Environmental Economics in the Central European Context

Time: Tuesday 4pm – 7pm

Location: at CERGE-EI, Room # 11

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Reading materials: **http://home.cerge-ei.cz/richmanova/Teaching.html**

Readings for this week:

Hardin, The Tragedy of the commons

Schotter, Microeconomics, A Modern Approach (2nd edition), Chapter 17, up to Section 17.4 (included), Chapter 18

Plott, Externalities and Corrective Policies in Experimental Markets

Holt, Laury, Voluntary Provision of a Public Good

Introduction

Why do we care about the environment?

- life supporting function (location and the basic conditions for the existence of life)
- natural resources (inputs for consumption and production)
- amenity values (natural beauty)

Natural resources:

- flow resources (solar radiation, wind or water energy – the current use does not affect future availability)
- stock resources (the current use affects future availability)
- renewable resources (forests, stock of fish, etc…)
- non-renewable (fossil fuels, mineral ores)

The problem is that with increasing human activity, industrial production, unclean technologies, there are adverse and often permanent impacts on biophysical environment.

Different types of resources and interactions => different types of environmental problems

- nature degradation due human activity (deforestation, pollution)
- conflicting usage of the natural resource (e.g. amenity vs. production)
- distribution of usage over time (this or future generation? concept of sustainability)
- distribution among agents (problem of too many fishermen)

=> need for VARIOUS TOOLS to remedy them => Environmental Economics

What would you say are current issues in the US?

Current issues in Europe and the CR

- water and air pollution, greenhouse effect (how to manage with growing industrial production, transportation)
- soil pollution (industrial fertilizers), state of forests
- energy intensity
- noise (transportation air/road/railway)
- waste management
- decrease in biological diversity and ecological stability (due agricultural production and fragmentation of the landscape due transportation and urbanization)

Instruments of environmental protection

- regulations,
- economic and financial (standards and charges, marketable pollution permits, taxes, fines, tax reliefs and subsidies, property rights),
- voluntary programs (environmental labelling),
- environmental education and public awareness

PRINCIPAL QUESTION – which tools are the most efficient for particular environmental situations/types of problems...

➔

ENVIRONMENTAL ECONOMICS

- a subfield of economics concerned with environmental issues
- undertakes theoretical or empirical studies (in search for effective environmental measures)
- of the economic effects of environmental policies

- impacts of economic instruments on decision-making when environmental impact is a concern
- e.g. costs and benefits of alternative environmental policies to deal with air pollution, water quality, toxic substances, solid waste, and global warming…

EXPERIMENTAL ECONOMICS

- a tool frequently used by environmental economists
- why? b/c they (not only) provide an important insight on environmental measures employed by governments and NGOs
- we will review couple of experimental articles throughout this course,
- for use of experimental methods see e.g.
  - **(G&G)** Greenstone, Gayer, (2007), Quasi-Experimental and Experimental Approaches to Environmental Economics.
  - **(L&L)** Levitt, List, (2009), Field experiments in economics: The past, the present, and the future.

Q: What comes to your mind when you hear (economic) experiment?

Merriam-Webster Dictionary:

"Experiment is a tentative procedure or policy; an operation or procedure carried out under controlled conditions in order to discover an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law."

Benefits of employing Experimental Methods

- **The effect of planned policy change** can be **tested at relatively low cost** (compared to allocation of much larger resources to an inefficient program; e.g. training program for the unemployed, new pricing scheme for electricity,…)
  - A new drug is tested to make sure that it has the expected effect which is not outweighed by possible side-effects → to minimize potential cost on public health
- **Explaining or predicting non-experimental outcomes** (e.g. Barr and Serneels 2004: correlation of wage outcomes of employees with their behavior in a trust game experiment) – again, relevant policy/strategy implications at relatively low cost
- **Testing theoretical predictions at relatively low cost** (economic theory, game/behavioral theory)
- Help to **generate the data** which are difficult to be obtained from "the field"
  - Estimation of a cost that the firm which produces pollution should internalize so that the (socially) more efficient outcome can be achieved

➔ ENVIRONMENTAL ECONOMICS

Externalities? How to correct them? → Environmental Economics (G&G)

- Imagine an example of air or water pollution as a by-product of the production of marketable good
- created pollution imposes health costs on inhabitants and/or costs on the down-the-river company not internalized by the firm which is responsible for producing the pollution
- government intervention might help to maximize net (social) benefits/welfare – require reliable estimates of the costs and benefits (how to set the tax? will the market participants react in expected way?) => ENVIRONMENTAL ECONOMICS
- **EE** addresses the inefficiencies resulting from production of externalities –> experimental and quasi-experimental methods
- hinge upon proper design, implementation, appropriate approach to the data analysis

Market failure

- one of the key concepts
- situations when markets alone (without any intervention) fail to allocate resources efficiently
- Hanley, Shogren, and White (2007) in their textbook Environmental Economics:

  "A market failure occurs when the market does not allocate scarce resources to generate the greatest social welfare. A wedge exists between what a private person does given market prices and what society might want him or her to do to protect the environment. Such a wedge implies wastefulness or economic inefficiency; resources can be reallocated to make at least one person better off without making anyone else worse off."
- scenarios where individuals' pursuit of pure self-interest leads to results that are not efficient, i.e. can be improved upon from the societal point-of-view.

Externality (Do you remember from Micro classes what it is?)

- one of the common causes of market failure -> another key concept of EnviEcon
- **an impact on a party that is not directly involved in the (economic) transaction**
- exists when a person makes a choice that affects other people that are not accounted for in the market price and thus the prices do not reflect the full costs or benefits in production or consumption of a product or service [➔ market failure].
- **Positive externality -** an action that imposes a positive side effect on a third party
- **Negative externality -** an action that imposes a negative side effect on a third party; many negative externalities are related to the environmental consequences of production and use.

  Q: Can you think of couple of examples on positive or negative externalities?

