Energy Economics and Policy
AUEB

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Lecture 2:
Economic Principles

Recap

Economic modelling

- What causes what in economic systems?
- At what level of detail shall we model an economic phenomenon?
- Which variables are exogenous (determined outside the model) and which are endogenous?

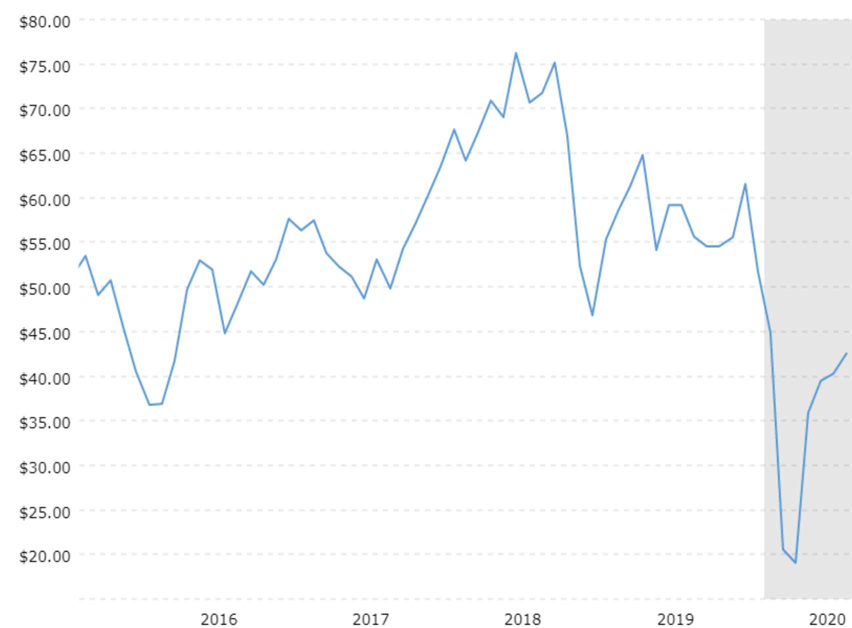
Example:

COVID-19 and the price of oil

Exogenous: SR and LR elasticities,

OPEC supply

Endogenous: p and q



Recap

Two basic assumptions:

- Equilibrium: total quantity supply = total quantity demanded
- Rationality: each person tries to choose the best alternative available

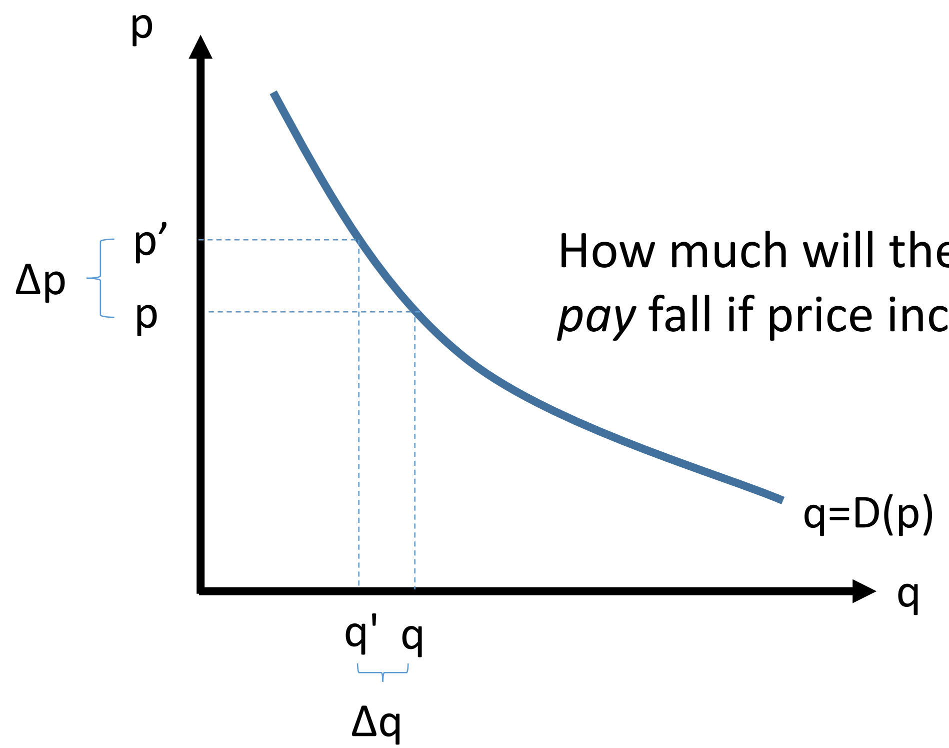
Competitive equilibrium:

- Both consumers and suppliers are «small» and cannot influence market prices – they are «price-takers»
- In case of an exogenous shock or policy, (p,q) adjust such that new equilibrium is reached
- This arrangement is Pareto efficient

Monopoly:

- Controls both price and quantity supplied
- Usually supplies less than market optimum and thus at a higher price
- This arrangement is not Pareto efficient

Recap – elasticities



How much will the *willingness to pay* fall if price increases by 1%?

$$\epsilon_D = \frac{\%\ change\ in\ q\ (demanded)}{\%\ change\ in\ p} \approx \frac{\frac{\Delta q}{q}}{\frac{\Delta p}{p}} = \underbrace{\frac{\Delta q}{\Delta p}}_{slope} \frac{p}{q} < 0$$

Elastic demand: $\epsilon_D < -1$ (consumers respond a lot)

Inelastic demand: $-1 < \epsilon_D < 0$ (consumers respond less)

Recap – elasticities

Income elasticity: $\epsilon_I = \frac{\Delta q}{\Delta I} \frac{I}{q}$

As people get reacher (poorer) how is does the quantity demanded change?

Cross-price elasticity: $\epsilon_{ij} = \frac{\Delta q_i}{\Delta p_j} \frac{p_j}{q_i}$

How does the price change in good j influence the quantity demanded of good i?

Close substitutes tend to influence the price of one-another (e.g. butter vs margarine)

Estimation: $\log q_i = a + \epsilon_D \log p_i + \epsilon_I \log I + \epsilon_{ij} \log p_j + \cdots + error$

Using *econometric regressions* one can explain changes in a *dependent variable* (q_i here) using data from *independent variables* (p_i, I, p_j,...)

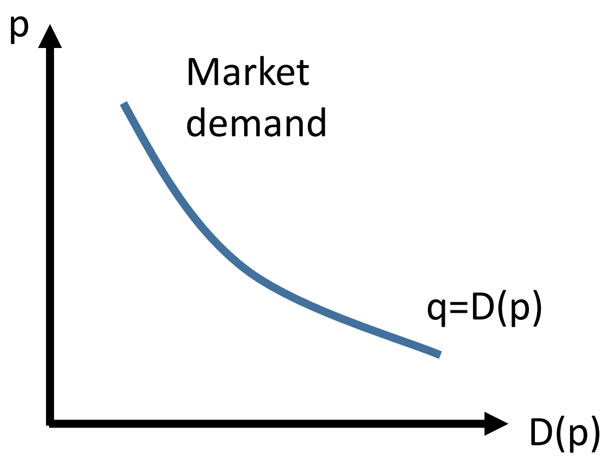
(wait for the 3rd lecture)

Objectives

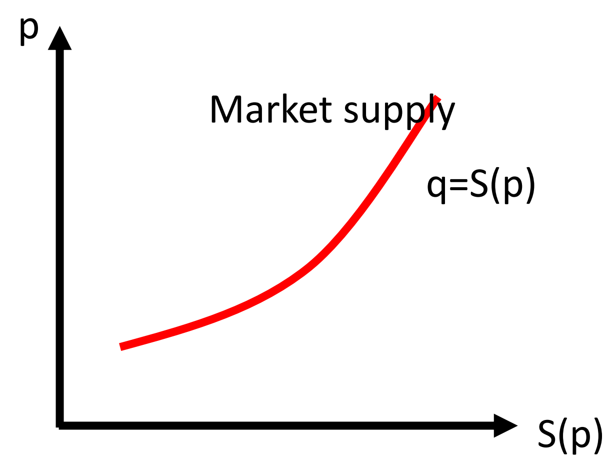
- Economic principles that will be used throughout the course (microeconomics, time value of money, NPV, adjustment for risk)
- Get acquainted with Microsoft Excel Solver
- Understand the reasons for a state intervention in the energy sector

Supply – Demand

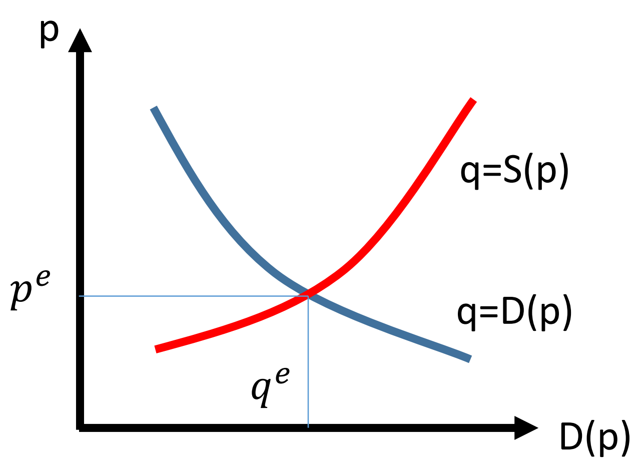
Demand curve (willing. to pay)



Supply curve (willing. to accept)



Equilibrium:

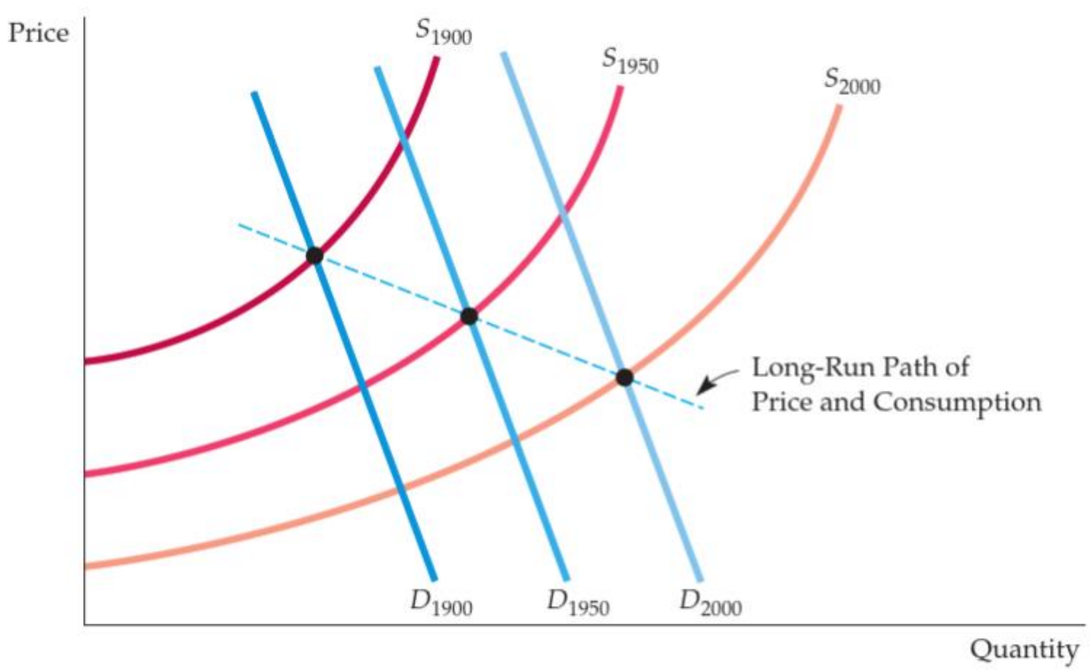


By equating *supply = demand* we get the market equilibrium:

$S(p^e) = D(p^e) \rightarrow p^e$ can be calculated
and then q^e from either supply or demand curve

Supply – Demand

Example: Consumption and the price of copper

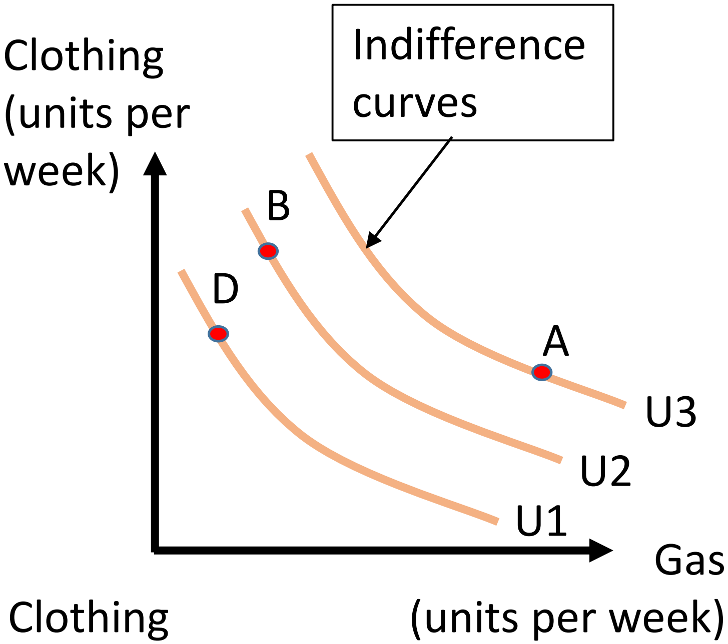


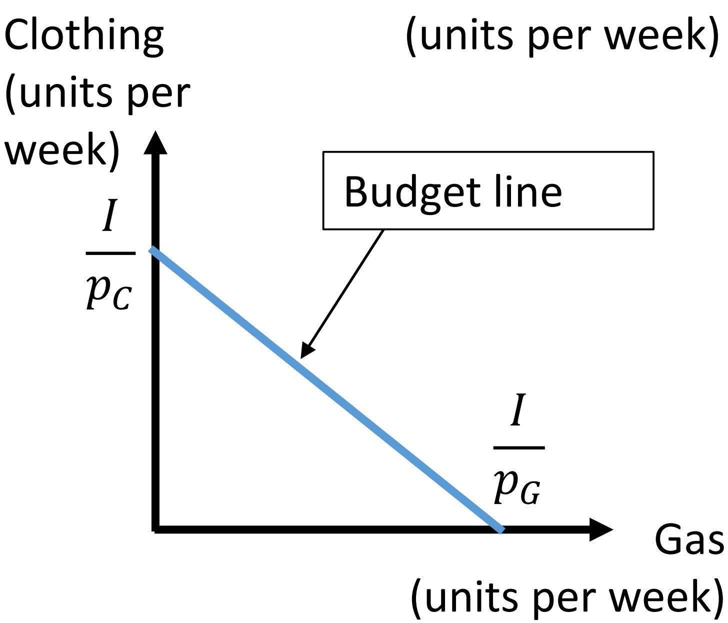
Although demand for most mineral resources (including copper) has increased over the past century, prices have fallen in real terms because **technological progress** lowers the cost of production and shifts supply curve just as much.

Relevant questions?

1. Where do demand and supply curves come from?
2. What is the role of technological progress for development?

Consumers





Consumer behaviour understood in three steps:

1) Available choices (Basket of goods):
clothing C & gas G. A basket is denoted by e.g. B={C,G}.

2) Consumer preferences (Indifference curves):

U=f(C,G): all combinations {C,G} that yield the same level of satisfaction (**utility U**)

Utility level U1<U2<U3 such that combination A is preferred to B, which is preferred to D

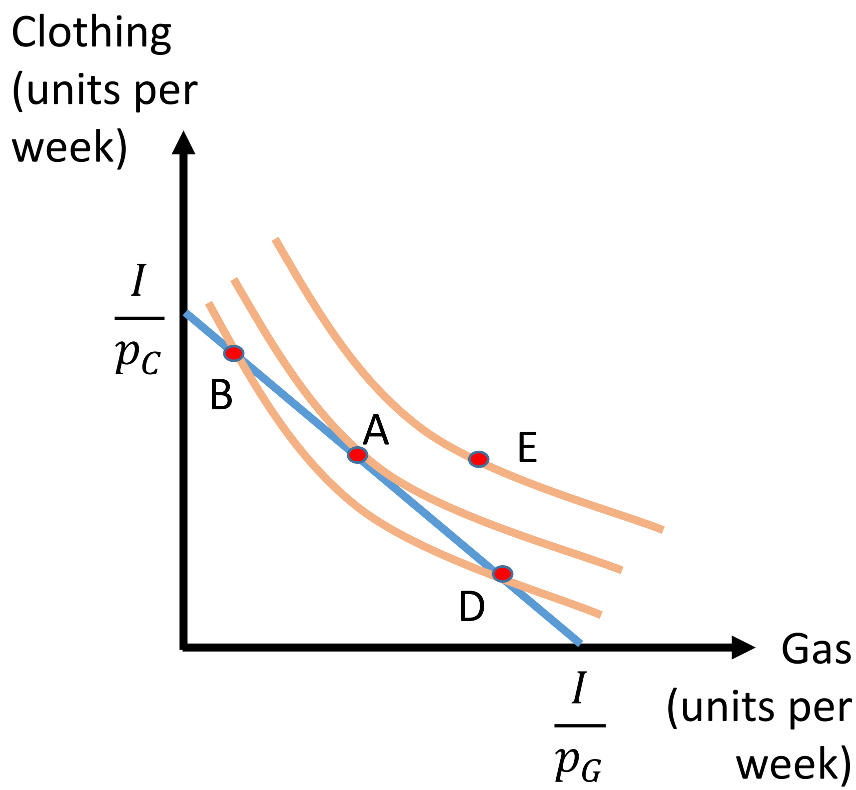
3) Budget constraint (Budget line):

Income = Expenditure on goods/services

$$\mathrm{I} = p_G G + p_C C \;\rightarrow C = \frac{I}{p_C} \underbrace{-\frac{p_G}{p_C}}_{slope} G$$

Consumers choose among available goods, in order to maximize their level of utility, while obeying their budget constraint (income = expenditure)

