ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

IED
Institut für Umweltentscheidungen
Institute for Environmental Decision

The Economics of Climate Change

Lecture 7: Policy Instruments

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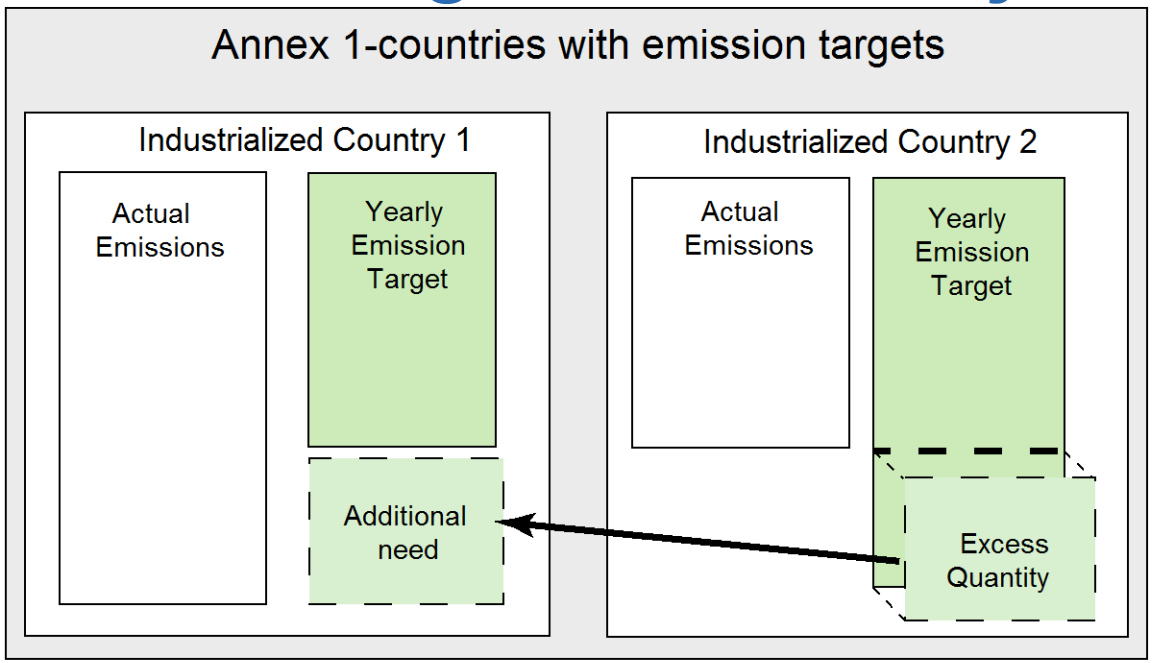
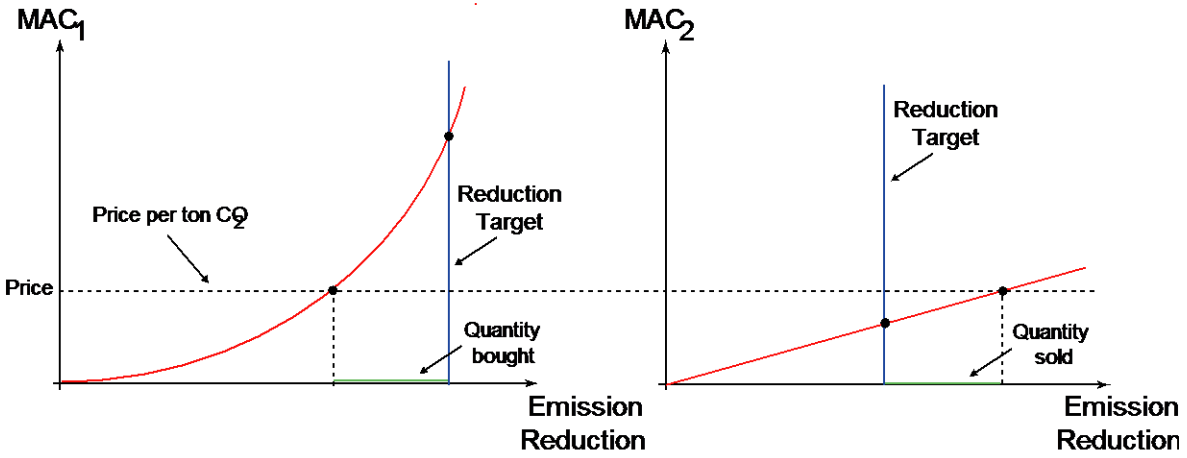
Emissions Trading: Two country-case





