Fundamentals of Climate Policy Instruments:

Recorded Session #3

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Fundamentals of Climate Policy Instruments

I. Categorizing Pollutants: Temporal and Spatial Dimensions

II. Choosing Primary Policy Goal: Efficiency vs Cost-Effectiveness

III. Additional Criteria for Evaluating Pollution-Control Policies

IV. Analytics of Cost-Effective Policy Instruments

V. Key Types of Policy Instruments

   A. Technology Standards

   B. Performance Standards

   C. Emissions Taxes

   D. Emissions Trading: Cap-and-Trade and Emissions Reduction Credits

   E. Subsidies (mostly later in specific context of climate change policies)

VI. Comparison of Taxes & Trading

VII. Summary of Alternative Solutions to Environmental Problems

The Temporal Dimension

Let $E_t =$ emissions of pollutant at time t

$D_t =$ decay of pollutant at time t

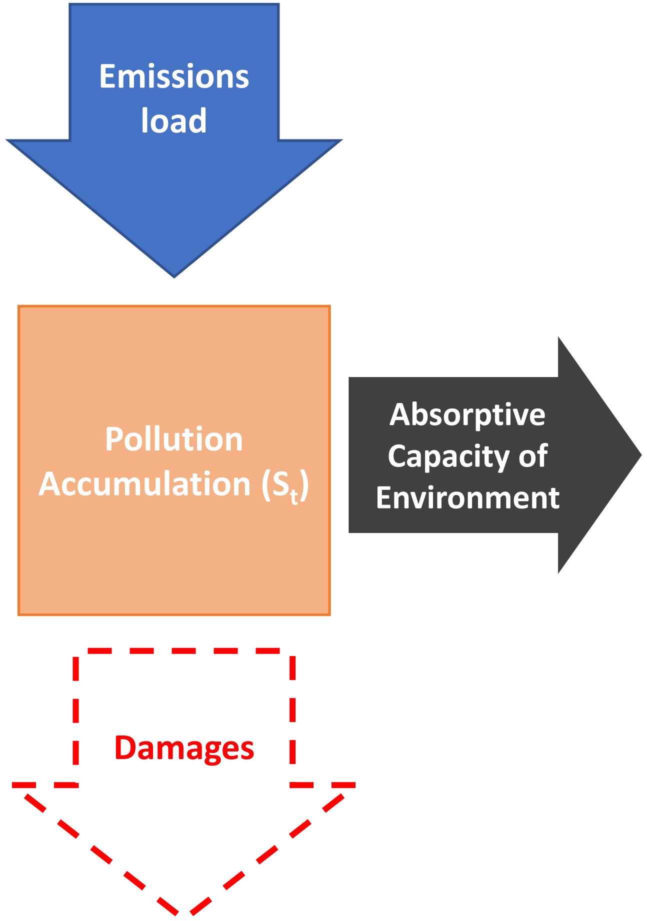
$S_t =$ stock of pollutant at time t

$$S_t = S_o + \sum_{i=1}^{t} E_i - \sum_{i=1}^{t} D_i$$

$$\frac{\Delta S}{\Delta t} \approx \frac{dS}{dt} = \dot{S} = E_t - D_t$$

Pure Stock Pollutant: $D_t = 0$ (~ climate)

Pure Flow Pollutant: $D_t = E_t$ (~ noise)



The Spatial Dimension

- **Relevant variable**: degree of mixing of pollutant in receiving body (airshed, watershed, etc.)
- **Local Pollutant**
  - Greatest damage near emission source
  - Example: carbon monoxide
- **Regional Pollutant**
  - Greatest damage far from emission source
  - Example: SO_2 and acid rain
- **Global Pollutant**
  - Damage distributed globally regardless of location of source
  - Example: CO_2 and climate change

