Reading material for Second year economics students

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Chapter Five

Economics of Pollution Control

Outline

- The following points will be presented in this chapter
  - Introduction: fundamental questions?
  - Categorization of pollutants or pollutant taxonomy
  - Market versus efficient allocation of pollution, and
  - Cost-effective pollution control instruments (policy responses)

Introduction

- In the preceding chapters we have discussed the economic environmental relationships.
  - One side depicted the flow of mass and energy to the economic system,
  - while the other depicted the flow of waste products back to the environment.
- In the last few chapters we dealt extensively with
  - achieving a balanced set of mass and energy flows;
  - now we examine how a balance can be achieved in the reverse flow of waste products back to the environment

- Two questions must be addressed:
  1. What is the appropriate level of flow? and,
  2. How should the responsibility for achieving this flow level be allocated among the various sources of the pollutant when reductions are needed?
- In this chapter we discuss
  - the policy approach to controlling the flow of these waste products by developing a general frame-work for analyzing pollution control to define efficient and cost-effective allocations for a variety of pollutants.

5.1 Pollutant taxonomy

- The amount of waste products emitted determines the load upon the environment; and
- The damage done by this load depends on the capacity of the environment to assimilate the waste products.
  - We call this ability of the environment to absorb pollutants its absorptive capacity.
  - If the emissions load exceeds the absorptive capacity, then the pollutant accumulates in the environment.

- Pollutants for which the environment has little or no absorptive capacity are called stock pollutants.
  - They accumulate over time as emissions enter the environment.
  - Examples, non-biodegradable bottles tossed by the roadside; heavy metals, such as lead, and persistent synthetic chemicals, such as dioxin and PCBs (polychlorinated biphenyls).
- Pollutants for which the environment has some absorptive capacity are called fund pollutants.
  - As long as emission rate does not exceed the absorptive capacity of the environment, pollutants do not accumulate.
  - Example, CO_2 is absorbed by plants and the oceans.

- Pollutants can also be classified by their zone of influence, defined both horizontally and vertically.
- The horizontal dimension deals with the spatial domain over which damage from an emitted pollutant is experienced.
  - The damage caused by local pollutants is experienced near the source of emission,
  - while the damage from regional pollutants is experienced at greater distances from the source of emission.
  - The limiting case is a global pollutant, where the damage affects the entire planet.
  - The categories are not mutually exclusive; sulfur oxides and nitrogen oxides, for example, are both local and regional pollutants.

- The vertical zone of influence describes whether the damage is caused mainly by ground-level concentrations of an air pollutant or by concentrations in the upper atmosphere.
  - For some pollutants, such as lead or particulates, the damage caused by a pollutant is determined mainly by concentrations of the pollutant near the earth's surface.
  - For others, such as ozone-depleting substances or greenhouse gases, the damage is related more to their concentrations in the upper atmosphere.
- Each type of pollutant requires a unique policy response. The failure to recognize these distinctions leads to counterproductive policy.

5.2 The Efficient Allocation of Pollution

- Pollutants are the residuals of production and consumption.
  - They must eventually be recycled or returned to the environment in one form or another since their presence may depreciate the service flows received,
  - An efficient allocation of resources must take this cost into account (that is the efficient allocation of pollution depends on the nature of the pollutant)

Stock Pollutants

- The efficient allocation of a stock pollutant must take into account the fact that the pollutant accumulates over time and the damage caused by its presence increases and persists.
  - There is an interdependency between the present and the future, since the damage imposed in the future depends on current actions.
- The damage caused by pollution can take many forms.
  - Human health can be adversely impacted even leading to death.
  - Other living organisms, such as trees or fish can be harmed.
  - Damage can even occur to inanimate objects; example, acid rain causes sculptures to deteriorate.

- The efficient allocation in these circumstances can be established easily using the intuition we gained from the discussion of depletable resource models.
- Suppose that the production of product X generates a stock pollutant.
  - The amount pollution can be reduced, but it takes resources away from the production of X.
  - That is, the stock of pollutants remains in the environment and the damage persists as long as production of X proceeds.
- The dynamic efficient allocation is the one that maximizes the present value of the net benefit.
  - The net benefit at any point in time t, is equal to the benefit received from the consumption of X minus the cost of the damage caused by the presence of the stock pollutant in the environment.

