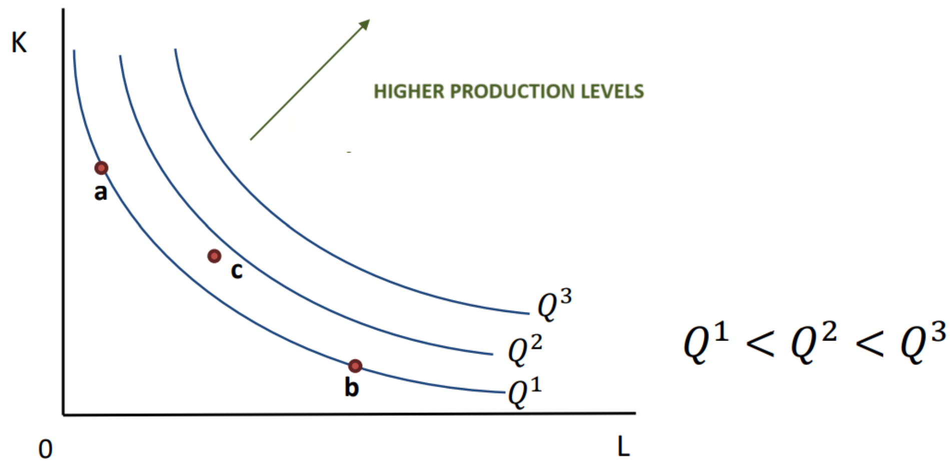
Properties of the average product:

- The coefficient of the origin to a point on the production curve
- When L -> 0: $AP_L = MP_L$
- MP > AP => AP increases
- Maximum AP_L : $AP_L = MP_L$ (not the point in the origin)
- MP < AP => AP decreases

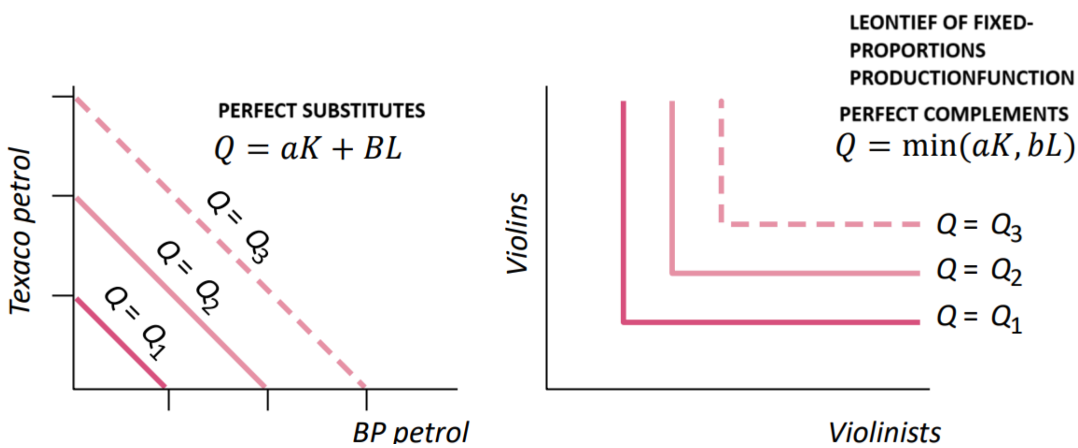
If we want to maximise production in the short-run with certain amounts of labours we should make sure $MP_{L1} = MP_{L2}$

Production in the long-run

In the long-run all production factors are variable. The production function will be described as Q = F(K, L). We can show this graphically with an isoquant map. This isoquant map consists of unlimited amounts of isoquant curves for which the amount of production is the same, regardless of the distribution of the production factors.



Perfect substitutes and complements also work the same for the isoquant map. These types of functions are illustrated below:



The marginal rate of technical substitution (MRTS): is the absolute value of the slope coefficient of the isoquant.

MRTS = $|\frac{dK}{dL}|$

The economic interpretation of the MRTS is the ratio to which capital can be exchanged for labour without changing the production quantity

Returns to scale

Returns to scale is about what happens with the production when you increase the production factors (inputs) proportionally. So both with the same proportion

- Increasing returns to scale
  F (cK, cL) > cF(K, L)
  This can happen because of specialisation, or the law of big numbers.
- Constant returns to scale
  F(cK, cL) = cF(K, L)
- Decreasing returns to scale
  F(cK, cL) < cF(K, L)
  This can happen when people for example get in each other's way while working. This is not the same as the law of diminishing returns.

Example exercise: Decide if the production function $F(K, L) = K^{1/4}L^{1/2}$ has increasing, constant or decreasing returns to scale.
Solution: F(cK, cL) = $c^{1/4}K^{1/4}c^{1/2}L^{1/2} = c^{3/4}K^{1/4}L^{1/2} < cF(K,\ L)$ so this function has decreasing returns to scale.

Microeconomics - IBEB
Lecture 10, week 4

Economic vs. accounting profit

Accounting profit is all revenue - all normal costs.

Economic profit is the accounting profit - the opportunity costs. So we want to look at opportunity costs also. For example if you invest 10 million in your business you could have also invested it and gained 10% per year. That would make for 1 million of opportunity costs.

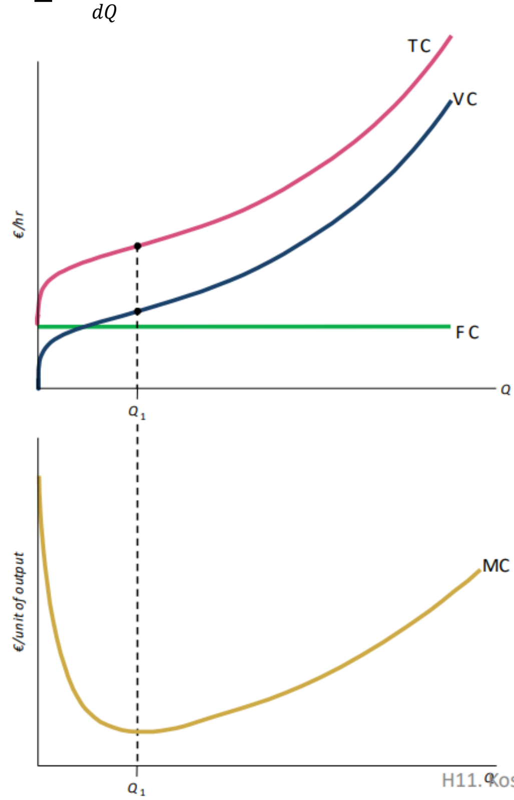
Short-run costs

In the short term we have:

- **Fixed costs (FC)**, a synonym for this is overhead costs.
  Where the cost of capital is defined as 'r' and fixed capital defined as K_0: FC = rK_0. You pay fixed costs even if you produce nothing.
- **Variable costs (VC)**, depends on how much you produce. The hourly wage we define as 'w', the hours worked we define as L_1 , and the output is defined as Q_1 .
  $VC_{Q1} = wL_1$
- **Total costs (TC)**, this is the sum of fixed and variable costs
  $TC_{Q1} = rK_0 + wL_1$

How do we calculate the fixed costs. Let's say we have $F(K, L) = K^{1/2}L^{1/2}$, K_0 = 4, r = 2
The fixed costs are FC = rK = 4*2 = 8.
The quantity of labour: $Q(L) = K^{1/2}L^{1/2} = 2L^{1/2}$ <=> $L(Q) = (Q/2)^2$
$TC_Q = FC + VC_Q = 8 + Q^2$

Marginal costs is the slope coefficient of the total costs.
$MC(Q) = \frac{dTC(Q)}{dQ} = \frac{d(FC+VC(Q))}{dQ} = \frac{dVC(Q)}{dQ}$



So we see that the MC is also the slope coefficient of the variable costs. If we want to illustrate this in a picture we can see that the inflection point of the TC and VC is the minimum point of the MC.

We can rewrite the marginal cost function also as $MC(Q) = \frac{w}{MPL}$. Here we can see that the slope of the TC and VC is inversely proportional with the slope of the TP. The inflection point of the functions will be the same, although the TP will diminishingly increase and the total cost will increase more than before. This works with the rules of diminishing returns. Which we talked about in the previous lecture.