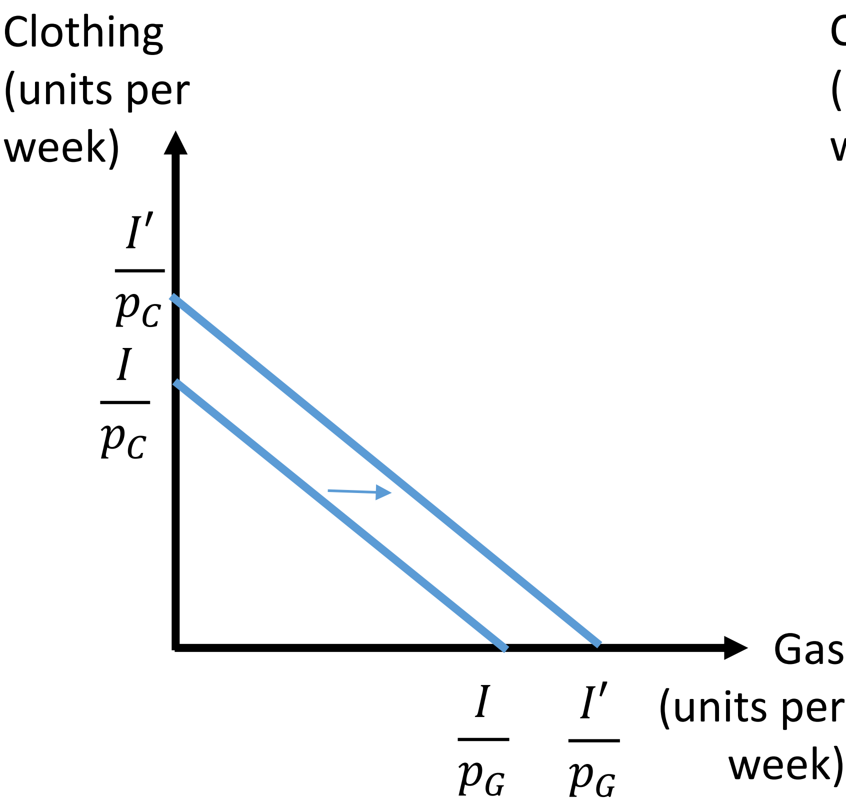
Consumers - Optimum



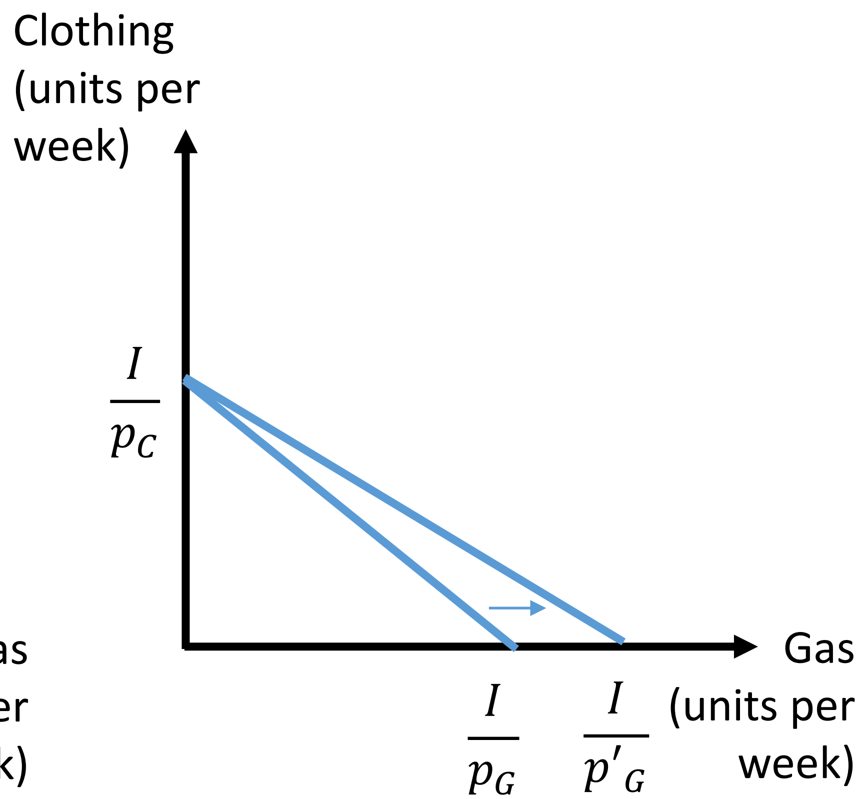
- Attainable baskets: A, B, D; Basket E is too expensive to be attained with this income level
- Consumers are indifferent between baskets B and D (they are on the same utility curve)
- Basket A is the **optimum basket**:

  utility is tangent to the budget line (point A reaches higher levels of utility while satisfying budget constraint)

Consumers - when income or prices change

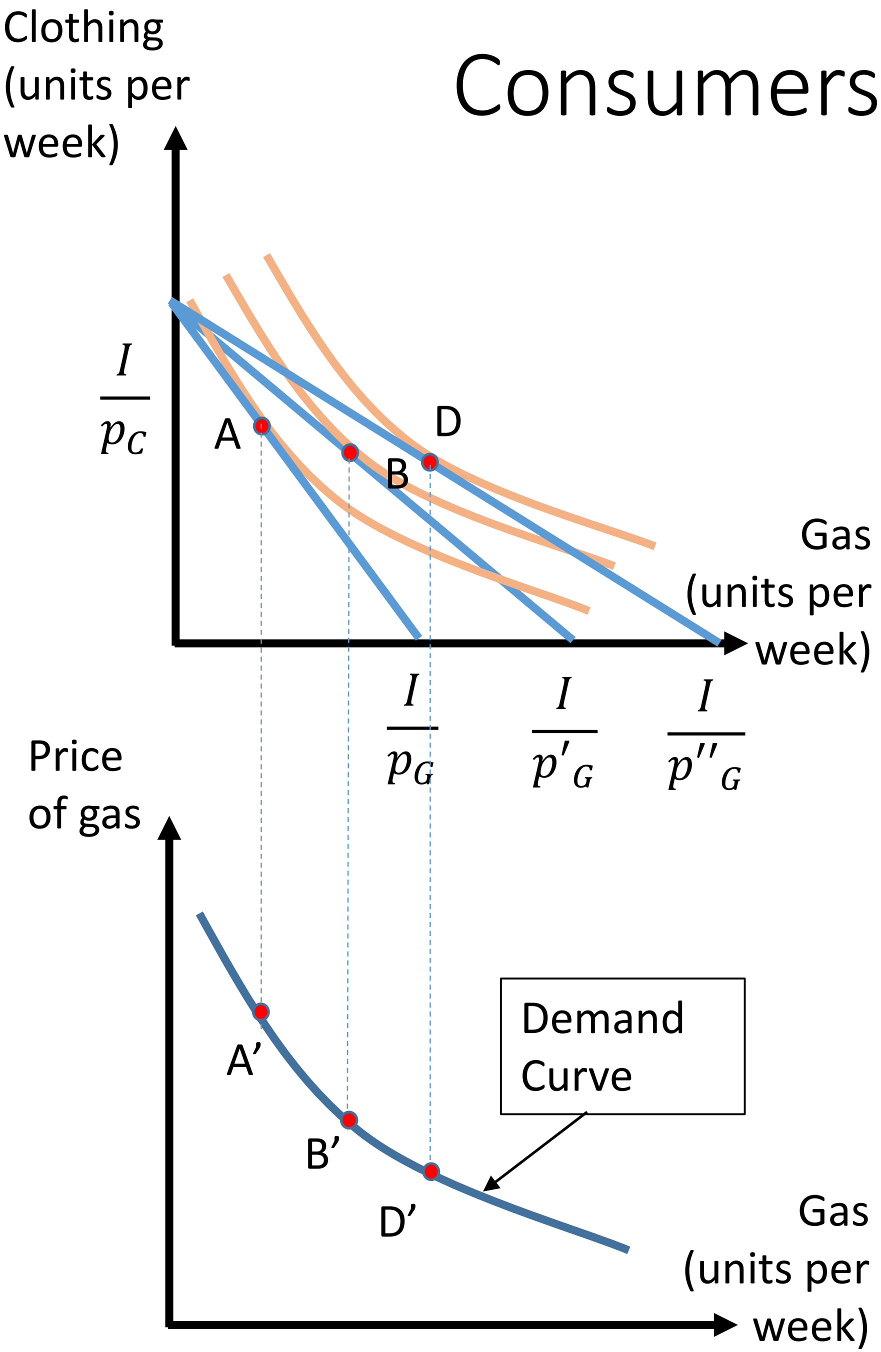


Increasing income: $I' > I$



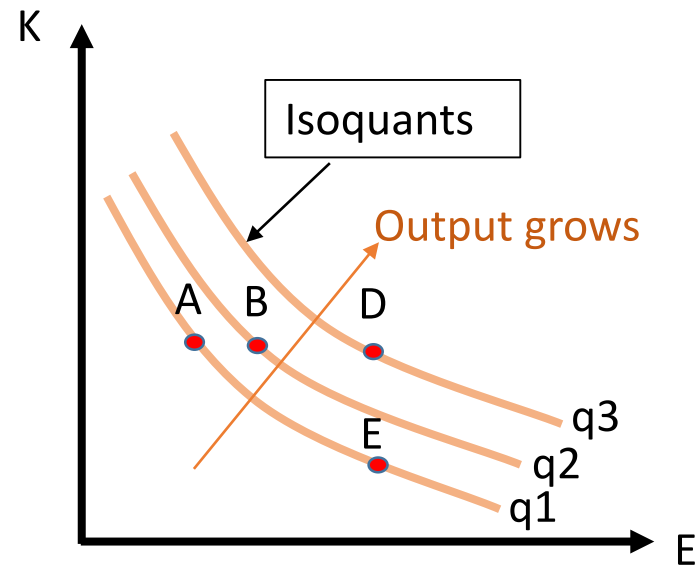
Lowering the price of gas: $p'_G < p_G$

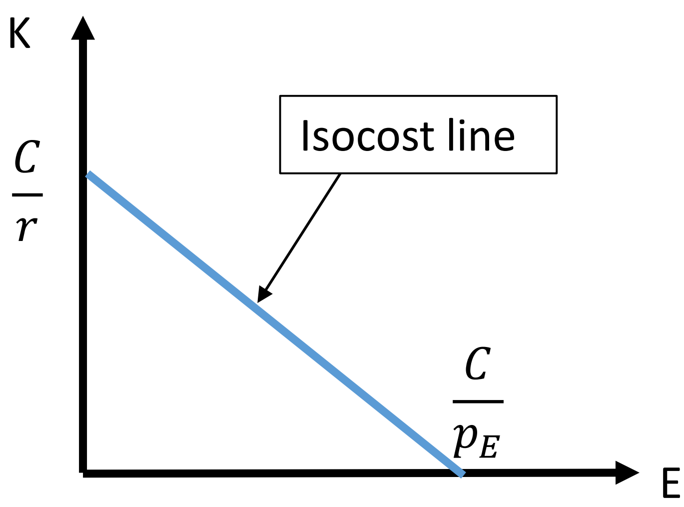
Consumers - when gas gets cheaper



- Lowering the price of gas results to a new optimal combination (Clothes, Gas) and higher utility
- *holding all else constant we can buy more gas so we get more satisfied (more is better → higher utility)*
- The lower graph gives the **demand curve** for gas: *what is the willingness-to-buy as price of gas changes:* $p_G > p'_G > p_G{''}$
- Points A', B', D' correspond to points A, B, D

Producers - Demand for inputs





Producer behaviour understood in 3 steps:

1) **Production function (technology)**
   q=f(K,E; T) with K capital and E energy

   How inputs (K,E) are transformed to output (q), given the level of technology the firm possesses (T)

2) **Input choices (Isoquants)**:
   all combinations of (K,E) that give the same output q

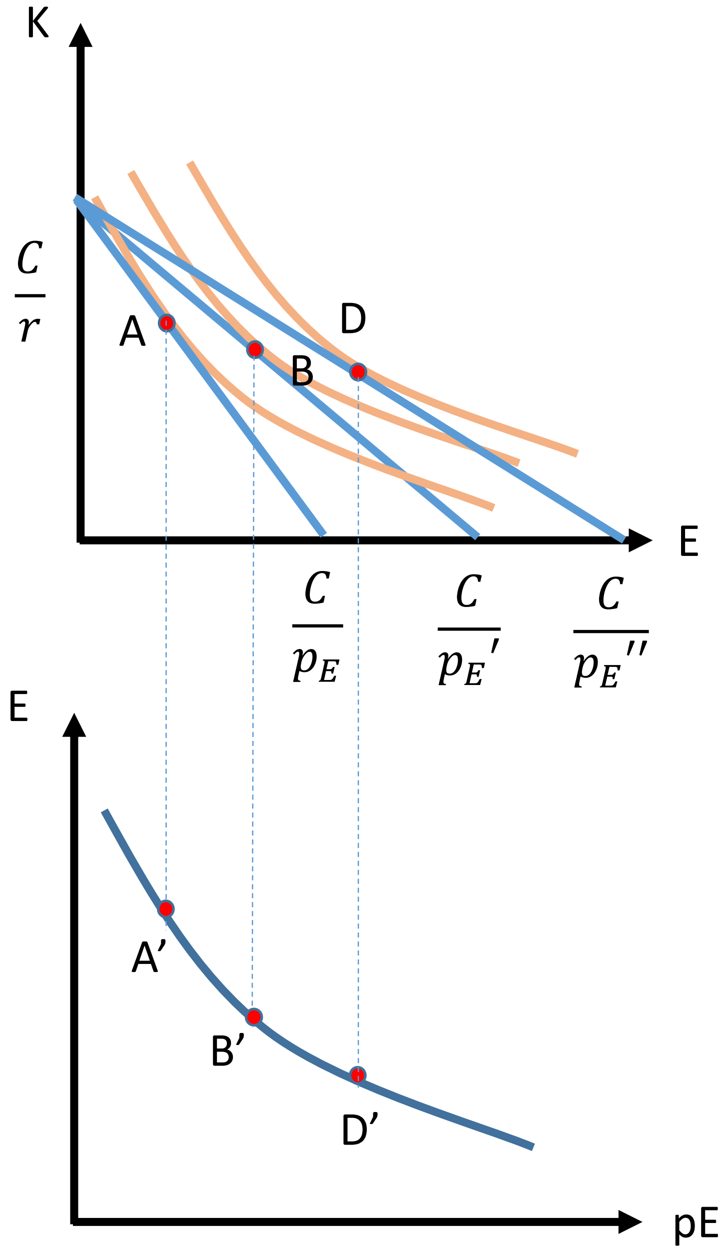
   Output at A (q1) is lower than at B (q2), which is lower than D (q3); Output at A is the same as at E (on the same isoquant)

3) **Cost constraints (Isocost):**
   the isocost line holds all combinations of (K,E) that yield the same cost C for the firm:

$$C = r\,K + p_E\,E \;\rightarrow K = \frac{C}{r} - \frac{p_E}{r}E$$

r is the unit cost of capital (e.g. rent, interest rates for loans)

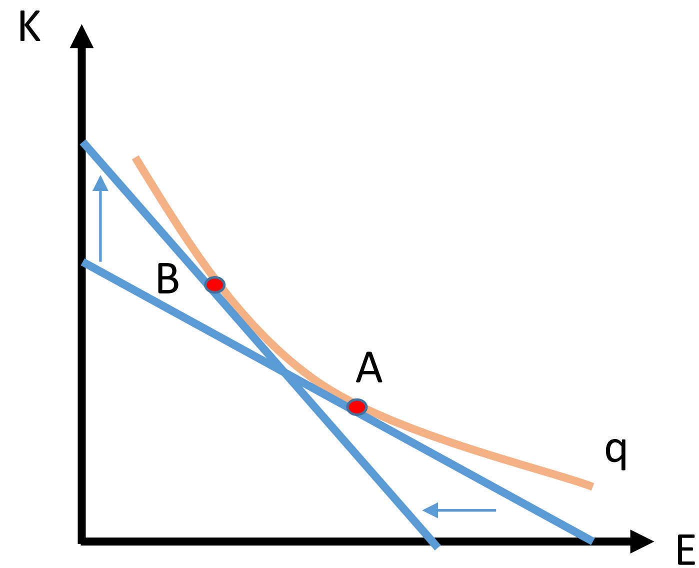
Producers - Demand for inputs

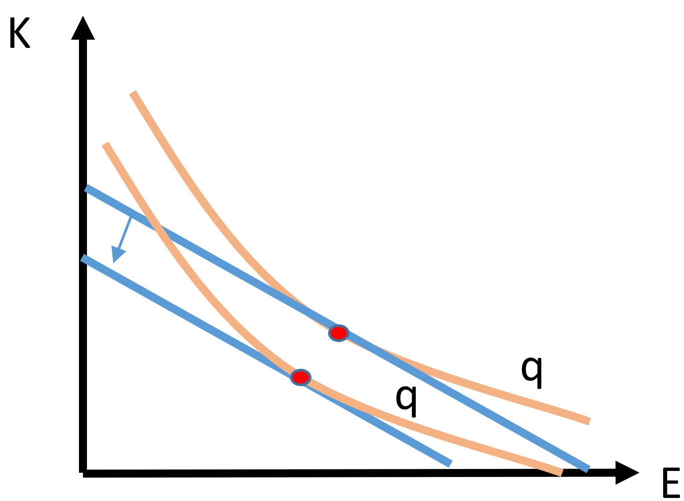


Firms are also consumers of goods and services so the same analysis applies

- *Optimum is at the point where the isocost line is tangent to the isoquant*
- At this point we have achieved highest production for given firm budget
- Lowering the price of energy results in a new optimal combination (K,E) and to a higher output (higher isoquant)
- The lower graph gives the firm's demand curve: *what is the willingness-to-buy as prices change*
- Points A', B', D' correspond to points A, B, D
- The fact that the firm can produce more, doesn't mean it's efficient. There needs to be demand for it → *market equilibrium*

Example - Energy efficiency





Policy makers are concerned with finding ways of reducing the use of energy in production, while not reducing output q.

There are essentially two ways:

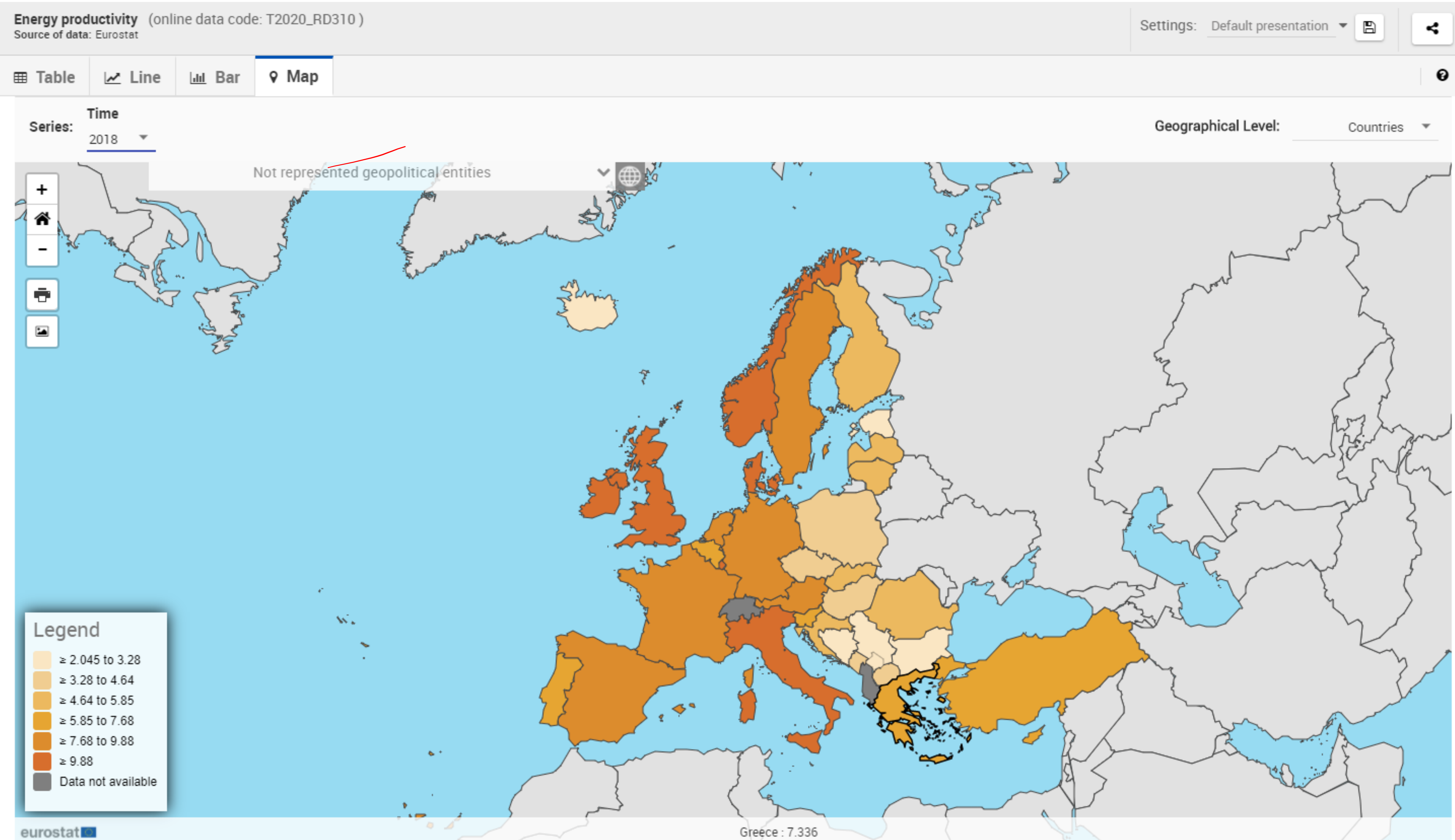
1) Substitute factors in production, e.g. capital for energy by making fossil fuels more expensive (upper figure)

2) Improving technology. With tech. progress there is less amount of inputs needed for the same output: q=T f(K,E), with T representing technology (lower fig.).