Non-Uniformly Mixed Pollutants

↕

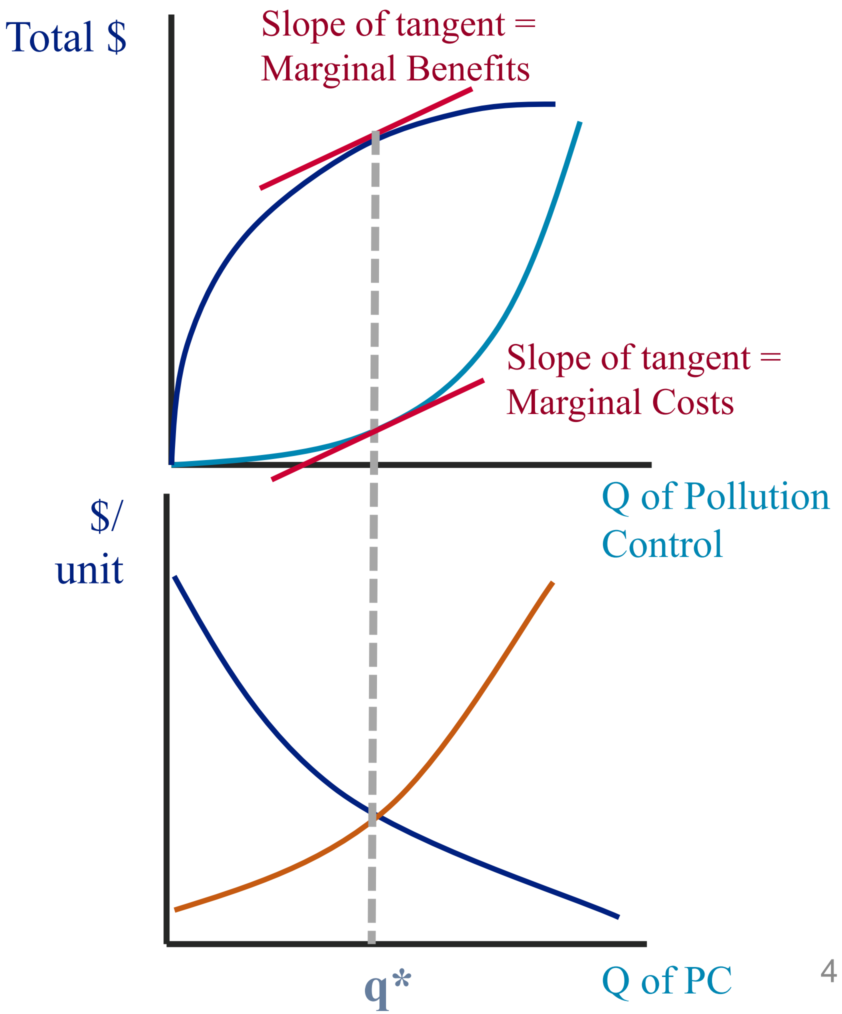
Uniformly Mixed Pollutants

Reminder: Economic Efficiency

- Economic efficiency criterion → Kaldor-Hicks benefit-cost analysis
- Formal efficiency criterion:

$$\max_{\{q_i\}} \sum \left[B_i(q_i) - C_i(q_i) \right] \Rightarrow q_i^*$$

- Difficult, because of need for benefit assessment!



More Modest Policy Criterion: Cost-Effectiveness

- More modest criterion: **cost-effectiveness** – does policy accomplish given goal in the least costly way?

- Mathematically, if goal is to achieve pollution reductions, Q, then we want to find the policy that minimizes cost to get there

$$\min_{\{q_i\}} \sum C_i\left(q_i\right) \quad s.t. \sum q_i \geq \bar{Q}$$

- Challenge: setting goal (total quantity of emissions reductions, Q) that's aligned with what's efficient

- Still useful, even if inefficient, but there are still other relevant criteria …

Criteria for Assessing Environmental Policy *Instruments*

1. Achieve stated goals/standards (whether or not efficient)
2. Cost-Effectiveness
3. Provide government with information it needs
4. Monitoring and enforcement possibilities
5. Flexible in the face of change (in tastes, technology, or resource use)?
6. Dynamic incentives for research, development, adoption, and diffusion of better pollution-control technologies?
7. Equitable distribution of economic & environmental impacts
8. Feasible, in terms of (political) enactment and (administrative) implementation

Intuition of Two Conditions for Cost-Effective Policy

1. Cost-Effectiveness Constraint

- Marginal private costs are equal at every firm.

$$MC_1 = MC_2 = MC_3 = MC_{4\ldots} \Rightarrow MC_i(q_i) = MC_j(q_j) \quad \forall i, j.$$

Intuition: Arbitrage argument - if the marginal costs of abatement at all firms aren't equal, then we could shift one unit of abatement from the higher marginal cost firm to the lower marginal cost firm. This would lower the overall cost without changing the quantity of pollution reduced.

2. Policy constraint

- Total reductions achieve policy target.

