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

Last week we talked about

- current environmental problems
- basic theoretical concepts such as
  - pareto-optimality
  - market failures
  - externalities positive or negative
  - public goods, free-riding, solutions
- The inconvenient truth film

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?):

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)

Any Problem?

How does this affect incentives of consumers/drivers?

Mileage?

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

- 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 (even more so 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 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 type of vehicle (more eco)

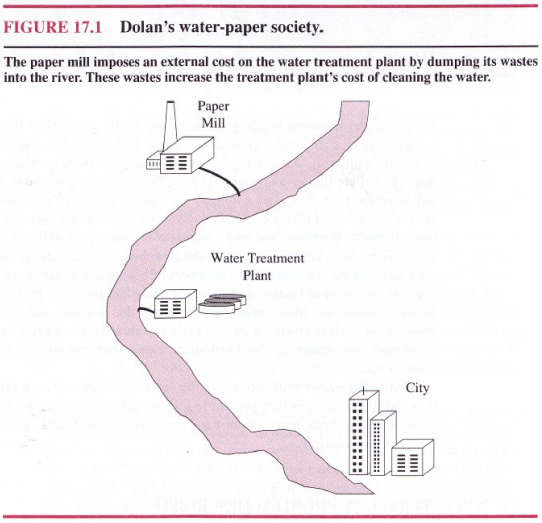
INTERVENTIONIST SOLUTIONS TO THE EXTERNALITY PROBLEM

- 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



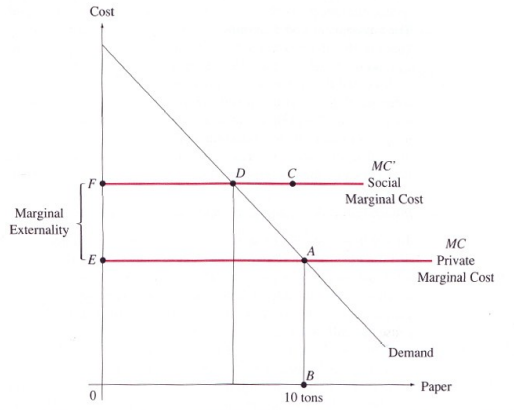
- the society produces paper (paper mill=PM) and clean water (water treatment plant = WTP)
- PM dumps waste into the river and thereby increases the cost of cleaning it => **externality** (as this cost is external to the mill, it is borne by the WTP) => not taken into account when making production decision (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)=1/10x$.05=$.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,

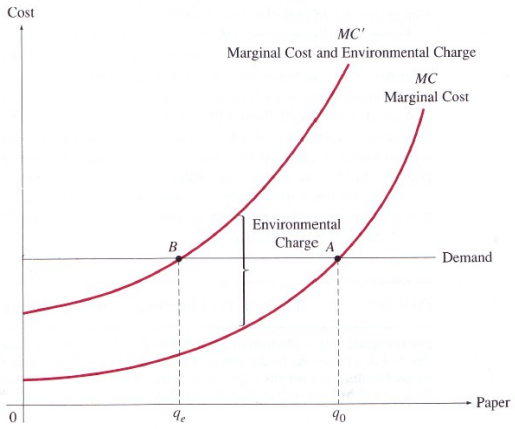
- might not be able to estimate accurately
- might have incentives to exaggerate (both, the mill and the WTP)

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.

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.



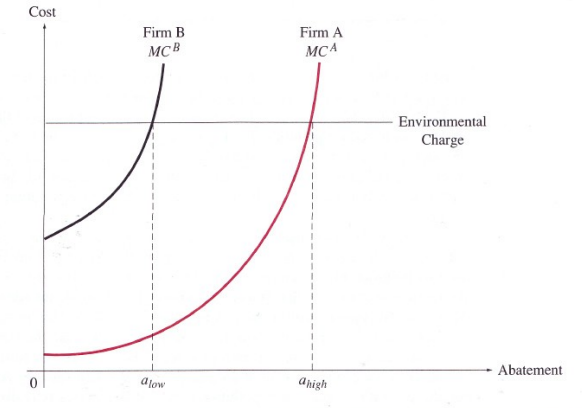
Case I: Single firm

- 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

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 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 – 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?**)

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
- 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 next week