Average costs:

- **Average Total Costs (ATC)**: $ATC(Q) = \frac{TC(Q)}{Q}$
- **Average Variable Costs (AVC)**: $AVC(Q) = \frac{VC(Q)}{Q}$
- **Average Fixed Costs (AFC)**: $AFC(Q) = \frac{FC}{Q}$

The relation between marginal/average costs:
$MC < ATC\text{: } ATC\ decreases$
$MC > ATC\text{: } ATC\ increases$
$MC\ hits\ ATC\ in\ its\ minimum$

$MC < AVC\text{: } AVC\ decreases$
$MC > AVC\text{: } AVC\ increases$
$MC\ hits\ AVC\ in\ its\ minimum$

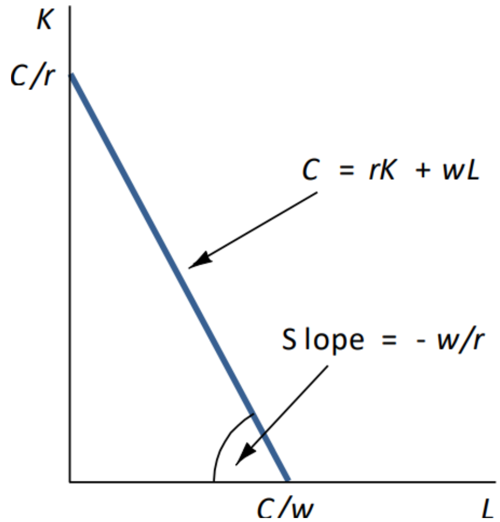
Optimal allocation of short-term costs:
The optimum for short-term cost allocation is when $\mathbf{MC_1=MC_2}$

I will illustrate this with an example: imagine you have two factories with two total cost functions. $TC_1(Q_1)=10(Q_1)$^2 + 10, $TC_2(Q_2)=5(Q_2)$^2 + $20Q_2$ + 3, $Q_1 + Q_2 = 31$

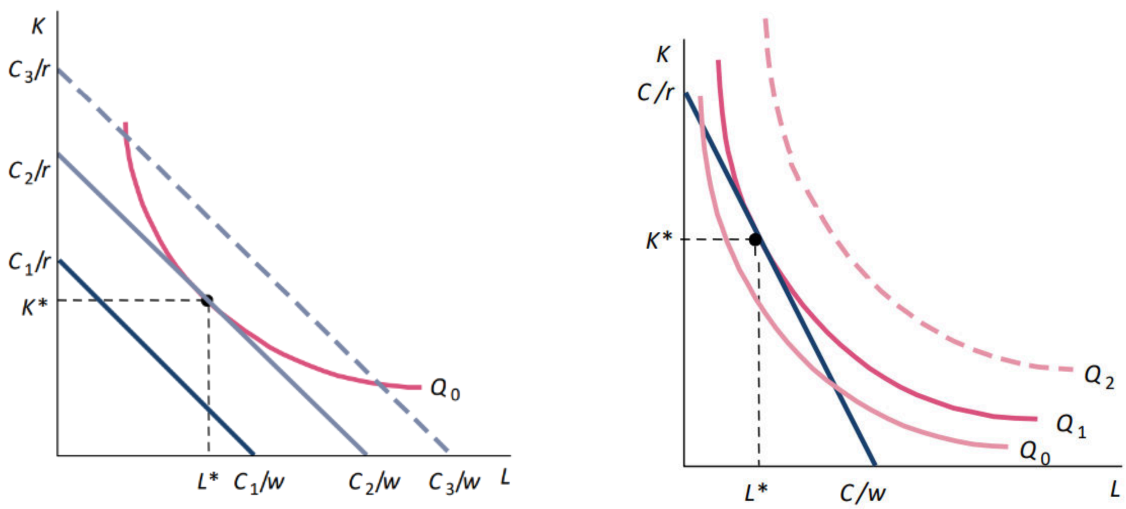
We can rewrite the last function as: $Q_1 = 31 - Q_2$
If we solve $TC_1(31\text{-}Q_2)=TC_2(Q_2)$ we will reach our answer. You can try this for yourself at home. The answer will be $Q_1 = 11$ and $Q_2 = 20$

Long-run costs

Isocost lines are like the budget curves of firms. In the long-term all production-factors are variabel. Therefore we define the isocost line as C = rK + wL. The slope coefficient of the line will be -w/r. It works almost the same as the consumer's budget curve, see the illustration for more.

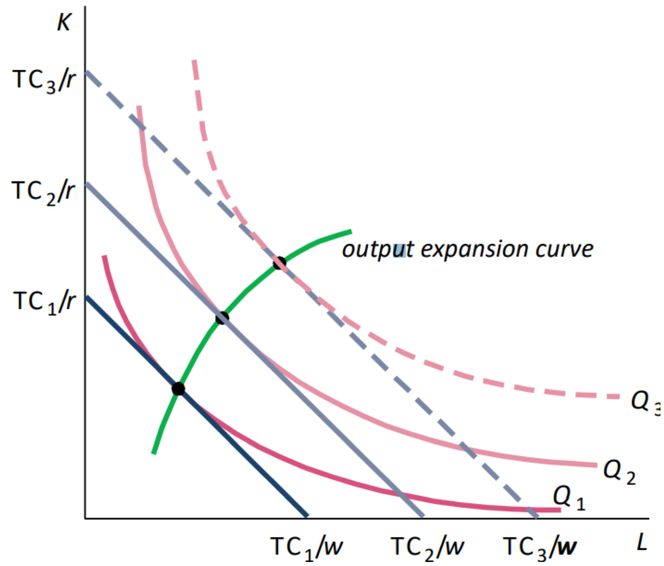


The **maximum output for a certain costs** is where $MRTS = \frac{w}{r}$. (We talked about the MRTS in previous lecture.) This equation can be rewritten as $\frac{MPl}{MPk} = \frac{w}{r}$. This works exactly the same when we are looking for the **minimum cost for a certain output**. See the difference in the illustration below.



The left illustration is the minimum cost for a certain output and the right illustration is the maximum output for a certain cost. Keep in mind that solving this works the same as solving for example the consumer problem. If you struggle with this I recommend looking back to that part of the summary.

The **output expansion curve** is the curve which measures the optimal cost allocation (most Q, quantity) for each amount of total costs.



- The **long-term total costs** will always go through the origin because in the long-term all the costs are variable.
- The **long-term marginal costs**: $LMC = \frac{dLTC}{dQ}$
- The **long-term average costs**: $LAC = \frac{dLTC}{dQ}$

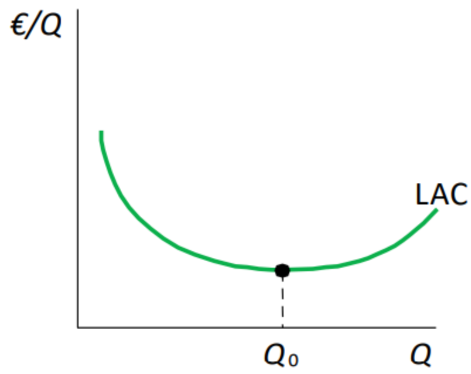
Market structure and curves

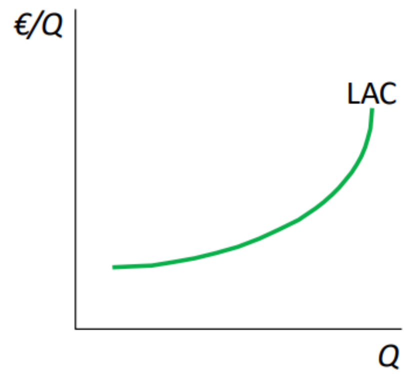
For constant returns to scale [F(cK, cL) = cF(K, L)], when output doubles the costs double, the LTC curve will be a straight line through the origin. The Long-run marginal costs will also be equal to the long-run average costs.

For decreasing returns to scale [F(cK, cL) < cF(K, L)], when output doubles the costs will increase more than double, the LTC curve will be a convex line through the origin. The long-run marginal costs and the long-run average costs will increase.

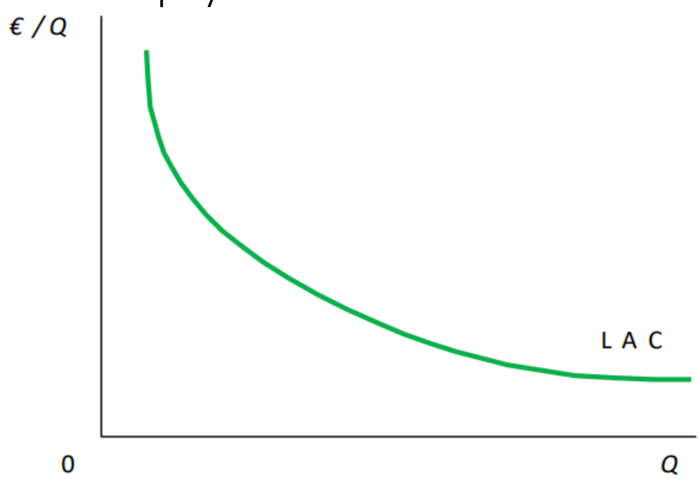
For decreasing returns to scale [F(cK, cL) > cF(K, L)], when output doubles the costs will increase less than double, the LTC curve will be a concave line through the origin. The long-run marginal costs and the long-run average costs will decrease.

The shape of the LAC curve is decisive for the market structure.
In a competitive market you want to produce at the lowest costs. Therefore you will see that the LAC curves are increasing or U-shaped. This indicates a market with lots of small firms.





When there are increasing returns to scale the LAC will be decreasing. A firm that grows faster will produce cheaper. This firm will push other firms out of the market. This is called a natural monopoly:



Microeconomics - IBEB

Lecture 11, week 4

Models in a market of perfect competition

Economic profit can be modelled as total revenue - total cost. We can rewrite this as $\pi = TR - TC \Leftrightarrow \pi = PQ - TC$

The **goal of firms** is to **maximise profit**. Profit is an important incentive for entrepreneurs in itself and when profit is low there is higher chance of faillisement, higher capital costs (because there is higher risk for capital providers), and there is a bigger threat of a takeover of the company.