$$q_1 + q_2 + q_3 + q_4 + \ldots + q_n \geq Q_{Target}$$

Intuition: Otherwise, failure to satisfy criteria to achieve policy target

Alternative Environmental Policy Instruments

1. **Conventional (Command-and-Control) Approaches**

* a. Technology Standards

   i. Good News: low monitoring costs

   ii. Bad News: wrong goal, not c/e, no incentive for further technological change

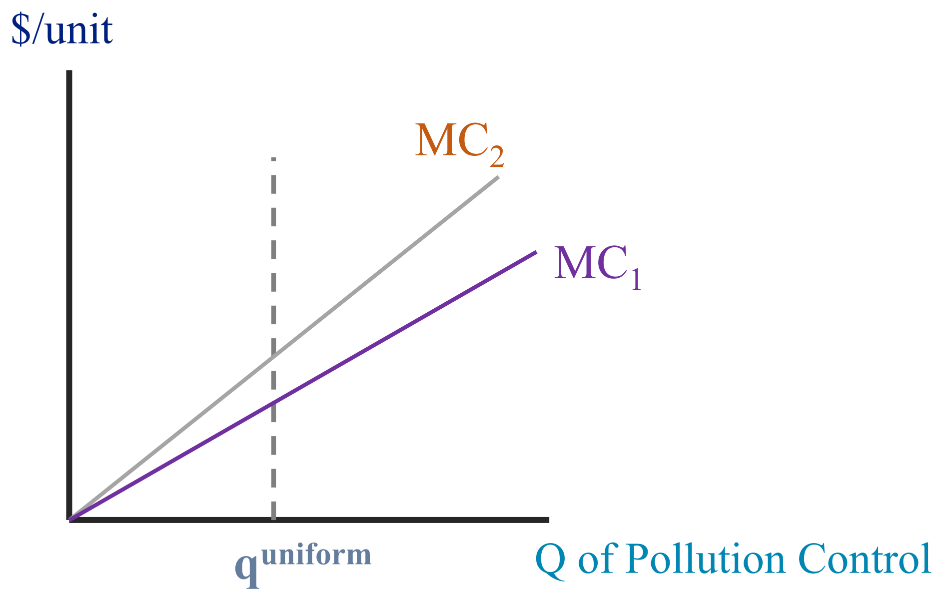
b. Performance Standards

* i. Uniform Emission Standard (not c/e) – see figure

   ii. Uniform Ambient Standard (not c/e)

Prescriptive Regulation (Command & Control)

- **Historically** most environmental regulation has been "command and control"
- **Technology standards** require all polluters to install specific piece of pollution control technology
  - Example: CAA required that all cars have catalytic converters
- **Performance standards** may allow level of pollution to vary among sources, but all sources must achieve same level of emissions per unit of production
  - Example: Steel industry emissions standards
  - Can be either mass-based limit or emissions rate per unit of product output
- **None of these approaches are cost-effective**
  - Do not equate marginal costs!



Alternative Environmental Policy Instruments

1. Conventional (Command-and-Control) Approaches

* a. Technology Standards
  - i. Good News: low monitoring costs
  - ii. Bad News: wrong goal, not c/e, no technological change
- b. Performance Standards
  - * i. Uniform Emission Standard (not c/e)
  - ii. Uniform Ambient Standard (not c/e)
  - * iii. Non-uniform standard
    1. Could be cost effective *in principle*
    2. *But* government lacks information (re abatement cost functions of all sources), & politics

Question: Is there a way the government can achieve **environmental objective**, do it **cost-effectively**, but **without information** about firms' abatement costs?

  - * i. Emissions/ambient fee (tax)
  - ii. Deposit-refund system
- b. Tradable Permits
  - * i. Cap-and-trade system
  - * ii. Emission-reduction-credit system