Minimization of an individual firm within an Emissions trading system

- Assume that without regulation the firm emits *e* units
- The firm is allocated *q* units of emission rights for free
- The firm can reduce *r* units of emission at cost *C(r)*
- The permit price on the market is P.
- The firm's optimization problem is then:

$$\min_{r} \quad \underbrace{C(r)}_{\text{cost of abatement}} + \underbrace{P \cdot (\bar{e} - r - q)}_{\text{Net supply / demand of permits}}$$

Is ET a cost effective way to reduce emissions?

- Let C_j (r_j) be the abatement cost of source *j*.
- Aim is to minimise the total abatement cost of reaching a CO_2 concentration of *A**.
- Mathematically, the regulator's optimization is:

$$\min_{r_j} \sum C_j(r_j)$$

subject to

$$A_{t-1} + \sum_{j=1}^{J} (\bar{e}_j - r_j) \leq A_t^*$$

$$r_j \geq 0 \text{ for } j=1,..., J$$

Kuhn-Tucker conditions

$$a + b\sum_{j=1}^{J}(\bar{e}_j - r_j) \le A^*$$

$$r_j\left[\frac{\partial C_j(r_j)}{\partial r_j} - \lambda\right] \ge 0 \quad \text{for } j=1,\ldots, J$$

$$\lambda\left[A_{t-1} + \sum_{j=1}^{J}(\bar{e}_j - r_j) \le A^*\right] = 0$$

$$\text{Lagrange Factor } \lambda \ge 0 \quad \text{for } j=1,\ldots, J$$

- The second equation shows that for a cost-effective allocation, all sources must have marginal abatement costs equal to the same constant $\lambda \Rightarrow$ marginal abatement costs are identical for all sources.

The firm on the market

- Assume source j receives q_j emission rights so that

$$\sum_j q_j = N \leq A^*$$

- Source wants to minimize the total cost of pollution abatement. Formally:

$$\min_{r_j} \quad \underbrace{C_j(r_j)}_{\text{cost of abatement}} + \underbrace{P(\bar{e}_j - r_j - q_j)}_{\text{Net supply / demand of permits}}$$

Where P is the permit price.

Kuhn-Tucker conditions (firm)

$$\frac{\partial C_j(r_j)}{\partial r_j} - P \geq 0, \text{ for } j=1,\ldots, J$$

$$r_j \left[\frac{\partial C_j(r_j)}{\partial r_j} - P \right] = 0, \text{ for } j=1,\ldots, J$$

$$r_j \geq 0, \text{ for } j=1,\ldots, J$$

Compare this market solution with the cost effective solution:

The permit market will be least cost when λ=P:

$$r_j\left[\frac{\partial C_j(r_j)}{\partial r_j}-\lambda\right]\geq 0,\ \text{for j=1 ,..., J}$$

$$r_j\left[\frac{\partial C_j(r_j)}{\partial r_j}-P\right]=0,\ \text{for j=1 ,..., J}$$

That is if the market is to be cost effective the shadow price of pollution control λ has to equal the permit price P! In this case, using a tradable market results in the least cost outcomes for emission reduction,l as the marginal abatement costs are equalized across polluters.

