Market Failure
Public Goods & Externalities

Climate change as a market failure

- Environmental economics is for a large part about *market failures*: goods (or bads!) for which one or more of these assumptions does not hold
- 2007 Stern Review on the Economics of Climate Change (political report by Sir Nicholas Stern (and co-authors) to British government):

  "**Climate change is the biggest market failure the world has ever seen**."

  - GHG emissions are due to an ***externality***
  - Low level of international co-operation is due to emission reductions being a (global) ***public good***

Public goods I

Characteristics of goods:

- **Excludability** in consumption or production: A good is excludable if it is feasible and practical to selectively allow consumers to consume the good, a bad is excludable if it is feasible to allow consumers to avoid the consumption of the bad.

  In short: agents can be prevented from using the good/service

- **Rivalry**: A bad (good) is rival if one person's consumption of a unit of the bad (good) diminishes the amount of the bad (good) available for others to consume, i.e. there is a negative (positive) social opportunity cost to others associated with consumption.

  In short: one agent's use is at the expense of another's

Public goods I

Characteristics of private and public goods:

	Excludable	Non-excludable
Rival	**Pure private good**	**Open-access resource**
	Ice cream	*Ocean fishery*
Non-rival	**Congestible resource**	**Pure public good**
	Wilderness area	

- Rivalry: one agent's use is at the expense of another's
- Excludability: agents can be prevented from using the good/service

Problems with the provision of public goods

- Non-Excludability: Excludability is needed to 'price-tag' a good

  We have to be able to deny the consumption if price is not paid

- Non-Rivalry: An additional consumer can enjoy the good at no extra cost of provision.

  Efficient equilibrium will no longer be where individual marginal rate of substitution=price ratio=marginal rate of transformation or marginal willingness to pay=price=marginal costs

We get back to this in a moment…

Excursion: Aggregate supply, demand, and efficiency

- Supply and demand curves can be obtained from utility and profit maximization.
- Demand corresponds to *marginal willingness-to-pay*. Aggregate demand given by ***horizontal*** aggregation of individual demand curves.
- Supply corresponds to *marginal cost curve*. Aggregate supply given by ***horizontal*** aggregation of individual supply curves.
- (Net) Consumer surplus: area between demand curve and horizontal line through the market price. Measure for (money metric) utility of consumers.
- (Net) Producers surplus: area between supply curve and horizontal line through the price. Measure for profit (revenue minus costs)
- In a competitive market equilibrium, the sum of consumers and producers surplus is maximized.

Equilibrium given where marginal costs equal marginal benefits

Demand for private good

- Assume a consumer i with willingness to pay $V_i(x_i)$ for consuming quantity x_i
- Consumer faces price p of the good
- Utility maximization: max $V_i(x_i)-p\,x_i$

  leads to $p= V_i'(x_i)$

Demand for private good

- Assume consumer *i* with willingness to pay $V_i(x_i)$ for consuming quantity x_i
- Consumer faces price *p* at which one can buy the good
- Utility maximization: $\max V_i(x_i)-p\,x_i$ *("benefits – costs")*

  leads to $p= V_i'(x_i)$

- *Remark*: Formally the setting corresponds to a money metric quasi-linear utility function $U_i(x_i,M_i)= V_i(x_i)+M_i$ which is linear in money and e.g. concave in x_i

  Then the marginal willingness to pay MWTP is the negative of the MRS between money and good x

$$MWTP = -MRS = -\frac{\Delta\$}{\Delta X} = \frac{MU_X}{MU_\$} = \frac{\frac{\partial U_i}{\partial X_i}}{\frac{\partial U_i}{\partial M_i}} = V_i'(X_i)$$

  We know that in efficient equilibrium $-MRS = \frac{p_X}{p_\$} = p_X \equiv p$

  yielding also $p = V_i'(x_i)$

Demand for private good

- Assume consumer i with willingness to pay $V_i(x_i)$ for consuming quantity x_i
- Consumer faces price p at which one can buy the good
- Utility maximization: $\max V_i(x_i) - p\, x_i$

  leads to $p = V_i'(x_i) = MWTP$

- **Demand** corresponds to *marginal willingness to pay curve*.
- If $V_i(x_i)$ is concave then by definition $V_i'(x_i)$ is falling . Example: $V_1(x_1) = x_1(100-x_1)$
- Gross consumer surplus is the area under the demand curve. Net **consumer surplus** is area between demand curve and horizontal line through the market price.
- Aggregate demand given by **horizontal** aggregation of individual demand curves.