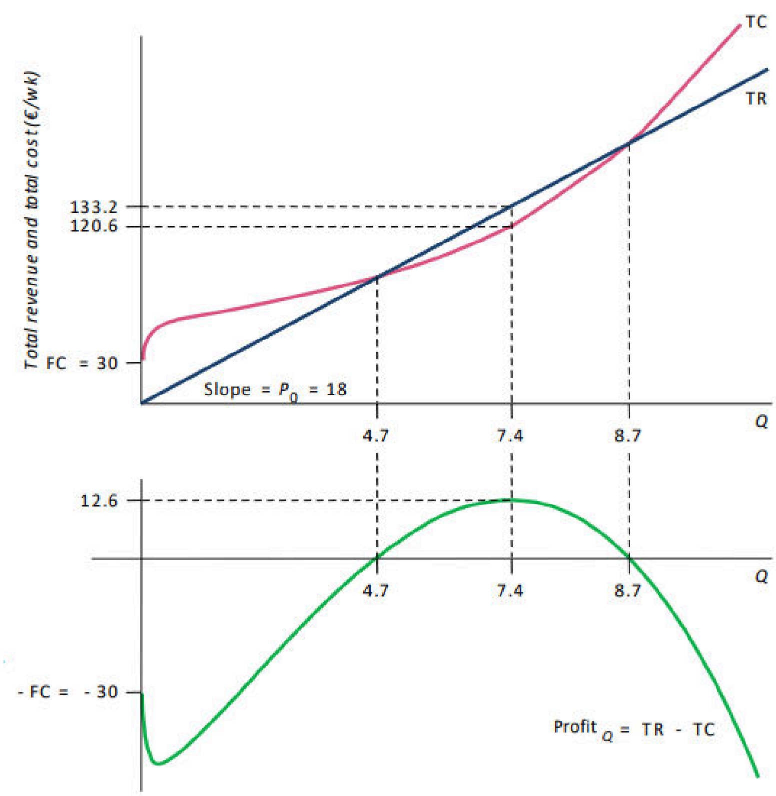
A **market of perfect competition** has a few conditions:

- **Standardised products**, consumers consider the goods as perfect substitutes.
- **Perfect** and **complete information**.
- Firms are **price-takers**. Individual decisions have no influence on the market price.
- **Production factors** are perfect mobile in the long-run. Capital and labour can be used wherever it earns most. There should be free entry and exit of the market.

Perfect competition in the short-run

The goal of firms is: $max\, \pi(Q) = TR(Q) - TC(Q)$. The first order conditions for this is $MR(Q) = MC(Q)$. The marginal revenue is equal to the marginal cost. Since $TR(Q) = PQ \Rightarrow MR(Q) = P$

This can be illustrated in a profit function. See the illustration.

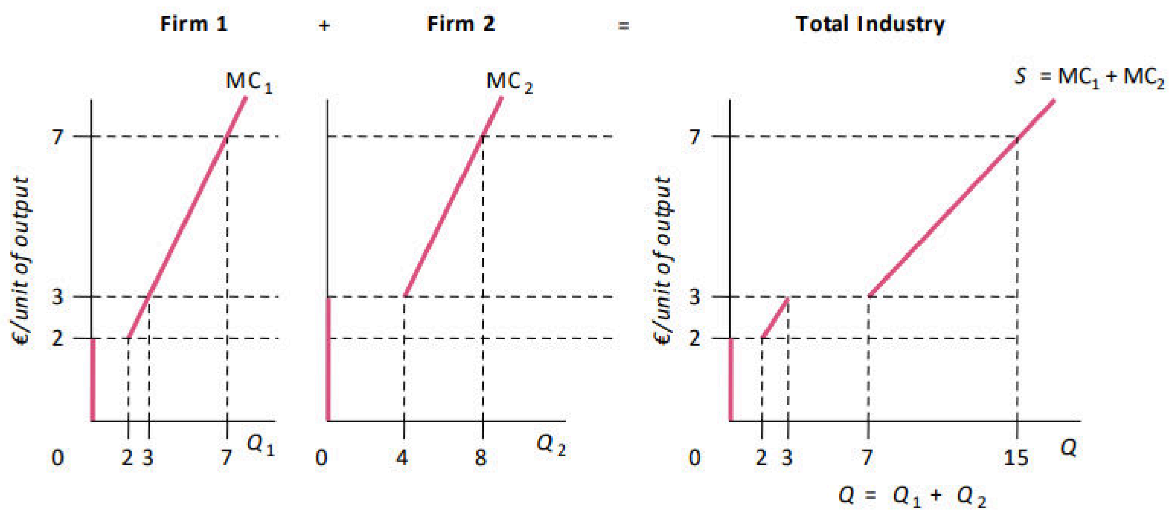


The first-order condition MC(Q)=P will be met at 2 different points. Although only 1 point will we be the optimum. The intersection point should be on a rising portion of the marginal cost curve. Therefore the first derivative should be positive.

When is profit positive? Some simple algebra will give us insights.
$\pi = PQ - ATC * Q = Q(P - ATC)$ therefore $\pi > 0 \Leftrightarrow P > ATC$

You will have a loss when P < ATC. So should you keep continuing producing?
If you produce: $\pi_{Q>0} = Q(P - AVC) - FC$
If you don't produce: $\pi_{Q=0} =- FC$
So you should keep producing in the short-run as long as the price is higher than the average variable cost.

The **market supply** curve is the horizontal summation of the individual supply curves. $Q(P) = \Sigma Qi(P)$. You should keep in mind that the market supply curve might differ per price level, because some companies might choose to not supply any goods at a given price. An illustration of this is shown below.



Short-term equilibrium in perfect competition:

- **Allocative efficiency** for every good: MB consumption = MC production
- **Pareto efficiency**: It is not possible to make one person better off without making another person worse off.

The producer surplus: The amount of benefit that a firm gains from producing a certain winstmaximising output. This is the difference between producing and not producing:

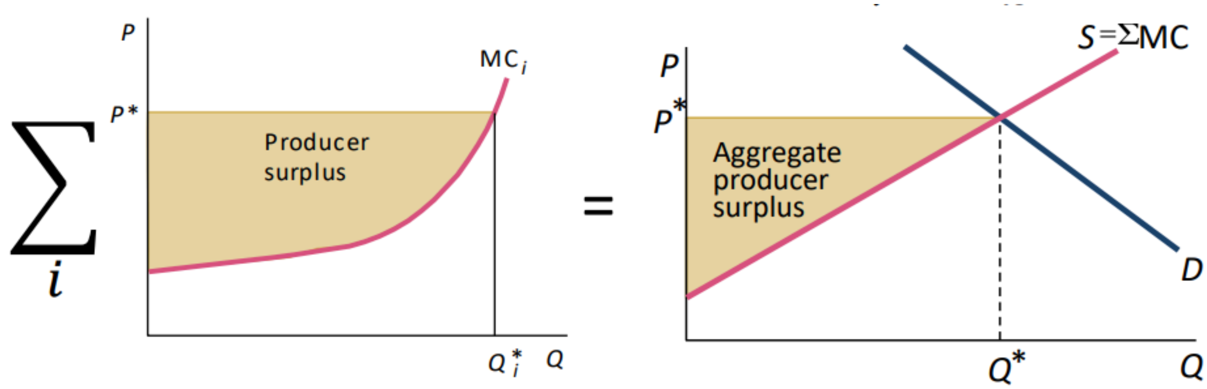
$\pi 0 =- FC$

$\pi 1 = TR - VC - FC$

$\pi 1 - \pi 0 = TR - VC$

Keep in mind that the producer surplus is not the same as economic profit!

The aggregated producer surplus: This is the summation of all individual producer surplus which will give the well-known triangle producer surplus.

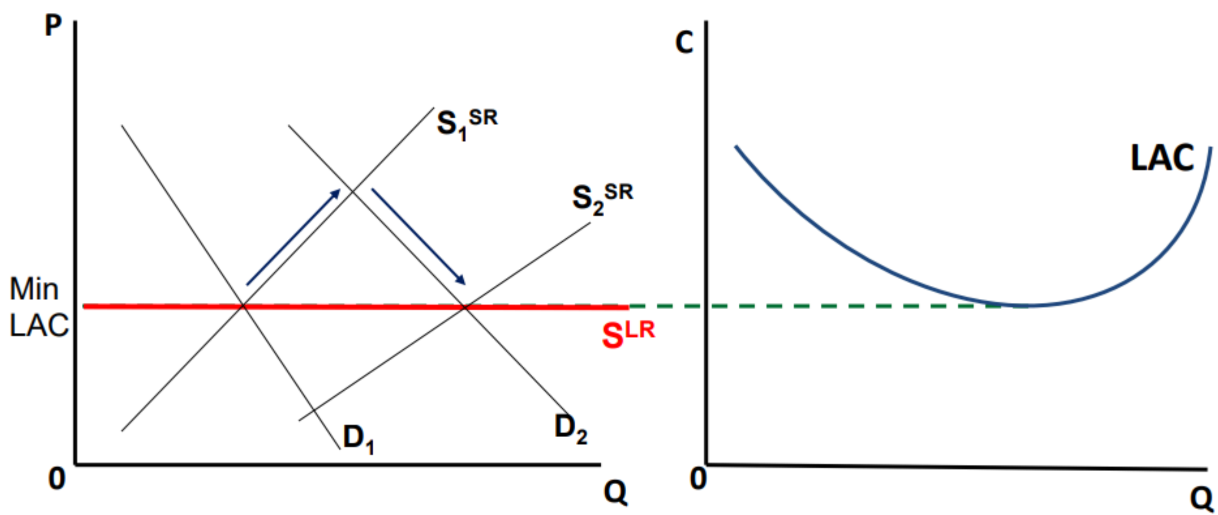


The total benefit of trade = Producer surplus + Consumer surplus.

