Lecture 5: Externalities

Economics 336

Introduction

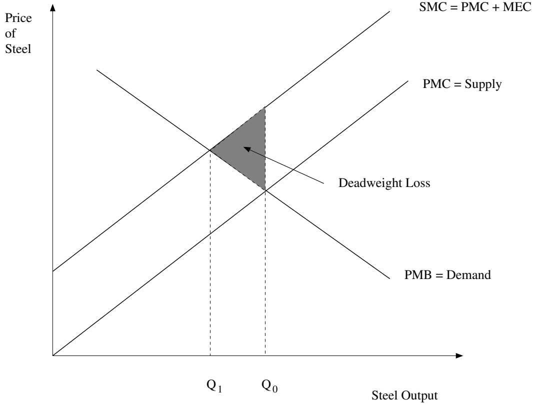
Externality: an action by one agent that results in costs or benefits accruing to another agent, for which no compensation is paid or redress given.

1. Review of the basic issue:
   - Standard example: air pollution (a *negative* externality).
   - Unregulated actions of private agents results in too much of a negative externality like pollution being provided – First Welfare Theorem does not apply.
2. Dealing with externalities:
   - private market solutions
   - public policy solutions based on prices
   - public policy solutions based on quantities

Review of basic theory

Classic example: a steel plant located next to a laundry. A *negative production externality*:

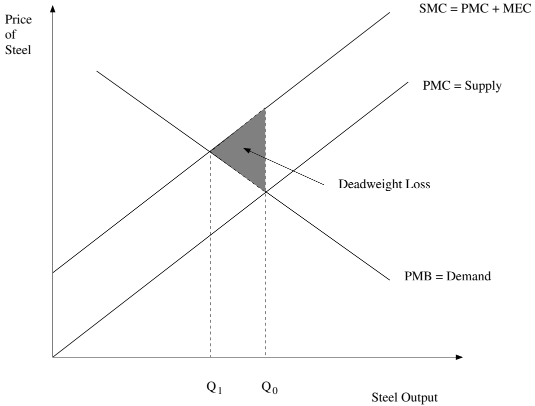
- The steel mill uses coal to produce steel, which produces soot.
- Soot makes it more costly for the laundry to clean clothes.



Key concepts:

- *private marginal cost*: MC of steel borne by steel firm.
- *marginal external cost*: MC of steel borne by laundry.
- *social marginal cost*: MC of steel to society.

In this case, the First Welfare Theorem fails: private costs do not equal social costs.



Numerical example

Exercise: Externalities in competitive markets

Let the cost functions of the firms

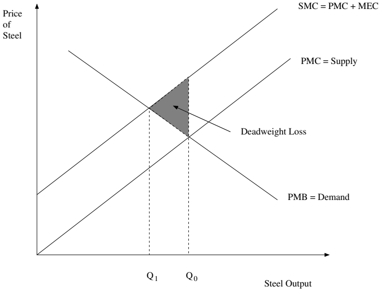
$$C_s(y_s) = \frac{1}{2}y_s^2$$
$$C_l(y_l, y_s) = \frac{1}{2}y_l^2 + \frac{1}{2}y_s$$

where y_s = steel output, y_l = laundry output. Suppose that the prices (p_s, p_l) are fixed in world markets.

1. Solve for the unregulated equilibrium output of steel, and the socially optimally level.
2. How much higher is social welfare (joint profit) in the socially optimally outcome, compared to the unregulated equilibrium?

The Coase theorem

In our initial example, too much steel was produced because steel plant ignored marginal external costs.



Now suppose that laundry has a legal right to clean air and could force the steel plant to shut down. Then the steel plant could offer to pay *MEC* to the laundry for each unit of steel to avoid legal action.

The laundry should accept this compensation, and steel plant should reduce output to Q_1 to maximize profit.

Coase Theorem I

Where there are well-defined property rights and efficient bargaining, negotiations between polluter and victim will *internalize the externality* and lead to efficient outcomes, without government regulation.

All government needs to do is establish property rights and enforce them through the courts – no taxes or regulation.

Role of property rights: Now suppose that the law assigns property rights to the steel plant, not the laundry – more realistic in this case. Can efficiency be achieved?

Coase Theorem II

The assignment of property rights is irrelevant to the efficiency of the negotiated outcome.