Pollution Charge

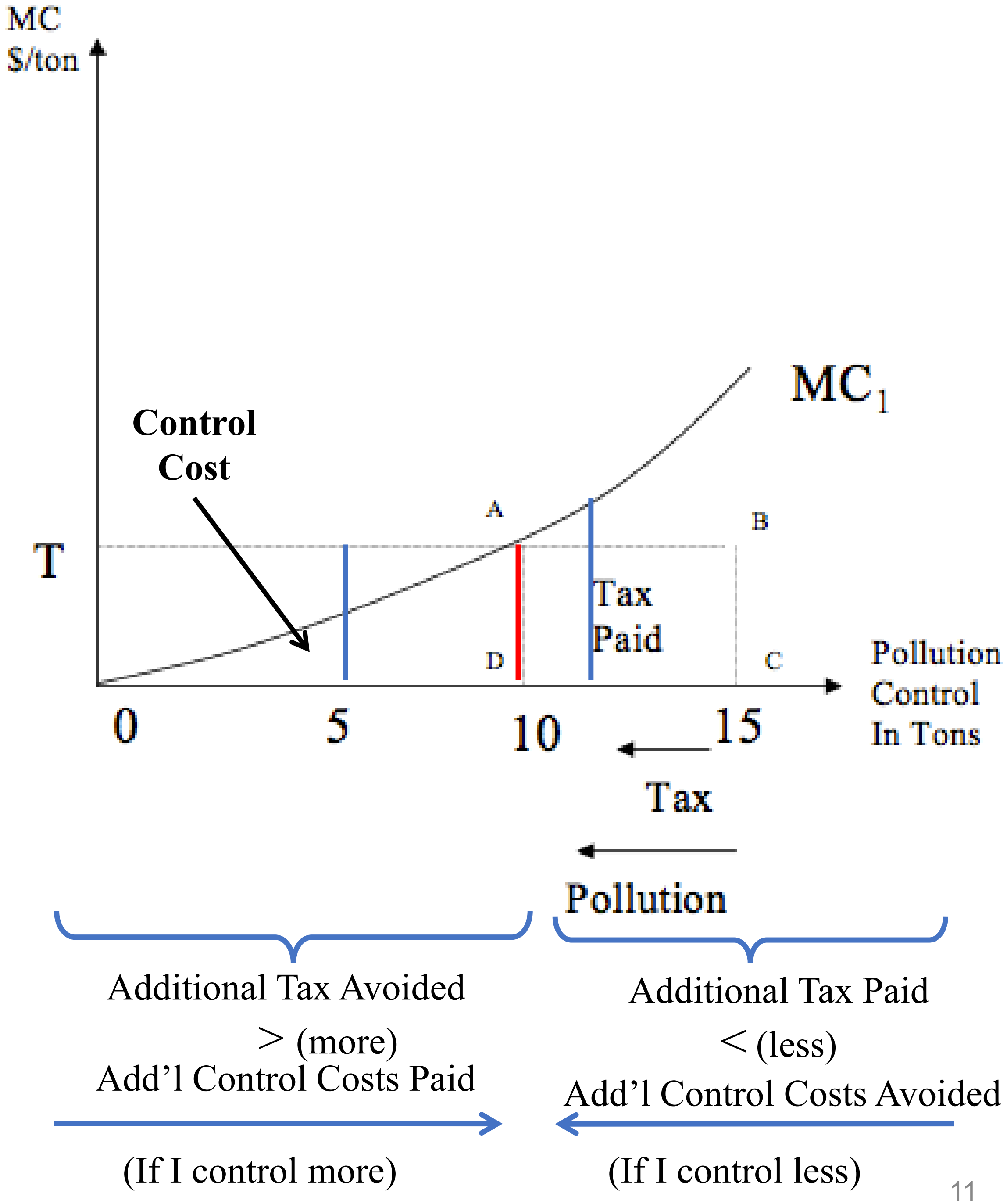
- Firm with MC_1 and a charge levied by government of T dollars per unit of pollutant emissions
- How does firm respond?
- Cost-minimizing firm wishes to minimize sum of control costs plus tax payments.
- What level of control minimizes sum?
  - 5 tons of control?
  - 12 tons of control?