Examples of positive externalities:

- A **beekeeper** => honey + pollination
- An **attractive garden** => amenity values, increased property values for all owners.
- **Home ownership** => owners more likely to be actively involved in the local community.
- **Education** => lower criminality

Examples of Negative Externalities

- **Transportation** => congestion cost + pollution
- **Industrial Production** => GHG emissions from burning oil/gas/coal => climate change
- **Water pollution** => poisons in the water ➔ plants, animals, and humans harmed
- **Industrial farm animal production** => increase in the pool of antibiotic-resistant bacteria + air quality problems + the contamination of rivers, streams, and coastal waters with concentrated animal waste + animal welfare problems
- **Fishing** => depletion of the stock of available fish => **Tragedy of the commons**.
- **Consumption of alcohol** => drinking and driving accidents

$$\underline{\text{marginal social benefit}}_{\text{of consumption}} < \underline{\text{the marginal private benefit}}_{\text{of consumption}}$$

$$\Downarrow$$

MARKET FAILURE

(over-consumption of the good; the price is too low)

FIGURE 17.1 Dolan's water-paper society.

The paper mill imposes an external cost on the water treatment plant by dumping its wastes into the river. These wastes increase the treatment plant's cost of cleaning the water.

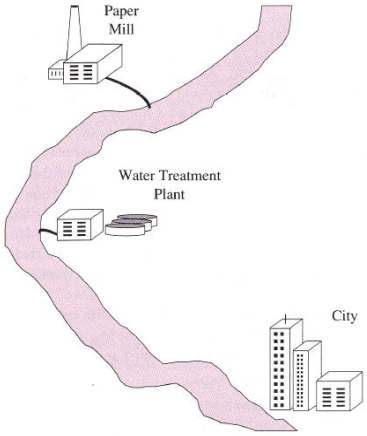
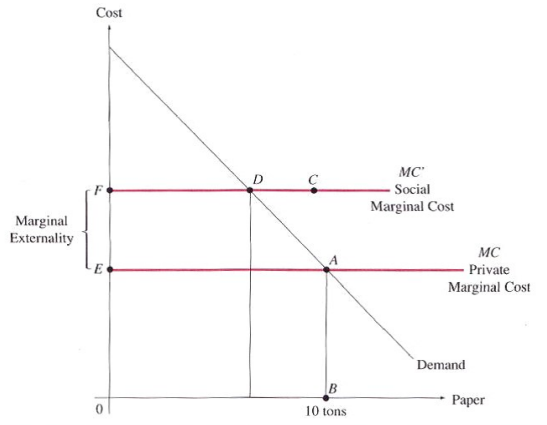


FIGURE 17.2 Pigouvian taxes.

The imposition of a tax equal to the marginal externality (distance *EF*) equates the private marginal cost *MC* faced by the paper mill with the social marginal cost *MC'* and thereby induces the mill to produce at the optimal level for society (point *D*).



Pareto efficiency (= Pareto optimality)

- a concept in economics; named after Vilfredo Pareto (an Italian economist who studied economic efficiency and income distribution)
- Situations in which it is **impossible to make one person better off without necessarily making someone else worse off**.

⇨ **Pareto improvement**

- given a set of alternative allocations of goods for a set of individuals: a change from one allocation to another that **can make at least one individual better off without making any other individual worse off**
- an allocation is defined as "**Pareto efficient**" or "**Pareto optimal**" (or "Allocative efficiency") when **no further Pareto improvements can be made**.
- **on consumption side:** resources cannot be re-allocated to make one consumer better off (in terms of utility) without making another worse off; or
- **on production side:** production inputs (capital and labor) cannot be re-allocated such that production of at least one good in the economy increases without decreasing the production of some other good.

A simple illustrative example:

- Imagine that Robinson Crusoe has invented a machine that can
  - make two mangoes out of one coconut, or
  - make one coconut out of two mangoes.
- Crusoe's utility is U(c,m)=c*m
- thus marginal utilities are U'_m=c and U'_c=m
- (➔the more of mangoes he consumes the happier he is from each additional piece of coconut and vice versa)
- Initial allocation: 4 mangoes + 4 coconuts
- **Is that Pareto-optimal allocation? If not, what would Crusoe have to do to get a P-O allocation?**

	he'll end up with	Robinson's final utility (c*m)
doing nothing	4 coconuts + 4 mangoes	16
converting 1 coconut into 2 mangoes	3 coconuts + 6 mangoes	18
converting 2 coconuts into 4 mangoes	2 coconuts + 8 mangoes	16
converting 2 mangoes into 1 coconut	5 coconuts + 2 mangoes	10
converting 4 mangoes into 2 coconuts	6 coconuts + 0 mangoes	0

- You can work through all the alternative allocations but it is easy to see in which case his utility function will be the highest…

⇨ in the P-E allocation, Robinson will end up with 3 coconuts + 6 mangoes.

- Note that more formally, you can solve the problem using the concepts of **Marginal rate of transformation**… those interested can find the solution in Schotter's textbook, Chapter 15, Solved Problem 15.1 (p. 581 in the 3rd edition)

  ⇨ This is just a simplest case, with just one individual, Robinson Crusoe.

  ⇨ What if we take into account also his "Man Friday", whose utility over coconuts and mangoes might be different?

  ⇨ Or even a larger economy with number of consumers and producers…. with potential externalities…

  ⇨ **Social efficiency** – efficient allocation from the social point of view when the total social (including external) costs are accounted for

Typical causes of market failures:

i. **externalities**
ii. **public goods or common goods ("the tragedy of the common")**
iii. market power (imperfect/no competition) – not relevant for us now

Public good

- is a good that is **non-rivalrous** and **non-excludable**.
- **Non-rivalrous** means that consumption of the good by one individual **does not reduce availability of the good for consumption by others**;
- **Non-excludable** means that **no one can be effectively excluded from using the good**.
- Non-rivalness and non-excludability may cause problems for the production of such goods
- markets alone might fail to produce optimal (or desired, for that matter) amount of public goods => market failure.
- environment is an example of public good

In the real world, there may be no such thing as an absolutely non-rivaled and non-excludable good; but we can get close enough… also, some goods might be mixed…

Examples of public goods (can you think of any?):

Here come some….