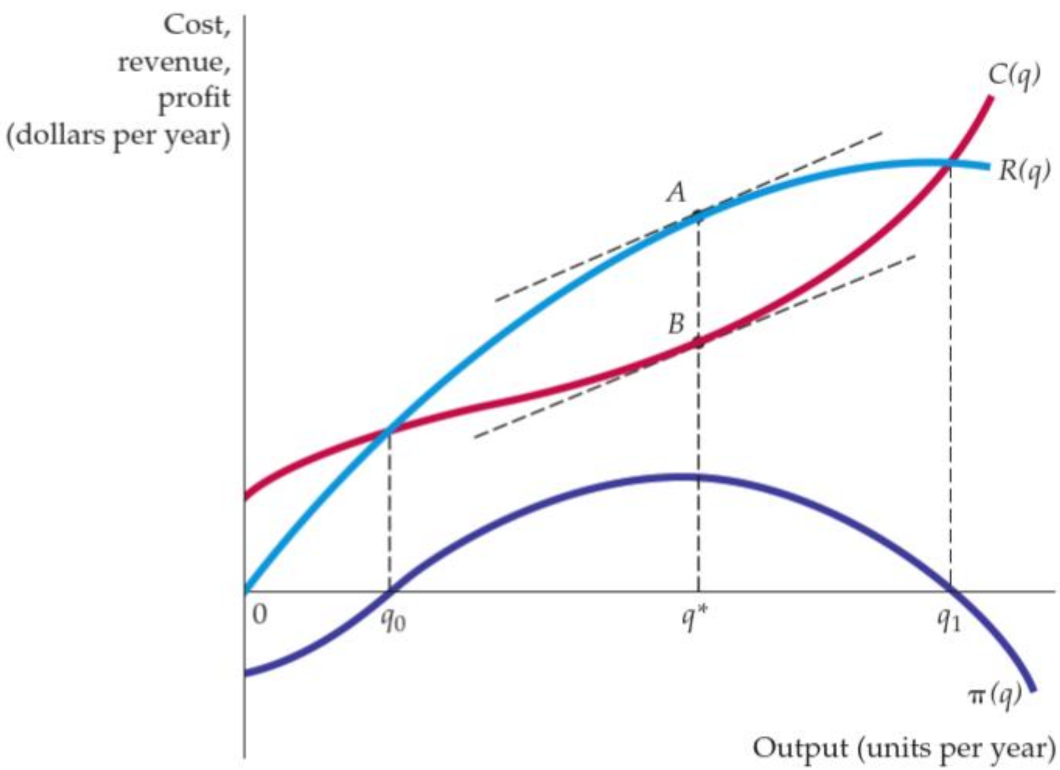
If T grows then we can produce the same q with less K and E

Example - Energy efficiency

GDP/available energy – [link]



Producers - Profit maximization



Profit = Revenue – Cost:

$$\boldsymbol{\pi(q) = R(q) - C(q)},$$

with $R = price\ (p) \times quantity\ (q)$

MR: marginal* revenue (slope of R)
MC: marginal* cost (slope of C)
Mπ: marginal* profit (slope of π)

At output point q*, R is parallel to C:

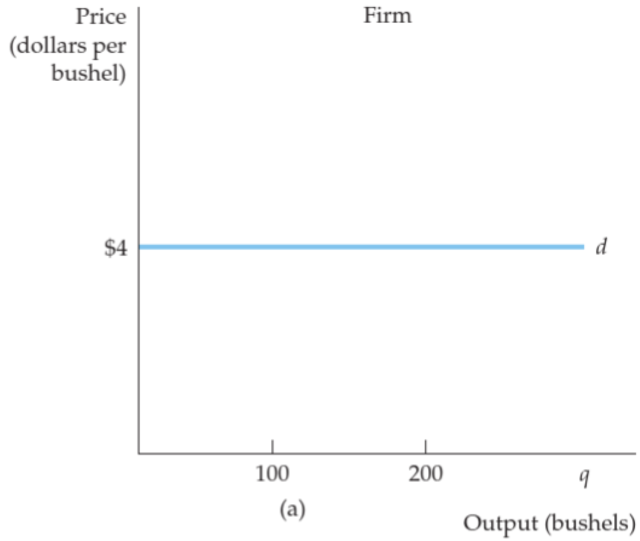
$$MR(q^*) = MC(q^*)$$

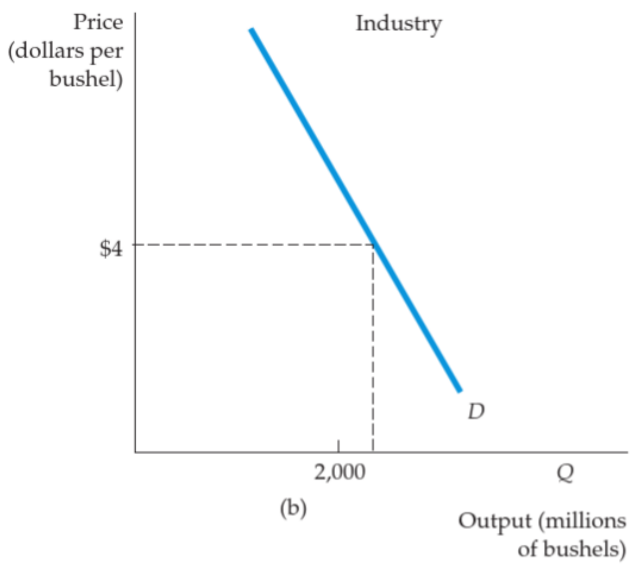
For q<q*, $M\pi > 0$
For q>q*, $M\pi < 0$
For q=q*, $M\pi = 0$ → Optimum!

Profit is maximized when $\boldsymbol{MR(q) = MC(q)}$ (Always!);
Any output should be produced at the level which maximizes profit (irrespective of market structure, i.e. competition or monopoly)

*marginal=incremental change of a measure (e.g. profit) from one extra unit of q

Competitive firm





A competitive firm is small and cannot influence the market (upper graph). It supplies only a small part of the market demand (lower graph)

The demand curve the firm is facing is simply flat: the firm sells its output at the market price (here \$4/unit).

The revenue the firm is making is $\mathrm{R} = p \times q$ such that $\mathrm{MR} = p$

The MC curve gives the demand curve of consumers: as the price increases, there is less market demand for the *additional unit* of the good

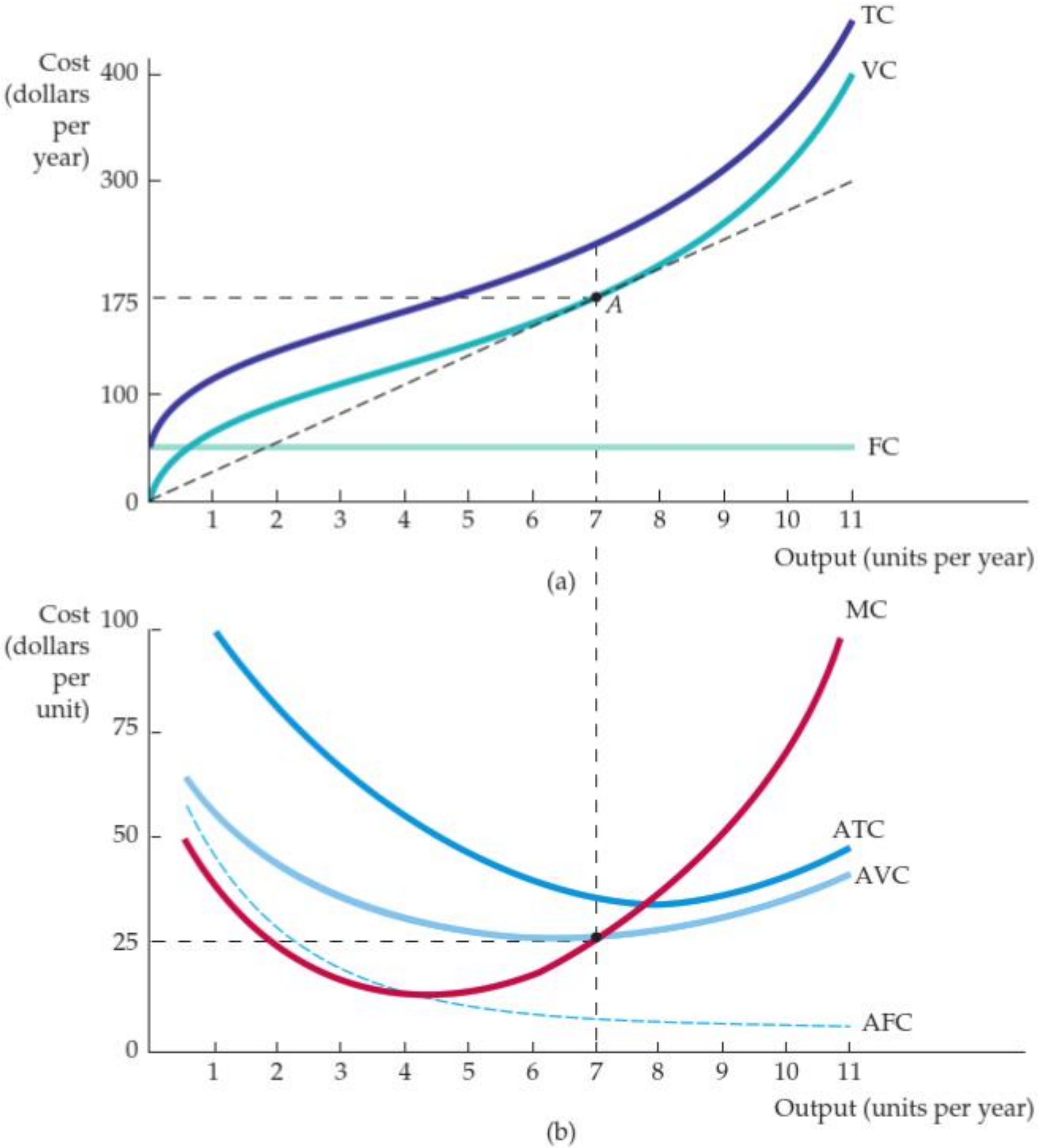
Profit maximization of a competitive firm:

$$MC(q) = MR = p$$

Competitive firm – what cost matters?

RATE OF OUTPUT (UNITS PER YEAR)	FIXED COST (DOLLARS PER YEAR)	VARIABLE COST (DOLLARS PER YEAR)	TOTAL COST (DOLLARS PER YEAR)	MARGINAL COST (DOLLARS PER UNIT)	AVERAGE FIXED COST (DOLLARS PER UNIT)	AVERAGE VARIABLE COST (DOLLARS PER UNIT)	AVERAGE TOTAL COST (DOLLARS PER UNIT)
	(FC) (1)	(VC) (2)	(TC) (3)	(MC) (4)	(AFC) (5)	(AVC) (6)	(ATC) (7)
0	50	0	50	—	—	—	—
1	50	50	100	50	50	50	100
2	50	78	128	28	25	39	64
3	50	98	148	20	16.7	32.7	49.3
4	50	112	162	14	12.5	28	40.5
5	50	130	180	18	10	26	36
6	50	150	200	20	8.3	25	33.3
7	50	175	225	25	7.1	25	32.1
8	50	204	254	29	6.3	25.5	31.8
9	50	242	292	38	5.6	26.9	32.4
10	50	300	350	58	5	30	35
11	50	385	435	85	4.5	35	39.5

Different cost curves



Fixed cost (FC): e.g. building rent, wages, internet connection etc.;

Variable cost (VC): cost that varies as output varies, cost of raw materials e.g. natural gas to produce electricity

Total cost (TC): TC=FC+VC

AC: average cost = $\frac{Cost}{q}$

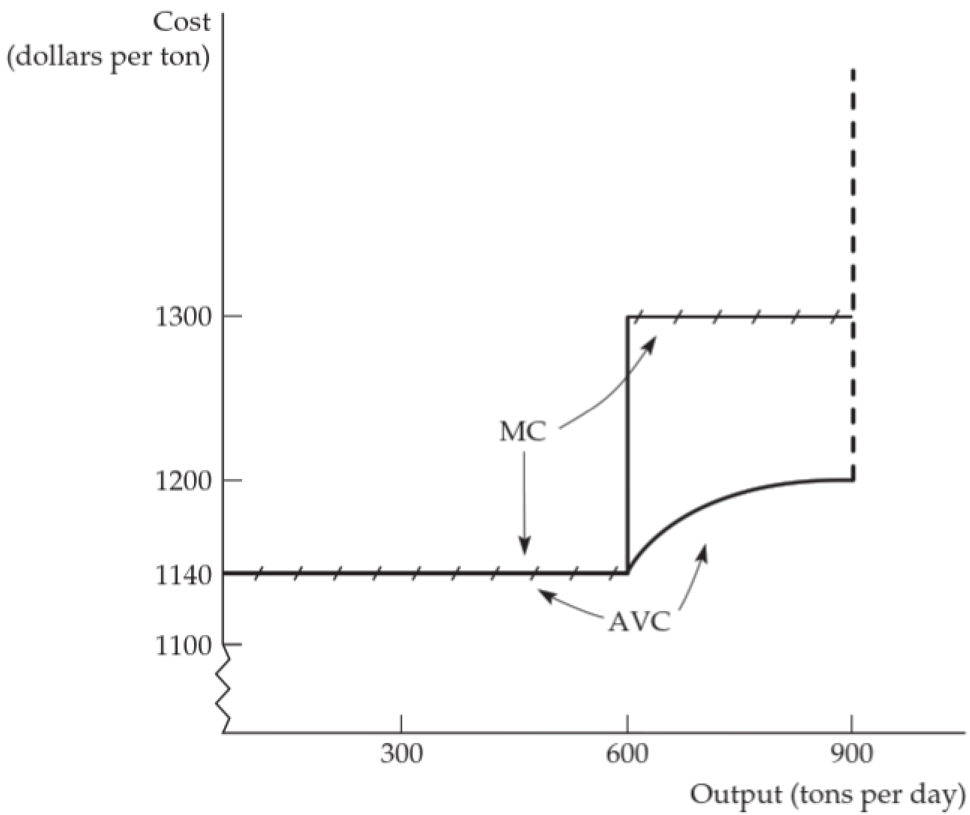
MC: marginal/incremental cost = $\frac{\Delta(TC)}{\Delta q}$

Example: Aluminium plant

PER-TON COSTS THAT ARE CONSTANT FOR ALL OUTPUT LEVELS	OUTPUT ≤ 600 TONS/DAY	OUTPUT > 600 TONS/DAY
Electricity	\$316	\$316
Alumina	369	369
Other raw materials	125	125
Plant power and fuel	10	10
Subtotal	\$820	\$820
PER-TON COSTS THAT INCREASE WHEN OUTPUT EXCEEDS 600 TONS/DAY		
Labor	\$150	\$225
Maintenance	120	180
Freight	50	75
Subtotal	\$320	\$480
Total Per-ton Production Costs	**\$1140**	**\$1300**

- Aluminium production is energy-intensive (needs a lot of electricity)
- After the mining of Bauxite, electricity is used to separate aluminium oxide into aluminium and oxygen.
- A typical plant would produce on average 600 tons per day (2 shifts, 300 tons per shift).
- If there is suddenly high market demand, the plant cannot expand in terms of capital (takes approx. 4 years to build a new plant) but can hire more people or pay overtime, increase freight etc. and add another shift to increase output levels. Production limit is 900 tons per day (including 3rd shift)

Example: Aluminium plant



- For an output of up to 600 tons total variable cost is $\$1140 \times q$. For more than 600 tons (i.e. *q-600*) it is:

$$TVC = 1140 \times 600 + 1300 \times (q - 600) = -96000 + 1300 \times q$$

- Average variable cost = TVC/q:

$$AVC = \frac{-96000}{q} + 1300$$

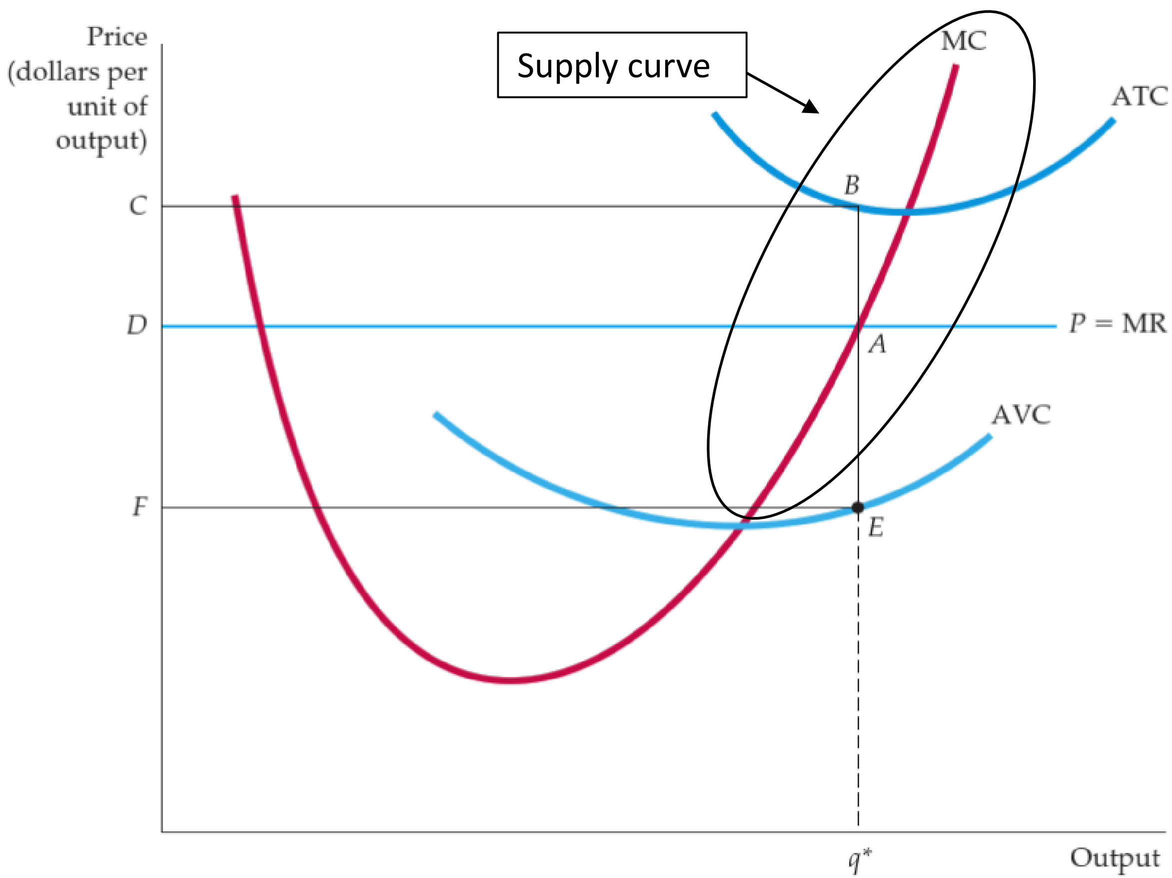
- Marginal cost is 1140 for q<=600 and 1300 for q>600