Problems with the Coase theorem

The Coase theorem required efficient bargaining, and this may not be realistic. For example:

- **Asymmetric information.** If parties do not know each other's cost and benefits, bargaining may break down, leading to excessive transaction costs and inefficient pollution. Examples?
- **Holdups and Free-riding.** Many externalities are *widespread*: there are many polluters and many victims. So negotiations to abate pollution are a public good: no party has the right incentives to conclude the efficient bargain. When number of affected parties is large, transactions costs to private solutions may be high.
- **Compensation and excessive damage.** If victims anticipate compensation, they have incentives to increase scale of exposure to externality, in order to increase compensation. Example: Compensation for homeowners living near airports/railways lines: What effect will this have on housing markets?

Public sector remedies for externalities

Pigouvian taxation

Efficiency is achieved when polluter internalizes marginal external cost. This is called a *Pigouvian tax*.

In the example, a unit tax on steel production equal to $t = MEC = \partial C_l / \partial y_s$ achieves efficiency.

At the optimum, polluter can pay for the right to pollute.

- there is some price people are willing to accept to tolerate the pollution.

Alternative policies often used:

- *Fines on polluters:* Set maximum pollution quantity and a "fine" of *MEC* if this level exceeded. (What difference would this make?)
- *Abatement subsidies:* A subsidy of *MEC* paid to polluter for reducing its pollution. (What difference would this make?)

Public sector remedies for externalities

Command-and-control regulation

In practice, governments often use quantity regulations, not prices or taxes, to address externalities. Examples:

- Quantity limits on pollution, e.g. fuel economy standards for cars, bans of lawn pesticides and other chemicals, plant-by-plant limits on sulphur dioxide emissions to control acid rain.
- Technology standards: Regulations require “best available technology” to control pollution; e.g. catalytic converters in gasoline engines, ban on styrofoam cups, elimination of coal-fired power plants in Ontario, etc.

How do we evaluate quantity regulations, compared to tax/price policies?

Taxes versus standards: An equivalence result

Simple model: single steel plant with initial pollution level Y^0, abates pollution to $Y = Y^0 - A$. The cost of abatement is $C(A)$, the external benefit of abatement is $B(A)$. (What are the supply and demand curves for abatement?)

Quantity standard. The social planner solves $\max B(A) - C(A)$ so optimal abatement A^* solves

$$B'(A^*) = C'(A^*)$$

which can be achieved with a quantity standard $Q = Y^0 - A^*$.

Pollution tax. With a tax on pollution $t = B'(A^*)$, steel firm maximizes profit

$$\max -t(Y^0 - A) - C(A)$$

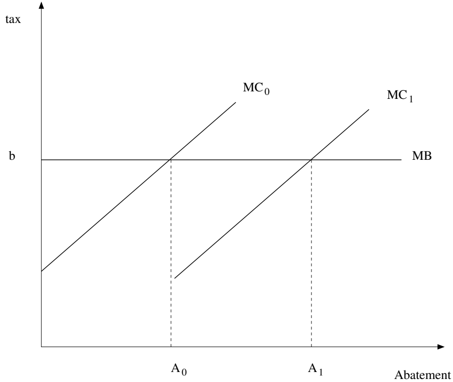
and so sets

$$C'(A^*) = t = B'(A^*)$$

A Pigouvian tax decentralizes the optimum.

The problem with quantity regulation

Suppose now there are two polluters with abatement cost functions $C_i(A), i = 0, 1$. Suppose that $C_0'(A) > C_1'(A)$: abatement is more expensive at the margin for polluter 0.



With two polluters, the social planner solves

$$\max B(A_0 + A_1) - C_0(A_0) - C_1(A_1)$$
$$\Longrightarrow B'(A_0^* + A_1^*) = C_0'(A_0^*) = C_1'(A_1^*)$$

Since $C_0'(A) > C_1'(A)$, we know that $A_0^* < A_1^*$: more abatement by those for whom it is less costly, not necessarily the bigger polluters.

Decentralizing the optimum.

- We know this can be decentralized with a Pigouvian tax $t = B'(A_0^* + A_1^*)$.
- If the planner knows the polluters' cost functions, it can also be achieved with firm-specific quantity standards $Q_i = Y_i^0 - A_i^*$.
- If individual abatement cost functions are unknown to the planner, then a Pigouvian tax is superior to a quantity standard.
  - Exercise: In the preceding example, show that a uniform quantity standard is inefficient.

