

# **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

## **Interventionist solutions to the Externality problem – Pigouvian taxes and standards and charges:**

Schotter, Microeconomics, A Modern Approach (2nd edition), Chapter 17, Sections 17.3 & 17.4

Plott, Externalities and Corrective Policies in Experimental Markets

## **In class experiment on public good provision:**

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)

### **Nature of environmental problems**

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

### **Current issues in Europe and the CR**

- a) water and air pollution, greenhouse effect (how to manage with growing industrial production, transportation)
- b) soil pollution (industrial fertilizers)
- c) energy intensity
- d) noise (transportation air/road/railway)

- e) waste management
- f) decrease in biological diversity and ecological stability (due agricultural production and fragmentation of the landscape due transportation and urbanization)

### **Instruments of environmental protection**

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

→ we will look into various instruments and will examine and compare their potential to treat various environmental problems... for that **Environmental/Behavioral/Experimental Economics** is a very useful tool

### **Environmental economics**

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

**Use of Experimental Methods** is discussed in the following two academic articles

**(G&G)** Greenstone, M., Gayer, T., (2007), Quasi-Experimental and Experimental Approaches to Environmental Economics, RFF Discussion Paper 07-22.

**(L&L)** Levitt, S., D., List, J., A. (2009), Field experiments in economics: The past, the present, and the future, European Economic Review 53, 1-18

- we will review couple of experimental articles throughout this course, why? b/c they (not only) provide an important insight on environmental measures employed by governments and NGOs

### **Benefits of employing Experimental Methods**

- A new drug is tested to make sure that it has the expected effect and at the same time that it is not outweighed by possible side-effects
- Explaining or predicting non-experimental outcomes
- Testing theoretical predictions
- 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

- the cost of experiments are low relative to putting inefficient/potentially harmful measures in practice

### **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."
- market failures can be viewed as scenarios where individuals' pursuit of pure self-interest leads to results that are not efficient – that can be improved upon from the societal point-of-view.

**Externality** one of the common causes of market failure -> another key concept of environmental economics,

**Externality** of an economic transaction is an impact on a party that is not directly involved in the transaction. The basic idea is that an externality 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 [and therefore typically results in a market failure].

- o **Positive externalities** - an action that imposes a positive side effect on a third party
- o **Negative externalities** - 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.

**Can you think of couple of examples on**

- a) positive externalities**
- b) negative externalities**

### Examples of positive externalities:

- A **beekeeper** keeps bees for their honey. A side effect or externality associated with his activity is the pollination of surrounding crops by the bees. The value generated by the pollination may be more important than the value of the harvested honey.
- An individual planting an **attractive garden** in front of his or her house may provide benefits to others living in the area, and even financial benefits in the form of increased property values for all property owners.
- **Home ownership** creates a positive externality in that homeowners are more likely than renters to become actively involved in the local community.
- **Education** creates a positive externality because more educated people are less likely to engage in violent crime, which makes everyone in the community, even people who are not well educated, better off.

### Examples of Negative Externalities

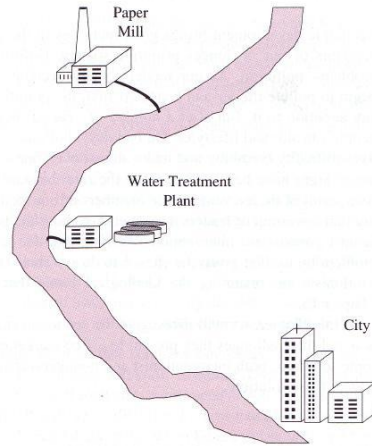
- **Transportation:** drivers imposing congestion cost on other drivers, pollution created affects health and quality of life of those living nearby roads
- **Industrial Production:** producing (as a by-product) greenhouse gas emissions from burning oil, gas, and coal -> climate change imposing cost on whole society
- **Water pollution** by industries that adds poisons to the water, which harm plants, animals, and humans.
- **Industrial farm animal production** – farms that were maybe more efficient as regards the production costs/revenues but they contributed to the increase in the pool of antibiotic-resistant bacteria because of the overuse of antibiotics + air quality problems + the contamination of rivers, streams, and coastal waters with concentrated animal waste + animal welfare problems, mainly as a result of the extremely close quarters in which the animals are housed.
- **Fishing:** harvesting by one fishing company in the ocean depletes the stock of available fish for the other companies and overfishing may be the result. This is an example of a common property resource, sometimes referred to as the **Tragedy of the commons**.
- **Consumption of alcohol** in some cases leads to drinking and driving accidents which injure or kill pedestrians and other drivers.

