31C01300 Energy & Environmental Economics

Lecture 2: Policy Instruments

Matti Liski

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The environmental policy problem

1. **The optimal policy**

What is the allocation of pollution that maximizes net benefits?

- How to measure benefits of environmental protection?
- How to measure cost?
- What is the optimal protection level?

2. **The cost efficient policy**

- How to achieve a given goal with minimum costs?
- Much of the economic analysis focuses on this question, largely because measuring benefits is difficult

Costs and benefits of SO2 reductions:

Table 1

Estimated Annual US Benefits and Costs of the SO_2 Allowance Trading Program; Title IV, Clean Air Amendments of 1990

(billions of US 2000 Dollars)

Benefits	
Mortality	50–100
Morbidity	3–7
Recreational visibility	2–3
Residential visibility	2–3
Ecosystem effects	0.5
Total	**59–116**
Costs	**0.5–2.0**
Net benefits	**58–114**

Source: Burtraw, Krupnick, Mansur, Austin, and Farrell (1998); Burtraw (1999); Chestnut and Mills (2005); Banzhaf, Burtraw, Evans, and Krupnick (2006).

Figure: See Stavings and Schmalensee in the readings folder

The optimal policy

To fix ideas:

- $i \in \mathcal{I} = \{1, .., N\}$, set of agents
- a_i, abatement by each source
- $B_i(a_1, a_2, ..., a_N)$, benefits for i
- $C_i(a_i)$, cost of abatement

The policy problem is to choose abatements such that the total gains are maximized:

$$\max_{\{a_1,...,a_N\}} \sum_{i=1}^{N} B_i(a_1, ..., a_N) - C_i(a_i)$$

The optimal policy

Marginal cost, $\frac{\partial C_i(a_i)}{\partial a_i}$, should equal the marginal gain,

$$\frac{\partial C_i(a_i)}{\partial a_i} = \sum_{i=1}^{N} \frac{\partial B_i(a_1, ..., a_N)}{\partial a_i}$$

Often the gains depend on the sum of actions so that $B_i(a_1, ..., a_N) = B(a_1 + ... + a_N)$ and

$$\frac{\partial C_1(a_1)}{\partial a_1} = ... = \frac{\partial C_N(a_N)}{\partial a_N} = NB'(a_1 + ... + a_N)$$

Cost efficiency: marginal abatement cost (MAC) should be equalized across agents.

The efficient policy: taxes

- τ, tax per unit of pollution
- u_i, unrestricted pollution by source i
- $u_i - a_i$, pollution after abatement

Firm i problem is to minimize costs:

$$\min_{a_i \leqslant u_i} C_i(a_i) + \tau(u_i - a_i)$$

The firm chooses

$$\frac{\partial C_i(a_i)}{\partial a_i} = \tau$$

Since this holds for all firms, we have

$$\frac{\partial C_1(a_1)}{\partial a_1} = \ldots = \frac{\partial C_N(a_N)}{\partial a_N}$$

Cost efficiency!

The efficient policy: tradable pollution permits

- E, total amount of pollution rights (permits)
- e_i, endowment of permits for i so that $e_1 + ... + e_N = E$
- p, market price for permits

Firm i problem is to minimize costs:

$$\min_{a_i \leqslant u_i} C_i(a_i) + p(u_i - a_i - e_i)$$

The firm chooses

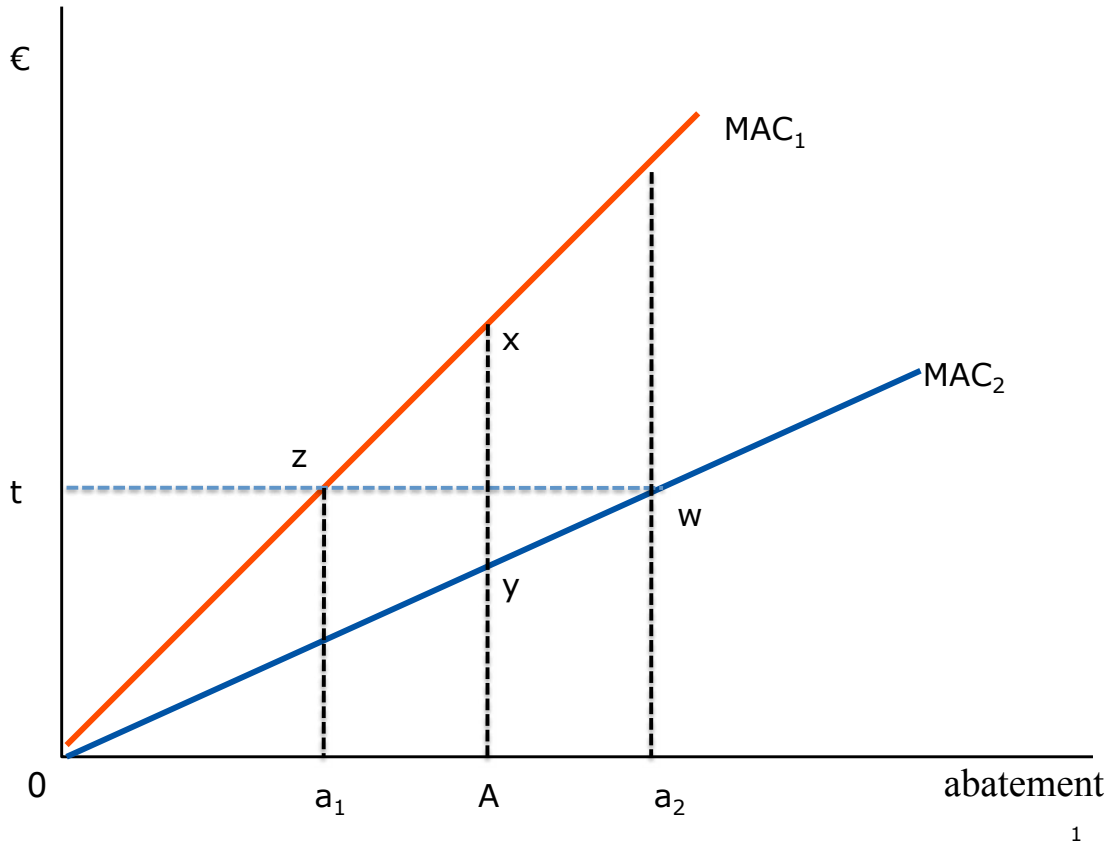
$$\frac{\partial C_i(a_i)}{\partial a_i} = p$$

Since this holds for all firms, we have

$$\frac{\partial C_1(a_1)}{\partial a_1} = ... = \frac{\partial C_N(a_N)}{\partial a_N}$$

Cost efficiency!

Can you identify the cost-savings under taxes and permits?



Uncertainty and the choice between prices and quantities

- Permits and taxes are equivalent instruments if the regulator knows the aggregate cost curves (for damages and abatement costs)
- The market-based instruments allow the regulator to ignore private information held by firms, that is, no need to know individual firm's costs
- Uncertainty about the aggregate cost of emissions reductions: Permits and taxes lead to different outcomes