Area ABCD = Tax Paid

+

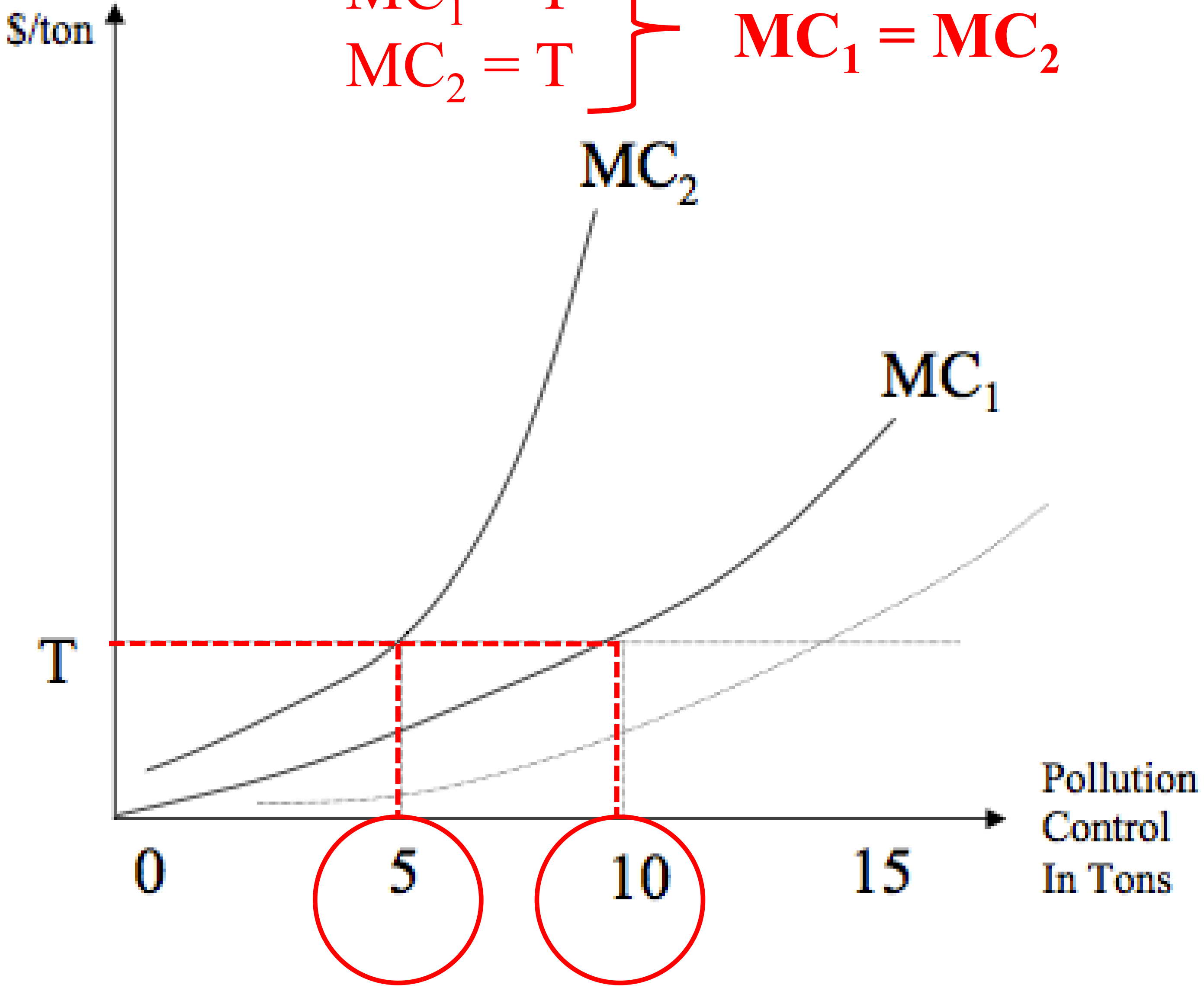
Area 0AD = Control Cost

- **Firm controls to where MC = Tax**



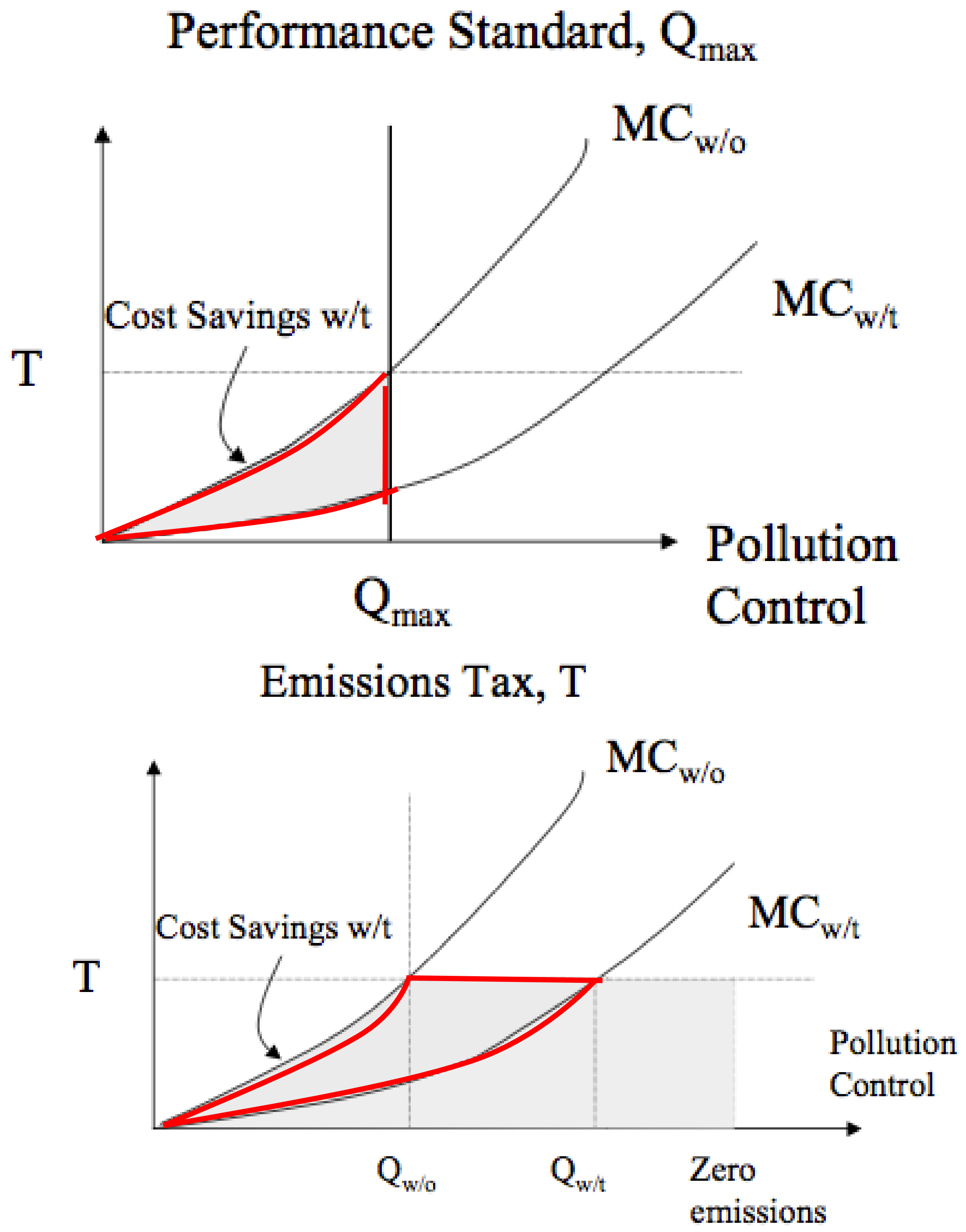
Pollution Tax (with multiple firms)