In these situations (speaking of negative externalities) the marginal social benefit of consumption (i.e. benefit of consuming one more unit of a product) is less than the marginal private benefit of consumption. This leads to the good or service being over-consumed relative to the social optimum -> **Market failure**. Without any corrective measure, the good or service will be under-priced as the negative externalities will not be taken into account.

## Illustration

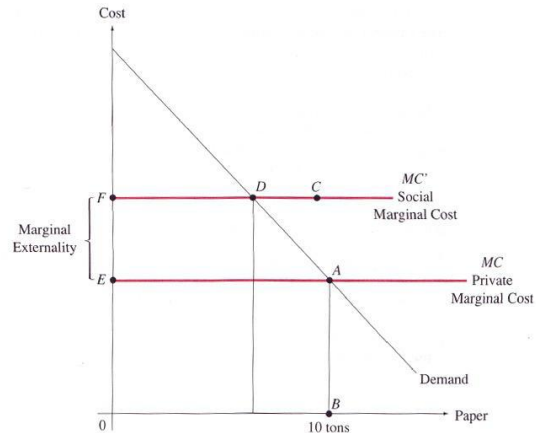
**FIGURE 17.1** Dolan's water-paper society.

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 (Italian economist)
- Situations in which it is **impossible to make one person better off without necessarily making someone else worse off**.

...a related concept is that of

### Pareto improvement

- given a set of alternative allocations of goods (or outcomes) for a set of individuals, Pareto improvement is 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**" when **no further Pareto improvements can be made**.

... so if the market fails to achieve the most efficient outcome, looking for Pareto improvement means looking for ways to make things work more efficiently (i.e. allocate resources more efficiently, or make consumption decisions of individuals more efficient)... when the efficiency cannot be improved anymore, the market is at Pareto optimal state = Pareto Efficient allocation = Allocative efficiency

- 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:** allocation of production inputs (capital and labor) is Pareto-efficient if it is not possible to re-allocate these inputs and produce more of at least one good in the economy without decreasing the amount of some other good that is produced

**A simple illustrative example:**

Imagine that Robinson Crusoe has invented a machine that can make two mangoes out of one coconut. Conversely, the machine can make one coconut out of two mangoes.

Assume that Crusoe's utility is  $U(c,m)=c*m$  (and thus marginal utilities are  $U'_m=c$  and  $U'_c=m$  meaning that the more of mangoes he consumes the happier he is from each additional piece of coconut and vice versa) .

Suppose Crusoe has, initially, four mangoes and four 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... Robinson would obviously end up with 3 coconuts and 6 mangoes in the P-E allocation.

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 3<sup>rd</sup> 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)

i) and ii) are interesting from the point of view of environmental economics (more details to follow), iii) is not so important 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**.
- this makes production of public goods problematic...
- markets alone might fail to produce optimal (or desired, for that matter) amount of public goods -> market failure.
- (clean) environment in general is an example of public good

In real world, there may be no such thing as an absolutely non-rivalrous 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....

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

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

- a) excludable but non-rival (like cable TV)
- b) non-excludable but rival (like public park... with too many visitors it becomes less enjoyable)

### **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, of public good... as individuals cannot be excluded from consumption of public good, they can often take advantage of public goods without contributing sufficiently to their creation. 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** and 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
  - o needs to know the cost of each alternative
  - o 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...