- Capacity limit is 900

Producers – supply curve

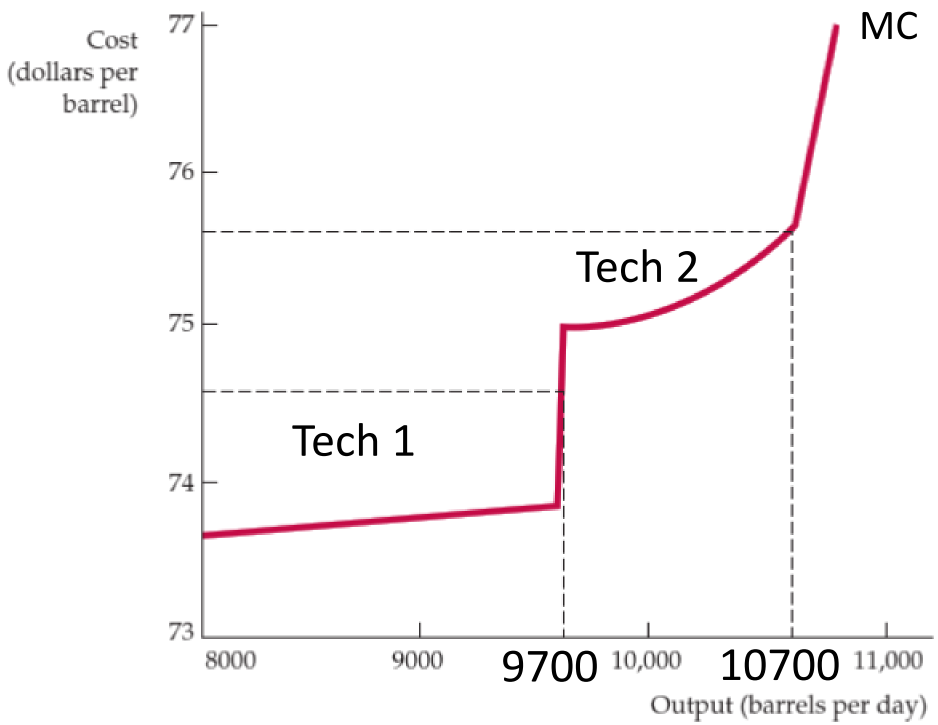
- Competitive firm sets p=MC but needs to shut down if price is below AVC (in this case firm cannot cover even fixed cost); it is necessary to cover at least the AVC

- The supply curve is given by the portion of the MC curve where MC>AVC



Example: Production of petroleum products

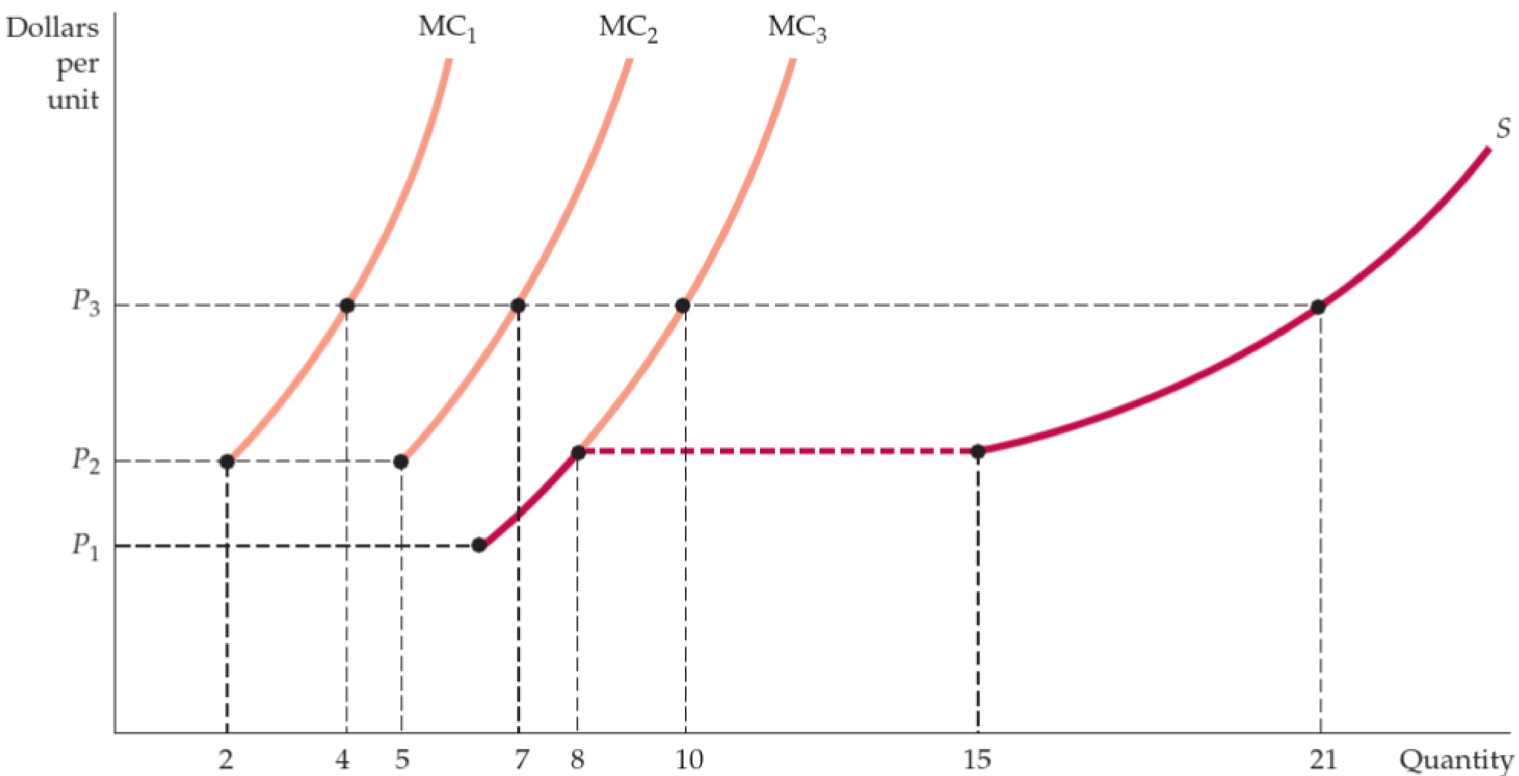
- A refinery can convert crude oil into different petroleum products
- Gasoline can be produced using a relatively cheap process. The capacity of this unit is 9700 barrels/day
- After the capacity is reached a more expensive technology is used with a capacity of 10700 barrels/day



- If market price is \$73 (below MC of production) no gasoline will be produced
- At a price between \$74-\$75, the refinery should produce 9700 b/d
- At a price a bit above \$75 the more expensive technology will be used up to 10700 barrels/day

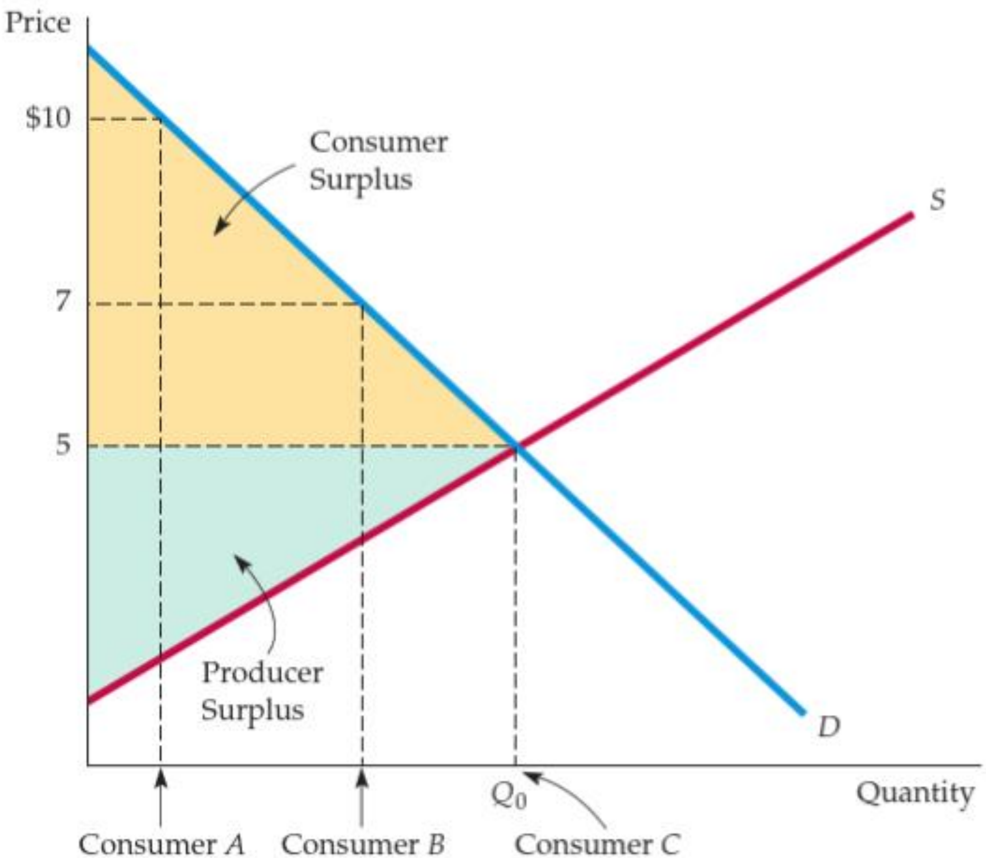
Note that for small price changes the technology doesn't change

Industry – supply curve



The short-run industry supply curve is the summation of the supply curves of the individual firms. Because the third firm has a lower average variable cost curve than the first two firms, the market supply curve S begins at price P_1 and follows the marginal cost curve of the third firm MC_3 until price equals P_2, when there is a kink. For P_2 and all prices above it, the industry quantity supplied is the sum of the quantities supplied by each of the three firms.

Consumer and producer surplus



Competitive price p*= 5

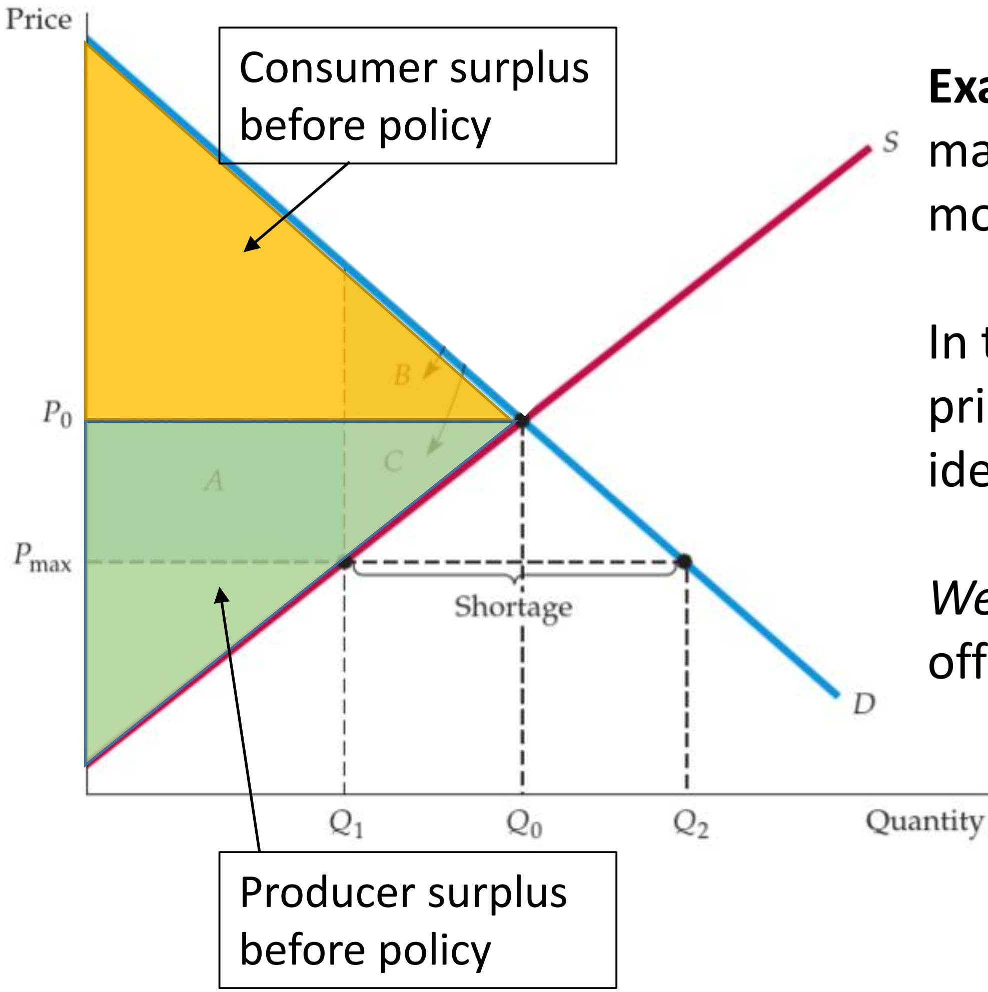
Consumer surplus: total benefit from the consumption of a product minus the total cost of buying it →

*Area between demand curve and p**

Producer surplus: total benefit from selling a product minus the cost of producing it →

*Area between supply curve (MC) and p**

Effect of a policy – who gains who loses?

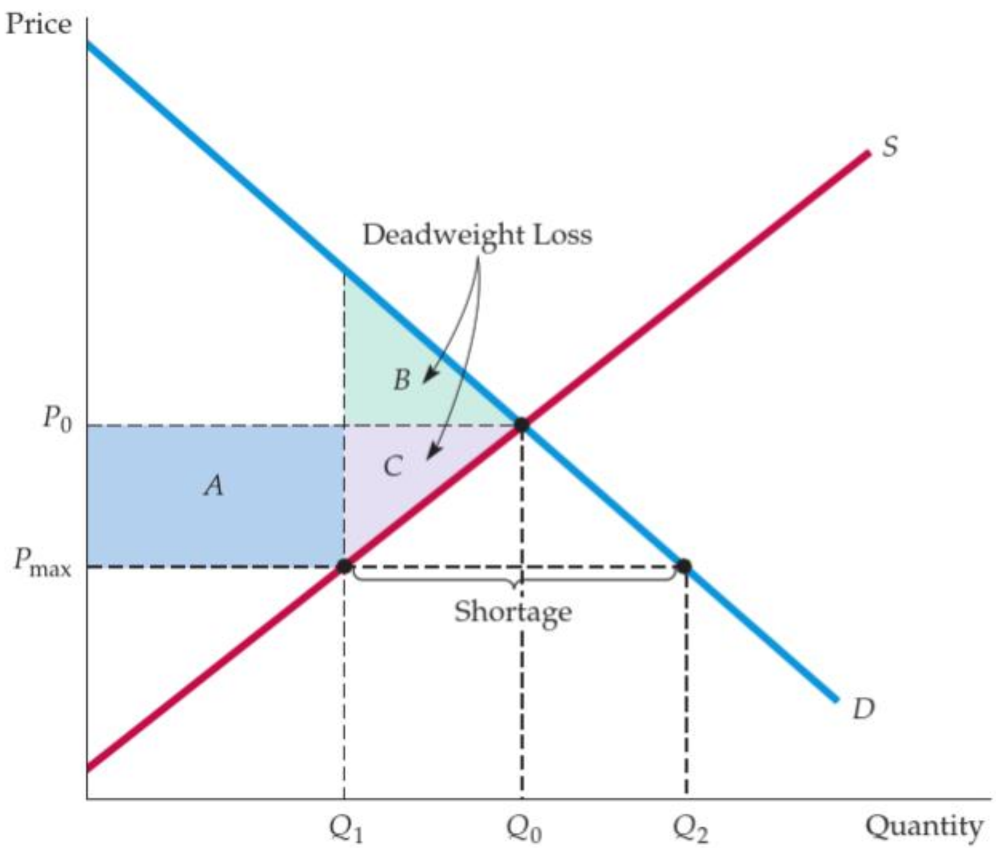


Example - *Price controls*. The govn't makes it illegal for someone to charge more than $P_{max}<P_0$, the competitive price.

In this case there is a shortage. At this price producers sell Q_1 while consumers ideally would want to consume Q_2.

Welfare analysis: How much better/worse off is each group?

Effect of a policy – who gains who loses?



Consumer surplus (CS): The consumers that are rationed out of the market are worse off. The ones who can still buy the good (e.g. because they fulfil social criteria) pay less for it so they are better off.

Better off (welfare gain): rectangle A
Worse off (welfare loss): triangle B
If A>B the policy is good for consumers

Producer surplus (PS): The producers with low production cost will stay in the market but will receive a lower price, while others leave the market. Producers simply lose from this policy. They have lost parts A and C (due to lower quantity produced).

Deadweight loss: Social welfare cost/gain of policy
Change in CS = ΔCS = A – B
Change in PS = ΔPS = – A – C

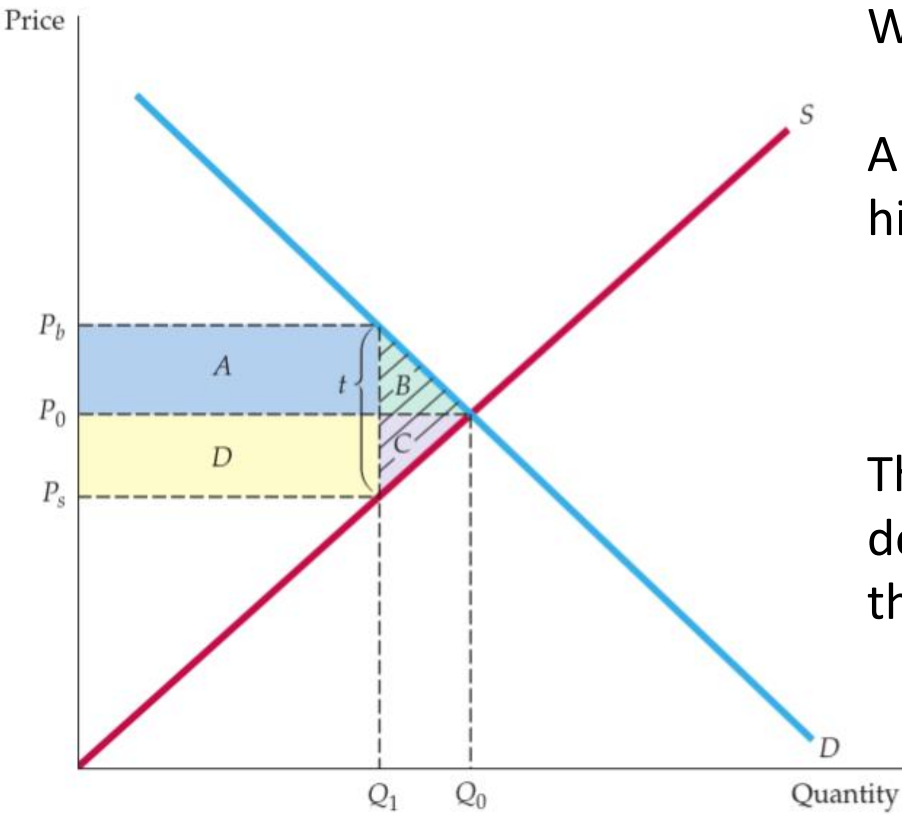
total change: ΔCS+ΔPS= – B – C

Taxation

Typical questions which arise concerning taxes:

- What is the effect of a tax on market equilibrium?
- How are prices affected?
- How is the quantity traded affected?
- Who pays the tax?
- How are the gains-to-trade altered?