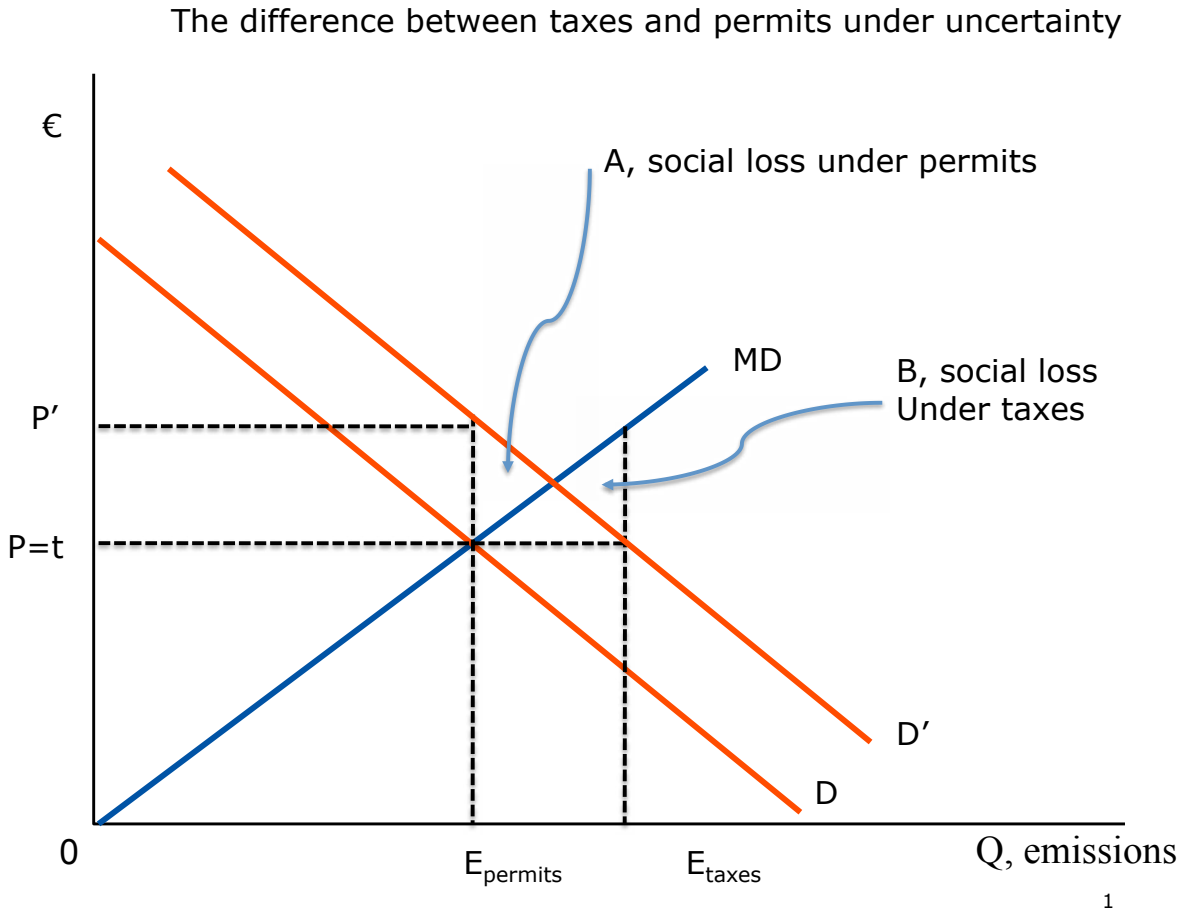
Prices vs. quantities

- Let D be the market demand of emissions. Without regulation, firms would produce until D=0. See figures below.
- The social marginal damage is MD, so that in the social optimum D=MD
- **Price regulation**: tax set at a level where D=MD
- **Quantity regulation**: supply of permits E such that the permit price settles at the desired level

Prices vs. quantities

- However, if D is not know at the time of regulation, D is only the expected value of emissions to firms. The true, realized value could be D', e.g., due to a boom. Then, the neither of the instruments is ex post optimal
- The social losses are given by areas A and B
- Depends on the relative slopes of the D and MD curves
- If MD is very steep, it is better to use permits. Makes sense: when serious damage can occur from excessive taxation, it is better to fix quantities. Toxic waste, for example.
- If MD is very flat, taxes are better. This is an argument for taxes in climate change

Prices vs. quantitites



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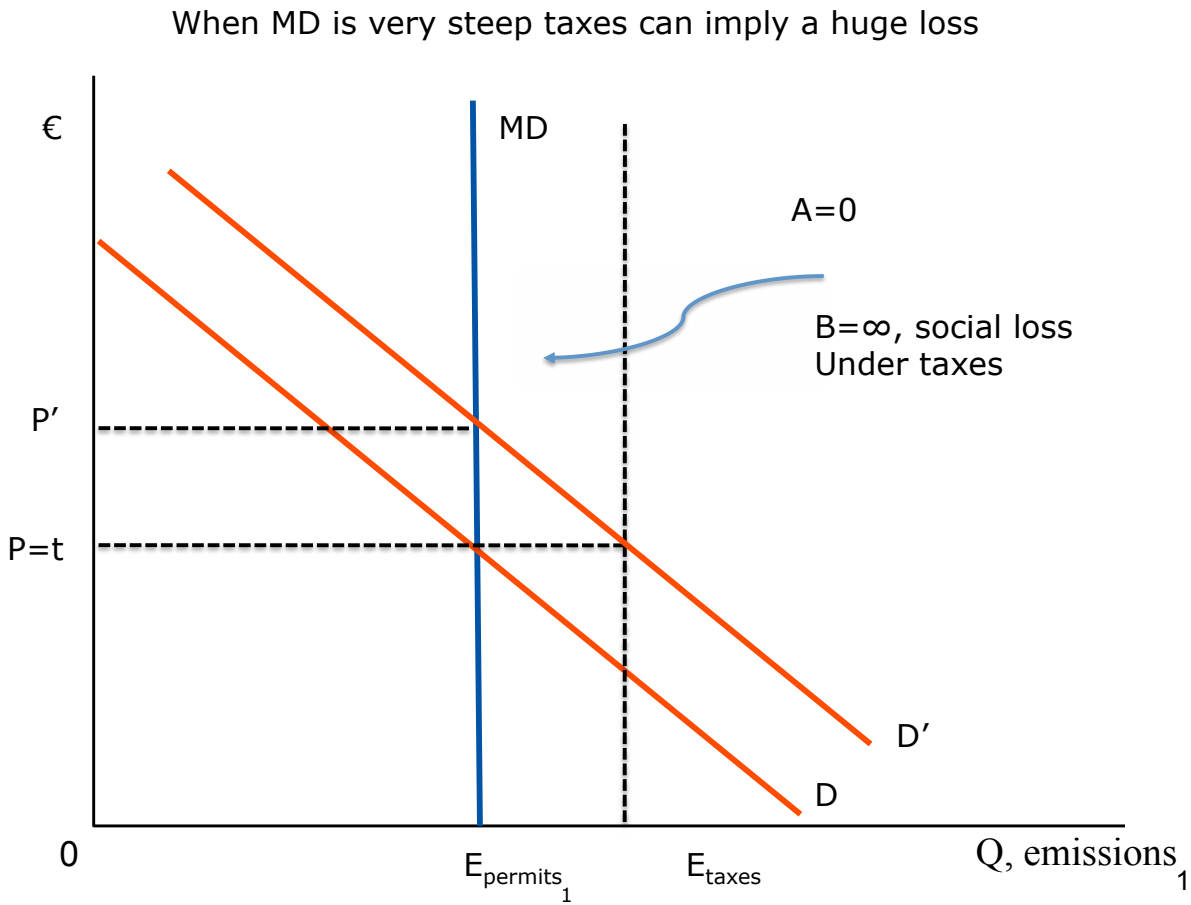