- light houses (cannot exclude ships from using it)
- defense and law enforcement
- fireworks
- streetlights
- roads
- informational goods (software development, authorship, invention)
- **environmental goods (clean air, clean water….environmental protection in general)**

Some goods are **"mixed"** in the sense that they have the properties of both, private and public goods

- excludable but non-rival (like cable TV)
- non-excludable but rival (like public park)

The free-rider problem

- **is a central problem and a reason why public goods often lead to an instance of market failure…**
- individually-rational and self-interested behavior on the market might result in an inefficient outcome
    - typically in underproduction, or no production at all
    - non-excludability +self-interest => individuals can take advantage of public goods without contributing sufficiently to their production
    - if private organizations don't reap all the benefits of a public good which they have produced, their incentives to produce it voluntarily might be insufficient.
- this is called the **free rider problem**
    - relies on assumption of individual rationality and self-interest maximization
    - if in unregulated market an individual cannot be excluded from consumption of public good (breathing clean air, riding good roads…etc) and there is no mechanism to ensure his contribution to creation of that good, why should a self –interested rational individual pay for something s/he would get to consume anyway?
    - that is why the government often has to step-in regulating, collecting taxes, etc… to correct the market failure and ensure the production of public good

Example

- consider national defense, a standard example of pure public good.
- suppose an individual thinks about exerting some extra effort to defend the nation.

- benefits to that particular individual might be very low (especially if the "defending activity" is not geographically close to our individual and he/she might not face immediate threat of being affected by the war)
- on the other hand, there is a high possibility that he or she could get injured or killed during the course of his or her military service.
- importantly, a free rider knows that he or she cannot be excluded from the benefits of national defense, regardless of whether he or she contributes to it (as long as the army exists, it does not matter too much whether there is one more soldier or not).
- thus a rational individual would not voluntarily exert any extra effort, unless there is some inherent pleasure or material reward for doing so (for example, money paid by the government, as with all-volunteer army or mercenaries).

Now, **to establish a national defense system**, the government needs to

- determine how much money to spend on it – small vs. huge military complex
- needs to know the cost of each alternative
- and know the maximum willingness of each member of the society to pay these costs

⇨ How to find out? Well, the government could try to ask…
⇨ It is not so simple…

…Suppose you know that everyone is reporting their true willingness to pay. You also know that there are so many people in the society that your response, however small, will not affect the level of national defense => no incentive to report truthfully => "economically rational" response would be to say that you are not willing to pay for national defense.

⇨ But if everyone would do so…..

Questions for an economist? (Schotter, Chapter 18)

1. what is the optimal amount of public good to produce, and what conditions must be satisfied at such optimum?
2. How can economy achieve that optimum?
3. Will free markets be able to achieve that optimum, or must the government help the economy to coordinate its activities?

Q: Think about how environmental protection can be conceptualized as a public-good-provision problem. Solutions?

Solutions:

1. **Lindahl "free market solution"**
   - relies on everyone truthfully revealing their preferences for public good;
   - the government serves as a "coordinator" (no intervention)

- the coordinator sets everyone's' share on the total cost if the good is provided
- people face prices and the market will take care of the rest: people will maximize their utility and state their demand for the public (as well as the private) good.
- In the equilibrium, prices of private goods and shares on cost of public good are set such that no one wishes to change his/her demand for private and for public goods + supply of private good equals the demand + everyone consumes the same amount of public good (due to non-excludability + non-rivalry).

  Problem: incentives not to be truthful in revealing one's preferences.

⇨ **Another proposed solution(s):**

2. A demand-revealing mechanism

- imagine a dark street and three equally costly plans to install streetlights (one very bright streetlight or combinations of less bright streetlights)
- ask inhabitants, how much they are willing to pay for each of the proposed plans and implement the one that maximizes the total willingness to pay)

  → still there is no guarantee that collected contributions will cover the total cost of implementing the streetlight plan.

3. An auction election mechanism:

- people submit their bids (bidding the money one is willing to pay + the quantity demanded);
- then if the public good is produced, everyone pays the difference between the cost and sum of the bids made by other people multiplied by average quantity demanded
- Everyone has a right to refuse his or her cost share
- If all people agree to pay their costs share the demanded quantity is produced.
- If no agreement is reached, public good is not produced – the experimental evidence suggests that people in general do not seem to be truth-telling (Smith, 1977)

4. Coase argument:

- with no transaction cost and unilateral property rights, most conflicts could be resolved by private bargaining [more on that later]

5. Government provision (public good financed by tax revenues)

- it might be difficult to ensure the government has an incentive to provide the optimum amount even if it were possible for the government to determine precisely what amount would be optimal
- A government may **subsidize production of a public good in the private sector;**
- unlike government provision, subsidies may result in some form of competitive market.

- Principal-agent problems can still arise between the citizens and the government or between the government and the subsidized producers.

6. An exclusion mechanism (club goods)

- developed for information goods,
- introduction of exclusion mechanisms which turn public goods into club goods.
- Example: copyright and patent laws (intellectual property laws) that attempt to remove the natural non-excludability by prohibiting reproduction of the good.
- Although they can address the free rider problem, the downside is that they imply private monopoly power and thus are not Pareto-optimal.

7. support public mindedness by **tradition** and **social norms** (a non-market solution)

...THE IN-CLASS EXPERIMENT...