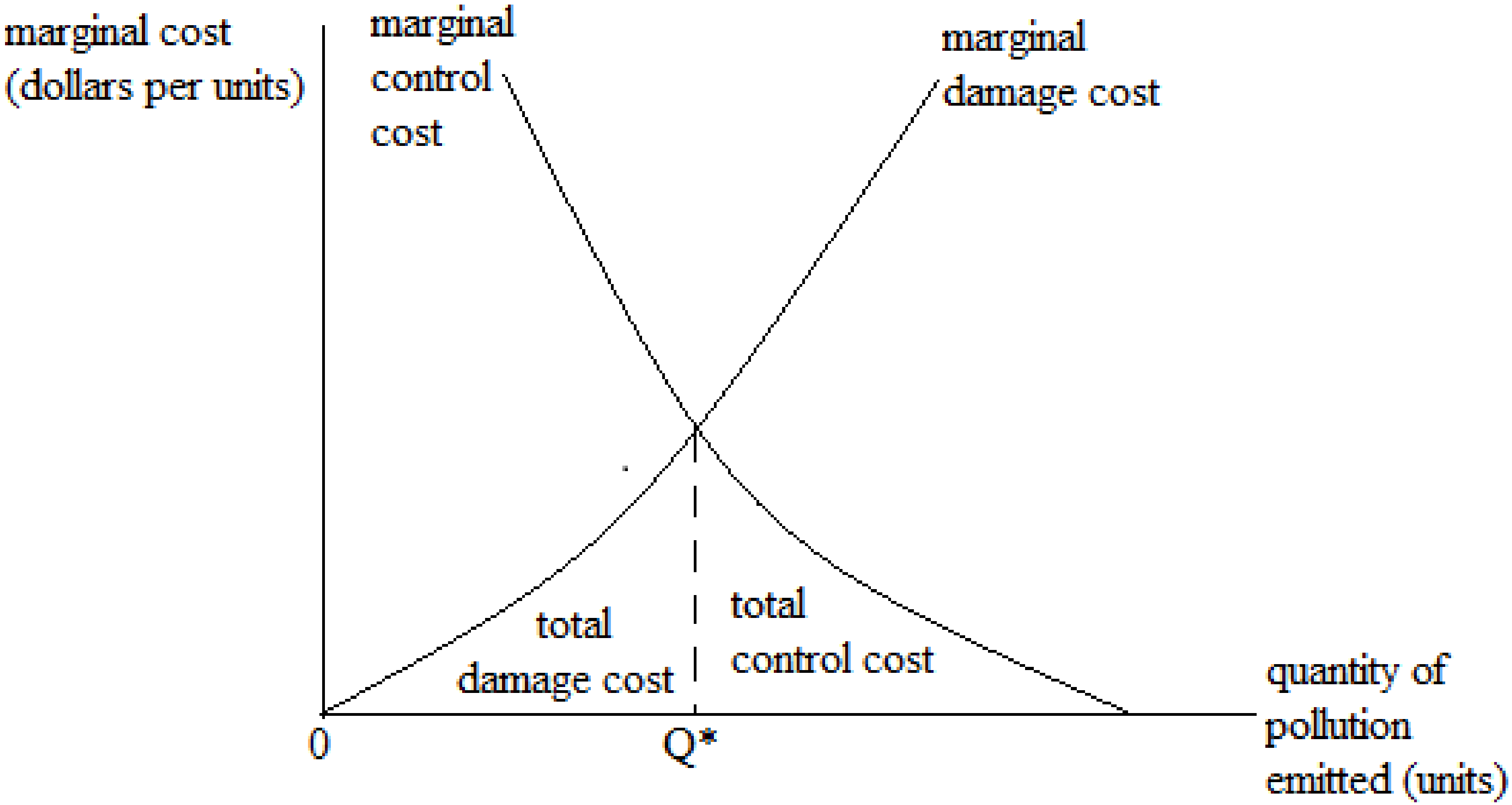
- Stock pollutants are the other side of the intergenerational equity coin from depletable resources.
  - Current generations create a burden for future generations by using up resources, thereby diminishing the endowment.
  - Stock pollutants can create a burden for future generations by passing on damages.
  - Though neither of these situations automatically violates the weak sustainability criterion, they clearly require further scrutiny.