Perfect competition in the long-run

The difference between the long-run and the short-run is that now the fixed production factors (inputs)can change. Therefore individual supply curves can change. Firms can also enter or exit the market. Therefore the aggregated curve changes.

If there are sudden changes which can make the profits higher (So not MC=MR). Firms will enter the market, the equilibrium price will lower because of the extra supply. Each individual firm will then produce less because of the decreased price. Therefore the profit will lower. This will continue till the economic profit will equal 0. So P = minimum LAC. This is process is illustrated below.



This U-shaped LAC curve is very common in markets of perfect competition. There will be a lot of medium-sized companies because producing at a higher amount will increase costs. Therefore the price will lower.

Next we will explain Smith's invisible hand of the free market.
"The invisible hand" of the free market:

- P*=MC:
  The last traded unit is worth the same to consumers as to producers (allocative efficiency).
- P*=min LAC:
  It is impossible to produce cheaper (Pareto efficiëncy).
- No "Economic profit"
  Consumers don't pay a single cent too much.

Lets say we want to calculate how many companies will stay in the long term in a market and we have the demand Q(P) = 80000 - 1000P and we have the long-term cost function LTC(Qi) = 400 + 10Qi + Qi^2:
1) First we will decide the minimum of the LAC(Qi) function.

$LAC(Qi) = \frac{400}{Qi} + 10 + Qi$

$\frac{dLAC(Qi)}{dQi} = -\frac{400}{Qi^2} + 1 = 0$

$Qi^2 = 400 \Leftrightarrow Qi = 20 \vee Qi = -20$

The market supply will be Qi=20.
2) Now we decide the long-term price:

$P = LAC(20) = 400/20 + 10 + 20 = 50$

3) Then we have to decide the total market amount.

$Q(50) = 80000 - 1000 * 50 = 30000$

4) Now we will divide the total market amount by the individual firm amount.
$Q(50)/Qi = 30000/20 = 1500$
So in this market 1500 firms will operate.

Price Elasticity of supply: $\varepsilon^s = \frac{P}{Q} * \frac{dQs}{dP}$ if there is a flat supply curve: $\varepsilon^s = \infty$

Short-Run	Long-Run
Profit/Loss is possible.	Loss isn't possible. Profit is only possible if the producer is more efficient than the marginal producer.
Supply curve slopes upward.	The supply curve is horizontal (unless the input prices aren't constant)
The equilibrium is efficient	The equilibrium is efficient

Microeconomics - IBEB
Lecture 12, week 5

Game theory

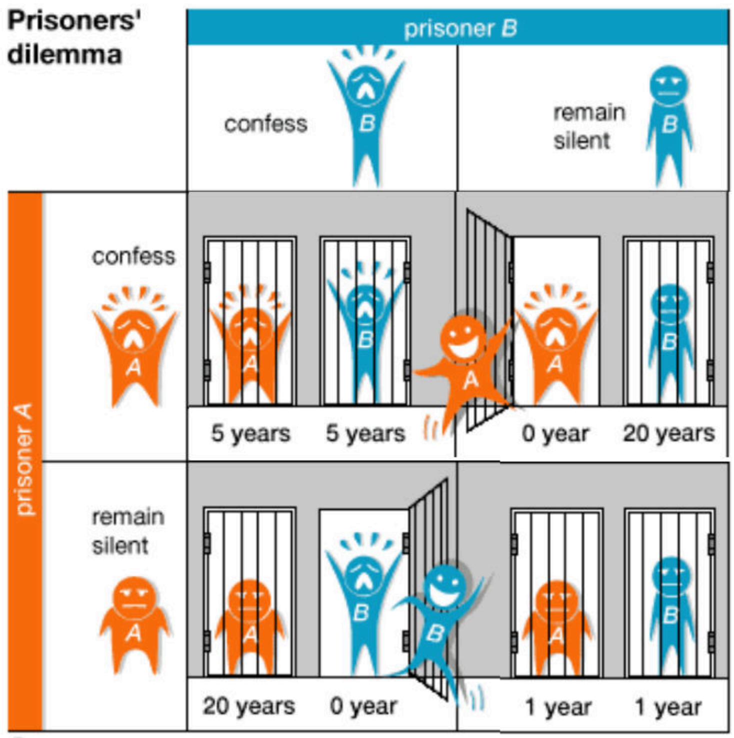
Remember from one of the first lectures on Pareto efficiency from Adam Smith: "Striving to self-interest leads to Pareto-efficiency". His main argument for this is that competition between producers leads to better products, cheaper production, higher profits, decreasing prices. This proces repeats itself. Competition out of self-interest is good for consumers.
A condition for Pareto efficiency is that all the agents are priceaccepters.

External costs and benefits are costs and benefits which are not carried by the person undertaking the activity.

Modelling strategic interactions via gametheory is very useful we will see.
The building blocks of a game:

- **Players** (N >= 2): They make decisions
- **Rules**: Who can and when choose what?
- **Payoffs**: What do players receive when everyone makes the choices.
- **Information**: Who knows what and when. We assume complete information.

A classic example of game theory is the prisoner's dilemma:



In gametheory we often write this as:

Game		Prisoner A	Prisoner A
		Confess	Remain Silent
Prisoner B	Confess	-5, 5	0, 20
Prisoner B	Remain Silent	-20, 0	-1, =1

Where the number on the left always is for the player on the left and the result on the right is for the player on top.
We can see that the combination (Confess, Confess) isn't **Pareto efficient**. Because both players can better their position without harming anothers position, see the

outcome for (Remain silent, remain silent). Although confessing is the **Dominant Strategy** for both. It is individual optimal to betray in both situations (-5>20 and 0>-1).

A **dominant strategy** gives a higher outcome regardless of the opponents strategy. A strategy gets dominated if another strategy is always better.
A **social dilemma** is a type of game where individual incentives conflict with efficiency. The reason for this is external costs and benefits (see the prisoners dilemma). This problem can disappear if we look at perfect competitive markets with lots of agents, where the individual has no impact.

We can also have a 3x3 game where we can use **iterative elimination** of strictly dominated strategies to find the equilibrium.

			Player B	
		Left (L)	Center (C)	Right (R)
	Top(T)	12,20	16,0	-10,1
Player A	Middle(M)	9, 10	15, 100	-11, 3
	Bottom(B)	15, 1	12, 2	-2,3

Row M gets strictly dominated by row T. (12>9; 16>15; -10>-11) therefore player A never chooses row M. Now we can compare column C and column R. Player B will never choose column C (1>0; 3>2). Therefore we can eliminate that row. Now we have four options left ((T, L); (T, R); (B, L); (B, R)). Player A will never choose row T (15>11; -2>-10). THerefore player B will choose R because 3>1. Therefore the equilibrium is (B, R)

Repeated interaction

When we play multiple times the same game strategies can help.
An example of an strategy is the tit-for-tat strategy:

- mn
- From then you repeat the action of your opponent in their previous turn (coöperate/defect)
- You should let your opponent know that this is your strategy.

Qualities of the tit-for-tat strategy is that it is friendly, strict and forgiving.
Although there is a very big problem with the tit-for-tat strategy: let's say I know that this is the last interaction I will choose to defect. Let's say I know this is the

penultimate interaction I will choose to betray and so on. Repeated interaction only leads to efficiëncy with an unknown end of the game.

Nash equilibrium

The definition of the **Nash** equilibrium is a combination of strategies, where no player has incentive to deviate from, given the strategy of the other player. It is possible to have multiple Nash equilibriums:

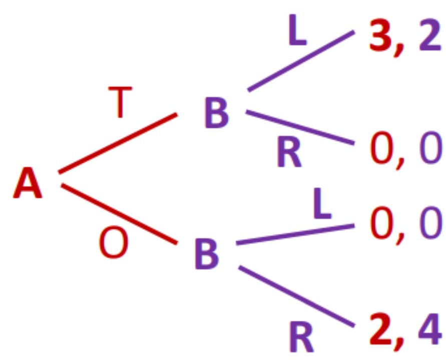
Game		Player 2	Player 2
		Option A	Option B
Player 1	Option A	**10, 10**	0, 0
Player 1	Option B	0,0	**8, 8**

Keep in mind that the Nash-equilibrium is a combination of strategies and not payoffs. Therefore in this example you should write (Option A, Option A) and (Option B, Option B).
If there is 1 Nash-equilibrium it's called a unique equilibrium.

Commitment problem: How do you make a threat credible? Let's say you are gonna choose A either way. The problem then is how do you make it believable to your opponent that you are gonna choose A either way. The commitment is the way you make it credible.
You deal with commitment problems via commitment devices, government coordination or alternative equilibriums.
An alternative equilibrium is the Maximin equilibrium: Maximise the minimal outcome. For example choosing A will give you 10000 or -1 and choosing B will give you 1 or 2. You will have to choose B.