Tragedy of the commons (Hardin, 1968)

- a dilemma in which **multiple individuals acting independently and solely** and rationally consulting their **own self-interest** will **ultimately destroy a shared limited resource** even when it is clear that it is not in anyone's long term interest for this to happen.
- Hardin uses an example, of herders sharing a common parcel of land (the commons), on which they are each entitled to let their cows graze.
- it is in each herder's interest to put the next (and succeeding) cows he acquires onto the land, even if the carrying capacity of the commons is exceeded
- if this goes on and on the land is eventually damaged for all as a result.
- This is because
  - **the herder receives all of the benefits from an additional cow,**
  - **the damage to the commons is shared by the entire group.**
- If all herders make this individually rational economic decision, the commons will be destroyed to the detriment of all.
- the problem arises when **property rights are not well defined** (the “commons”)
- private property then provides a mechanism to avoid externalities
- the owner cares about the property and controls its use + can exclude others from overusing it (see the discussion in Hardin as well)

- private property is not the only available mechanism – regulations work as well (with legal system to enforce them)

Examples (**can you think of any?**):

- **over-herding** cows (see Hardin)
- **over-fishing** (each fisherman has a negligible impact on the total fish stock… but too many fisherman might result in serious depletion)
- **automobile pollution** – each automobile lowers the air quality and it is not likely that the free market would result in the optimal amount of pollution → emission standards for automobiles

  → **Practical Example: Possible solutions** to automobile problem**:**

  - 1963 Clean Air Act and its amendments set automobile emission standards for the manufacturers of vehicles in the US and Lawrence White examined the costs and benefits of this program
  - cost per car is estimated at
    - $600 for emission control equipment
    - $180 for extra maintenance
    - $670 due to reduced gasoline mileage and the necessity of unleaded gasoline

  => **total cost of $1450** (in 1981 dollars) per car

Any Problem?

How does this policy affect incentives of consumers/drivers? Mileage?

Does the pollution in the area matter for everyday driving decision?

- White identifies following problems:
  - everyone who buys a car must pay extra $1450, whether they live in highly polluted area or not
  - most of the responsibility falls on the manufacturer, only little on the user

    => car owners have little incentives to keep the pollution control equipment in working order unless they are inspected
  - no incentive to economize driving – people who drive 2000 miles in less polluted areas pay exactly the same amount of money as people who drive 500,000 miles in heavily polluted areas → it would make sense to encourage people to drive less (at least in heavily polluted areas)
- **Can you think of alternative solution that would address White's criticism?**

- Alternative solution that White offers: **effluent fees**
- annual inspection of all vehicles estimating the car's likely emissions during the past year
- different communities (areas) could levy different fees => people face the true cost of generating pollution => encouraged to generate "socially optimal amount of pollution" (or, well, at least closer to it)
- **Why do you think it should work better?**
- the system would encourage the owners to search for low-cost ways of reducing their emissions, including changing their driving habits and the type of vehicle (more eco)

INTERVENTIONIST SOLUTIONS TO THE EXTERNALITY PROBLEM

- based on Schotter, Microeconomics, A Modern Approach (Second edition) **Section 17.3**
- problem of externality and solutions: interventionist vs. non-interventionist (free market) solutions

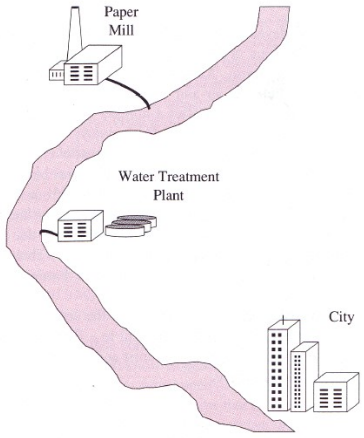
Interventionist solutions:

- Pigouvian Taxes
- Standards and Charges
- Marketable Pollution Permits

PIGOUVIAN TAXES

FIGURE 17.1 Dolan's water-paper society.

The paper mill imposes an external cost on the water treatment plant by dumping its wastes into the river. These wastes increase the treatment plant's cost of cleaning the water.



- the society produces paper (paper mill=PM) and clean water (water treatment plant = WTP)
- PM dumps waste into the river and thereby increases the cost of cleaning it

  => **externality** (as this cost is external to the mill, it is borne by the WTP)

  => not taken into account when making production decision

  (in the competitive market: price of paper=marginal cost of producing paper)

- Say the **mill** is producing
  - **10 tons of paper** (or, **20,000** pounds)
  - with a **(private) marginal cost MC** (of labor and capital) of **$0.005/pound=$10/ton**.

  ➔ In a competitive market, price **p=MC**

  ➔ **p=$0.005 per pound of paper**

- **Water treatment plant's MC**
  - when the mill is idle is **$.50/1,000** gallons;
  - when the mill is active, additional cost of **$.05/1,000 gallons for each ton** of paper produced

⇨ given the current mill's production, the total MC is **$.50 +10*$.05=$1 per 1,000 gallons**

⇨ In a competitive industry the **price of water will be $1 per 1,000 gallons**.

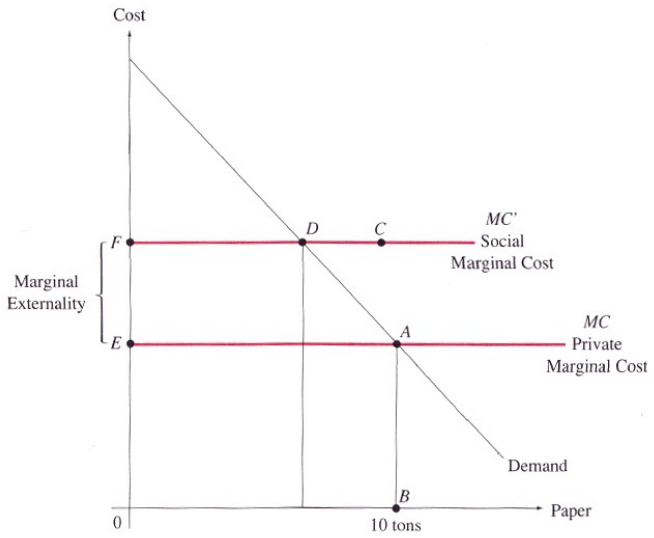
⇨ Assume at such price 1 mil. gallons of water is demanded

⇨ Society spends $1,000 on water

- **Can we expect the society to produce PARETO OPTIMAL amounts of water and paper?**
- Intuitively, we might expect the answer to be **NO**.
- The paper mill is imposing an additional cost on the water treatment plant, but there is no mechanism to make the mill accountable for this cost, so it seems unlikely that the outcome for society will be Pareto-optimal. Indeed it is not …

FIGURE 17.2 **Pigouvian taxes.**

The imposition of a tax equal to the marginal externality (distance *EF*) equates the private marginal cost *MC* faced by the paper mill with the social marginal cost *MC'* and thereby induces the mill to produce at the optimal level for society (point *D*).