Emissions trading in a simple simulation

- The concept of the tradable permit market can best be be understood in a simulation:

Environmental policy instruments

- Path: http://www.vwl.ethz.ch/down/simula/flash/Eng/ET.html

The initial allocation of permits (Coase and Montgomery)

- Recall the Coase theorem: The trade between rights will produce an efficient outcome no matter the initial allocation of rights.
- Montgomery (1972) in JET proved this for tradable permit markets:
- *The efficiency at the market equilibrium is independent of the initial allocation of permits*
- Logic: given a perfectly competitive market, each source will trade permits till their marginal abatement cost is equal to the permit price, so no matter what initial allocation is given it will be traded until marginal abatement costs are equalised

Types of initial allocation

- ‘Grandfathering’
  1. Based on historical emissions
  2. Based on benchmarking
  3. Based on output
- Auctioning
  1. Government sells permits on an auction and firms can submit bids to win them.
  2. Usually multi-unit Sealed-bid auction with clearing price
- By Montomgery (1972), it doesn’t matter (in terms of efficiency) which process is used. What about the real-world?

Example for Permit Market: EU ETS

- First international trading scheme for *CO2*
- 46% of total EU *CO2* emissions
- covers 12,000 installations
- Sectors included: energy; mineral refining; steel production; glass; cement manufacturing; paper and pulp
- Phase I:2005-2007
- Phase II:2008-2012 (Kyoto commitment period)
- Phase III: 2013-2020
- Each member state has created a National Allocation Plan (NAP): details how many allowances members state intends to allocate to their domestic firms (adhere to EC criteria)

Assumptions

- A Government knows all information about: benefits of pollution; costs and damages of pollution
- Government knows the marginal benefit and damage functions of an economy
- This is the first best situation with no uncertainties and will be relaxed in the next lecture

An alternative Policy instrument: The (First Best) Pigouvian Tax

- Create a price for greenhouse gases so that firms that pollute have to pay a tax, per unit of emissions.
- Generate opportunity cost that firms take into account and alters behaviour (internalising the externality)
- Tax is an economic instrument: uses market forces to change behaviour of polluters (instead of direct regulation)
- Tax has similar efficiency result to a tradable permit market
- Tax should be placed directly on emissions and not on other criteria such as products (petrol, plastics): distortions may occur

The concept of the Pigouvian Tax

- The concept of the Pigouvian Tax and its comparison to the instrument of tradable permit markets as well as environmental standards will be discussed by use of the the following simulation:

Environmental policy instruments

- Path: http://www.vwl.ethz.ch/down/simula/flash/Eng/Taxes.html

In summary

- Tax levied provides incentive to reduce emissions $\Rightarrow$ in form of tax avoided
- All adjust their firm specific abatement levels
- If tax rate higher than MAC $\Rightarrow$ incentive to reduce pollution
- If tax rate is lower than MAC $\Rightarrow$ incentive to pay tax (not abate pollution)
- If tax rate is levied at t* efficient (and socially optimal) level of GHG pollution is attained without coercion or command and control regulation
- "Internalises the externality"

Estimates of implementation of a carbon tax

- Most estimates put future damage (and hence tax) from today's emissions at USD 5-20 per ton of CO2, or USD 20-75 per ton of carbon. From
- Clarke et al (2007) report:

	450ppm	550ppm	650ppm
Price per (metric) tonne of CO2	USD 40−95	USD 5−30	USD 1−10

- This should rise between 3-5% per year thereafter in real dollars i.e. above inflation