Sequential games

In the game below A will choose first and then B will choose. You notate the strategy for B as: (Choice if T, Choice if O). B chooses from four strategies: (L, L), (L, R), (R, L), (R, R).



We can also write this as a game matrix

	(L, L)	(L, R)	(R, L)	(R, R)
T	3,2	3,2	0,0	0,0
O	0,0	2,4	0,0	2,4

The nash equilibriums here are (T, (L, L)), (T, (L, R)) and (O, (R, R)). Although (O, (R, R)) is not believable. When B chooses the choice of A is already known so why would A still choose for T.

To bypass this problem you can use backwards induction. Start at the last decision point and work towards the start. If we do this we will end up with the **'Subgame perfect'** equilibrium: (T, (L, R))

Microeconomics - IBEB

Lecture 13, week 5

What is a monopoly?

A monopoly is a market where there is a **Monopolist**.
A **Monopolist** is the only supplier of a good and all close substitutes.
What are causes of a monopoly?

1. **Exclusive access to production inputs** (For example railways)

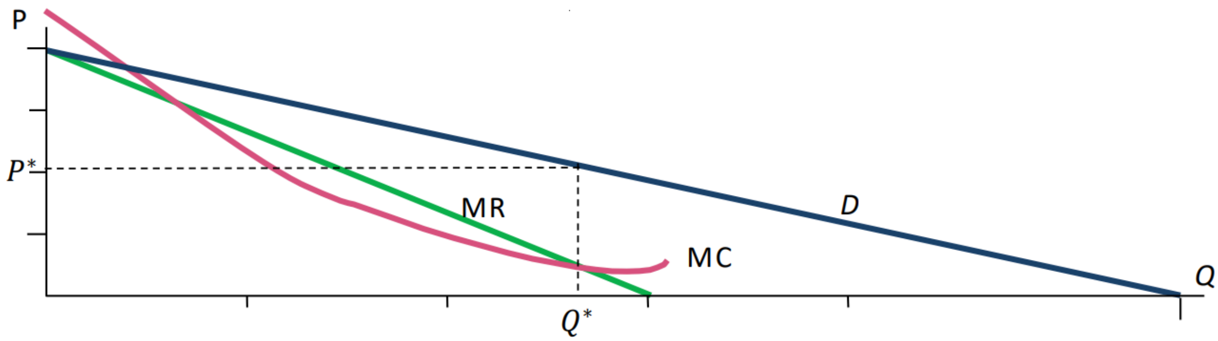
2. **Increasing returns to scale.** Therefore the LAC curve is downward shaped. If a firm produces more their average cost will go down. A **Natural Monopoly** is a market where it is most efficient in terms of costs to let one firm serve the entire market.
3. **Patents**: Patents help protect inventions during a few years/decennia. This helps to promote innovation. If there weren't any patents it would be possible to steal other firms' ideas.
4. **Network Effects**: A product gets more valuable if more people use it. For example operating systems or social media. This is strictly seen a form of returns to scale.
5. **Monopoly Licenses granted by the government**: For example restaurants next to the motorways.

Profit Maximising by the monopolist

Remember profit is $\pi(Q) = TR(Q) - TC(Q)$. In perfect competitions the price equals the marginal cost therefore TR(Q) = PQ. In the case of the monopolist he can change the price, so therefore the price isn't the market price anymore. Now we define the P in TR(Q) as the market demand: $TR(Q) = P(Q) * Q$
The marginal revenue curve can be written as $MR(Q) = P(Q) + \frac{dP}{dQ}Q$.
This can be rewritten as $MR(Q) = P(Q) + P(Q)\frac{dP}{dQ}\frac{Q}{P(Q)} = P(Q) * (1 - \frac{1}{|\varepsilon|})$. Where the ε is the elasticity of demand. This can help us understand that $0 = MR(Q) \Leftrightarrow \varepsilon = -1$.

Profit is maximised where MR(Q)=MC(Q) & P>AVC (remember from perfect competition). P<AVC is the firms shutdown condition.

In the figure below is illustrated that the marginal cost and marginal revenue curve intersect twice. So where is profit maximised. For this we have the second order condition that the MR intersects the MC from above. This can mathematically be written as $\frac{dMR(Q)}{dQ} < \frac{dMC(Q)}{dQ}$.

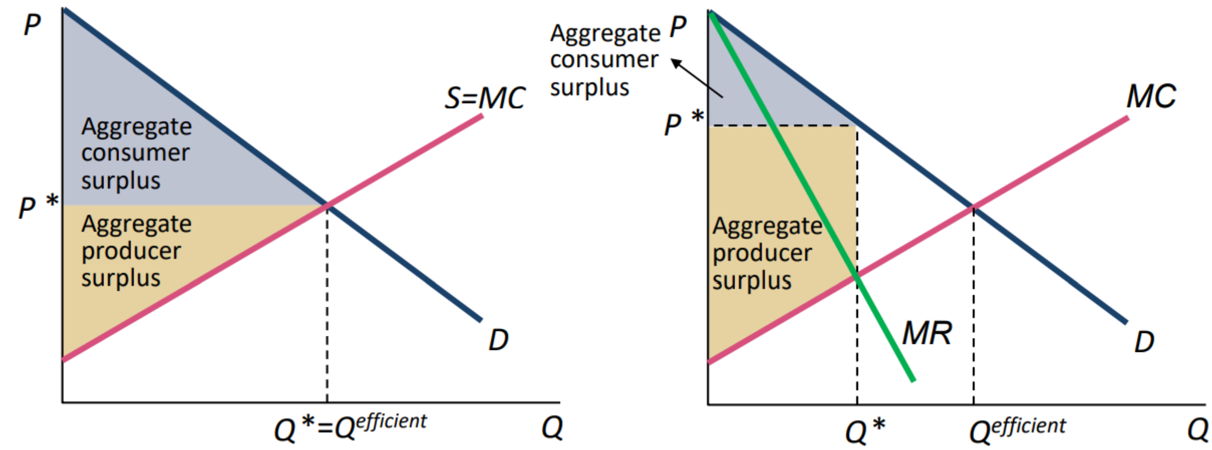


Below I illustrated an exercise for profit maximising.
Demand curve: P(Q)=100-2Q
Total costs: $TC(Q) = \frac{1}{2}Q^2$
What is the profit for an optimising monopolist? What is the price?

Answer:
$TR(Q) = 100Q - 2Q^2$
$MR(Q) = 100 - 4Q$
$MC(Q) = Q$
$MR(Q) = MC(Q) \Leftrightarrow 100 - 4Q = Q \Leftrightarrow Q = 20$
$P(20) = 100 - 2 * 20 = 60$
$\pi = 100x20 - 2x20^2 - (\frac{20^2}{2}) = 1000$

The mark-up of a monopolist: $\frac{P-MC}{P}$. How much higher are the prices in comparison to the marginal costs? This says something about the market power a monopolist has. In perfect competition the markup is 0, because the producers have no profit.

In a monopoly the amount produced is less than what is efficient (in perfect competition). Therefore the consumer surplus is smaller than in the equilibrium and the producer surplus is smaller. The total surplus will be smaller. This is illustrated below



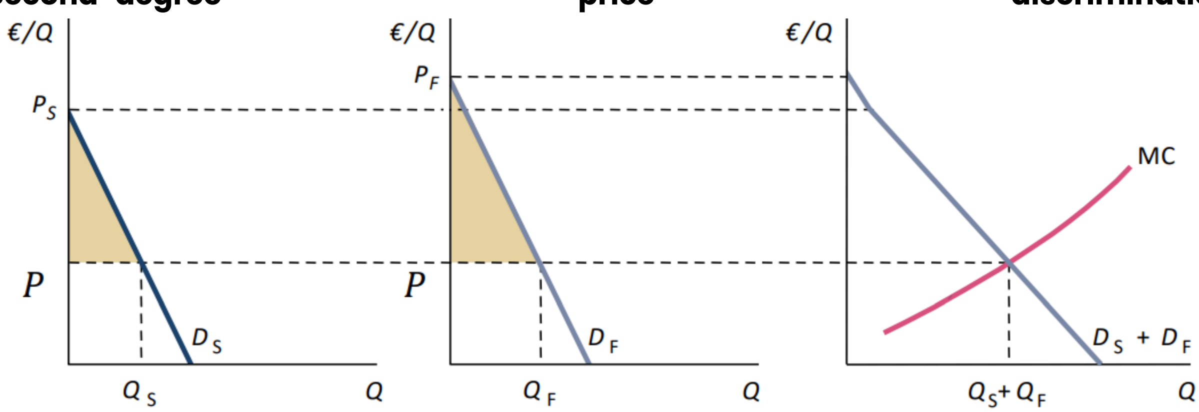
The white triangle in the right figure is the loss of prosperity caused by a monopoly. This is the called the “**deadweight loss**” or “**Wedge**”

The dynamic efficiency of a monopoly is the observation that efficiency loss in the present can provide economic growth in the future. Because without patent protection (one of the causes of a monopoly) there would be less innovation and innovation helps economic growth.