But that 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. In that case, you have no incentive to report truthfully -> your “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)

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

### Solutions:

- **Lindahl “free market solution”**
  - relies on everyone truthfully revealing their preferences for public good; then the government serves as a “coordinator” (no intervention)
    - o sets everyone’s’ share on the total cost if the good is provided
    - o 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 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).

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

**Proposed solution:**

- i) 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.
  - ii) an **auction election mechanism:**
    - people submit their bids (bidding the money one is willing to pay and the quantity demanded);
    - then if 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)
- **Coase argument:** with no transaction cost and unilateral property rights, most conflicts could be resolved by private bargaining [more on that later]
  - **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 optimum
  - 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.
  - an **exclusion mechanism (club goods)** is another solution, which has evolved for information goods, is to introduce exclusion mechanisms which turn public goods into club goods.
  - support public mindedness by **tradition** and **social norms** (a non-market solution)

**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.
  - o 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
  - o is this goes on and on the land is eventually damaged for all as a result.
  - o 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.
  - o 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** (hence 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?):

Example:

Automobile pollution

- each automobile lowers the air quality
- it is not likely that the free market would result in the optimal amount of pollution

→ One possible solution is emission standards for automobiles:

- 1963 Clean Air Act and its amendments set automobile emission standards for the manufacturers of vehicles in the US
- Is this solution the best possible?
- Lawrence White looked into this, examining the costs and benefits of this program
  - cost of emission control equipment is estimated at \$600 per car,
  - extra maintenance cost at \$180 per car,
  - the cost of reduced gasoline mileage and the necessity of unleaded gasoline at about \$670 per car

→ total cost at **\$1450** (in 1981 dollars)

- White identifies the following problems:
  - everyone who buys a car must pay extra \$1450, whether they live in high pollution 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 would face the true cost of generating pollution, which would encourage them to generate "socially optimal amount of pollution" (or, well, at least closer to it)
  - **Why should it work better?**
  - the system would encourage the owners to search for low-cost ways of reducing their emissions, including changing their driving habits and 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

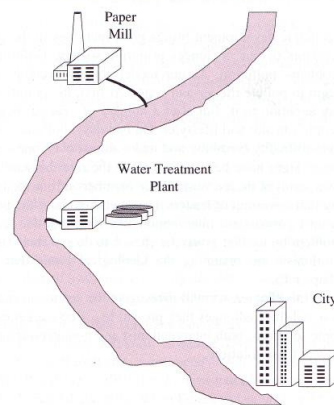
#### Interventionist solutions:

1. Pigouvian Taxes
2. Standards and Charges
3. Marketable Pollution Permits

#### 1. 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.



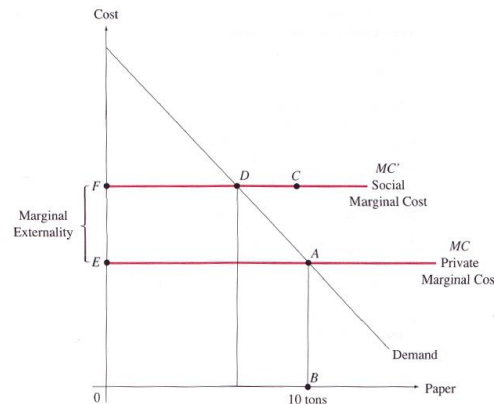
- the society produces paper (paper mill=PM) and clean water (water treatment plant = WTP)
- PM dumps waste into the river and thereby increases the cost of cleaning it => **externality** (as this cost is external to the mill, it is borne by the WTP) => not taken into account when making production decision (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**
- **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 a 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 ...