- **point A** – the level of production of paper resulting from a competitive market -> Not Pareto Optimal
- **Illustration**
  - assume the mill would reduce its production by 200 pounds (0.1 ton). Given the market price that would mean **a loss of** (200x$.005=)**$1 in revenues**

  ⇨ cost of producing clean water is now reduced by (200p/2000p)=1/10x$.05=$.005 per 1,000gal.

  ⇨ 1 mil. gallons would be produced at a cost of $995 instead of $1,000

  ⇨ **$5 saved for the water treatment** = Pareto Improvement

  - **HOW COME?**
    - **WTP can compensate that $1 lost to PM due to reduced production and still have $4 extra…**
    - **this means that PM is not worse off, while the WTP is better off…**

  - the cost savings of the WTP are sufficient to allow it to produce more water and to compensate the mill for its lost revenues!

PIGOU

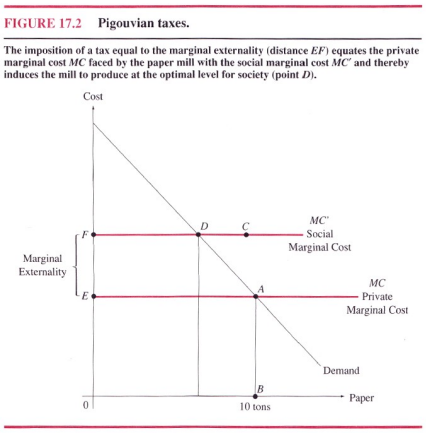
- the “pollution” cost is external to the mill and thus it does not affect its production decision
- from the social point of view

⇨ Social Marginal cost MC’ of the paper production = production cost + pollution cost

- point A is not optimal for society – “BC” (social MC)>”BA” (social marginal benefit)

⇨ **point D** is the **social optimum**

Pigou – suggested imposing **TAX on paper**; unit of paper produced to be taxed by the amount of the marginal externality (“EF”) in order to internalize the externality and directly affect mill’s paper production => this would shift our artificial society straightly to **point D, the social optimum**



Q: Can you think of possible (practical) problems with implementing this solution?

- **PROBLEM** – To set the tax, the government needs to know the exact amount of the externality (the cost). The afflicted party, however,
  - might not be able to estimate accurately
  - might have incentives to exaggerate

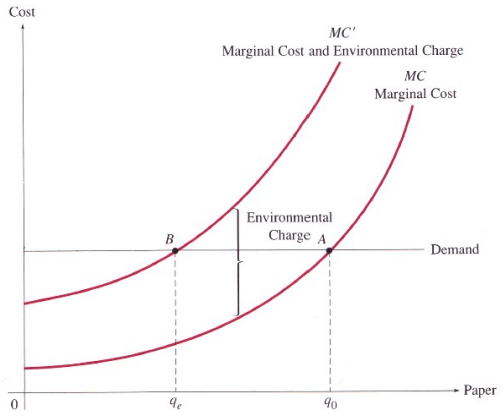
STANDARDS AND CHARGES

- a similar solution as taxes, the mechanism is slightly different, though. Here, the government sets the standard – the amount of externality considered acceptable – and then charges (per unit of pollution) in order to induce the agents to reduce the externality to the acceptable level.
- *NOTE: Some literature does not distinguish and calls this a Pigovian tax too…. here we will distinguish.* ***"Tax" is always per unit of final product, "Charge" per unit of pollution****. Even though the result is the same (in that polluter pays for pollution), the effect through which they work is not. And this has consequences for (proper) applicability of the two.*

Case I: Single firm

FIGURE 17.3 The effect of an environmental charge on a single firm.

The imposition of an environmental charge equal to the distance between the marginal cost curves *MC* and *MC'* induces the firm to cut back its output from q_0 to q_e.



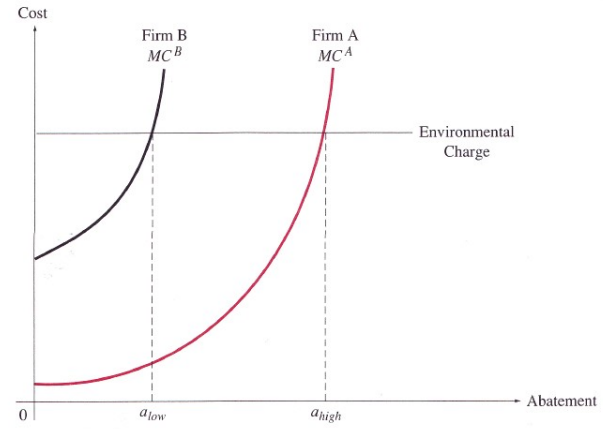
- the government conducts a study to determine how much pollution is acceptable
- charge **on each gallon of waste** to induce the mill to reduce the pollution to the acceptable level
- when the mill's cost is MC => it will produce at point A
- charge=> MC'=> it will produce at point B
- Ideally, with q_c the production of waste is at the STANDARD

Case II: Two or more firms

- 2 firms: mill A produces 70 gallons of waste a day, mill B 30 gallons. Say the STANDRD is set at 50 gal.
- an across-the-board 50% cut might not be the most efficient (different MCs for waste reduction = marginal cost of abatement, depending on technology used by each producer)
- A would have to reduce by 35, B by 15 gal. Say A's cost of reducing by additional 1 gal. is \$5, B's is \$8 => if A's total abatement is 36 gal. and B's is 14 gal. the total abatement is same but the society could save \$8-\$5=\$3.
- **Firms with lower cost (of abatement) should reduce by more and firms with higher cost by less!**

FIGURE 17.4 The effects of an environmental charge on two firms.