- The emission of the pollutant created by the production of X - controlled through introduction of technologies (such as recycling)
- The price of X and the quantity consumed would remain constant
- Technological progress to lower the marginal damage cost
  - Reduce the amount of pollutant generated per unit of X
  - Recycle the stock pollutant rather than inject
  - Innovate ways of rendering the pollutant less harmful

Fund Pollutants

- To the extent that the emission of fund pollutants exceeds the assimilative capacity of the environment,
  - they accumulate and share some of the characteristics of stock pollutants
- When the emissions rate is low enough, however,
  - the discharges can be assimilated by the environment, and future damage may be broken
- For the fund pollutants, the efficient level of emission obtained where the marginal damage to the environment exactly equals the marginal cost of pollution emission control (MD = MC).

- Pollution control is analyzed from the perspective of minimizing costs
  - Pollution Damage Costs - damage
  - Pollution Control/Abatement Costs – cleanup
- Pollution (Marginal) Damage Costs
  - Damages increase with the amount of pollution emitted to the environment
- Pollution (Marginal) Control Costs
  - Abatement cost increase with the amount of pollution that is controlled/cleaned/abated; but, decrease in the control cost rises the emission



Efficient allocation of a fund pollutant

- The efficient allocation is represented by Q*, the point at which the damage caused by the marginal unit of pollution is exactly equal to the marginal cost of avoiding it.
  - Greater degrees of control (points to the left of Q*) are inefficient because the further increase in avoidance costs would exceed the reduction in damages, hence, total costs would rise.
  - Similarly, levels of control lower than Q* would result in a lower cost of control but the increase in damage costs would be even larger, yielding an increase in total cost.
  - Increasing or decreasing the amount controlled causes an increase in total costs; thus, Q* must be efficient.

- Factors that determine the position of Marginal Control Cost Curve are:
    - Production technology
    - Technology of pollution control
    - Input use
    - Pollutant/Residual recycling methods
- Factors affecting the ***Marginal Damage Cost***:
    - Changes in people's preference for environmental quality
    - Changes in population
    - Discovery of new treatment(s) to damage
    - Change in the nature of assimilative capacity of environment

5.3 Environmental policy instruments

- This topic is the key in this course in terms of conceptual matters
  - The market system, left to itself, is likely to malfunction when matters of environmental pollution are involved
  - This brings us to the policy question: ‘If we do not like the way things are currently turning out (economic activity and pollution), what steps should be undertaken to change the situation?

- The policy problem includes a number of closely related issues
  - identifying the most appropriate level of environmental quality we ought to achieve
  - how to divide up the task of meeting environmental quality goals
    - If we have many polluters, how should we seek to allocate among them an overall reduction in emissions?

- Does market lead to efficient allocation of pollution?
  - Damage costs are externalities
  - Control costs are not externalities (they are costs to a firm/s)
    - Therefore, what is cheapest for the firm is not always what is cheapest for society as a whole
    - Firms that attempt to control pollution unilaterally are placed at a competitive disadvantage
    - Hence, market fails to generate efficient level of pollution control and penalizes firms that control pollution
  - Thus, a policy response is essential to arrive at optimal pollution control/management