Welfare effects of taxation



Without taxes equilibrium is at price p_0

A tax rate t makes the price paid by buyers p_b higher than the price received by sellers p_s:

$$p_b = p_s + t$$

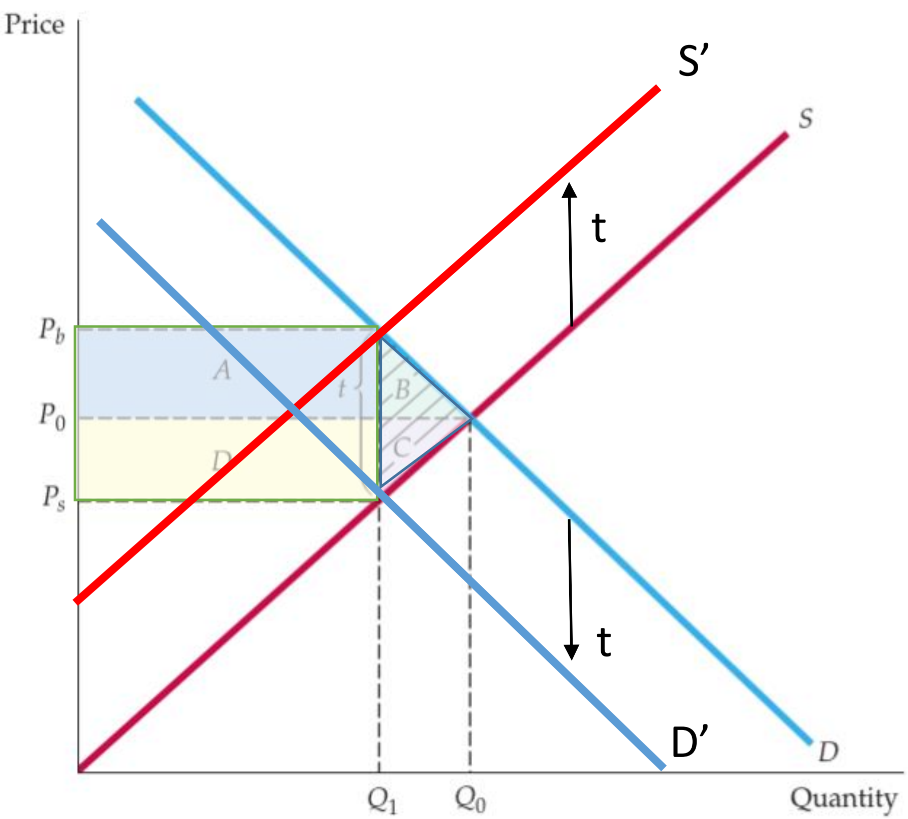
The quantity bought at p_b must lie on the demand curve and the quantity sold at p_s on the supply curve. Market equilibrium holds:

$$q_D(p_b) = q_S(p_s)$$

Buyers lose A+B
Sellers lose D+C
Government wins A+D

Deadweight loss is (-A-B)+(-D-C)+(A+D)=(-B-C)

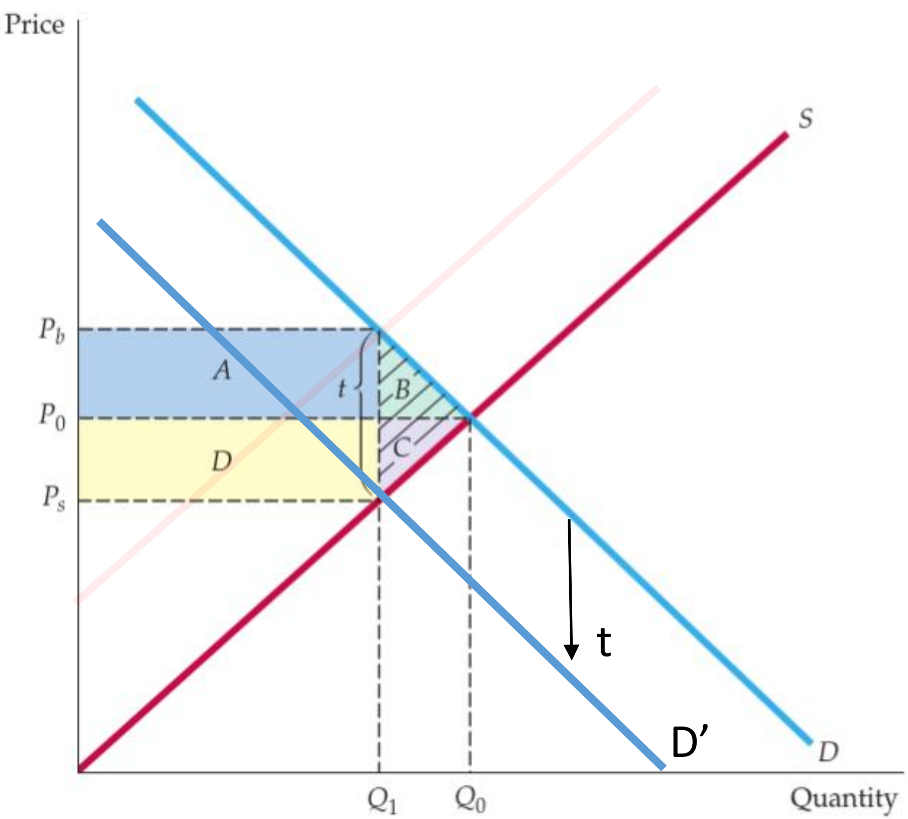
It doesn't matter who pays the tax



From a market perspective it shouldn't matter who pays the tax.

A sales tax on consumers at a rate t €/unit has the same effect to an excise tax a rate t €/unit on sellers.

It doesn’t matter who pays the tax



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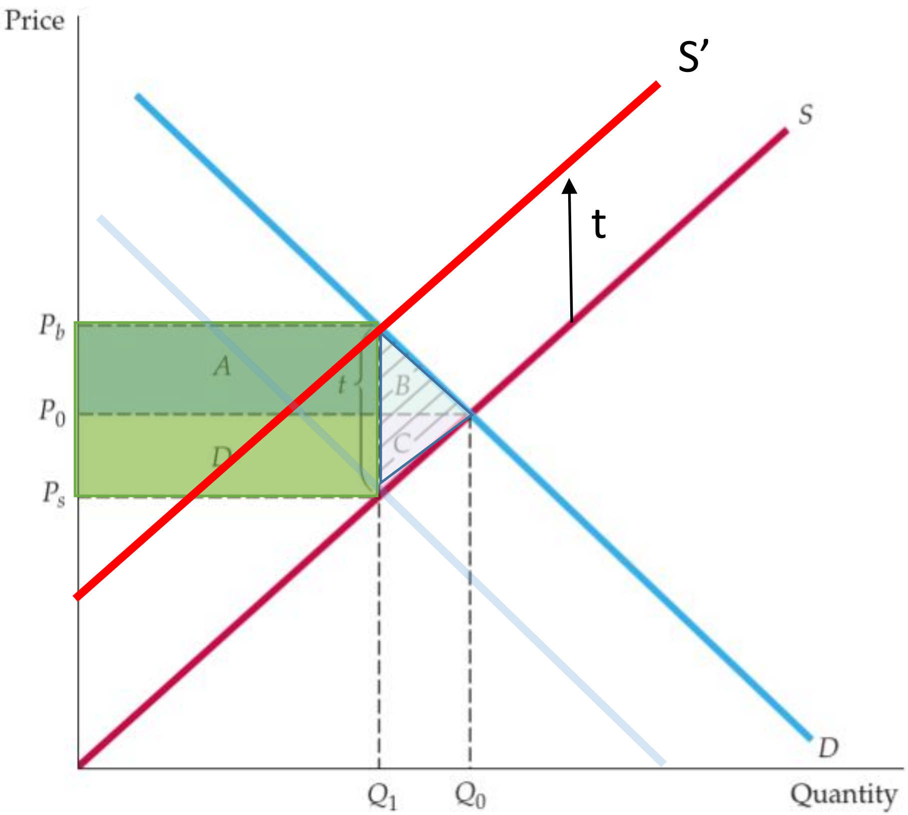
Tax levied on consumers

It doesn’t matter who pays the tax

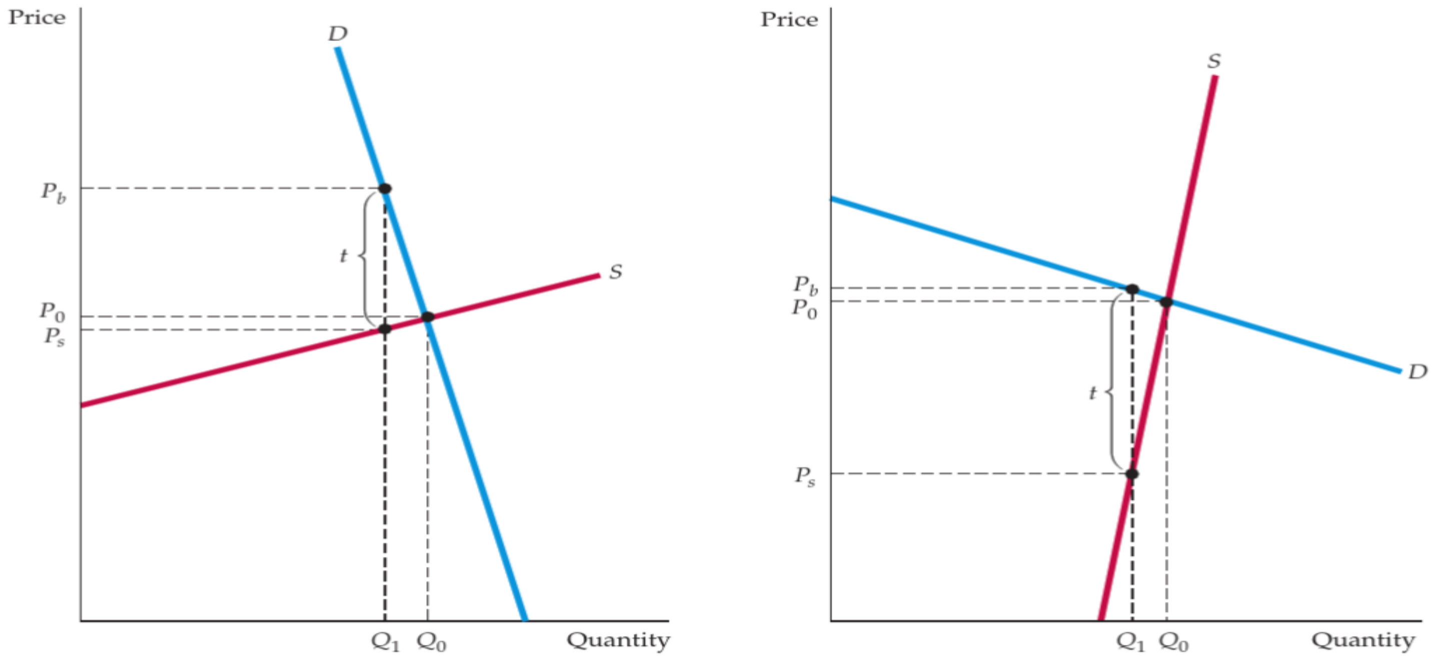


From a market perspective it shouldn’t matter who pays the tax.

A sales tax on consumers at a rate t €/unit has the same effect to an excise tax a rate t €/unit on sellers.

A tax levied on sellers

The geometry of taxation



The impact of a **tax** depends on the elasticities of supply and demand:

- The burden falls mostly on buyers if demand is relatively inelastic: ϵ_D/ϵ_S small
- The burden falls mostly on sellers if demand is relatively elastic: ϵ_D/ϵ_S large

Opposite with subsidy! A **subsidy** can be thought as a negative tax.

- The benefit accrues mostly to buyers if ϵ_D/ϵ_S is small
- The benefit accrues mostly to sellers if ϵ_D/ϵ_S is large

The burden is almost equally shared if $\epsilon_D = \epsilon_S$ in absolute terms

Example: Tax on gasoline

What is the effect on welfare of a carbon tax on Greek gasoline consumption?

Facts:

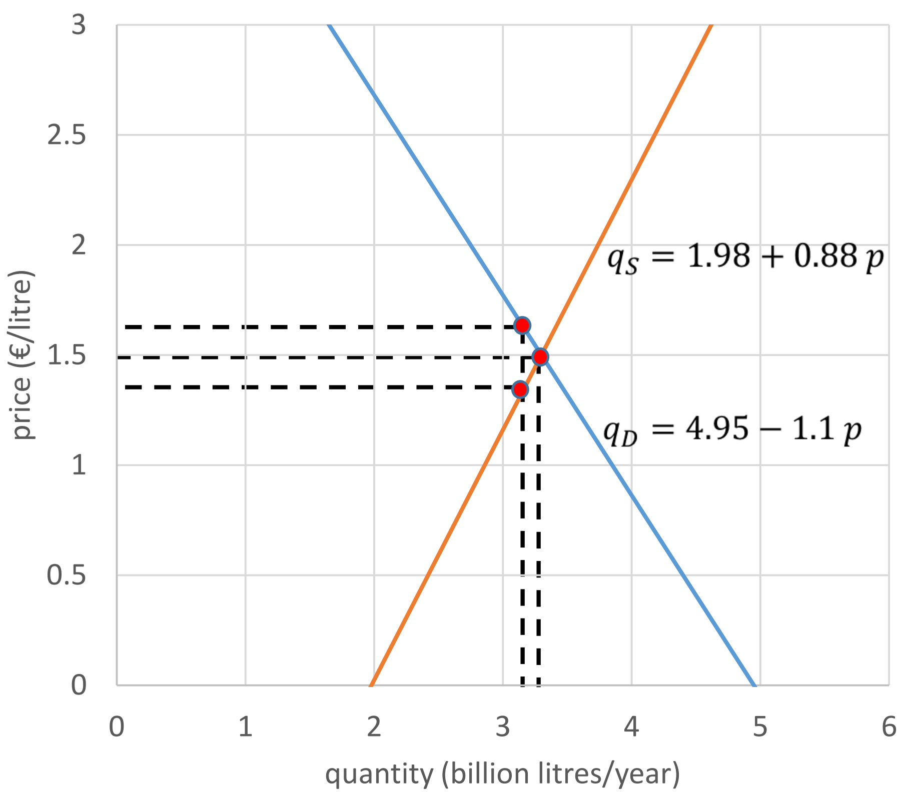
- Assume optimal carbon tax ~100 $/tC (more on that later in the course)
- 1lt gasoline burnt emits 0.65 kg carbon (i.e. 0.00065 tC/lt)
- Optimal carbon tax = 0.00065 (tC/lt) x 100 ($/tC) x 0.9 (€/$) ~ 0.06 €/lt

We took 2015-2016 prices as benchmark such that exchange rate is 0.9 €/$

More facts:

- Price (2015-2016) = 1.5€/lt, Quantity Consumed (2015-2016) = 3.3 billion lt
- long-run elasticity of demand (>1 y. after change): $\epsilon_D = -0.5$
- long-run elasticity of supply (>1 y. after change): $\epsilon_S = \ \ 0.4$

Example: Tax on gasoline



Using elasticities and equilibrium price and quantity we can calculate:

$$q_D = 4.95 - 1.1\,p$$
$$q_S = 1.98 + 0.88\,p$$

Applying the tax of t=0.06 €/lt:

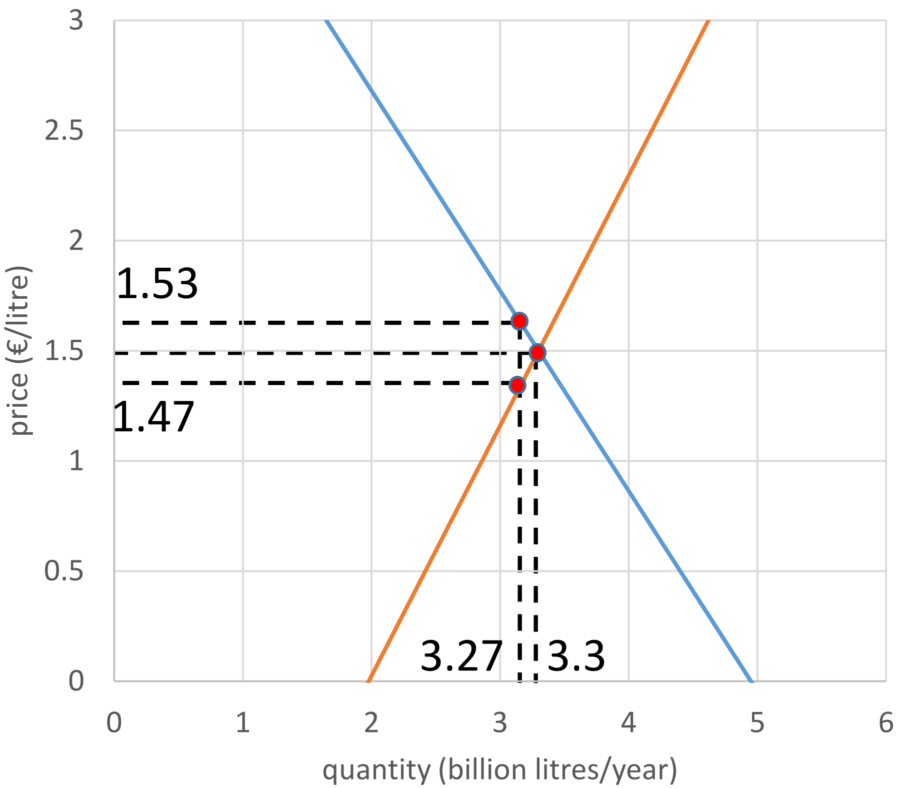
$$p_b - p_S = 0.06$$

Supply must equal demand, $q_S = q_D$:

$$1.98 + 0.88 \underbrace{p_S}_{p_b - 0.06} = 4.95 - 1.1\,p_b$$

$$p_b = 1.53, p_S = 1.47$$

Example: Tax on gasoline



Using elasticities and equilibrium price and quantity we can calculate:

$$q_D = 4.95 - 1.1\, p$$
$$q_S = 1.98 + 0.88\, p$$

with

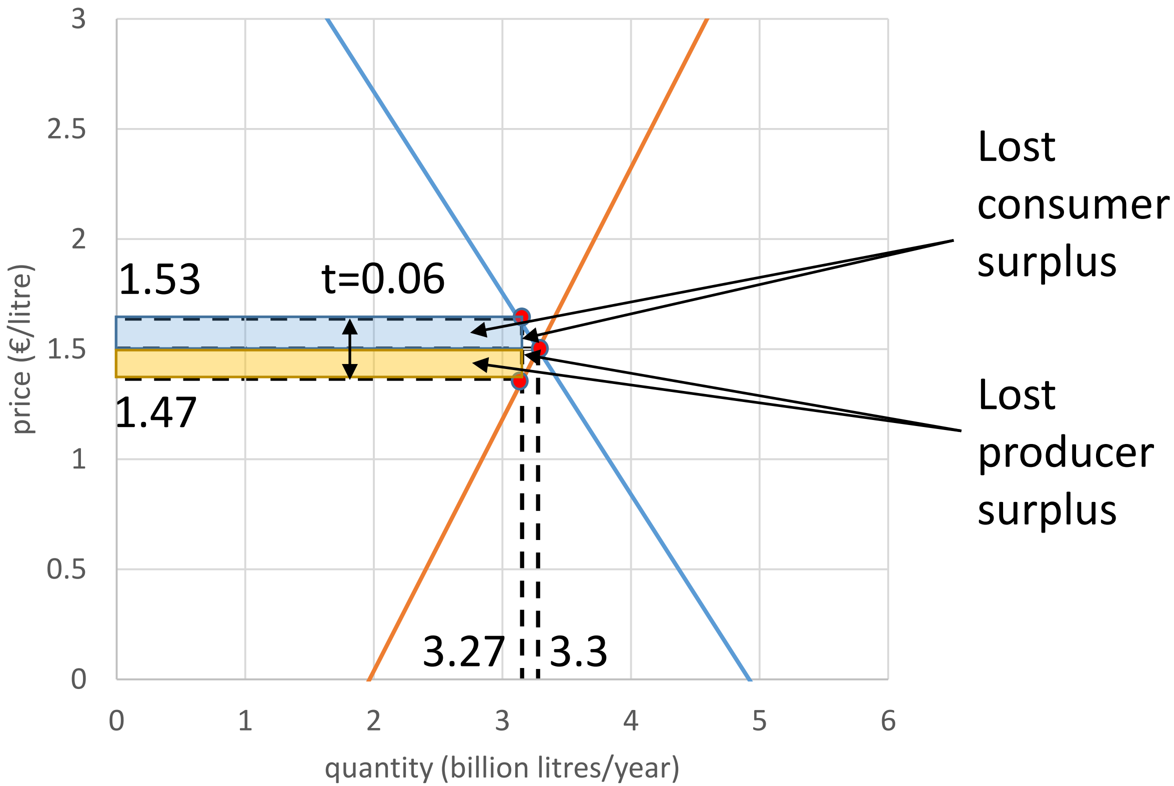
$$p_b = 1.53, p_S = 1.47$$

give: $q_D = q_S = 3.27$

Since elasticities are close to each other the burden of the tax is about equally shared among suppliers and buyers.

