5. Economics of Pollution Control and Environmental Policy

- Up until this point, we have focused on the flow of resources into the economic system. We now consider the flow of wastes back into the system.
- Recall that any activity that consumes resources must generate waste that is disposed to the environment.
- The damage caused by waste disposal depends crucially upon the environment's ability to absorb the waste.
- If emissions exceed the absorptive capacity of the system, they will accumulate in the environment and cause damage.
- Our concern is with the wastes or emissions that are not assimilated.
- Pollution is waste or emission in excess of the absorptive or assimilative capacity of the environment.

1. A Pollution Taxonomy/ classification of pollutants

1.1 By absorptive capacity

A) Stock pollutant:

- the environment has little or no absorptive capacity for such pollutants
- Stock pollutants accumulate over time as emissions enter the environment
- It creates a burden for future generations
  - There is a link b/n present emissions and future damage
  - b/s current emissions cause future damage

Example: Non-biodegradable bottles, Heavy metals (e.g. lead), Some synthetic chemicals

b) Fund pollutant:

- The environment has some absorptive capacity for fund pollutant.
- If the emission rate is low, the discharges can be assimilated by the environment
- The effect of fund pollutants on future generations can be avoided
  - The link between present emissions and future damage may be broken.
  - current emissions cause current damage and
  - Future emissions cause future damage (but the level of future damage is independent of current emissions).
- But if emission of fund pollutants exceeds the assimilative capacity of the environment,
  - They accumulate over time
  - The will have an effect similar to that of stock pollutants
- Examples: Carbon dioxide, Waste paper products

1.2 By horizontal zone of influence

a) Local pollutant:

- The damage (caused by a local pollutant) is experienced near the source of the emissions.

Examples: Non biodegradable plastics
Indoor air pollution
Sanitation problems

b) Regional pollutant:

- The damage caused by a regional pollutant is experienced at greater distances from the source.

Examples: **Sulfur dioxides** from coal emissions is believed to be a culprit in the acid rain problem.

- It is possible for a pollutant to be both. E.g. Carbon dioxide.

1.3 By vertical zone of influence

a) Surface pollutant:

- Damage is determined by its concentration near the earth's surface.

  Examples: Water pollutants, Plastics

b) Global pollutant:

- Damage is determined by its concentration in the upper atmosphere.

  Examples:
  - Carbon dioxide is often cited as a contributor to the greenhouse effect.
  - Chlorofluorocarbon emissions are linked to ozone depletion.
- The above taxonomy is useful because:
  - Different pollutants require different policies.
  - Failure to recognize these distinctions can lead to flawed, counterproductive policies.

2. The Efficient Allocation of Pollution

- Pollution - waste that exceeds the assimilative or absorptive capacity of the environment.
- Pollution causes damages on the environment and on human health
- In general, the greater the pollution, the greater the damage it produces
- Reducing emissions reduces the damages caused by pollution.
- But reducing emissions involves costs referred to as abatement costs
- Abatement costs are costs of reducing emission
- Thus, there is a trade-off between pollution damage and the cost of reducing emissions,

  i.e. between pollution damage and abatement costs.

→ Suppose a firm produces a product that generates Q_0 units of Pollutants.

What is the efficient amount of pollution emissions versus pollution control?

- There are two marginal cost curves, both of which are increasing.

i) The marginal cost of pollution damage (marginal damage cost- MDC)