Price Discrimination

First-degree price discrimination: charge different prices to different consumers. This helps for the perfect willingness to pay. This way the producer can obtain the entire consumer surplus. THis works the same as the two-part tariff in chapter 6.

Second-degree price discrimination



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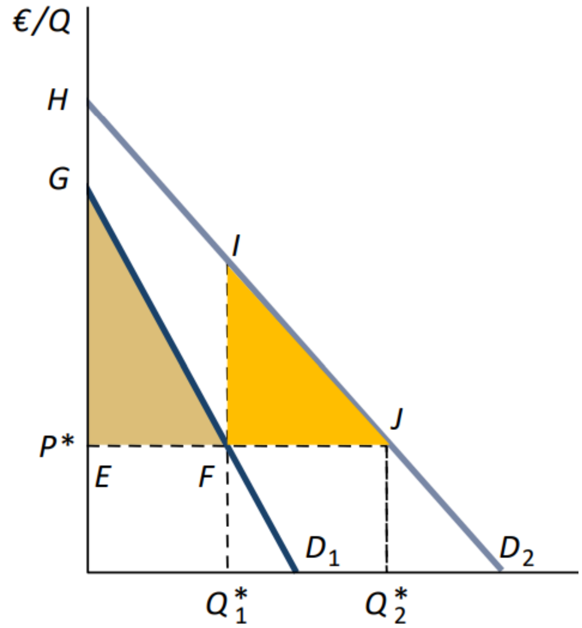
Can’t differ prices between different customers. Therefore you should offer different quantities for different prices.

An example of this is:

For 0< Q < Q_1 : P = P_1

For $Q_1 < Q < Q_2$: $P = P_2$
For $Q_2 < Q < Q_3$: $P = P_3$
Etcetera.



Above you see an example. Let's say we have 2 consumers. Consumer 1 has low demand and consumer 2 has high demand. Therefore we have a standard package, where the consumer pays EFG: max use = Q_1. We also have an unlimited package: with price P*, where the subscription price is M. Now we wonder how high M possibly can be. If consumer 2 buys the standard package his consumer surplus is FGHI. For the unlimited package his consumer surplus is HEJ-M. Therefore we should make sure M<= EFG+IJF. That way the consumer has at least the same consumer surplus as he used to have if he bought the standard package.

Third-degree price discrimination: Selling the same product to different groups for different prices (for example countries or age groups).
If we want to maximise profit we can set up some conditions:
$TC(Qt) = TC(Q1 + Q2)$
$\pi(Q1, Q2) = P1(Q1) * Q1 + P2(Q2) * Q2 - TC(Q1 + Q2)$
The first order condition is $MR(Q1 + Q2) = MC(Q1 + Q2)$. The MR(Q1+Q2) can be found by summating both marginal revenue curves. We also covered in this lecture that $MR(Q) = P(1 - \frac{1}{|\varepsilon|})$ therefore the first order condition can be rewritten as $P1(1 - \frac{1}{|\varepsilon 1|}) = P2(1 - \frac{1}{|\varepsilon 2|})$

Hurdle model of price discrimination: Consumer has to take a hurdle for a discount. For example sending a discount voucher to the producer for a discount. Customers with a lower price elasticity don't take the hurdle and pay more.

Government policy in case of natural monopoly

- **Public companies** might help for working at an efficient price. Although a big problem is X-inefficiency: without profit motive there is little incentive for an efficient organisation.
- **Regulating private monopolies** for example maximises the prices to MC or LAC. Although the government doesn't observe the MC and LAC curve. If the price set by the government is too low, firms will go out of the market, if the price is too high it isn't efficient anymore.
- **Exclusive contracts**: private firms bid on exclusive contracts.
- **Forbidding monopolies**: This prevents innovation and sometimes its too expensive to produce on a small scale.
- **laissez-Faire policy:** This is a hands-off policy. This is for a lamborghini a better policy than for an electricity producer.

Microeconomics - IBEB
Lecture 14, week 6

Oligopolies

A **Oligopoly** is a market form where there are a few small producers.
A **Duopoly** is a market form where there are two producers.

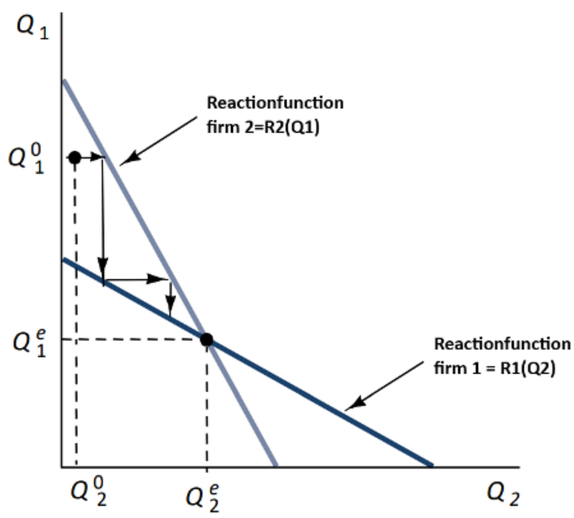
Firms have direct influence on the market equilibrium (unlike perfect competition) and therefore each others decisions. This leads to strategic interaction (game theory).

Cournot Model: Duopoly

There are two firms in the cournot model. $Firm\ i\ with\ i\ \in\ (1,2)$.
These firms sell perfect substitutes in the same market.
Firms **choose simultaneous** the **produced quantity**.

Each firm will look for the best quantity (Qi) to produce given the quantity produced by the opponent. This is most relevant when production decisions are made in advance.

The market demand is $P(Q) = a - bQ\ with\ Q = Q1 + Q2$
The market demand per firm is $P_i(Q_i)=a-bQ_1-bQ_2$
Therefore the TR curve is $TR_i(Q_i)=Q_i*P(Q_1+Q_2)$
And this shows the marginal revenue curve can be written as $MR_i=a-bQ_j-2bQ_i$
We want to maximize profit. We can do this by setting $MR_i(Q_i)=MC_i(Q_i)$ or maximizing π_i by taking the derivative and setting it to zero.
If we do this for both the quantity of firm 1 and firm 2. We get a scheme with 2 functions. These functions are the reaction functions: How much does firm i produce for every Q firm j produces.
$Q_1=(a-bQ_2-c_1)/2b$; $Q_2=(a-bQ_1-c_2)/2b$. Solving this will give the best outcomes this will also lead to the Nash-equilibrium. No firm has incentive to change the quantity they produce. The invisible hand to the equilibrium is illustrated below.



In the cournot model firms produce individually less than in a monopoly. Although together they produce more than a monopoly. Therefore the price in a cournot duopoly is lower than in a monopoly.
$Q_1=Q_2<Q^{mon}$ and $Q_1+Q_2>Q^{mon}$

The total profit in a duopoly is loewe than in a monopoly. In a monopoly the profit for the producer is at it's maximum. $\Pi_1+\Pi_2<\Pi^{mon}$

Bertrand Model: Duopoly

Bertrand criticized the assumption that every player the quantity produced of the opponent as a given takes in the Cournot model. In the bertrand model the firms choose the prizes. Every firm takes the price of the opponent as a given.

In the base model there are 2 firms i=1, 2. The marginal costs are equal $MC_1=MC_2=c$. The goods sold are perfect substitutes. The firms choose the prices. THe consumers only buy the lowest prices. The market demand is $Q(\min\{P_1,P_2\})$. The firm with the highest price doesn't sell anything, the firm with the lowest price sells the whole market demand and for equal prices both firms sell 50% of the market demand.

Let's say $P_1>C$(Marginal cost). The best response for firm 2 is to set it's price a tiny bit lower than firm 1 -> $c<P_2<P_1$. This situation is unstable and firm 1 will lower it's prices again. This will happen until P = MC (just like perfect competition). The nash-equilibrium is $P_1=P_2=c=MC$

Collusion in economics is the collaboration between companies that seek to gain an extensive competitive advantage in the marketplace. Collusion is illegal. This means that if firms conspire together, they will reach a higher profit. They could for example set the market price to the monopoly price(/Quantity). This reaches the highest profit for both of them.

Stackelberg Model: Duopoly

In the stackelberg model a firm is the market leader and the other firms identify as followers. An example of this is Albert Heijn for Dutch supermarkets. Firms choose their quantities although and both firms try to maximize their profit. Although in this case it is a sequential game:

1. First the leader chooses his quantity
2. The follower then sees what the leader does, and reacts by choosing its own quantity.
3. The total quantity is sold and the market decides the price.
4. Firms receive their profit and the game ends.

The game has the same nature as the Cournot model although in this case it's a sequential game. Remember for sequential games we can find the subgame equilibrium by using backward induction. Therefore we start with the decisions for the follower who sees Q_L (Quantity of leader) as a given. The follower wil try to maximize it's profit: $\Pi_v=P(Q_L+Q_v)Q_v-c_vQ_v=(a-b(Q_L+Q_v))Q_v-c_vQ_v$
The optimum is $Q_v=(a-bQ_L-c_v)/2b$. The leader knows the reaction function of the follower and will therefore try to maximize it's own profit. $\Pi_L=P(Q_L+R_v(Q_L))Q_L-c_LQ_L$.
Maximizing this will give the quantity the leader is gonna produce and we can substitute this in the quantity of the follower and so find the solution to this problem.