$$\left.\begin{array}{l} MC_1 = T \\ MC_2 = T \end{array}\right\} \quad \mathbf{MC_1 = MC_2}$$



Incentives for Technological Change Under Conventional and Market-Based Instruments

- Incentive to adopt new pollution-abatement technology is cost savings due to adoption
- Cost savings with performance standard
- Net Cost Savings = Abatement Cost Savings – Adoption Cost
- Cost savings with emissions tax are **greater**
- Market-Based Instruments provide greater incentive for technological change



Challenges with Tax Approach

- **Government**
  - Will target reductions be achieved? *Information r*
  - Iterate up or down?
  - Forget quantity, set t
- **Private sector**
  - Costs may be *greate*
  - Tax is c/e, command
- **Environmental adv**
  - Taxes make costs *vis*
  - Fear that this will lea
- **Politics**
  - *T-word*

Question: Is there a way the government can:

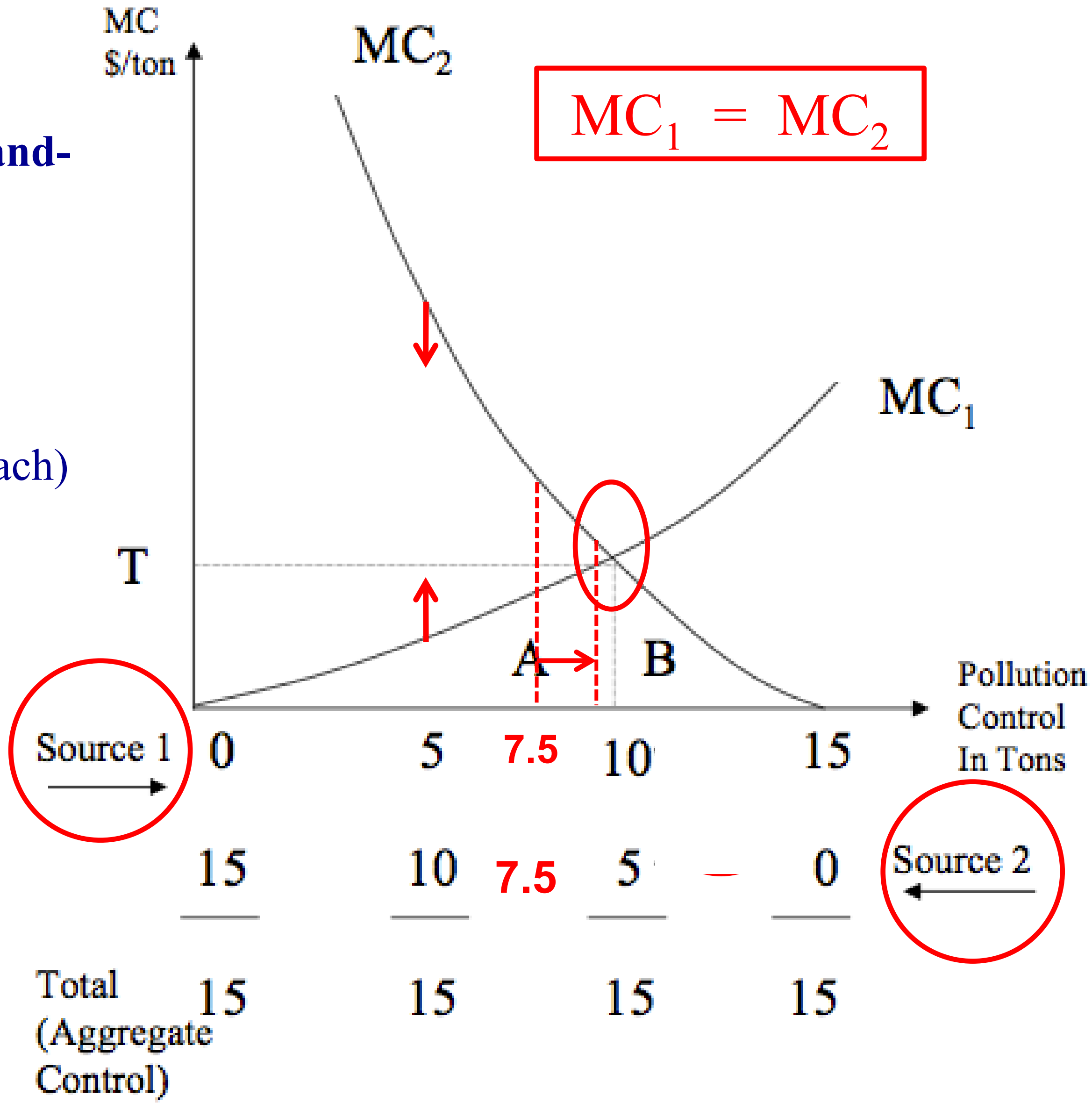
- ironmental objective
- *ffectively*
- *ormation* about firms' costs
- *ertainty* of whether target will
- *of placing greater costs* on or
- kings *costs transparent*
- while *avoiding the T-word?*