  Example: $V_1(x_1) = x_1(100-x_1)$ $V_2(x_2) = x_2(100-0.5x_2)$

Supply of private goods

- We can break down profit maximization into
  1. Minimizing costs for a given output by optimizing inputs -> cost curve $C(x)$
  2. Maximizing profits by choosing optimal output level
- Assume producer j with cost $C_j(x_j)$ for supplying quantity x_j
- Producer faces price p at which he can sell the good
- Profit maximization:

$$\max p\, x_j - C_j(x_j)$$

  leads to

$$p = C_j'(x_j)$$

- Supply corresponds to *marginal cost curve*. Increasing if $C_j(x_j)$ convex.
- Aggregate supply given by ***horizontal*** aggregation of individual supply curves.

- Example: $C_1(x_1) = 8 + x_1^2$, $C_2(x_2) = 0.5\, x_2^2$

Supply of public goods

- Assuming that the public good G_j is priced, everything as before.

- Profit maximization:

$$\max p\, G_j - C_j(G_j)$$

  leads to

$$p = C_j'(G_j)$$

- Supply corresponds to *marginal cost curve*.

- Aggregate supply given by ***horizontal*** aggregation of individual supply curves.

Demand for public good

- Assume consumer *i* with willingness to pay $V_i(G)$ for consuming quantity *G*
- Note that *G no longer carries an index*. Every consumer consumes all of the G as the good is non-rival
- Consumer faces price p at which one can buy the good
- Utility maximization:

$$\max V_i(G) - p\,G$$

leads to

$$p = V_i'(G)$$

- Individual demand corresponds again to *marginal willingness to pay curve*.
- Social demand given by ***vertical*** aggregation of individual demand curves, because all consumers are willing to pay for the same public unit of *G*.

- Example: $V_1(G) = G(100-0.5G)$ $V_2(G) = 2G(100-0.5G)$

Optimal provision of public good

- Aggregate marginal willingness-to-pay should equal marginal costs of providing the public good:

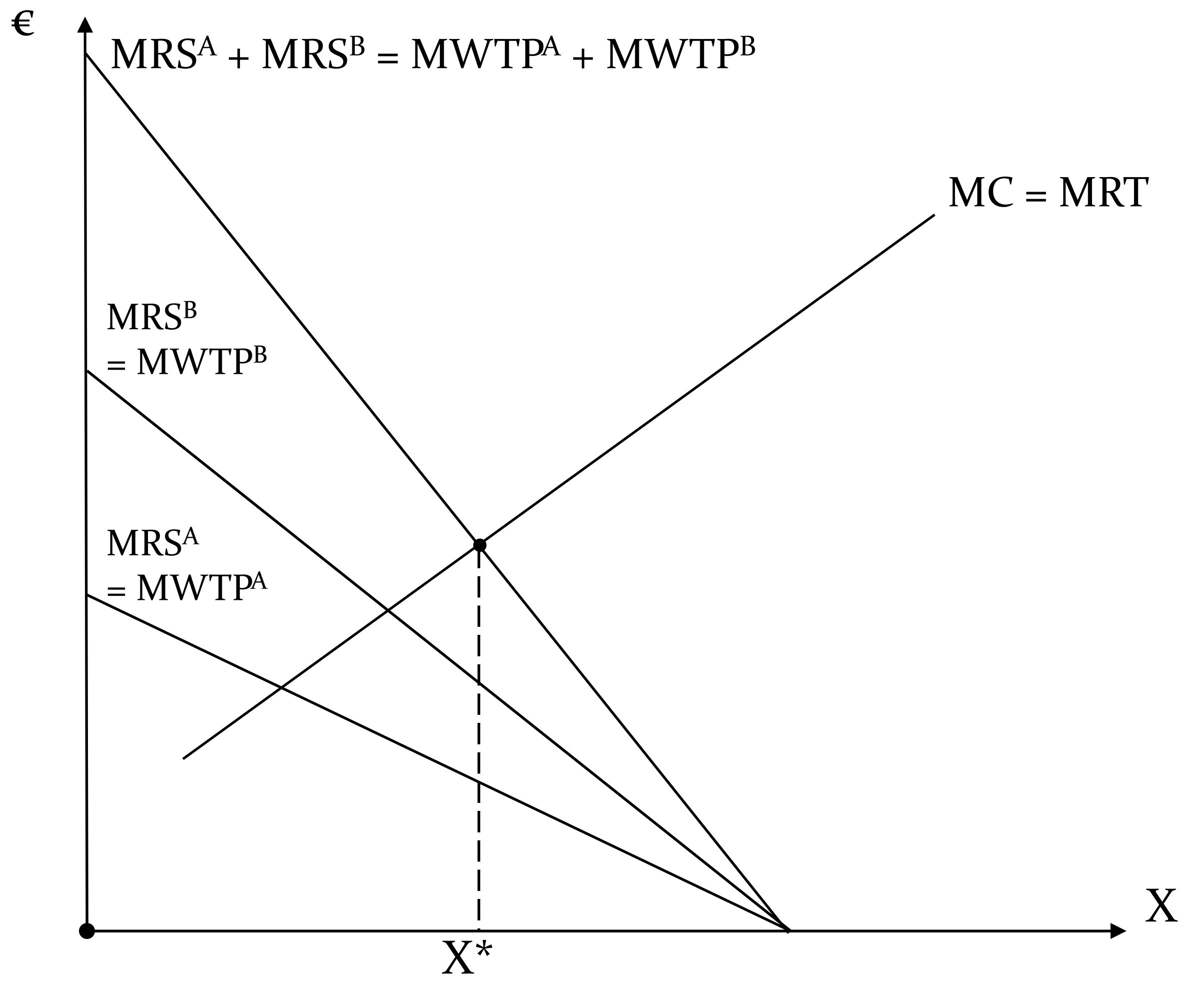
$$\sum_i V_i'(G) = C_j'(G_j)$$

for all producers *j*. The produced quantities G_j sum to the total amount of public good provided *G*: $\sum_j G_j = G$

- Or more general for the marginal rate of substitution between private and public goods is has to hold
- $$\sum_i MRS_i = MRT \quad with \quad MRS = -\frac{\Delta private\_good}{\Delta public\_good}$$
- This relation is known as the

Samuelson-condition

Optimal provision of public goods



Public goods II

- With private good, each individual consumes *different* amount, but pays *same* price: equal marginal valuation by each individual.
- With public good, each individual has to consume *same* amount, but marginal valuation can *differ*: only the sum of the marginal valuations has to equal the marginal cost.
- Public goods are nonexcludable, so no link between payment and provision: public goods cannot be provided by the market.
- Government can provide public good and finance it via taxes. For efficient amount of public good it needs to know marginal willingness to pay for all individuals. However…
- Nonexcludability gives consumers incentive to *free-ride* and to understate their willingness to pay!

Lindahl markets

- Assume that an individual market can be introduced for each consumer of a public good G
- Then there are N consumers, each consuming good G_i, i=1,…N at price $p^G{}_i$, i=1,…N
- Denote the aggregate supply of the public good by G and its price by p^G

A Lindahl equilibrium as an allocation of goods (including G, G_i, i=1,…N) and a set of prices (including $p^G{}_i$, i=1,…N *and a price*) such that

  - all firms maximize their profits,
  - all individuals maximize their utility (given the budget constraint),
  - all markets clear and for the public good it holds $G=G_i$ for all i=1,…,N
  - for the price of the public good holds: $p^G = \sum_i p^G{}_i$.

Then (under some conditions) a Lindahl equilibrium is Pareto efficient

- Pretty much says the same thing as our picture and the Samuelson rule.
- Because of non-excludability and the difficulties of price discrimination Lindahl markets generally stay a theoretic construct

Note: Excludability can be necessary for an efficient market outcome, even though in the efficient market outcome, in general, nobody will be excluded from consuming a non-rival good!

Externalities I

Definition

An **externality** exists when the consumption or production choices of one person or firm negatively or positively affect the utility or production of another entity without that entity's permission or compensation.