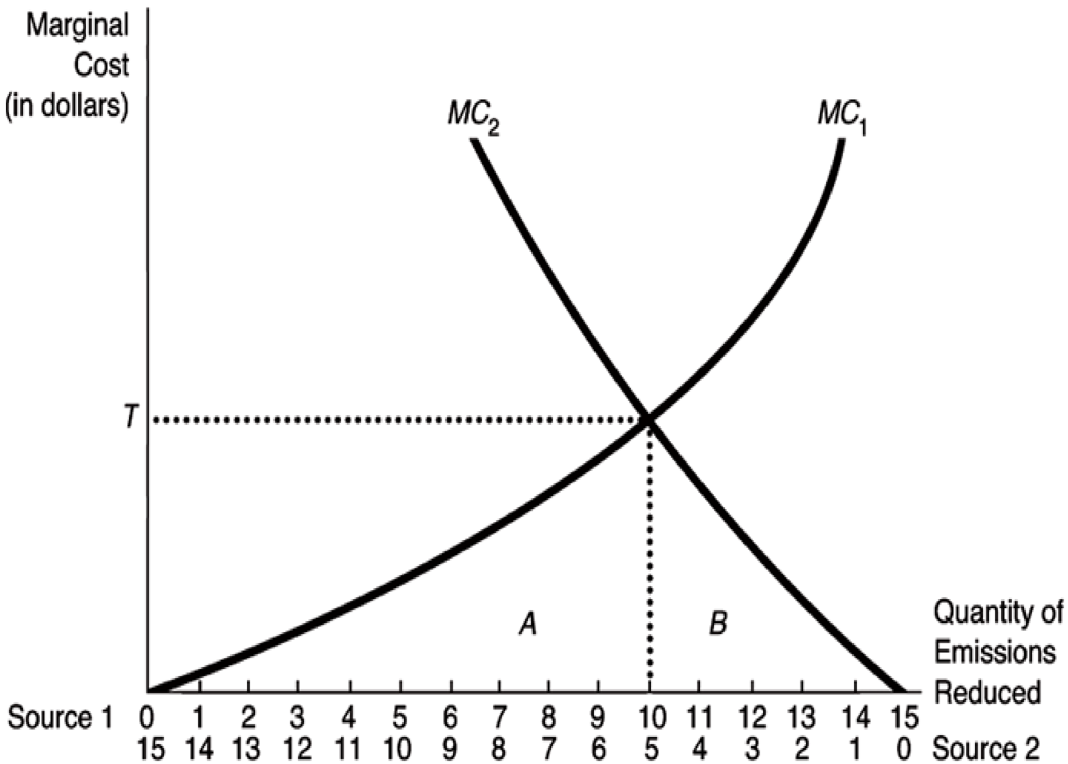
Defining a Cost-Effective Allocation for <u>Uniformly Mixed Fund Pollutants</u>

- A uniformly mixed fund pollutant - damage depends on the total amount of pollutant entering the system (does not matter where the source is)
- Policy can focus on controlling the total amount of emissions - that minimizes the cost of control
- The cost-effective allocation is found by equating the Marginal Control Costs of the sources or firms
  - Total cost is the area under the marginal control cost curve,
  - total costs across the two firms is minimized by minimizing the two areas and found by equating the two marginal costs as it indicated in the figure bellow

Example is:

- total amount of pollution from the two sources=30;
- government wants a reduction of 15 units

Cost-Effective Allocation of a Uniformly Mixed Pollutant



The first source cleans up ten units, while the second source cleans up five units

- The control authority might use several policy instruments to achieve cost effective allocation once the allocation is defined.
  - Sources have options for controlling the amount of pollution
  - Cheapest method of control will differ among industries and among plants in the same industry
  - Selection of the cheapest method requires information on the possible control techniques and their associated costs
  - Unlike plant managers government authorities responsible for meeting pollution targets may be constrained of information – difficult for control authorities