A. Experimental Evidence

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

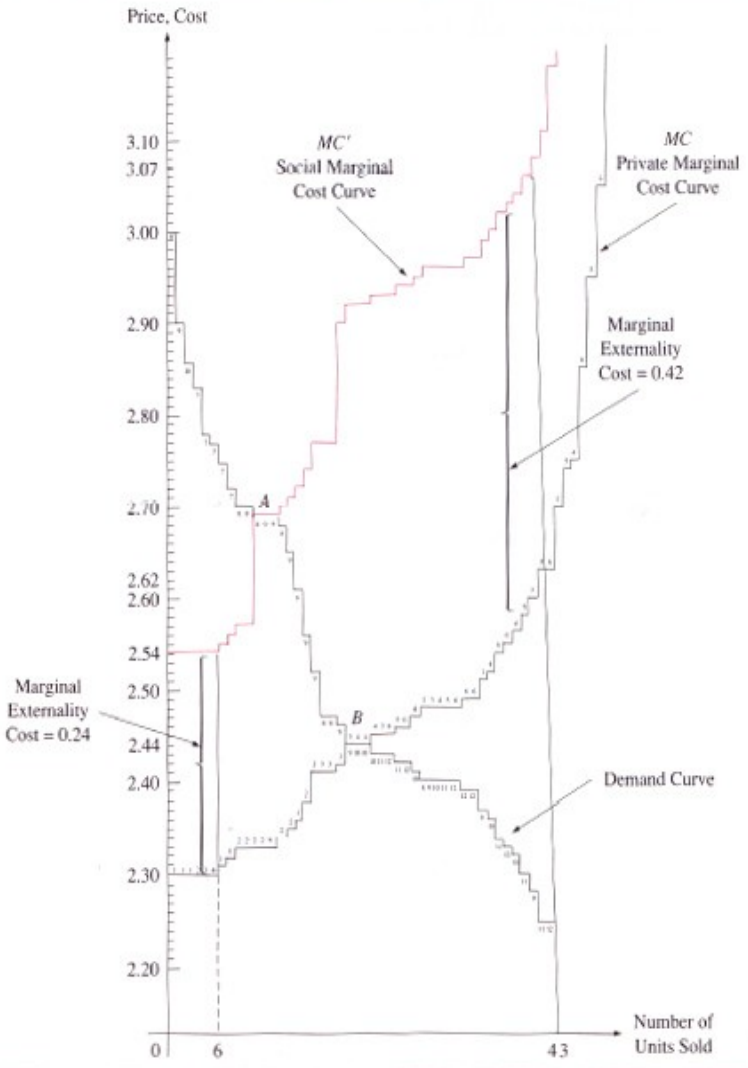
A series of experiments to evaluate how well the interventionist solutions work in practice

- 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)
- 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 **[Can you think of real-life analogy?]**

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

- 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

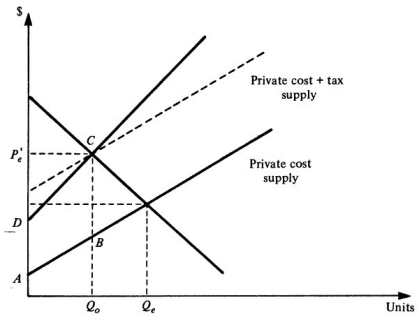


Fig. 2

Q: How are the individual interventionist solutions implemented?

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:

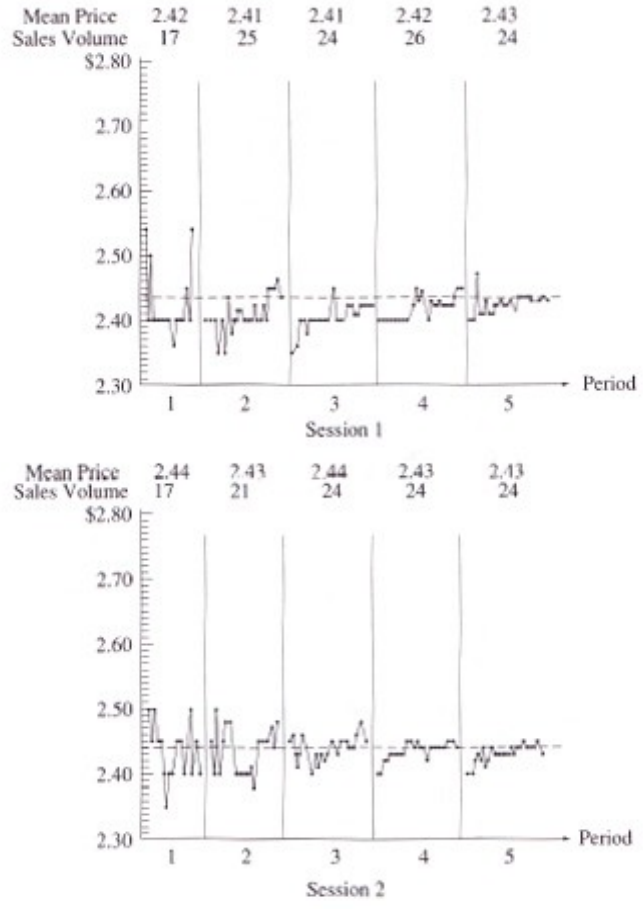
1. Market with externality

Q: What can you conclude about the results 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.

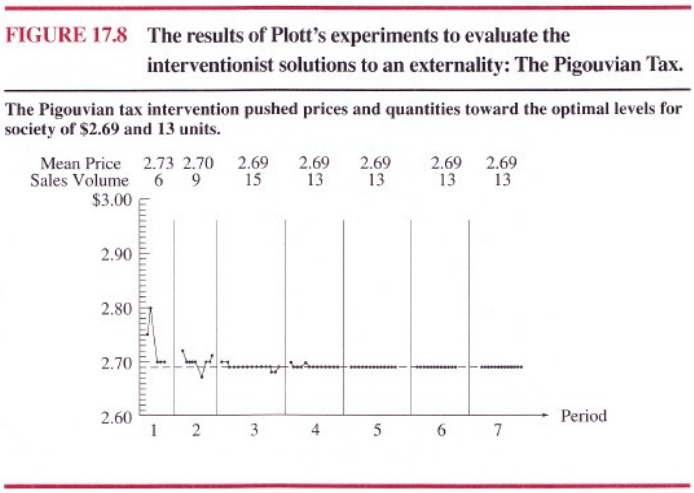


- unregulated market

- 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

2. **Pigouvian tax policy**

- at the top of the 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?

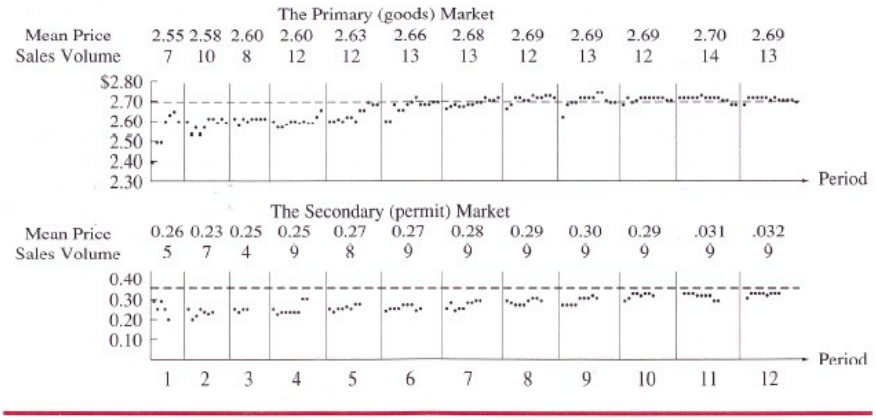
- marginal social cost, calculated at the optimum quantity Q_0, is imposed on sellers as a per unit tax
- cost schedule is increased by a tax equal to the amount of marginal externality
- the imposition of tax simply becomes a change in supply
- TAX effective in pushing the volume down to the Pareto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

3. 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 licence 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?

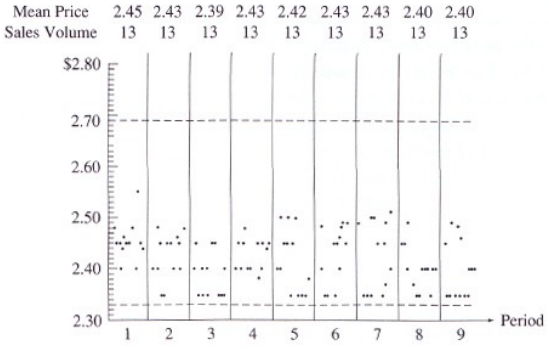
- secondary market for permits is created: in order to sell 1 unit of the good on the primary market, a seller first had to purchase a permit on the secondary market
- PERMITS effective in pushing the volume down to the Pareto optimal level of 13, and price up to eq. level of 2.69
- ALSO the price per 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

- 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**

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