Cap-and-trade regulation

Alternatively, planner can assign pollution permits to polluters, but let them trade in a market.

- This is often proposed to regulate greenhouse gas emissions, in lieu of a (Pigouvian) carbon tax.
- Permits can be given freely to polluters, or they can be auctioned off by government.

Example: Acid rain regulation

Primarily caused by SO_2 emissions from coal-fired power plants and metal smelters.

- Canada uses command-and-control quantity regulation: SO_2 emissions determined through negotiations between governments and each major polluter (e.g. no coal-fired generation in Ontario).
- US uses cap-and-trade: polluters are assigned permits for pollution which can be bought and sold in markets.

Prices vs. quantities

Let Q_i pollution permits be granted to polluter $i = 0, 1$, with $Q_0 + Q_1 = A$. Suppose the market price of pollution permits is p.

Polluters maximize profits

$$p(Q_i - Y_i^0 + A_i) - C_i(A_i)$$

so polluter chooses $C'(\hat{A}_i) = p$.

In equilibrium, the permit price adjusts so that

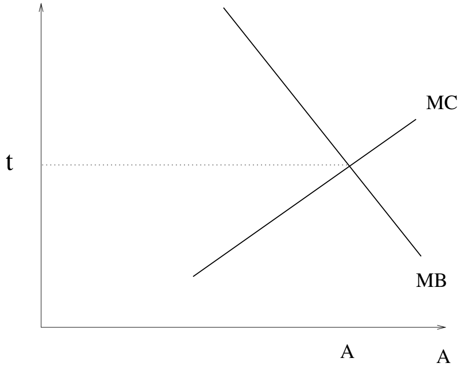
$$\hat{A}_0 + \hat{A}_1 = A$$

so that $p = B'(A)$ in equilibrium.

We know that a Pigouvian tax $t = B'(A)$ achieves the same outcome. For any cap-and-trade limit A, there is an equivalent Pigouvian tax rate $t = B'(A)$.

How does the planner choose t or A if abatement cost functions are unknown? See analysis in Metcalf (2009), based on Weitzman (1974).

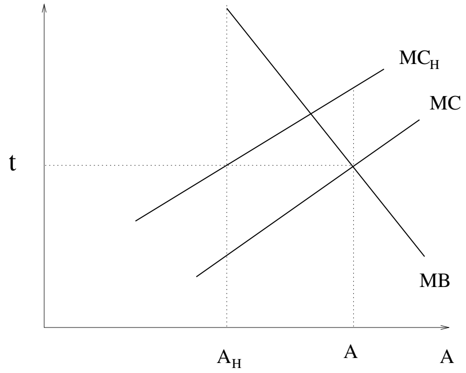
Prices vs. quantities: The role of uncertainty



Suppose initially that the benefit of abatement *MB* and the cost to polluters of abatement *MC* are known with certainty.

The figure again shows that either a Pigouvian tax *t* or an abatement standard *A* achieves efficiency in this case.

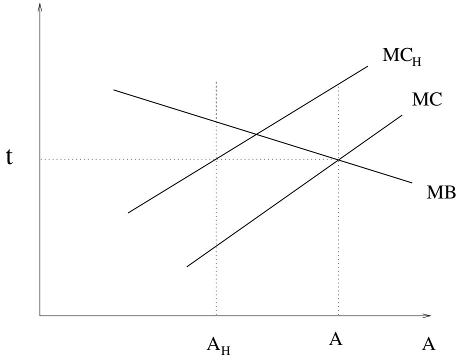
Prices vs. quantities: The role of uncertainty



Now suppose that the planner acts as though abatement cost is MC, but there is some probability true abatement cost is $MC_H > MC$.

What are the deadweight costs of the two policies in the event that true abatement costs are MC_H? Which policy is more efficient?

Prices vs. quantities: The role of uncertainty



Now suppose uncertainty about abatement costs is as before, but the marginal benefit of abatement is different. (In the previous case, the polluting activity has a "threshold effect"; here, $B'(A)$ is fairly constant.)

What are the deadweight costs of the two policies in the event that true abatement costs are MC_H? Which policy is more efficient?