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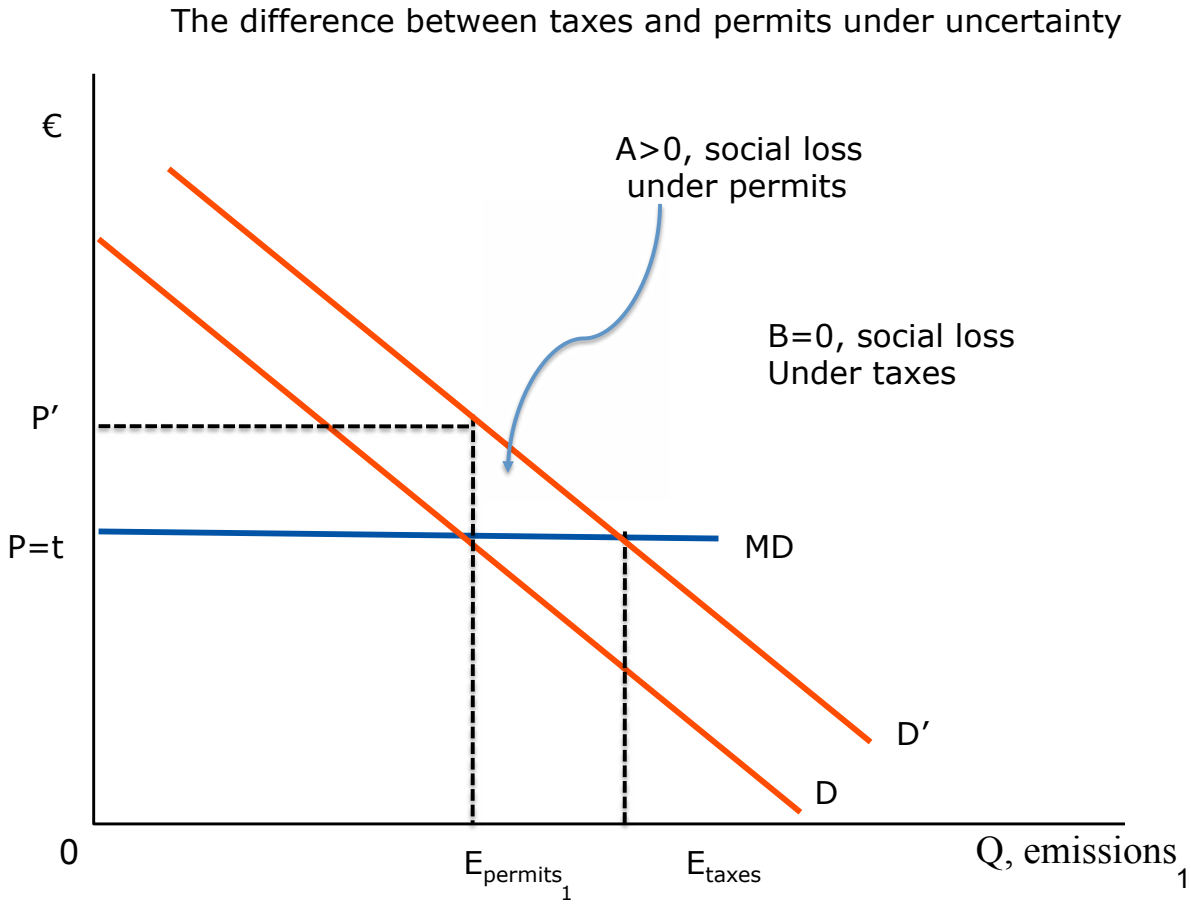

Comment on instruments: policies have distributional impacts

- Costs to Consumers (low income households spend a high fraction of income on heating fuel and electricity)
- Costs to Factors (firms invest in abatement technology, increasing the relative demand for capital, not labor)
- Benefits from Scarcity Rents (cap and trade systems usually handout valuable permits to shareholders)
- Benefits from Environmental Protection
- Costs of Transition (costs on laid off workers as % of income)
- Capitalization Effects (stock prices rise or fall, house prices rise or fall)

Source: Fullerton, see the readings folder