## WHY?

**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
- ⇒ 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  $(200p/2000p)=1/10 \times .05 = .005$  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, so 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?**

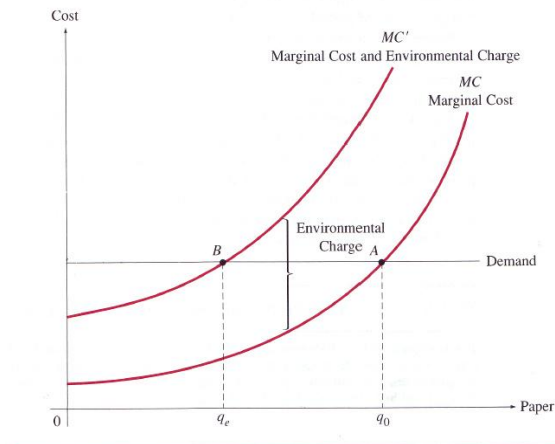
- ⇒ **PROBLEM** – To set the tax, the government needs to know the exact amount of the externality (the cost). The afflicted party, however,
  - might not be able to estimate accurately
  - might have incentives to exaggerate (both, the mill and the WTP)

## **2. 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.

**Case I: Single firm****FIGURE 17.3** The effect of an environmental charge on a single firm.

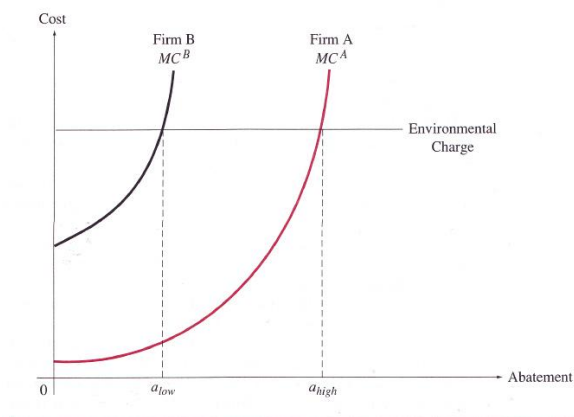
The imposition of an environmental charge equal to the distance between the marginal cost curves  $MC$  and  $MC'$  induces the firm to cut back its output from  $q_0$  to  $q_e$ .



- 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  $MC \Rightarrow$  it will produce at point A
- charge  $\Rightarrow MC' \Rightarrow$  it will produce at point B
- Ideally, with  $q_c$  the production of waste is at the STANDARD

**Case II: Two or more firms****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 ( $a_{low}$ ).



- 2 firms: mill A produces 70 gallons of waste a day, mill B 30 gallons. Say the STANDARD 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 – once the environmental charge (per unit of pollution) is set, each firm will reduce by the corresponding amount.  $a_{low} + a_{high} = a_{total}$  ( $MC^A = MC^B = \text{charge}$ ; 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?**)

Note the difference between the two mechanisms: tax is per unit of paper while charge is per unit of pollution.

### 3. 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
- The 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...
- we will talk more about this next week.

#### A. Experimental Evidence

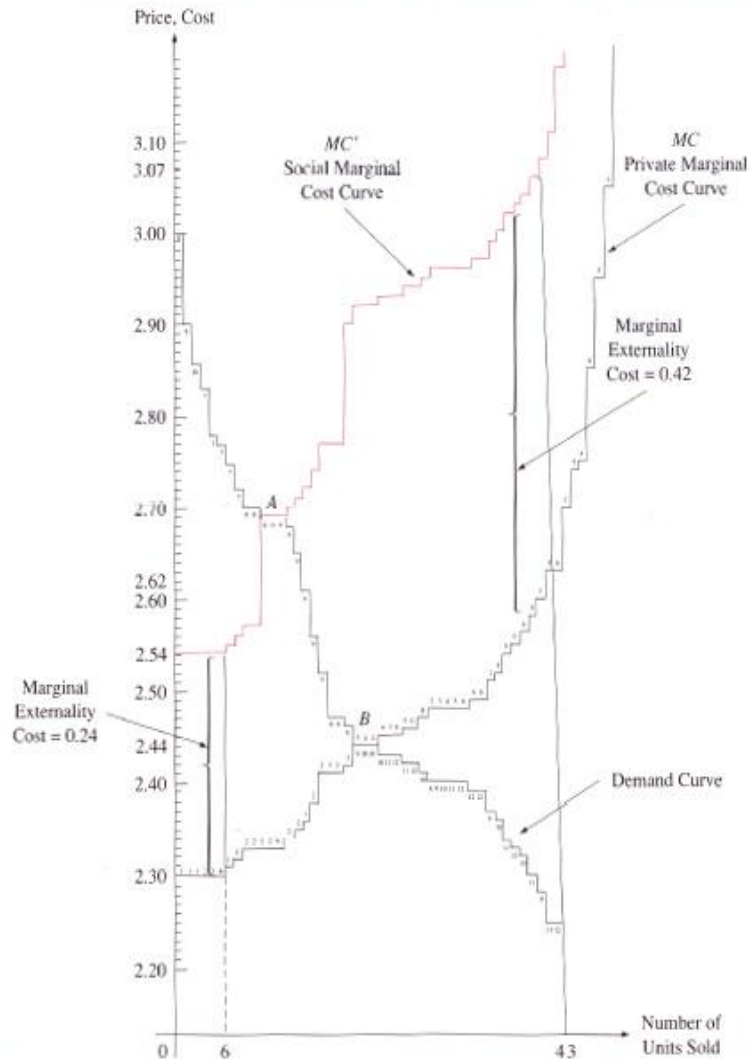
Based on: Plott, Externalities and Corrective Policies in Experimental Markets, also Schotter, Section 17.4