Alternative Market-Based Instrument: Cap-and-Trade (one type of tradeable permits)

- To set the tax to achieve some quantity target, government still needs to know the *aggregate* marginal cost curve (in order achieve environmental goal)
- An alternative is for the government to just set the goal (pollution level) directly – that's the cap (Nothing here about efficiency; we're focused completely on cost-effectiveness)
- The government can then issue pollution permits (allowances) and require firms to relinquish one permit for every unit of pollution they emit
- The sum of the permits equals the cap
- This approach – in theory – addresses the problems with the pollution tax, and achieves the goal cost-effectively …

Cap-and-Trade System

- Two-source model of **cap-and-trade**
- Source 1: Low-cost
- Source 2: High-cost
- Possibly start with uniform allocation of permits (7.5 each)
  - What happens?



- **Incentives to trade:**
  - Firm #1 will sell permits (control more) at price > MC_1
  - Firm #2 will buy permits (control less) at price < MC_2

Major Generic Issues for Cap-and-Trade Systems

1. **Point of regulation** (issue for other policy instruments, as well)
   a. Input (example: carbon content of fossil fuels)
   b. Emissions (example: SO_2)
   c. Ambient concentration (partial example: LA)
   d. Exposure
   e. Risk

Price Collar

2. **Allocation of allowances**
   a. Free — *how* to allocate (historical baseline): *independence property*
   b. Auction — *use* of revenue (same as with tax – cut distortionary taxes, reality)

3. **Cost-containment mechanisms**
   a. Banking
   b. Borrowing

   Implicit banking and borrowing within compliance period.

   c. Price ceiling (safety-valve, hybrid of CaT and Tax)
   d. Price floor (RGGI)
   e. Linkage and offsets (Emissions Reductions Credits, ERC)

can be included with any policy

Emission Reduction Credit (Offset) Systems

- With ERC system, there is *no cap on aggregate emissions*
- If individual source reduces emissions *below* what they would *ordinarily* be, …
  - … that source generates a *credit* that can be used or sold.
- Credits can be used for *compliance with some other policy*, such as a performance standard, cap-and-trade system, or emissions tax.
- So, in *theory*, ERC option can *reduce compliance costs* under the other policy
- *Examples*:
  - U.S. EPA criteria air pollutant emissions trading (1970s)
  - Kyoto Protocol's Clean Development Mechanism (2008-2020)
- Key Problem:
  - Comparison with *unobserved and fundamentally unobservable hypothetical!*
  - *Systematic incentive* for sources to propose projects that are most *profitable*, and hence would have been developed *without* the offset system.

ERC (Offset) Systems (continued)

- You board your flight from Boston to Chicago, and the airline gives you the opportunity to offset a share of the flight's CO_2 emissions by donating to a fund used to buy offsets from Brazil. Do you do it? Why, why not?