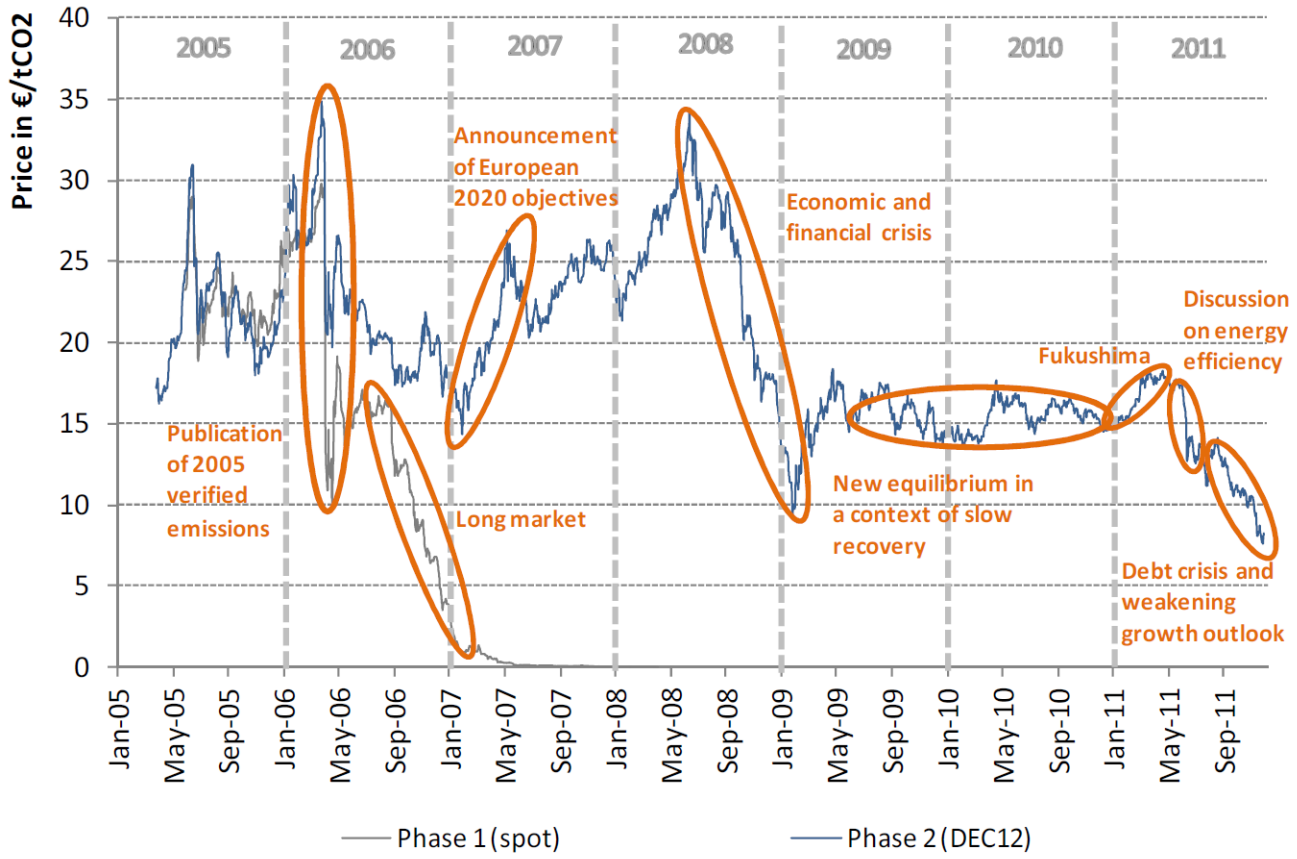
Advantages of a tax over a tradable permit market

- Carbon taxes establishes well defined price for emissions known to firms so they can calculate costs of emissions reductions
- Can improve incentive to invest in R&D and long term capital In contrast, permit market:
- As supply is fixed and demand can vary considerably: price is volatile and uncertain
- Demand for permits changes for number of reasons: change in energy demand; fuel price changes
- may reduce incentive to invest in abatement R&D

Flexibility in level of emissions (taxes)

- Allows quantity of emissions to change in face of prevailing economic conditions (e.g. recession/ boom)
- Fixed tax allows quantity of emissions to change which may make sense to allow for nation-wide emissions to vary due to prevailing economic conditions
- In contrast, markets as often claimed:
- Do not have inherent flexibility in market. So could be more costly to firms
- Makes only economic sense to have this if we are rapidly approaching threshold of atmospheric greenhouse gas concentrations beyond which are dangerous impacts
- **Discussion: Other issues to be taken into account when comparing both instrument types.**

The carbon price within the EU ETS



Source: Climate Economics Chair from BlueNext and ICE ECX Futures

Reconciliation between taxes and permits

What has been compared is a standard tradable permit market and tax. however, comprise can exist between the two: "Hybrid schemes“.

Tradable permit markets can be adapted to include:

- Price ceiling "safety valve" (to improve price stability): unlimited amount of permits that can be sold at the set "safety valve"
- Banking and borrowing or permits (to improve price stability)
- Reserve (to improve price stability): limited stock of permits that can be sold at a price ceiling Auctioning of permits (to obtain revenues for reduction in distortionary taxes)