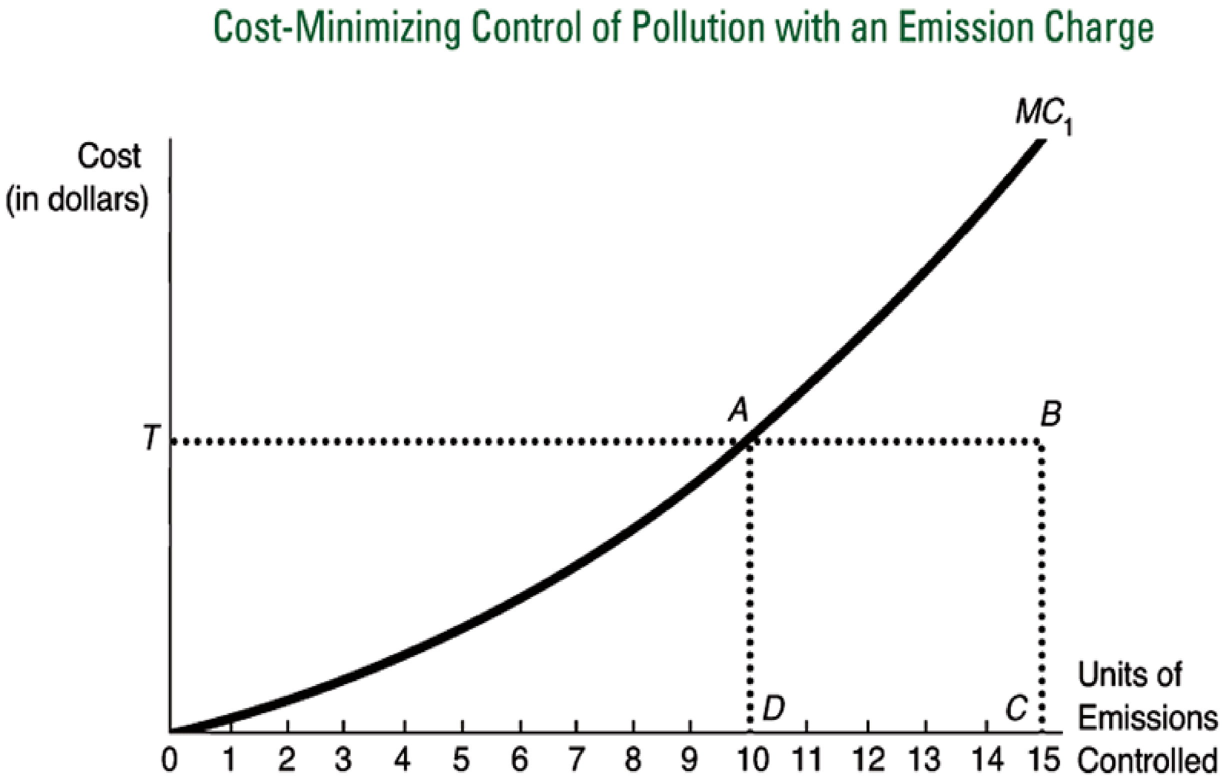
(i) Emission Standards

- This approach is known as a command-and-control approach, and is a legal limit on the amount of the pollutant an individual source is allowed to emit
- In the absence of adequate information (such as in the previous figure) the options are to allocate each source an equal reduction
- But the strategy would not be cost-effective - total costs would increase if both sources were forced to clean up the same amount

- There are other policy instruments which allow the authority to allocate emissions reduction in a cost-effective manner even when it has no information on the magnitude of control costs
- Such policy approaches rely on economic incentives to produce the desired outcome
- The two most common approaches are known as;
  - emissions charges, and
  - emissions trading