What about welfare?

Example: Tax on gasoline



What about welfare?

Consumers

Rectangle = (1.53-1.5)x3.27=0.098

Triangle = (1/2)x(1.53-1.5)x(3.3-3.27)
= 0.00045

Total = 0.09845

Producers

Rectangle = (1.5-1.47)x3.27=0.098

Triangle = (1/2)x(1.5-1.47)x(3.3-3.27)
= 0.00045

Total = 0.09845

Government (gains from taxes)

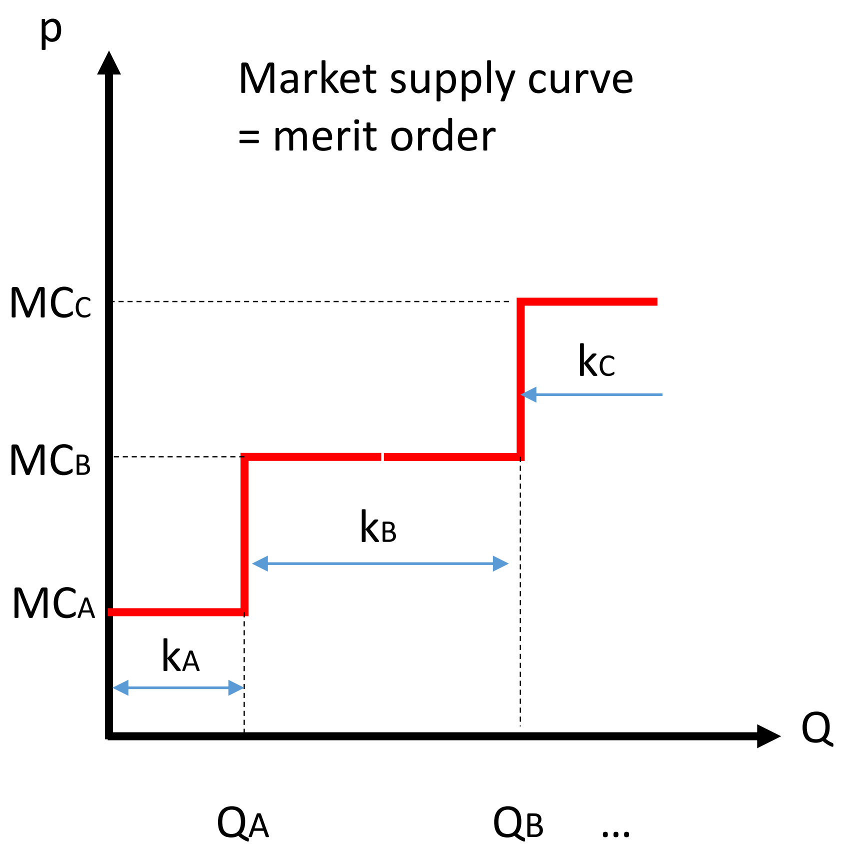
Rectangle = 0.06x3.27=0.1962

Overall welfare loss / gain:

0.1962-0.09845-0.09845= -0.0009

The welfare loss is 0.0009/0.1962 < 0.5% of government tax revenue. If balanced by the lower climate change burden of carbon emissions this is a good policy!

Side-note: Stepwise supply

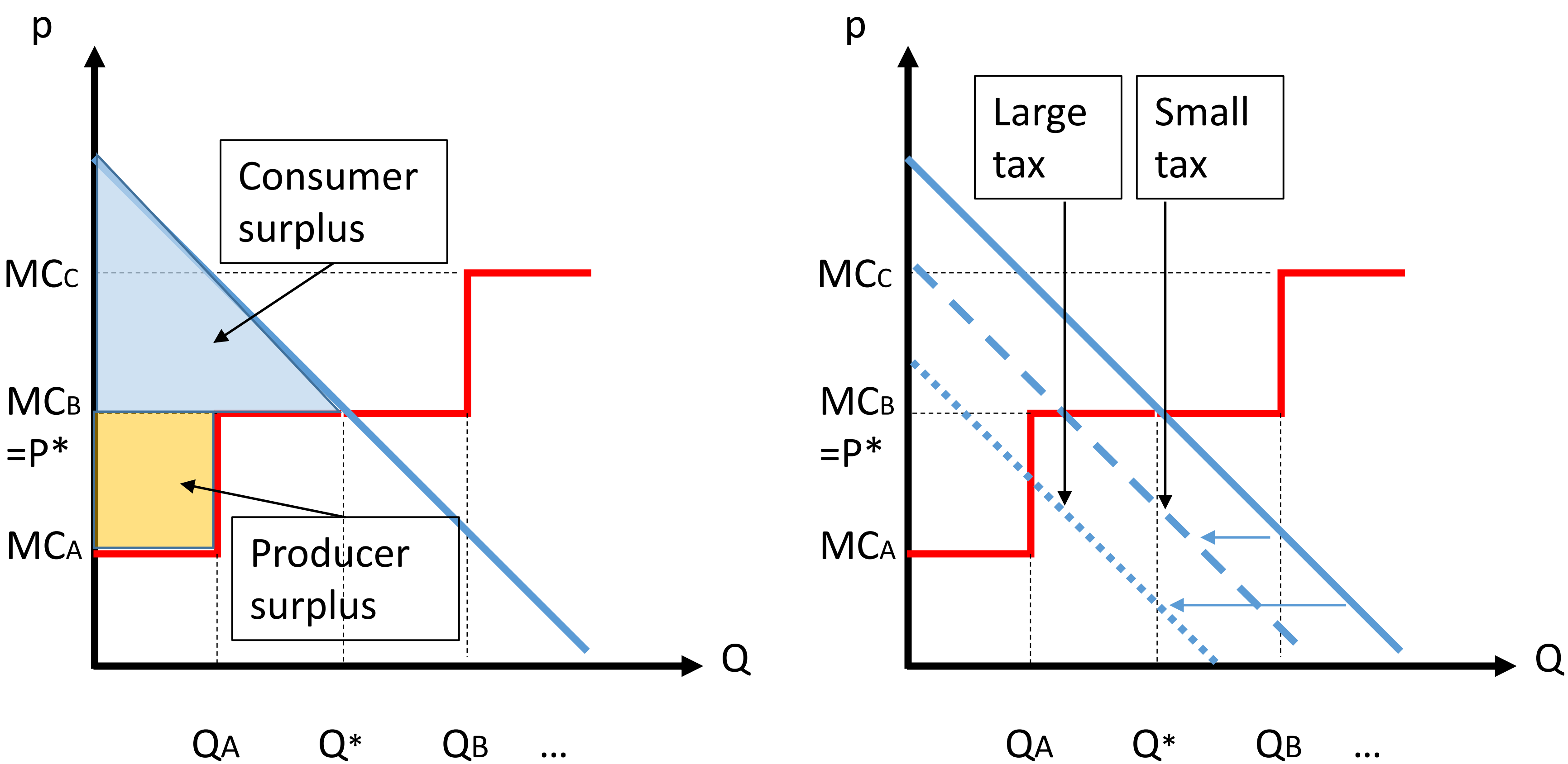


When there are a discrete set of technologies (e.g. different electricity production techs), each characterized by a MC and a capacity constraint (k here), the supply curve becomes a step function, corresponding to the sorted sequence of plant capacities.

Example electricity production:

Technology A produces and dispatches first as the cheapest technology until its capacity limit k_A is reached. Then tech B takes over and then tech C. It is assumed here that tech C is abundant (e.g. coal)

Side-note: Stepwise supply



The supply is stepwise, i.e., there are portions with infinite supply elasticity (horizontal) and portions with zero supply elasticity (vertical)

Depending on the equilibrium, a tax policy might affect only consumers (e.g. small tax here), or even drive producers out of the market (e.g. tech B with large tax)

Market power - Monopoly

- A market with “only one” seller but many buyers
- The monopolist *is* the market
- Monopolist can simultaneously set price and quantity supplied
- In general quantity supplied will be lower and its price higher than the competitive case
- A pure monopoly is rare (we will also talk about cartel pricing)

Monopoly

Monopolist has information about market demand: p=p(q)

Rule of thumb for monopoly pricing

Revenue $R = p(q)\ q$

$$MR = \frac{\Delta R}{\Delta q} = p + q\,\frac{\Delta p}{\Delta q}$$

Extra revenue from an additional increase in q has two components:

- Producing <u>one</u> extra unit at price p brings additional revenue 1 x p=p
- The firm faces a downward-sloping demand curve so an extra unit supplied reduces the price by $\frac{\Delta p}{\Delta q}$ which reduces revenue marginally by $q\,\frac{\Delta p}{\Delta q}$

$$MR = p + p\underbrace{\left(\frac{q}{p}\frac{\Delta p}{\Delta q}\right)}_{1/\epsilon_D} = MC \rightarrow \quad \boldsymbol{P} = \frac{\boldsymbol{MC}}{\mathbf{1} + \left(\frac{\mathbf{1}}{\boldsymbol{\epsilon_D}}\right)}$$

Monopoly

Pricing rule of thumb for monopolist

$$P = \frac{MC}{1 + \left(\frac{1}{\epsilon_D}\right)}$$

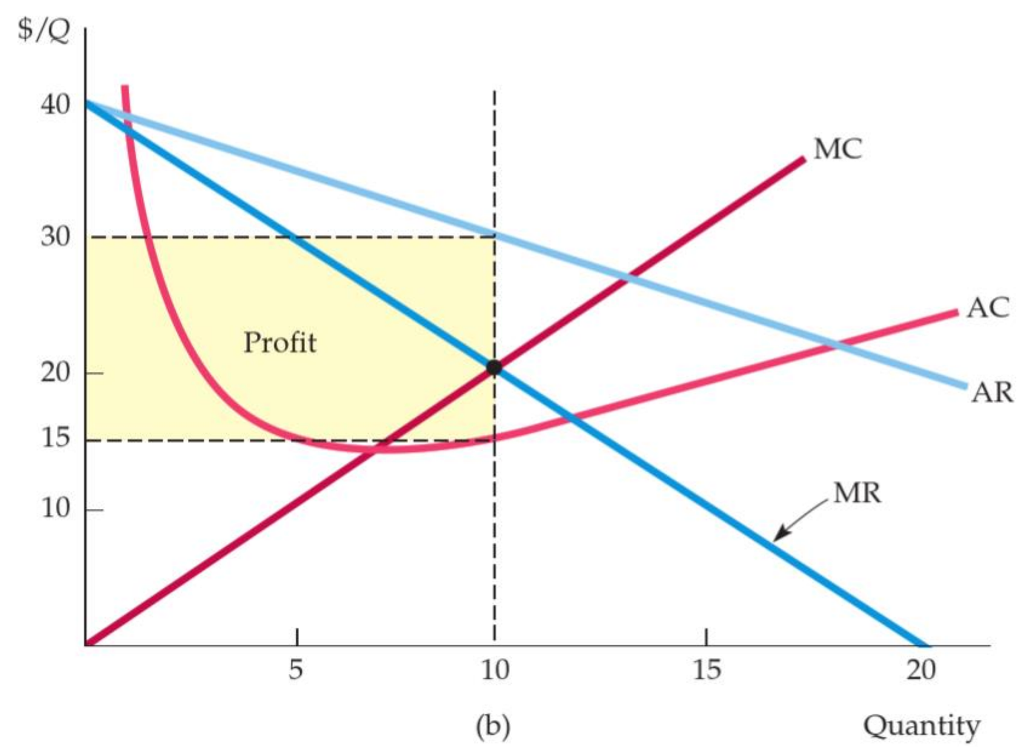
- A monopolist charges a price higher than the marginal cost (remember in competition P=MC) but by an amount that depends inversely on the elasticity of demand

- The more elastic consumers are (i.e., the easier they switch their consuming behaviour), the less room has the monopolist to raise price above competition

→ **Knowing price elasticity of demand is crucial for the monopolist**

Market power - Monopoly

- Monopolist's <u>average revenue (AR)</u> = the price it receives per unit sold is precisely the <u>demand curve</u> it faces: R= p x q → AR=p
- $MR = p\left(1 + \frac{1}{\epsilon_D}\right) = AR\left(1 + \frac{1}{\epsilon_D}\right) \rightarrow$ MR below AR
- So: the monopolist sets quantity q such that MR=MC (profit is maximized) and p=AR for this q



Oligopoly

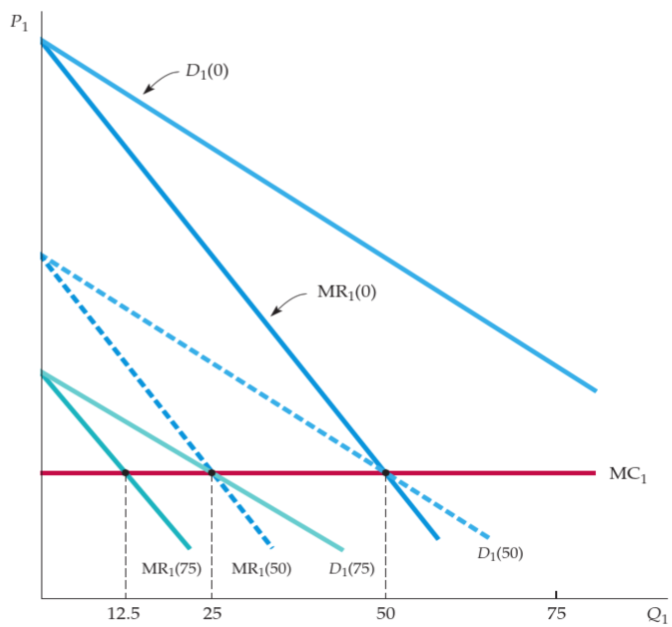
- Only a few firms account for most or all of total production
- Product is at large not differentiated (e.g. oil, gas, electricity)
- Substantial barriers to enter the market. Examples:
  - high upfront costs
  - Scale economies for the market leaders (cheaper production)
  - Strategic response from the market leaders (e.g. oversupply)
- In oligopoly firms take into account their competitors when pricing
  - At the same time competitors' decisions depend on the firm's decisions
- Remember: in equilibrium, firms are doing the best they can
  - In competition a firm is selling all that it produces and maximizes profits by MR=MC=p
  - In monopoly profit maximization (MR=MC) still applies but AR=p

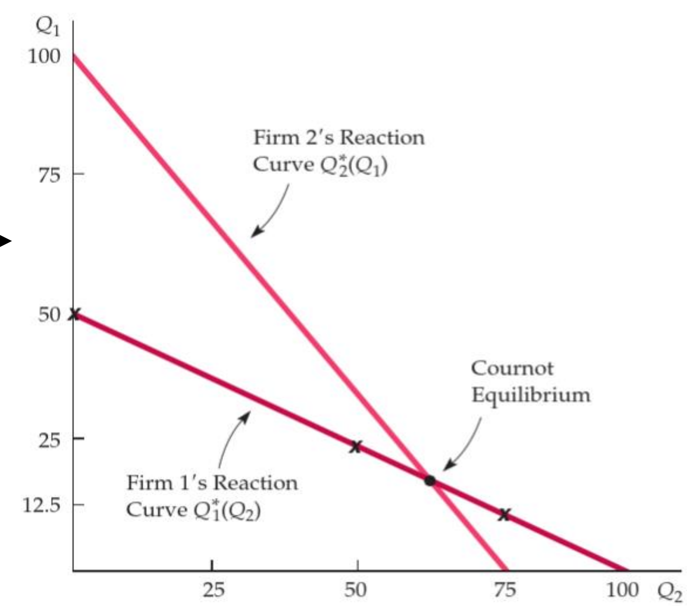
Oligopoly

Cournot equilibrium: Each firm treats the output level of its competitor as fixed when deciding how much to produce. Decision on production is made simultaneously

Example below (left). Assume MC is constant

- If firm 1 thinks that firms 2 will produce nothing it faces D1(0) and MR1(0). If firm 1 thinks firm 2 will produce 50 units it faces D1(50) and MR1(50). This leads to a curve $Q_1^*(Q_2)$, i.e., a *reaction curve* of firm 1's output given output of firm 2 (red).
- Firm 2 makes the same assessment
- Cournot equilibrium is at the intersection of the reaction curves





Oligopoly

Cournot Example

Assume market's demand curve: $P = 30 - Q$, where $Q = Q_1 + Q_2$
Also suppose firms have zero marg. cost, i.e., $MC_1 = MC_2 = 0$

Firm 1: Revenue $R_1 = P \times Q_1 = (30 - Q)\, Q_1 = (30 - Q_1 - Q_2)Q_1$

Marg. Rev. $MR_1 = \frac{\Delta R_1}{\Delta Q_1} = 30 - 2Q_1 - Q_2$

MR = MC $MR_1 = 0 \rightarrow$ $Q_1 = 15 - \frac{1}{2}Q_2$

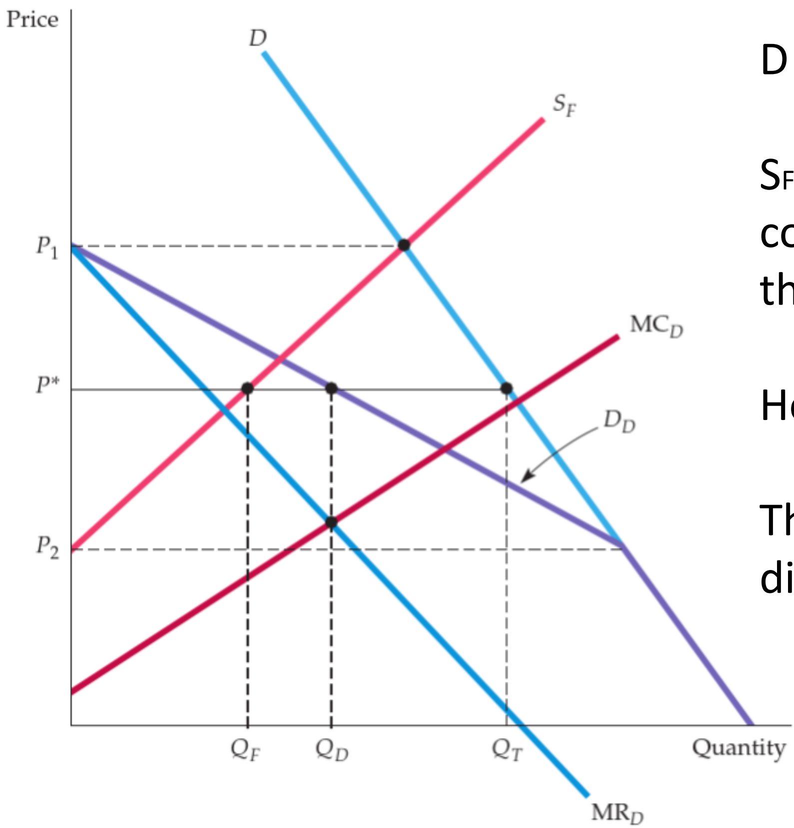
Firm 2: … $Q_2 = 15 - \frac{1}{2}Q_1$

Cournot equilibrium: $Q_1 = Q_2 = 10$ and market $Q = 20$

What if the two firms colluded in a way that maximizes their total profit?
Total revenue is $R = P \times Q = (30 - Q)\, Q$
Marginal revenue is $MR = 30 - 2\,Q$
Profit optim. MR=MC $Q = 15 \rightarrow$ both firms produce less (e.g. 7.5-7.5) and profits are higher. Thinking of cartel?