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)
- 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.

**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.



- Note that after 6 units sold, the marginal externality cost is \$.24, after 43 transactions, it is \$.42
- Pareto optimal solution -- **point A** (13 units at price \$2.69), 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:
  - ⇒ "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?)

⇒ “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

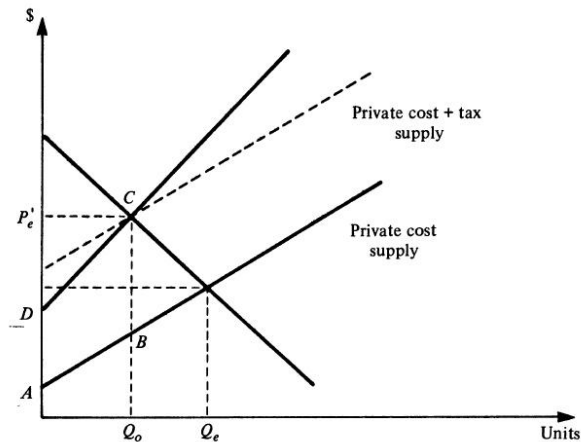


Fig. 2

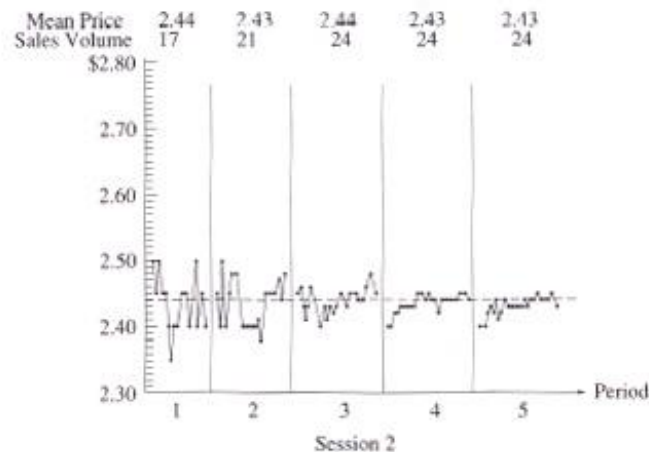
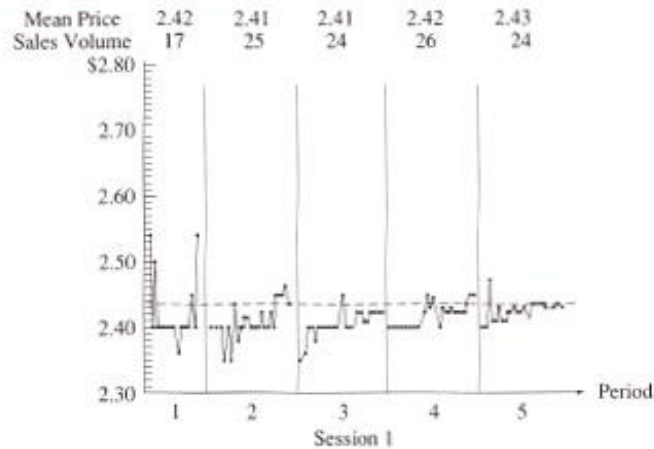
- 1. Market with externality** (no policy, 5 periods in each)
  - benchmark, to see the market solution (expected to end up at point B)
- 2. Pigouvian Tax policy** (6+7 periods)
  - the amount of marginal social cost is calculated at the optimum quantity  $Q_0$ , and is imposed on sellers as a per unit tax. Tax revenues are then redistributed back.
- 3. 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)
- 4. 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 =  $Q_0$ ; licenses should be held by the low-cost sellers