Examples

- Driving a car produces noise and pollution which might affect other people.
- The emission of carbon dioxide by a firm adds to the atmospheric stock of greenhouse gases and thereby contributes to global warming/climate change.
- Discharging pollution into a river or lake can have negative impact on swimming, fishing etc.
- Research in new drugs or new technologies can produce positive externalities on other potential users of these new methods.

Externalities II

Externality classification (here negative externalities)

Arising in	Affecting	Utility/production function
Consumption	Consumption	$U^A(\underset{+}{X^A}, \underset{+}{Y^A}, \underset{-}{X^B})$
Consumption	Production	$X(\underset{+}{K}, \underset{+}{L}, \underset{-}{Y^A})$
Production	Consumption	$U^A(\underset{+}{X^A}, \underset{+}{Y^A}, \underset{-}{X})$
Production	Production	$Y(\underset{+}{K}, \underset{+}{L}, \underset{-}{X})$

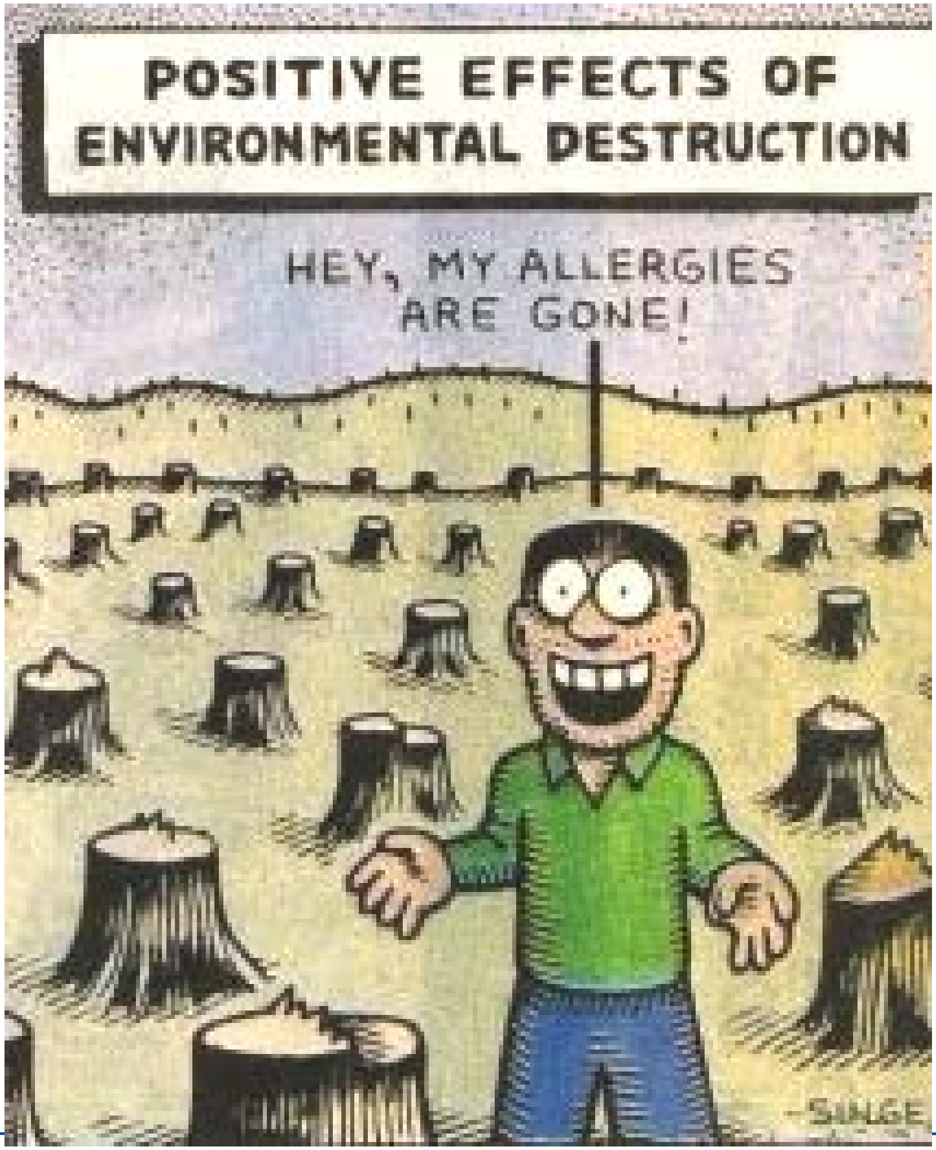
Externalities III

Beneficial (positive) and harmful (negative) externalities

Effect on others	Originating in consumption	Originating in production
Beneficial	Vaccination against infectious decease	Pollination of blossom due to proximity to apiary
Adverse	Noise pollution from radio playing in park	Chemical factory discharge of contaminated water into water systems