Economic Factors to Consider:

- Additionality
- Performance (of forestry project)
- Double Counting
- (but charitable contribution to possibly "good cause")

Experience with Tradable Permit Systems

(see Economics of the Environment, Chapter 12)

• Criteria air pollutant trading (1974-)	ERC	**B**
• Leaded gasoline phasedown (1980s)	~ CaT (TPS)	**A**
• Water-quality trading	CaT	**Inc**
• **SO_2/Acid Rain**	CaT	**A-**
• **EU Emissions Trading Scheme (CO_2)**	CaT	**A-**
• **Regional Greenhouse Gas Initiative (CO_2)**	CaT	**B+**
• **AB 32/398 California (CO_2)**	CaT	**A**

Comparing Charges and Tradable Permits

- **Responsiveness to Change**
  - **Economic Growth** – more and/or larger sources (very important in DCs)
    - Fixed Supply of permits: demand increases, price rises, emissions unchanged
    - Fixed Tax: increase in aggregate emissions
  - **General Price Inflation**
    - Permits: higher nominal permit prices, constant real prices, no change in aggregate emissions or allocation.
    - Unit ($/ton) taxes (*not* ad valorem, % of price): real tax decreases, pollution levels increase.
  - **Technological Change**
    - Permits: marginal abatement costs decreases, permit price falls, but aggregate emissions unchanged.
    - Taxes: increase in control levels (decrease in aggregate emissions).
- **Distributional Effects**
  - Taxes: higher costs for sources, transfer to government, property rights to gov't (unless rebated).
  - Permits: lower costs for sources (unless auctioned)

Comparing Charges and Tradable Permits (continued)

- **Transaction Costs**
  - Permits: increase control costs directly and by reducing permit trades; also, for certain TC functions (decreasing marginal TC costs), costs are sensitive to initial allocation – violation of "independence property"
  - Taxes: administrative costs may be non-trivial
- **Visibility to Public**
  - Taxes more transparent than permits, benefit-cost comparisons, lower public demand for regulation
  - But successful demonization of CO_2 cap-and-trade as "cap-and-tax" in 2009-2010
- **Strategic Behavior**
  - Permits more susceptible, if concentration in permit market or product market
  - Will examine in cases of SO_2 and CO_2
- **Uncertainty and Relative *Efficiency***
  - Weitzman analysis – relative slopes rule, only cost uncertainty matters (1974)
  - Simultaneous and correlated uncertainty (1996)
  - Empirical question: MB steeper → quantity instrument; MC steeper → price instrument

Alternative Solutions to Environmental Externalities

PROBLEM	SOLUTION	POLICY MECHANISM	CONCERNS
Incomplete property rights	Assign Property Rights-Markets Arise	Eliminating Market Barriers, e.g., water transfers	Transaction costs Equity issues Public good problems Political feasibility
Incomplete/ Missing Markets	Create a Market	Tradable Permits	Transaction costs Specifying endowments Imperfect markets
Inadequate Prices	Tax or subsidy - Trade	Pollution Charges Deposit-Refund System Eliminating Gov't Subsidies	Uncertain response Equity: tax can't go to injured party if free entry
Non-enforced Property Rights	Use courts to enforce prop. Rights... Internalize externalities	Law suits and related legal action	Transaction costs Intergenerational problem Multi-jurisdictional problem
Inadequate Regulation	Set regulation	Conventional command-and-control regulation	Allocative inefficiency No incentives for technological change Equity issues

Major Types of Environmental Policy Instruments

Category of Instrument	Prescriptive Regulation (Command & Control)		Market-Based Instruments			Other Voluntary/ Behavioral
Type of Instrument	**Technology Standards**	**Performance Standards**	**Taxes/Fees**	**Tradeable Permits**	**Subsidies**	**Information/ Nudges/Etc**
What it means	Requires particular pollution control technology	Ceiling on emissions/pollution discharge or rate	Tax or fee negative externalities	Cap on pollution, allocate permits and allow trading	Payment for positive externalities	(e.g., information, change of defaults)
Examples	Energy efficient technologies, catalytic converter	Clean energy standards	Carbon taxes, Effluent taxes, deposit-refund	Cap and trade, Emissions reduction credits	Renewable Investment Tax Credit	Energy Star, Smokey the Bear
Key Strengths	Low monitoring costs	“fairness”, greater flexibility than tech stds	c/e, flexibility, encourages dynamic innovation	c/e, flexibility on how to abate	c/e, (often) politically popular	Simplicity, often lower cost
Key Weaknesses	Wrong goal, not c/e, inflexible under technological change	Not c/e (typically gov’t lacks information to make it such)	Politics, risk of hot spots for localized pollutants	Implementation costs, politics, risk of hot spots for localized	Gov’t/taxpayer cost (can generate DWL)	Effects can be small & not guaranteed

Key Take-Aways

- Pollution problems vary along key spatial and temporal dimensions
- Efficiency and cost-effectiveness are very different criteria
- There are a number of other, broader criteria that are important for policy analysis
- The necessary condition of equal marginal abatement costs is very useful
- Each of the major types of policy instruments (taxes, trading, subsidies, standards) exhibits advantages & disadvantages
- Price and quantity instruments differ along a number of key dimensions