Stackelberg leadership:

- Every player wants to be the "Stackelberg Leader"
- Being the leader requires commitment: The leader announces the quantity it's gonna produce and sticks to it.
- The follower believes the commitment and reacts.
- Therefore the commitment should be believable.
- An example of a commitment is a sunk investment in extra productioncapacity.

Below i structured a scheme with all the outcomes for the different models with $P(Q)=a-bQ$ and $TC_i=cQ_i$.

Model	Industry output Q	Price P	Industryprofit Π
Shared monopoly (cartel)	$Q^{mon}=\frac{a-c}{2b}$	$P=\frac{a+c}{2}$	Π^{mon}
Cournot	$4/3*Q^{mon}$	$P=\frac{a+2c}{3}$	$8/9*\Pi^{mon}$
Stackelberg	$3/2*Q^{mon}$	$P=\frac{a+3c}{4}$	$3/4*\Pi^{mon}$
Bertrand	$2Q^{mon}$	c	0
Perfect competition	$2Q^{mon}$	c	0

Microeconomics - IBEB
Lecture 15 - week 6

Partial vs general equilibrium

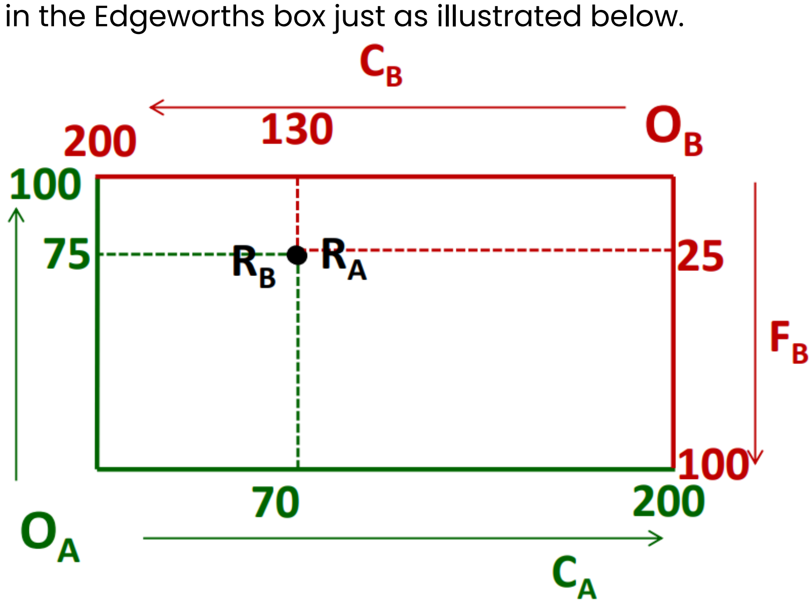
The **partial equilibrium analysis** focusses on the market for one product. This market is isolated from the rest of the economy.

The study of broader interactions in the economy is called the **general equilibrium analysis**. For example a cycle in which businesses demand labour and capital supplied by households and supply products to the households. The households supply labour and capital, and demand products.

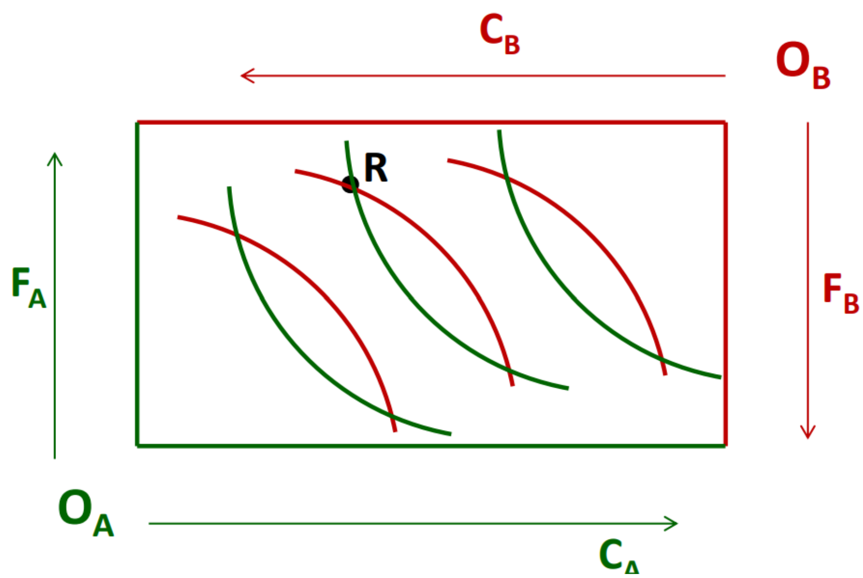
We'll firstly focus on a trade economy without production.
We assume there is a production with only consumers.

- 2 Consumers: A & B
- 2 Consumption Goods: C(clothing) and F(food)
- $C_A+C_B=C$; $F_A+F_B=F$

The **allocation** is every combination of C & F in possession of A & B.
For this we huge the **Edgeworths box**. We will set the initial endowments $R_A=(70, 75)$, $R_B=(130, 25)$ up in the Edgeworths box just as illustrated below.



In this box is every possible allocation of F & C between A & B.
Now we can also set the indifference curves of both consumers in the edgeworth boxes. Although they will be mirrored because of the box's nature. These indifference curves will have the same assumptions as talked about in an earlier lecture (for example, convexity, transivity etc).

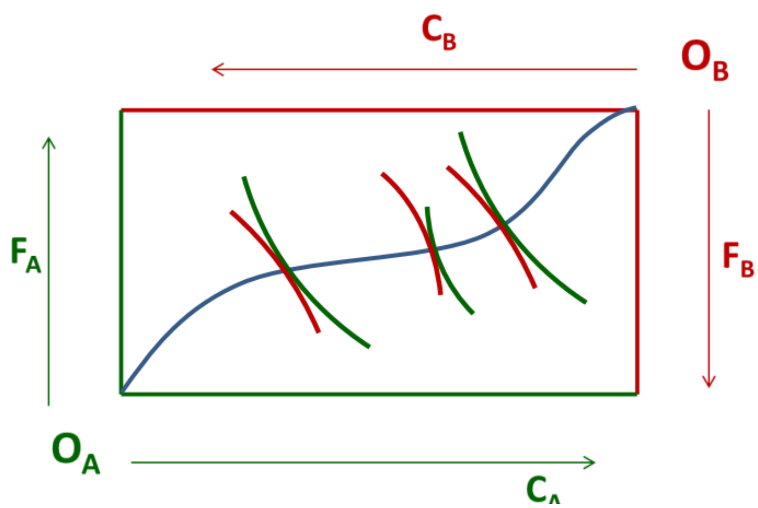


At the moment R is the current allocation of F & C. You can see the indifference curves crossing R make some sort of ellipse shape. Every point in this ellipse shape is **Pareto preferred**. This ellipse is called the "**eye of Pareto**".

Pareto superior = Allocation that at least one individual prefers and the others like at least as well.
Pareto preferred = The movement to a pareto superior allocation.

The two consumers will trade so that the point R will move in the eye of pareto. They can't trade outside of the eye of pareto, because one player would gain a disadvantage and they wouldn't trade. This continues until there is no eye of pareto left.
This is where $MRS_A = MRS_B$. So where the indifference curves touch eachother. This point is the **Pareto optimal** distribution.

The **contract curve** is a set of all Pareto optimal distributions, so a line of all touchpoints of the indifference curves touch.

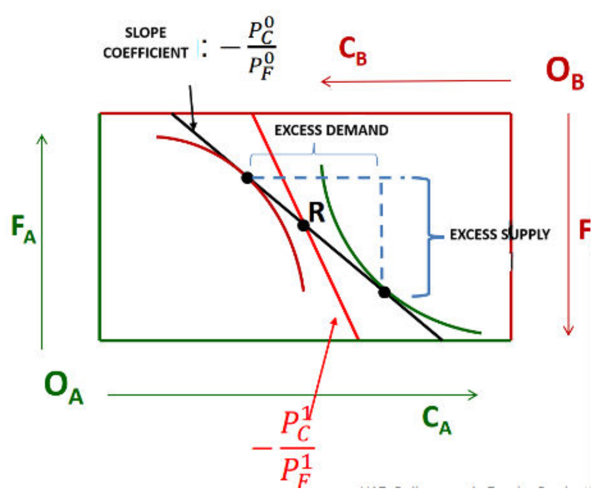


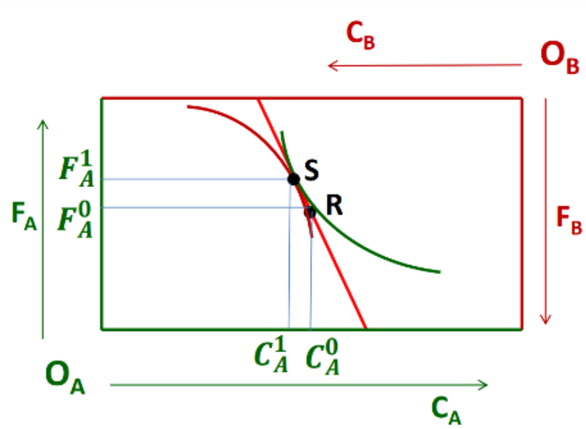
So the contract curve is a curve of all the points where $MRS_A=MRS_B$ with $C_A+C_B=C$ and $F_A+F_B=F$. When an allocation isn't on the contract curve both will want to trade until they reach the contract curve.