- GHG emissions can be in all 4 quadrants!!

Example of an externality: Production on consumption



Example of an externality: Production on production

- Two producers of goods X and Y, with costs

  $$C_X(X) = \frac{X^2}{100} \quad , \qquad C_Y(Y, X) = \frac{Y^2}{100} - X$$

  E.g. two stylized Californian ‘farms’: a windmill farm and a winery
- What type of externality do we face here?
- Let prices be p_X=2 and p_Y=3
- Unregulated market outcome is

  X= Π_x=

  Y= Π_Y=
- Is that a Pareto optimum, i.e. efficient?

Example of an externality: Production, Inefficiency

- Two producers of goods *X* and *Y*, with costs

$$C_X(X) = \frac{X^2}{100} \quad , \qquad C_Y(Y, X) = \frac{Y^2}{100} - X$$

Let prices be $p_X=2$ and $p_Y=3$.

- Try increasing the number of windmills by ΔX=10
- X=110 $\Pi_x=$

  Y=150 $\Pi_Y=$
- Is that a Pareto improvement as opposed to the situation X=100 and Y=150?

Example of an externality: Production, Inefficiency

- Two producers of goods X and Y, with costs

  $$C_X(X) = \frac{X^2}{100} \quad , \qquad C_Y(Y,X) = \frac{Y^2}{100} - X$$

  Let prices be p_X=2 and p_Y=3.

- *Only if we compensate producer X, the windmill farmer!*
- E.g producer Y, the winegrower, can pay him 5 monetary units (or some amount of wine) for the additional *10* windmills
- Might such bargaining actually take place?
- Will it lead to Pareto optimality?
- What are the obstacles?

Example of an Externality: !Homework!

- Two producers of goods *X* and *Y*, with costs

  $$C_X(X) = \frac{X^2}{100} \quad , \qquad C_Y(Y, X) = \frac{Y^2}{100} - X$$

  Let prices be $p_X=2$ and $p_Y=3$.

- *How do we find the Pareto optimal allocation of X and Y?*
- One way is to combine both farms:

  max $\Pi = \Pi_x + \Pi_y = p_X X + p_Y Y - C_X(X) - C_Y(Y)$ jointly over X and Y

- Calculate at home and let me know the outcome next time!!
- X=
  Y=
  Π=

Externalities and Public Goods

- An externality involves a good or bad whose level enters the utility or production function of several people / firms.
- That implies effectively a degree of non-rivalry and non-excludability.
- Therefore negative (positive) externalities can generally also be framed as public bads (goods) and vice versa

Climate Change and GHG's

So what does the theory on public goods and externalities tell us about GHG emissions?

- GHGs are a public bad, mitigation is a public good. Thus
  - A *competitive market equilibrium* alone will not yield a Pareto optimal (efficient) allocation
    -> In principle we can make some individuals better of without making anyone worse of
  - *Non-excludability* of the benefits from mitigation makes individuals want to free ride
  - Because of non-rivalry the *marginal cost of mitigation* (cost of last unit emitted) should *equal* the *sum of the marginal benefits from mitigation* (including the benefits of avoiding climate change impacts in all countries, industries and for all individuals)

Climate Change and GHG's

Another way to think about GHG emissions:

- GHG emissions cause negative externalities in production as well as directly on welfare
- These externalities affect everyone around the globe and in particular also individuals not yet alive

HOW CAN WE CORRECT FOR EXTERNALITIES AND PROVIDE PUBLIC GOODS AT AN OPTIMAL LEVEL?

WHAT DIFFICULTIES DO WE FACE DEPENDING ON THE CHOICE OF OUR INSTRUMENT (policy measure)?