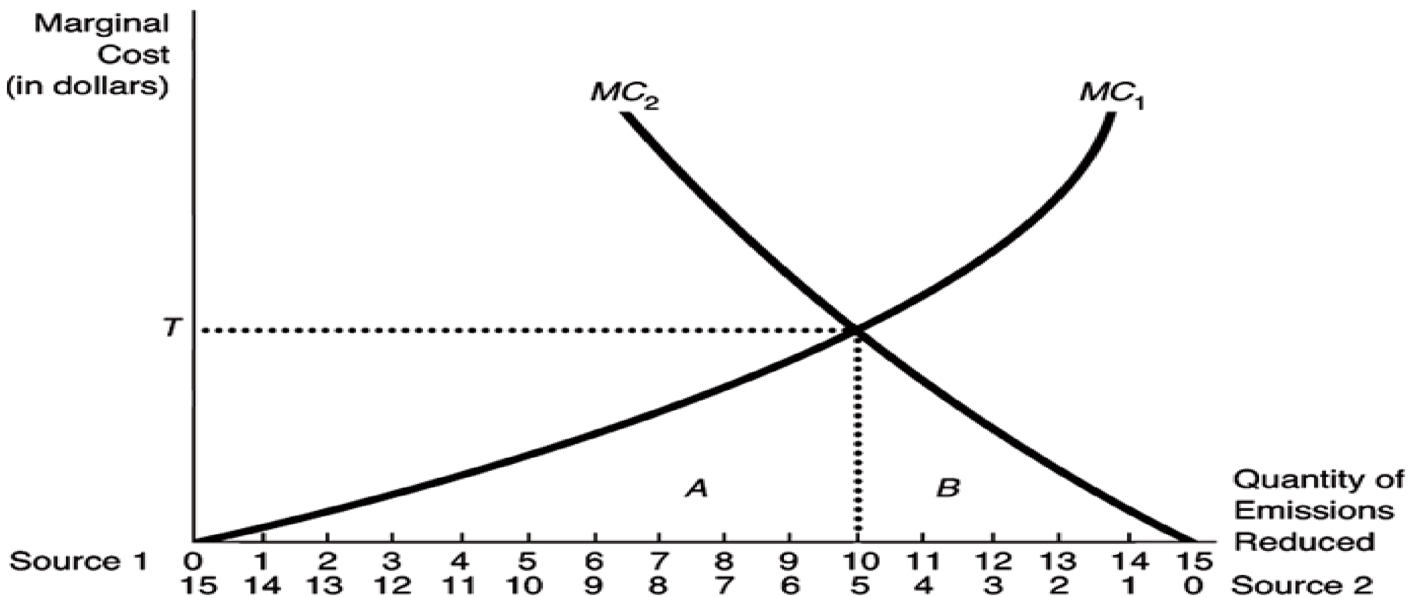
(ii) Emission Charge

- An emission charge is a per-unit of pollutant fee collected by the government
  - Charges are economic incentives
- Total payment could be found by multiplying the fee times the amount of pollution emitted
  - Emissions charges reduce pollution since it rises firm’s cost; hence, the source seeks ways to reduce or control its pollution emission to save its money
- If the firm is not reducing its emissions it would be forced to pay the full amount for the emission multiplied by the rate



Each firm will independently reduce emissions until its marginal control cost equals the emission charge, and this yields a cost-effective allocation

Cost-Effective Allocation of a Uniformly Mixed Pollutant

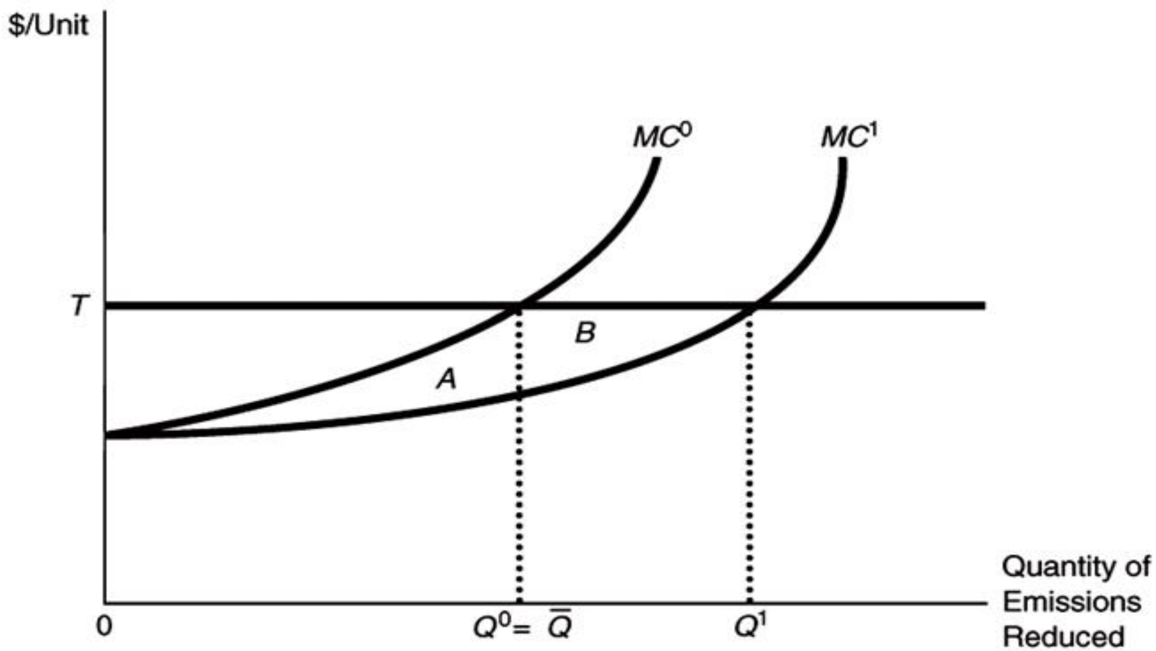


- Faced with an emissions charge T, the second source would clean up 5 units and first source would clean up 10 units
- Since they both face the same emissions charge, they will independently choose levels of control consistent with equal marginal control costs

- Difficulty with this approach - determining how high the charge should be set - to ensure the resulting emission reduction is at the desired level
- What ever the case, emission charges:
  - cost effective allocation of the control responsibility
  - stimulates the development of newer, cheaper means of controlling emissions
  - promoting technological progress
- With an emissions charge system, the firm saves money by adopting cheaper new technologies (otherwise sources may hide technology)

- As long as the firm can reduce its pollution at a marginal cost lower than T, it pays to adopt the new technology
- The firm saves A and B by adopting new technology and voluntarily raises its emissions reduction from Q_0 to Q_1