The marginal cost of abatement curve for firm A(MC^A) is lower than that for firm B (MC^B). Each firm will choose a level of abatement such that its marginal cost of abatement is equal to the constant environmental charge. Thus, the level of abatement chosen by firm A (a_{high}) will be higher than that chosen by firm B (a_{low}).



- Figure 17.4 – once the environmental charge (per unit of pollution) is set, each firm will reduce by the corresponding amount. $a_{low}+a_{high}=a_{total}$ ($MC^A=MC^B$=charge; STANDARD is induced; note that this is marginal cost of abatement, not of production); basically each firm is reducing pollution by one additional unit as long as marginal cost of abatement for that particular unit is lower than the environmental charge… because if charge was lower the firm would prefer paying the charge instead of reducing pollution released

Q: Can you think of possible (practical) problems with implementing this solution?

- **PROBLEM** – even more difficult to administer than taxes, need to know the exact damage to society to set the STANDARD + the cost of abatement for each firm to be able to set the charge right, so that it induces the desired reduction of pollution (guess and verify is the only possibility but changing the parameters too often would not be good for industry and might be administratively expensive, we don't want the firms to reduce neither too much nor too little – **WHY?**)

MARKETABLE POLLUTION PERMITS

- For each unit of produced waste the firm pays not only the cost of labor and capital, but also a permit that will allow producing that unit. A firm with higher MC of abatement is willing to pay more for the permit than the firm with lower MC of abatement (up to its cost of abatement for the corresponding number of units)
- The government first finds an acceptable level of pollution and then offers for sale the corresponding number of permits
- Each firm can only pollute with the permit.
- Thus the mechanism works similar as with standards and charges (the government sets the standard and issues corresponding number of permits – thereby directly regulating the acceptable amount of pollution), but here we have additional market for permits where firms bid according to their abatement cost

⇨ **the government does not need to know abatement costs for each firm** like with standards and charges, just needs to set the standard and set up extra market for permits and the market forces will take care of the rest…[analogical to "setting the charge right"]

- we will talk more about this one next week

Experimental Evidence

Based on: Plott, Externalities and Corrective Policies in Experimental Markets or Schotter (**17.4)**

Questions:

What was the main purpose of Charles Plott's experimental paper?

Was he successful?

Look at Figure 17.6, how does the author simulate the market? Can you explain the meaning of the curves?

How does he model externality in this artificial market?

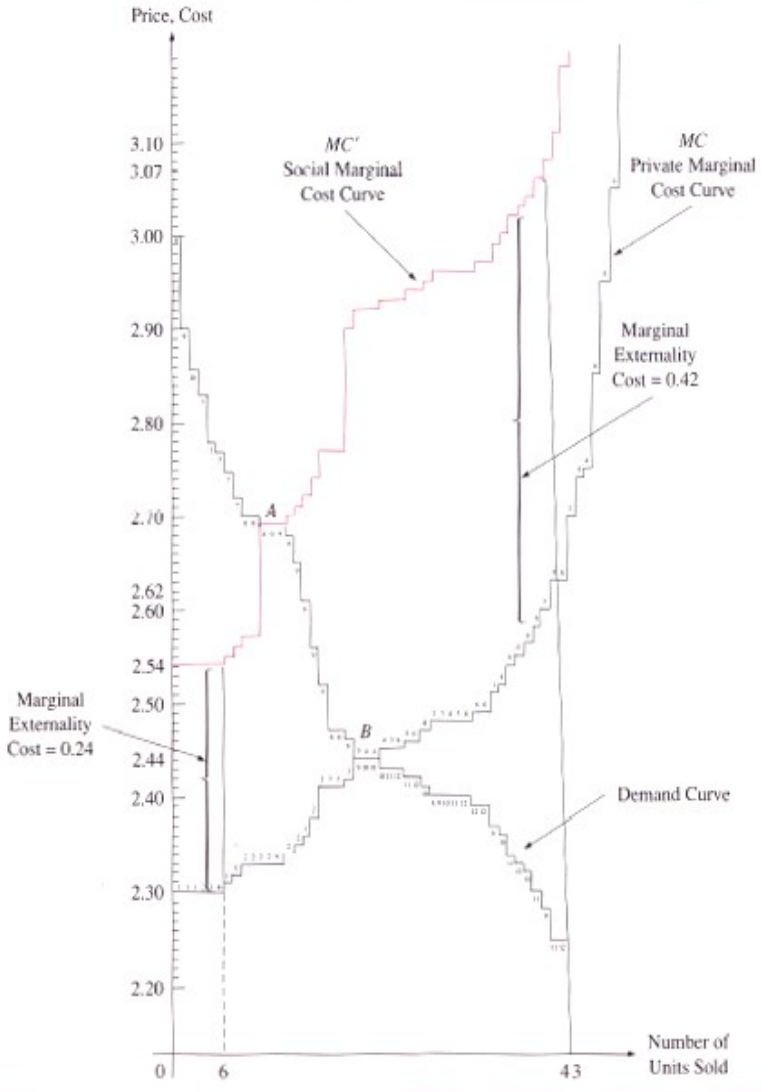
A series of experiments to evaluate how well the interventionist solutions work in practice

- the subjects buy and sell units of a fictitious good using a double oral auction

- *In such a **double oral auction** any potential buyer (or, seller) can make a verbal bid (or, offer) to buy a unit of the good at a specified price. Any seller (buyer) can accept a bid. If a bid is accepted a binding contract is closed for a single unit at the specified price. Any ties are resolved randomly.*
- each buyer is paid a redemption value for every purchased unit according to a predetermined redemption schedule → ***induced demand curve***
- each seller must pay a premium for each unit he sells according to a predetermined cost schedule → ***private marginal cost curve (~induced supply curve)***

FIGURE 17.6 Plott's laboratory model of a market with an externality.