**RESULTS:**

## 1. Market with externality

**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.

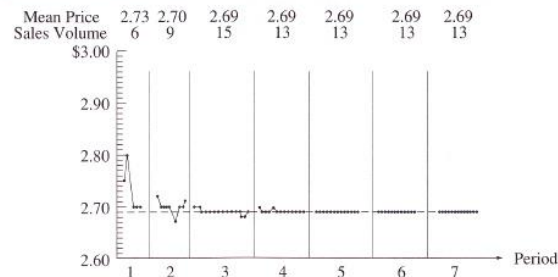


- unregulated market
- at the top of each graph, see the mean price and the number of units sold in each period
- in both sessions
  - the volume sold tended to move toward the competitive eq. of 24 units
  - price close to the competitive equilibrium level of \$2.44
- **the market failed => the theoretical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

## 2. Pigouvian tax policy

**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.

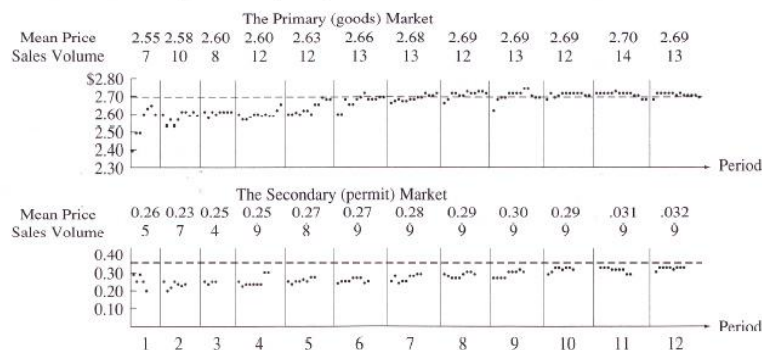


- **Q: What has changed? What can you conclude from the figure above?**
- marginal social cost, calculated at the optimum quantity  $Q_0$ , is imposed on sellers as a per unit tax
- at the top of the graph, see the mean price and the number of units sold in each period
- cost schedule is increased by 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

## 3. Permits policy

**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.



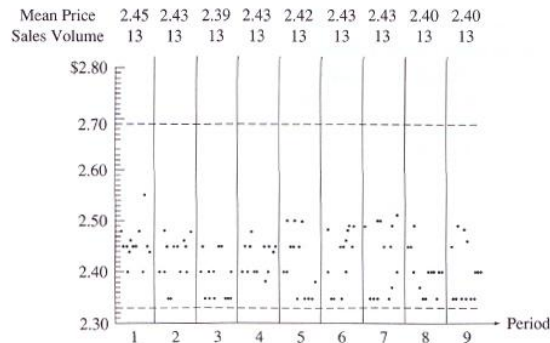
- only 13 (=  $Q_0$ ) permits exist and only licensed units can be produced, price of licence should = marginal externality at  $Q_0$
- **Q: What has changed? What can you conclude from the figure above?**

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

### Standards policy

**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.



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