The Dominant Firm

Dominant firm: Firm with a large share of total sales sets price to maximize profits, taking into account the supply response of smaller firms



D is the market's demand curve

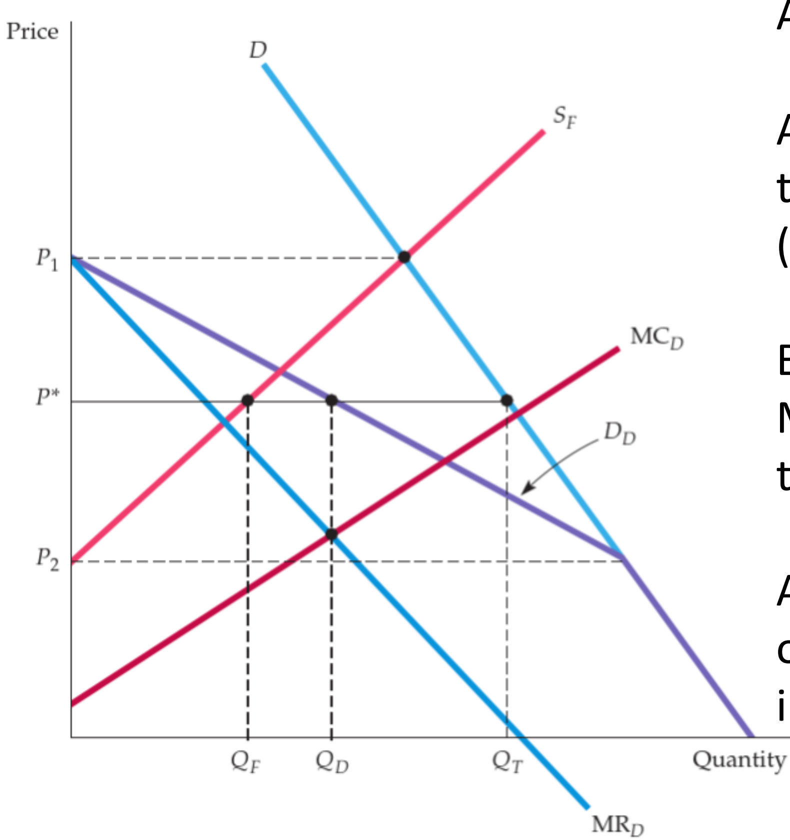
S_F the supply curve of the rest of the market (smaller competitive firms, i.e., the fringe *F*), i.e. the "sum" of their MC curves

How should the dominant firm (DF) set its price?

The DF must determine its demand curve D_D; it is the difference between D and S_F

The Dominant Firm

Dominant firm: Firm with a large share of total sales sets price to maximize profits, taking into account the supply response of smaller firms



At P1, the fringe can supply the whole market;

At P2 the fringe cannot supply anything so the DF faces the demand curve of the market but profit is too low (low price);

Between P1 and P2 the DF produces Q_D such that $MR_D=MC_D$, while the price is set at the intersection with the AR(=D_D) curve.

At price P* the DF produces Q_D while F covers the rest of the market demand at the point where their MC=P*, i.e. the intersection with their supply curve

Cartel

- Producers explicitly agree to cooperate in setting price and output

- Cartel may drive prices well above competitive prices if:
  1) enough producers adhere to the cartel's agreements
  2) demand is sufficiently inelastic

- Antitrust laws prohibit companies from colluding in certain markets, but local laws cannot prevent foreign state-owned companies from forming cartels

- Example: the OPEC oil cartel
  - O(rganisation) of P(etroleum) E(xporting) C(ountries)
  - Established in 1960s by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela
  - Current members: the above plus Algeria, Angola, Guinea, Gabon, Libya, Nigeria, Congo, United Arab Emirates
  - Since 2016 OPEC+ includes: Russia, Azerbaijan, Bahrain, Brunei, Kazakhstan, Malaysia, Mexico, Oman, South Sudan and Sudan

Cartel

Conditions for cartel success

Stable organization must agree on price and production levels and adhere to the agreement. Difficult because:

- Different members may have different production costs
- Different assessment on market's demand
- In general different objectives

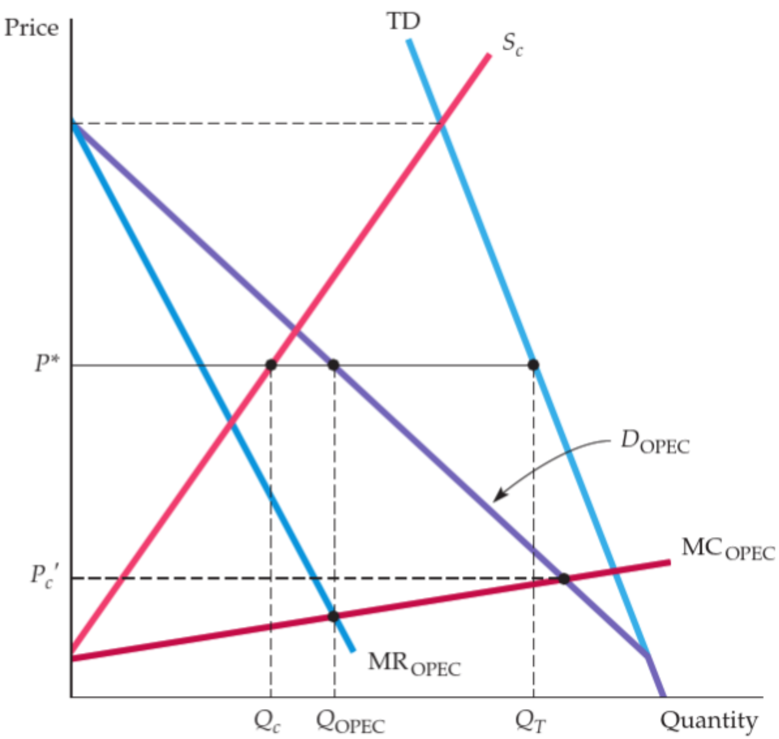
Potential monopoly power → consumers are not very price elastic

- If consumers respond a lot to price changes there is less room to raise prices

The last is most important. If there are gains to be made members will find a way to cooperate

Cartel

Analysing OPEC using the dominant firm paradigm



TD is total demand for oil; Sc the competitive supply curve (non-OPEC); D_{OPEC} the demand curve for OPEC oil (the difference between TD and Sc; MR_{OPEC} is the OPEC MR curve

OPEC has much lower production cost than the rest of the market as reflected by the slope of its MC curve MC_{OPEC}

According to the dominant firm's example the price set by OPEC is P*

If OPEC would follow competitive pricing (P=MC) the price would have been much lower Pc'<<P*

But because <u>both</u> demand and competitive supply are inelastic, OPEC has substantial monopoly power and room to raise prices

Externalities

Side-effects of economic activities / interactions that are not reflected in market prices

Examples:

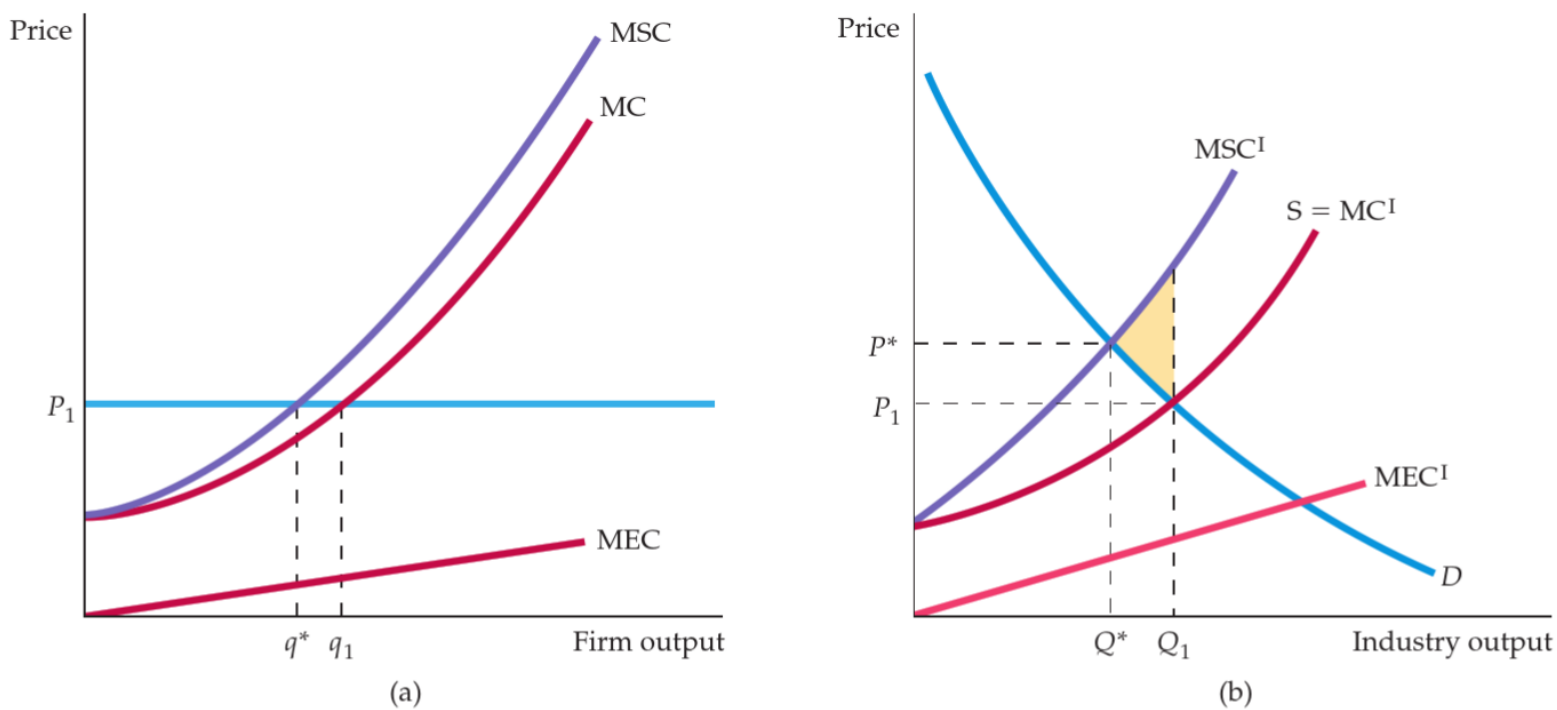
- **Positive Externalities**: knowledge spillovers from R&D; a nice garden that improves the looks of the whole neighborhood

- **Negative Externalities**: Pollution from burning fossil fuels; water contamination from manufacturing activities, etc.

These benefits / costs are external to the decision-maker and not valued in the market transactions → equilibrium is not socially optimal

→ Policy is important to restore social optimum

Externalities



Negative externalities (e.g. Production that pollutes)

(a) In competitive market (and in the short-run) a firm's demand curve is perfectly elastic. MC=P sets equil. price. When firm doesn't take emissions into account there is a marginal external cost (MEC) that increases with output (higher output = higher pollution); Marginal Social Cost (MSC) is MC+MEC. Externality leads to overproduction (q1>q*)

(b) If the whole market acts the same way we have overproduction (Q1>Q*) from the social optimum (Q*,P*) and deadweight loss = reduction in social welfare

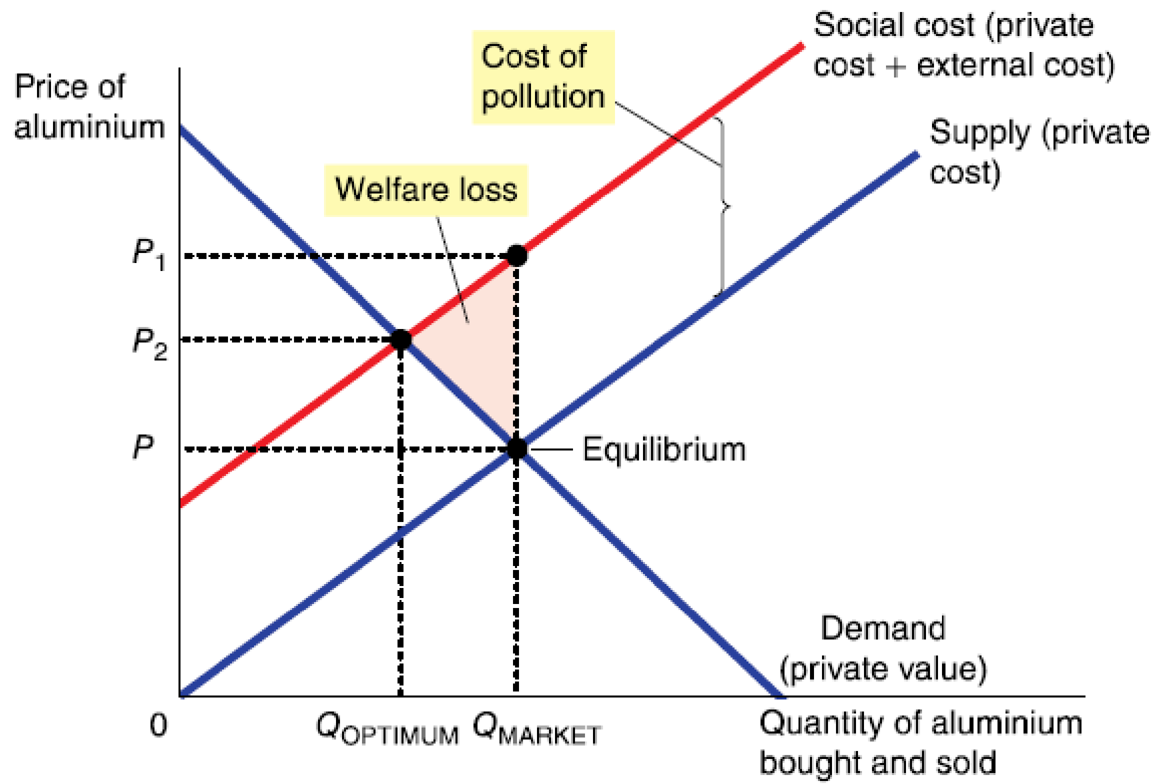
Externalities

Negative externalities

The market produces larger quantities of a good than what is socially desirable

Example burning fossil fuels for aluminium production

The socially optimal output level is less than the market equilibrium



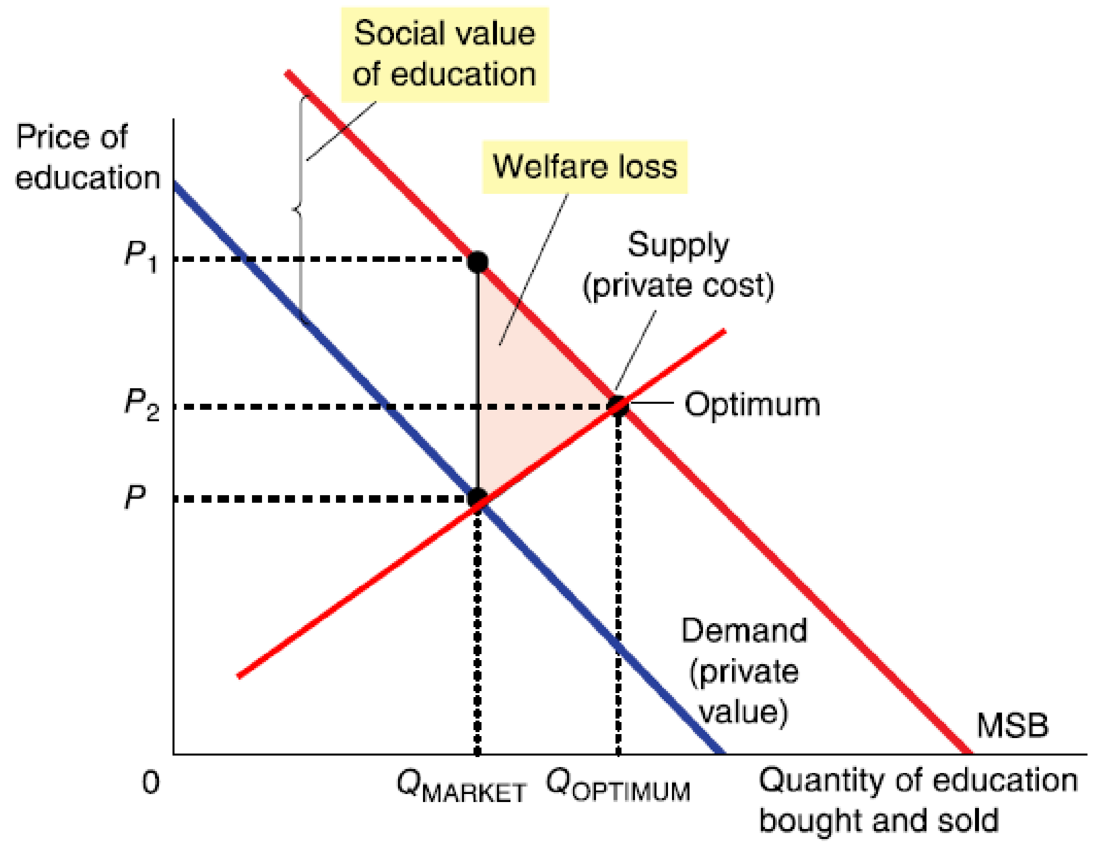
Externalities

Positive externalities

The market produces too few of the socially desirable good

Example *Learning-by- doing spillovers* (later adopters of a new technology learn from the early adopters), *Technological or R&D spillovers* (rival firms get free information about new products, technologies, etc.)

The socially optimal output level is more than the market equilibrium



Ways of correcting market failures

- Internalization of externalities aims at **changing incentives**

- Can occur through govn’t **regulation** or **private** solutions

- Government regulation
  - Taxation / subsidization
  - Standards (e.g. A+ electric devices)
  - Industrial policy (e.g. patents to protect intellectual property)

- Private solutions
  - Private bargaining – Coase theorem

- Hybrid solutions
  - Tradeable Emissions permits, e.g. EU-ETS

Time value of money

- "Money" in different dates does not have the same "value"
- In economics "value" has to do with purchasing power of goods/services
- Example: 100€ invested at a constant r% rate will yield:

$100 \times (1 + r)$€ next year,
$100 \times (1 + r) \times (1 + r)$€ the year after,
…
$100 \times \underbrace{(1 + r) \times (1 + r) \times \cdots \times (1 + r)}_{t}$€ $= 100 \times (1 + r)^t$€ after t years.