Economic theory predicts that the market, if left alone, will ignore the externality and will reach its equilibrium at point *B*, where the private marginal cost curve *MC* and the demand curve intersect. Point *A*, where the social marginal cost curve *MC'* and the demand curve intersect, is the optimal solution for society.



- every completed transaction imposes an additional cost in all subsequent transactions; the cost increases with the number of units sold → externality → ***(induced) social marginal cost curve.***

- Note that after 6 units sold, the marginal externality cost is $.24, after 43 transactions, it is $.42 **[Can you think of real-life analogy?]**

Q: Where can you expect the unregulated outcome? The Pareto efficient one? [note]

- Pareto optimal solution -- **point A** (13 units at price $2.69), i.e. where the social marginal cost curve intersects the (induced) demand curve
- without intervention -> theory predicts the competitive outcome "as with no externality" -> **point B** (24 units at price $2.44)
- Charles Plott:
  1. "Do markets with externalities behave in accordance with the law of supply and demand?" (in other words, will the unregulated market end up in point B?)
  2. "How do pollution tax, pollution standard and pollution licenses compare as methods for correcting the externality?" (i.e., will they help the market to move to point A?)

  ⇨ 4 treatments, 2 sessions for each, 6 buyers and 6 sellers in each market
- individual demands and costs are assumed to be unknown, only the optimum level of pollution and marginal social cost at the (social) optimum are known for the license and the tax policy

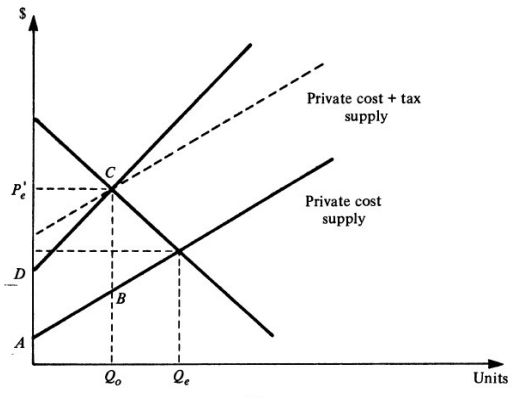


Fig. 2

Q: How are the individual interventionist solutions implemented?

- **Market with externality** (no policy, 5 periods in each)
    - benchmark, to see the market solution (expected to end up at point B)
- **Pigouvian Tax policy** (6+7 periods)
    - the amount of marginal social cost is calculated at the optimum quantity Q_0, and is imposed on sellers as a per unit tax. Tax revenues are then redistributed back.
- **Standards policy** (9+7 periods)
    - the ABCD area is the 'optimum' value of pollution damage

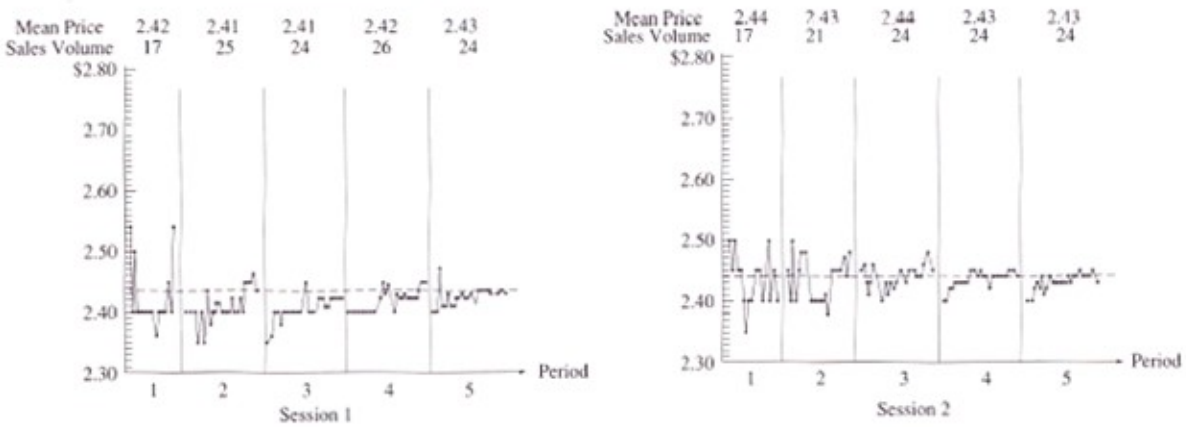
    ⇨ STANDARD limits the amount of admissible pollution such that imposed damage is ABCD (so here, number of trades is limited such that the total environmental damage equals ABCD = 13 units in fact – on the first-come, first-served basis)
- **Permits policy** (10+12 periods)
    - only Q_0 permits exist and only licensed unites can be produced, 13 licenses are issued
    - EQ: price of license = BC; market price of the good = P_e'; quantity = Q_0;

RESULTS:

- **Market with externality:** **Q: What can you conclude based on the figure below?**
- at the top of each graph, see the mean price and the number of units sold in each period

FIGURE 17.7 The results of Plott's experiment to investigate the behavior of a market with an externality.

As economic theory predicts, the prices in the experimental market moved toward the competitive equilibrium price of $2.44 and the quantities sold moved toward the competitive equilibrium volume of 24 units rather than toward the optimal price and volume for society of $2.69 and 13 units.