Consumers get on the contract curve by:

- Negotiation and exchange
- Using a third good: money
- Trade for given relative prices

1. We can insert the budget curve in the Edgeworths box. The curve of the Edgeworthsbox is $-(P_C^0/P_F^0)$
2. Then we will move the budgetcurve until $P_C/P_F=MRS_A=MRS_B$.
3. Keep in mind the prices are relative as we can change the budget curve.





The two welfare theorems

The **first welfare theorem**: If there are complete markets (for every good which agents care about there is a market) and all agents are price-takers, then the market equilibrium is always Pareto-efficiënt.
The **second welfare theorem**: If there are complete markets and all agents are price-takers, then every allocation on the contract curve can be reached as equilibrium.

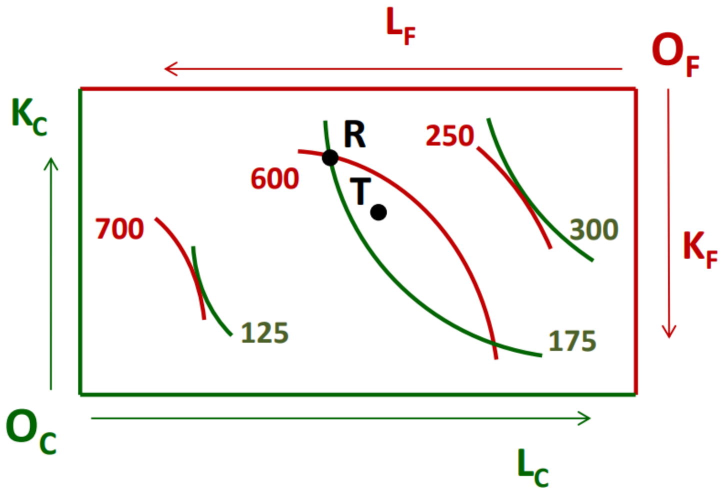
If consumer A got all the clothing and all the food in the system it also is a pareto efficient equilibrium. No consumer can reach a better position without making one other worse off.

The general equilibrium with production

This model is called the 'Simple' model. It is the model we talked about in the start of this lecture.

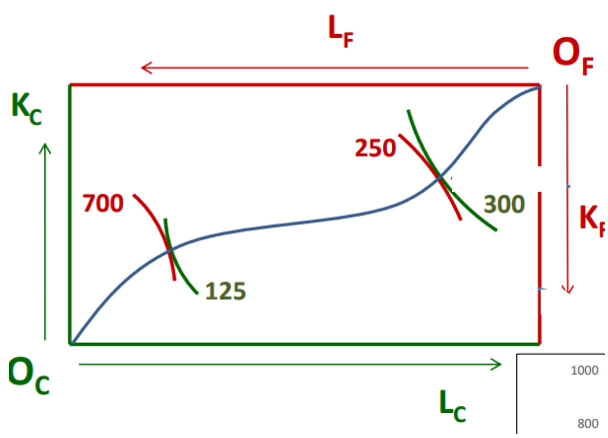
- Two price-taking firms: 1 & 2
  - 1 produces F (food)
  - 2 produces C (clothing)
- Two production-inputs: K(capital) & L(labour)
- Two consumers: A & B
  - A in possession of K_A & L_A
  - B in possession of K_B & L_B
  - $K_A+K_B=K$ & $L_A+L_B=L$
- Prices depend on preferences, scarcity, technology
- Price: w(labour), r(capital), P_C(clothing), P_F(food)
- $M_A=wL_A+rK_B$
- $M_A=wL_A+rK_B$

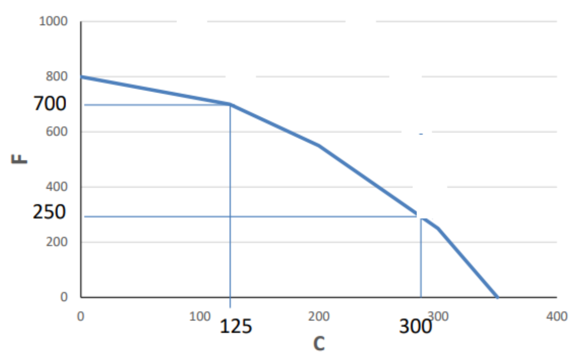
We can set up an Edgeworths box with isoquants for the producers.



We can set up a contract curve for the producers as well. This is where the MRTS(Marginal rate of technical substitution/$\frac{MPl}{MPk}$) of both firms touch each other on the entire map.

The optimal mix for each business is where MRTS = w/r as illustrated a few lessons before. All the combinations on the contract curve lead to the **production possibility frontier**. This is each level of production for each point on the contract curve. See the illustration below:





The slope of the possibilities frontier is the **marginal rate of transformation (MRT):**
MRT=$\left|\frac{dF}{dC}\right| = \frac{MCc}{MCf}$

In the most efficient production mix there are a few conditions:

- $MRT = \frac{MCc}{MCf}$
- $Pc = MCc$, P_F=MC_F
- MRS=P_C/P_F

- MRS=MRT
- MRTS=w/r
- P_{Prod}=MR_{prod}=MC_{prod}
- MRT=P_C/P_F

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Externalities

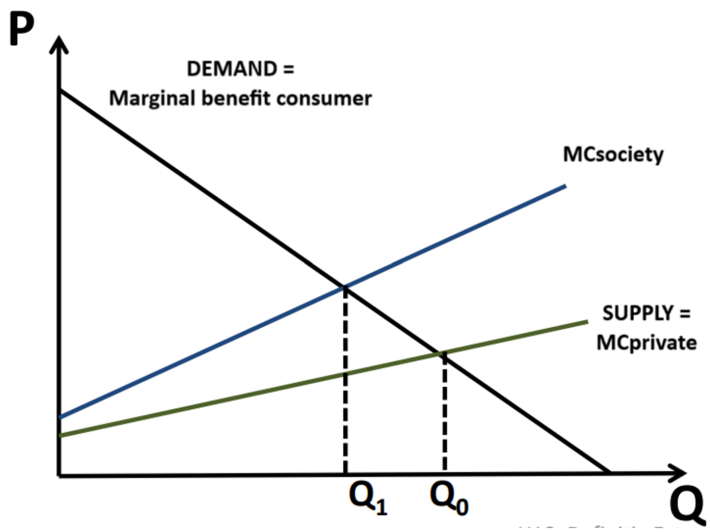
Private benefits of an activity: amount that an individual is willing to pay to do an activity.
Private costs of an activity: amount that an activity costs for an individual
This is what we analyzed in the first lecture in the cost benefit analysis. If B(x) > C(x) i will do activity x.

Social benefit of an activity: the combined amount that individuals in a society are willing to pay.
Social cost of an activity: the combined amount that an activity costs for the whole society.
Efficiëncy requires that the marginal social cost of an activity doesn't exceed the marginal social benefit. Therefore : SB(x) > SC(x)

An **externality** is an activity that causes costs or benefits that aren't taken account for in the private costs and benefits.
A **negative externality**: A social cost not taken account for by an individual.
A **positive externality**: A social benefit not taken account for by an individual.

Individuals will choose the option which is individually best for them, but that isn't necessarily a social optimum.

We can illustrate the problem by setting the supply curve as the private marginal cost curve. We will set the demand curve to the private marginal benefit curve. We can also illustrate the MC of the society. This one will be higher than the private marginal cost curve when there are negative externalities. Below we can see that the social optimum is where MCsociety = MBprivate so at Q0. Although the consumer will choose the quantity at Q1. We see that the marginal cost of society lies higher than the private marginal benefit.



Positional externalities: agents want to do relatively well against each other. When the acting of the individuals influences a part of society, then there positional externalities. This is a suboptimal equilibrium.
When one person decides to work extra hours for free, he is sort of forcing you to also work more hours., because if you don't you won't get the raise for example. This is a suboptimal equilibrium. If he didn't work extra these extra hours both might have gotten the raise.

The social marginal cost/benefit curve of the society is find by summating all the private marginal cost/benefit curves.

Property rights

The **Tragedy of the commons (1833):** Livestock farmers share the common pasture (the 'common'). Overgrazing of the sheeps reduces the quality of the pasture and therefore the quality of the sheeps. You would think therefore overgrazing wouldn't happen a lot, although it does. This is because of a lack of property rights and the individual shepherd only looking at private costs/benefits. This story is applied to a lot of places.

The ways to calculate problems about for example the tragedy of the commons is the same way as methods for duopolies.

Someone has **property rights** when that person has the right to use the property and that person can exclude others from use. Granting property rights can help solve the problem of externalities. Negotiation between the agent with property rights and the agent without leads to an efficient outcome.

Coase's theorem:
If all agents cause or experience that externality are able to negotiate with each other free of charge and binding, make appointments, then the outcome is efficient. Regardless of how property rights are distributed.
The payoffs to each party differ however with how property rights are distributed.

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