These correspond to the future value of 100€ next year, the year after etc.
In the same spirit, 100€ received t years from now is equivalent to
$100 \times \frac{1}{(1+r)^t}$ in **present value (PV)** terms

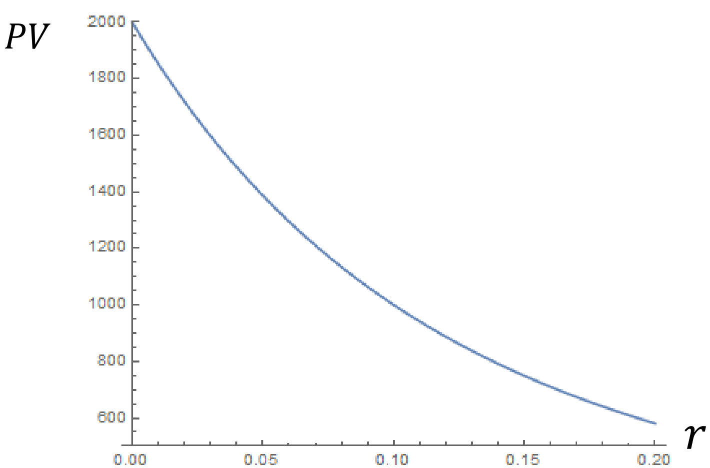
Time value of money

Example: the value of a **bond**.
A contract in which a borrower agrees to pay the bondholder a stream of money (coupon) plus the *principal* (also the *face value* of the bond).

Assume a corporate bond that makes coupon payments of 100€ for 10 years and the principal payment of 1000€ at the end of the 10 year period. What is the "fair" value of such a bond?

$$PV = \frac{100}{1+r} + \frac{100}{(1+r)^2} + \frac{100}{(1+r)^3} + \cdots + \frac{100}{(1+r)^{10}} + \frac{1000}{(1+r)^{10}}$$

Depends on the interest rate r:



Time value of money

Let’s say the investor is buying a 10y corporate bond on the *secondary market* (through a broker) for P=800€; its *face value / principal* is 1000€ and coupon payments of 100€ occur yearly. What is the *effective yield*?

Effective yield (yield-to-maturity): the interest rate at which you need to discount future payments to get observed bond’s prices:

$$P = 800 = \frac{100}{1+r} + \frac{100}{(1+r)^2} + \frac{100}{(1+r)^3} + \cdots + \frac{100}{(1+r)^{10}} + \frac{1000}{(1+r)^{10}}$$

- We can solve the above for *r* using “Goal Seek / Solver” on Excel: *r=13.8% - Junk Bond!* High yield-to-maturity implies high risk of firm defaulting on its debt.
- What if the price were P=1000€ (exactly its face value)? Same calculation implies *r=10%.* It makes sense since coupon is 10% of face value.
- What if the price were P=1200€? Then *r=4.9%.* This bond would imply a less risky company.

Excel – Goal Seek (what-if-analysis)

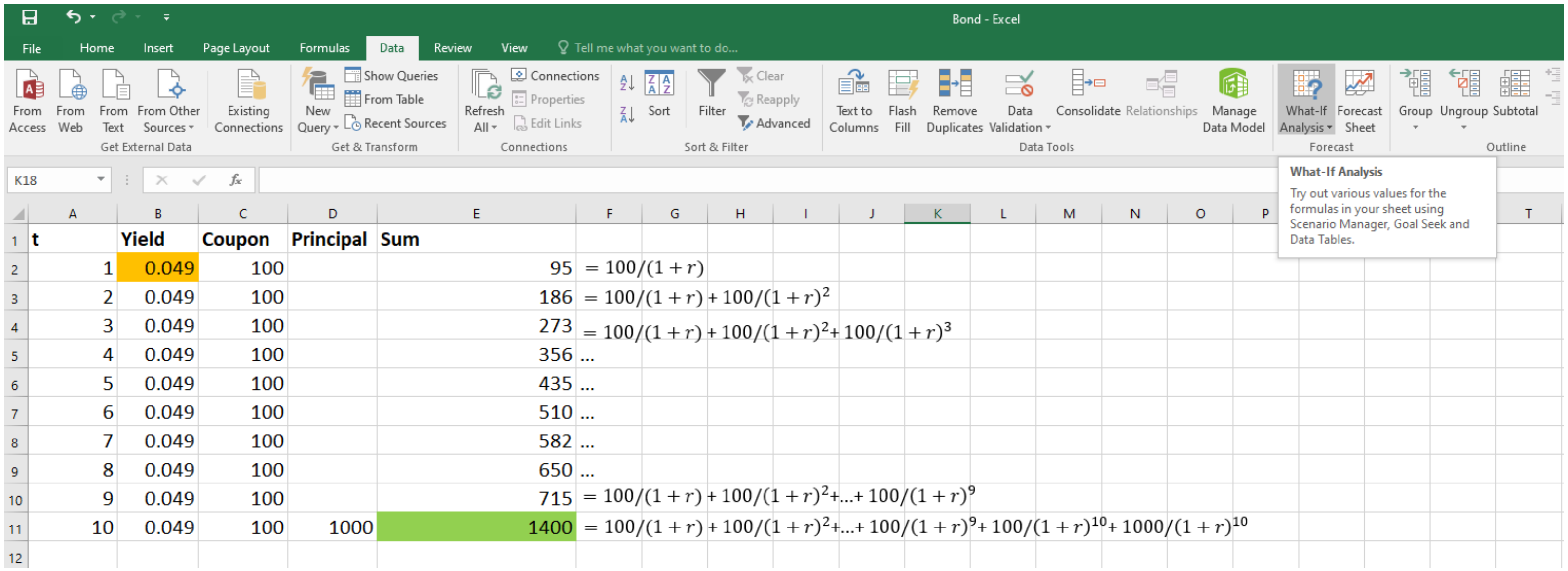
1) Automatize your spreadsheet as shown

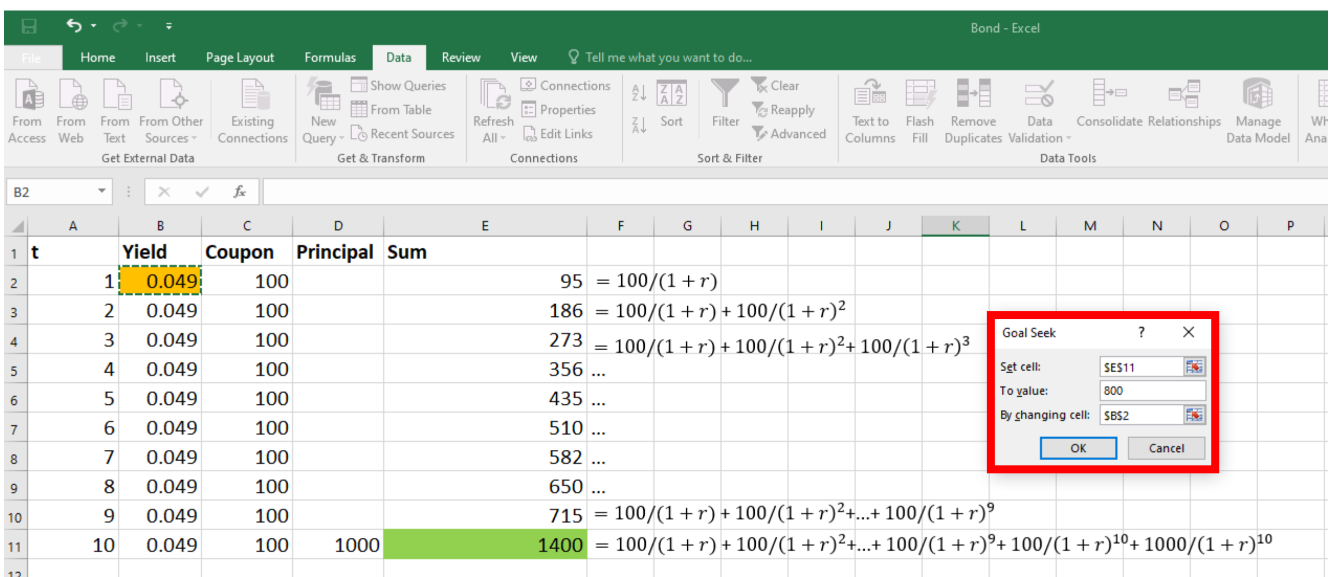
2) Data → What-if-analysis

t	Yield	Coupon	Principal	Sum	
1	0.049	100		95	$= 100/(1+r)$
2	0.049	100		186	$= 100/(1+r) + 100/(1+r)^2$
3	0.049	100		273	$= 100/(1+r) + 100/(1+r)^2 + 100/(1+r)^3$
4	0.049	100		356	...
5	0.049	100		435	...
6	0.049	100		510	...
7	0.049	100		582	...
8	0.049	100		650	...
9	0.049	100		715	$= 100/(1+r) + 100/(1+r)^2 + \ldots + 100/(1+r)^9$
10	0.049	100	1000	1400	$= 100/(1+r) + 100/(1+r)^2 + \ldots + 100/(1+r)^9 + 100/(1+r)^{10} + 1000/(1+r)^{10}$

t	Yield	Coupon	Principal	Sum	
1	0.0485	100		=C2/(1+B2)^A2	$= 100/(1+r)$
2	=B2	100		=E2+C3/(1+B3)^A3	$= 100/(1+r) + 100/(1+r)^2$
3	=B3	100		=E3+C4/(1+B4)^A4	$= 100/(1+r) + 100/(1+r)^2 + 100/(1+r)^3$
4	=B4	100		=E4+C5/(1+B5)^A5	...
5	=B5	100		=E5+C6/(1+B6)^A6	...
6	=B6	100		=E6+C7/(1+B7)^A7	...
7	=B7	100		=E7+C8/(1+B8)^A8	...
8	=B8	100		=E8+C9/(1+B9)^A9	...
9	=B9	100		=E9+C10/(1+B10)^A10	$= 100/(1+r) + 100/(1+r)^2 + \ldots + 100/(1+r)^9$
10	=B10	100	1000	=E10+C11/(1+B11)^A11+D11/(1+B11)^A11	$= 100/(1+r) + 100/(1+r)^2 + \ldots + 100/(1+r)^9 + 100/(1+r)^{10} + 1000/(1+r)^{10}$

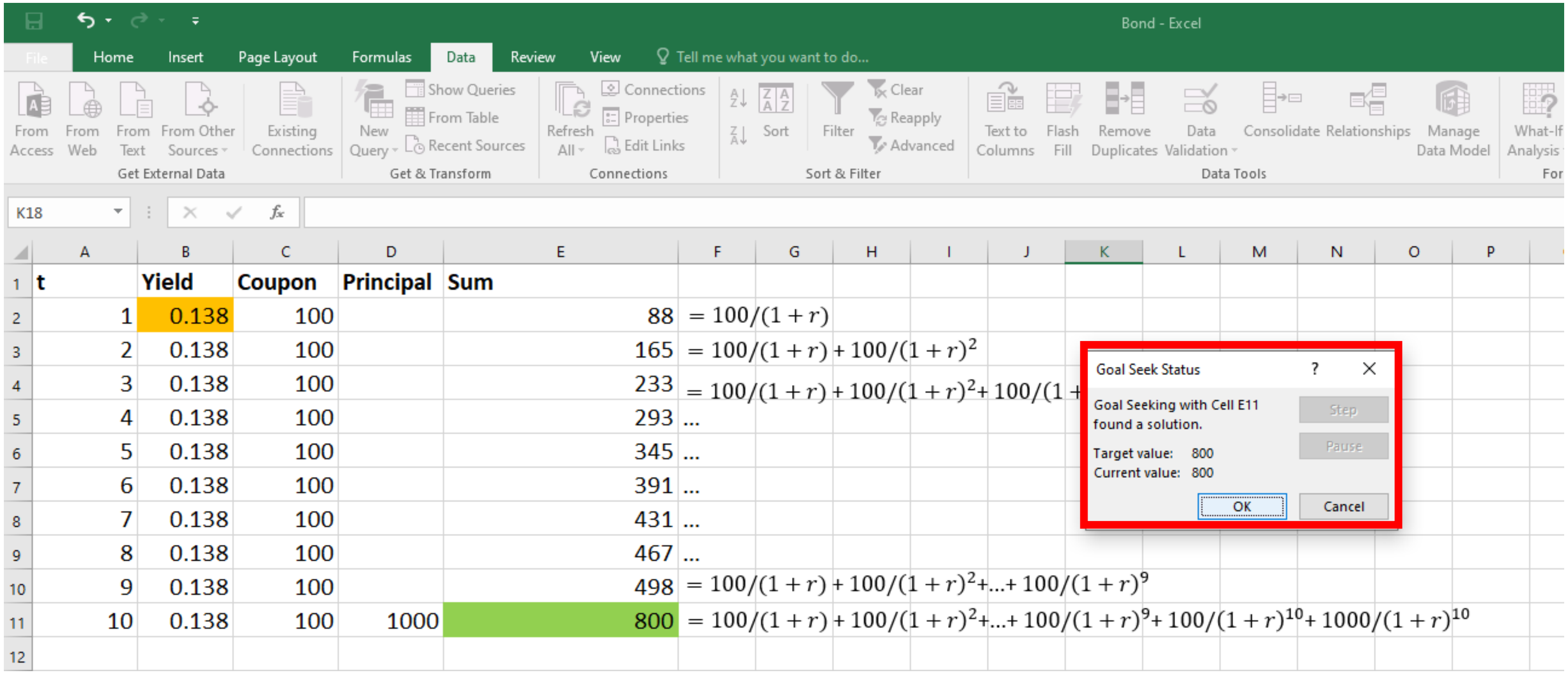
Excel – Goal Seek (what-if-analysis)





3) Set your goal, e.g., here we want to calculate r for P=800

Excel – Goal Seek (what-if-analysis)



Although very useful, it comes with its limitations:

- Excel cannot handle a huge amount of data
- Solver is limited to a single control optimization (one variable)
- Solver might find a “local minimum” and not the truly optimal solution
- Very slow for a big amount of data

Cost-Benefit analysis (Net Present Value - NPV)

Suppose a **PV plant** costs C and is expected to generate yearly revenue R, while its yearly maintenance costs M; at the end of its lifecycle (20 years) decommissioning is expected to cost D. Is this investment good or bad?

Yearly profit is $\pi = R - M$. Cost of decommissioning D comes at the last time period:

$$NPV = -C + \frac{\pi}{1+r} + \frac{\pi}{(1+r)^2} + \frac{\pi}{(1+r)^3} + \cdots + \frac{\pi}{(1+r)^{20}} + \frac{(-D)}{(1+r)^{20}}$$

Criterion for investment:

- NPV > 0 → Go for it!
- NPV <= 0 → Makes no sense

Cost-Benefit analysis (Internal Rate of Return - IRR)

You can reverse this calculation to calculate the internal rate of return (IRR) r such that your investment *breaks even* (NPV=0) in e.g. 10 years, while decommissioning still happens after 20 years:

$$0 = -C + \frac{\pi}{1+r} + \frac{\pi}{(1+r)^2} + \frac{\pi}{(1+r)^3} + \cdots + \frac{\pi}{(1+r)^{10}} + \cdots + \frac{(-D)}{(1+r)^{20}}$$

- We calculate r again using Excel's Solver
- An investment makes then sense if the IRR of this investment cannot be matched by an alternative investment
- For example if the r calculated is 3%, it's probably better to go for an investment in real estate which can have the same yield but it's safer
- Market Risk (and market's risk appetite) determines interest rates

How are interest rates determined?

Supply – Demand again! This time supply and demand for loans

Supply of loans:

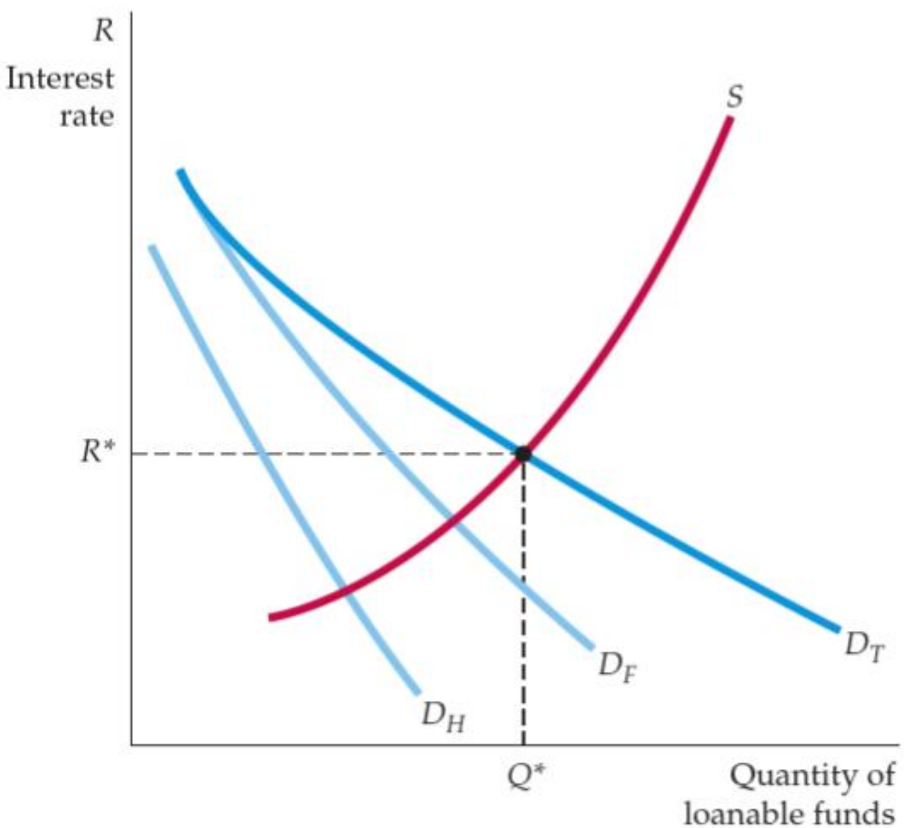
households who wish to save part of their income in order to consume at a later date (e.g. saving for retirement); the higher the interest rate, the more households want to save

Demand for loans:

i) Households who want to consume now (e.g. buy a car) and government who needs to maintain infrastructure but don't have the available capital
ii) Firms who want to expand their business and make capital investments

Total demand is i) + ii)

How are interest rates determined?



Market conditions determine supply and demand. Suppose an economy falls into a recession. What happens:

Firms expect lower sales and lower future profits. The NPV of projects falls and so does the willingness to invest: D_T shifts to the left. On the other hand the government collects less taxes so it needs to borrow more: D_T shifts to the right.

Central banks can create money shifting the supply curve to the right and lowering interest rates. Now people can borrow more easily to make their investments.

D_H: Demand from households (+govn't)
D_F: Demand from firms (adjust for risk)
D_T: Total demand for loans
S: Supply from households (central banks)

Adjustment for risk

- The riskier an investment, the higher should it's *expected return* be in order to attract investors (higher than what?)

- The Capital Asset Pricing Model (CAPM) measures this *risk premium* (excess return over a "risk-free" rate) by comparing the investment's expected return with the expected return of the (stock?) market

- The CAPM summarizes this relationship by the following:

$$r_i = r_f + \beta_i(r_m - r_f)$$

r_i is the expected return on the investment i
r_m is the expected return on the market as a whole (e.g. S&P 500)
r_f is the risk-free rate (e.g. 1y government bond)
β_i the asset's beta: how well its return co-moves with the market's

→ high co-movement = higher risk
→ low co-movement = lower risk
→ negative co-movement = insurance

Adjustment for risk

- If the asset's return correlates well with the market (positive and high β) it means that this asset pays well when things are good but pays poorly when things go wrong and people feel poor. As a human investor however you would need an asset that pays well when things don't look bright, and not the opposite
- To hold a risky asset, it should "promise" a high expected return
- E.g. if $\beta=1.5$, $rf=1\%$ and $rm=7\%$, this asset should yield at least $ri=10\%$
- Prices and returns move in the opposite direction: high expected return means high risk and therefore a low price (see sl. 59)
- An asset with a negative β is actually an insurance: it pays well only when things go wrong; ri is negative. This is the reason why insurances are expensive (prices and rates move in the opposite direction)

Next Lecture

- Empirical estimation of elasticities
- Measurement of energy efficiency
- Simulation of a global commodity market
- Computable General Equilibrium models