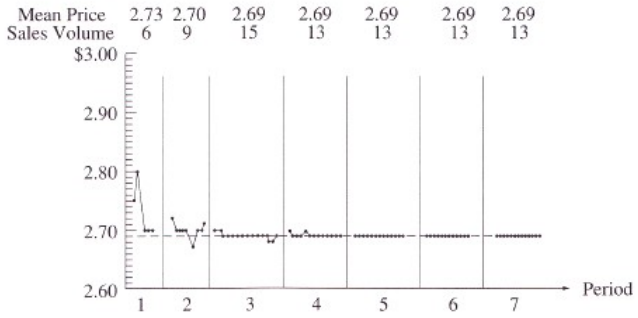
- unregulated market
- in both sessions
  - the volume sold tended to move toward the competitive eq. of 24 units
  - price close to the competitive equilibrium level of $2.44
- **the market failed => the theoretical prediction confirmed:** subjects ignored the externality and arrived to competitive rather than the Pareto optimal outcome

1. Pigouvian tax policy

- at the top of the graph, see the mean price and the number of units sold in each period

FIGURE 17.8 The results of Plott's experiments to evaluate the interventionist solutions to an externality: The Pigouvian Tax.

The Pigouvian tax intervention pushed prices and quantities toward the optimal levels for society of $2.69 and 13 units.



Q: What has changed? What can you conclude from the figure above?

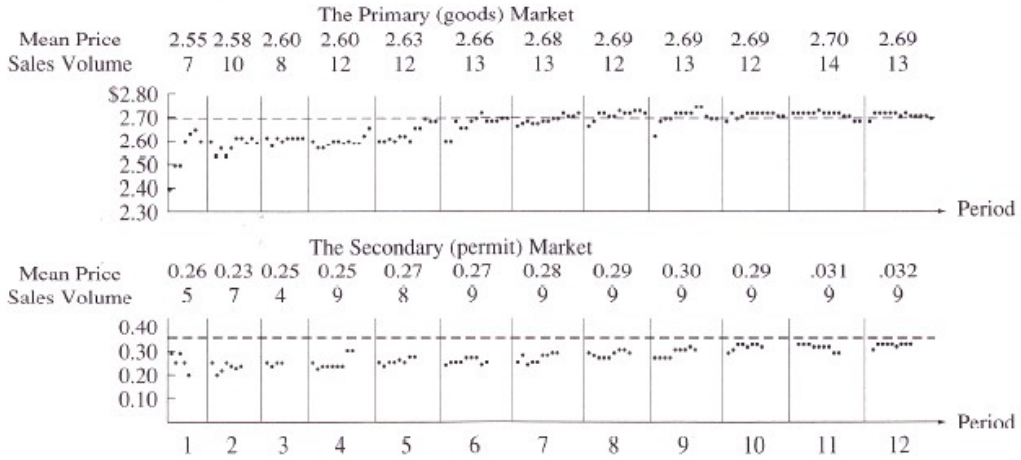
- marginal social cost, calculated at the optimum quantity Q_0, is imposed on sellers as a per unit tax
- cost schedule is increased by a tax equal to the amount of marginal externality
- the imposition of tax simply becomes a change in supply
- TAX effective in pushing the volume down to the Pareto optimal level of 13, and price up to eq. level of 2.69

2. Permits policy

- at the top of the graph, see the mean price and the number of units sold in each period
- only 13 (= Q_0) permits exist and only licensed unites can be produced, price of license should = marginal externality at Q_0

FIGURE 17.9 **The results of Plott's experiments to evaluate the interventionist solutions to an externality: Permits.**

Like the Pigouvian tax intervention, the permit intervention succeeded in pushing prices and quantities toward the optimal levels for society. However, the permit intervention was more efficient in terms of the amount of consumer and producer surplus captured.



Q: What has changed? What can you conclude from the figure above?

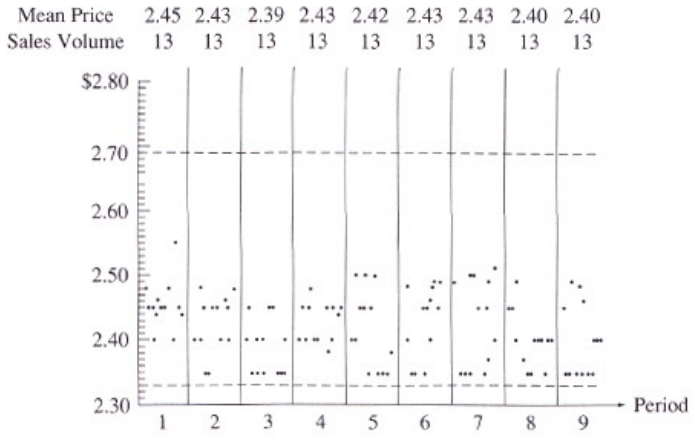
- secondary market for permits is created: in order to sell 1 unit of the good on the primary market, a seller first had to purchase a permit on the secondary market
- PERMITS effective in pushing the volume down to the Pareto optimal level of 13, and price up to eq. level of 2.69
- ALSO the price per permit converged to the equilibrium level of $.36 (check with the picture in the original paper, p.110)
- more efficient than TAXES in terms of surplus captured by subjects

4. Standards policy

- at the top of each graph, see the mean price and the number of units sold in each period
- number of trades is limited to 13; first-come, first-served

FIGURE 17.10 The results of Plott's experiments to evaluate the interventionist solutions to an externality: Standards.

The standards and charges intervention was the least effective of the three forms of intervention tested by Plott. It led to prices that were not at the optimal level for society.



Q: What has changed? What can you conclude from the figure above?

- the least efficient way of intervention
- because the total number of permits was limited to 13, the subjects rushed into concluding the deals => dispersed prices, means close to the levels with no intervention

CONCLUSION:

- with efficiency measured as ratio of total earnings captured by subjects to total earnings possible
- the LEAST efficient is the unregulated market
- the MOST efficient is the permits policy
- theoretical predictions supported by the data