Cost Savings from Technological Change: Charges Versus Standards

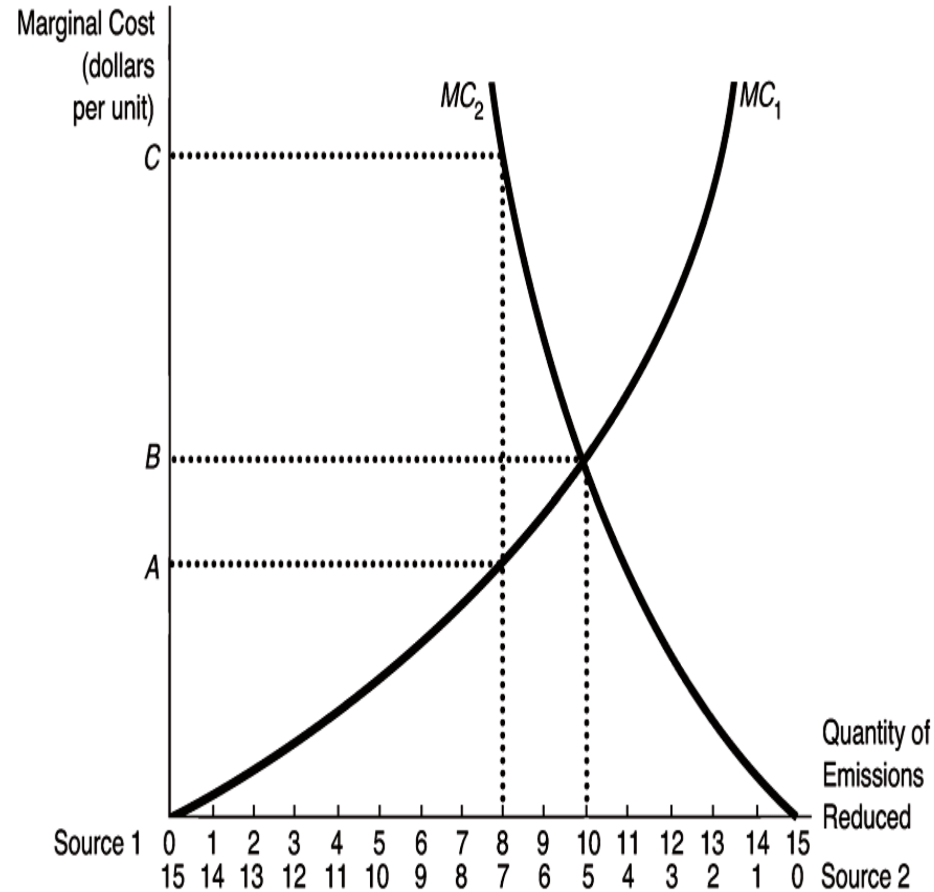


(iii) Emissions Trading

- All sources are allocated allowances to emit either on the basis of criterion or by auctioning
  - allowances are freely transferable
- Equilibrium price will be the price at which Marginal Control Costs are equal for both (or across all) firms
- Market equilibrium for an emission allowance system is the cost-effective allocation
  - Example: governments want to arrive at 15 units that shall be cleaned

- ***Source 1*** is allocated ***7 allowance*** – must ***clean 8 units***
- ***Source 2*** is granted ***8 allowance*** – must ***clean 7 units***
- Both firms ***have incentive to trade***
- MCC for second source is higher (C) than the first (A)

- Second source could lower its cost:
  - if it buys allowance at price lower than C; and
- First source would be better off:
  - if it sells allowance higher than A
- Transfer of allowances would take place
  - until the first source had only 5 allowances left while the second source had 10 allowances and controlled 5 units
- The allowance price
  - would equal *B* - allowance market would be in equilibrium $MC_1=MC_2$



(iv) Liability rules

- They allow the costs of damage to be attributed to the agent who caused the damage
  - Originator of damage will be forced to pay - will not be able to transplant costs of his action on others
  - Tend to bring private and social costs into line - efficient social institution for dealing with negative externalities
- Liability is consistent with market system-introduce an incentive to prevent damages to third parties
  - Originator of damage can expect to be liable for damage - attempt to avoid damages, and is an attractive policy instrument in a market economy

Discussion Questions

1. Explain and graphically show the determination of optimal depletion level for stock and fund pollutants.
2. however it is impossible to limit the pollution emission rate to zero, economists suggest different mitigation strategies.
   – Discuss these strategies and are those strategies ensure environmental sustainability over time?