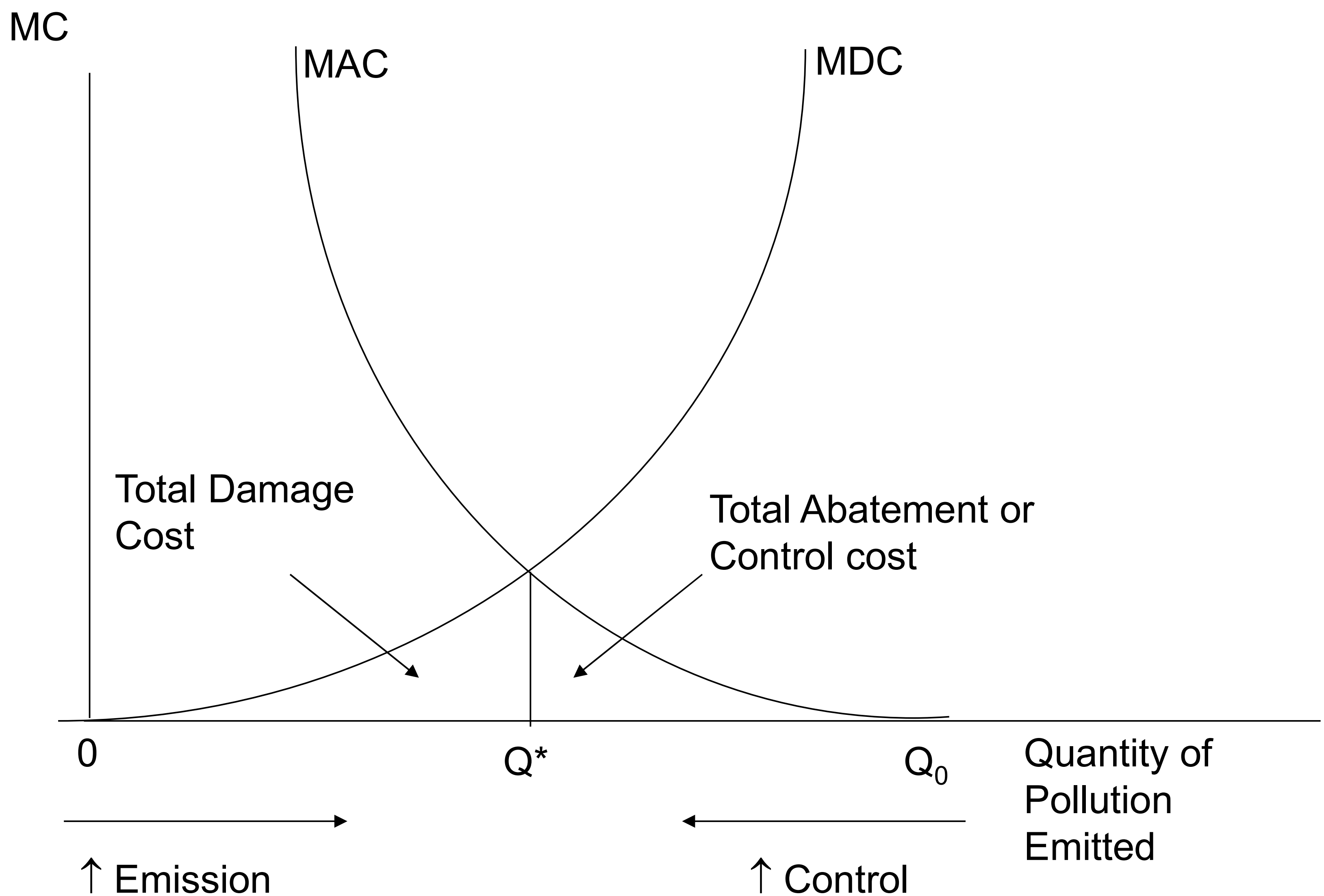
- **MDC** : pollution damage resulting from a unit increase in emission
- This increases as the quantity of pollution increases.

ii) The marginal cost of pollution control (marginal abatement cost – MAC)

- **MAC**: the additional cost of achieving a one-unit decrease in emission level
- This increases with the quantity of pollution reduced (controlled)

iii) Total social cost of pollution: the sum of the total damage costs and the total abatement costs.

- Efficient level of pollution



- **The efficient level of pollution**:
  - One that minimizes the total social cost of pollution.
  - Total social costs are minimized at the level of emission where the marginal damage costs equal the marginal abatement cost.
  - Efficiency → MDC = MAC

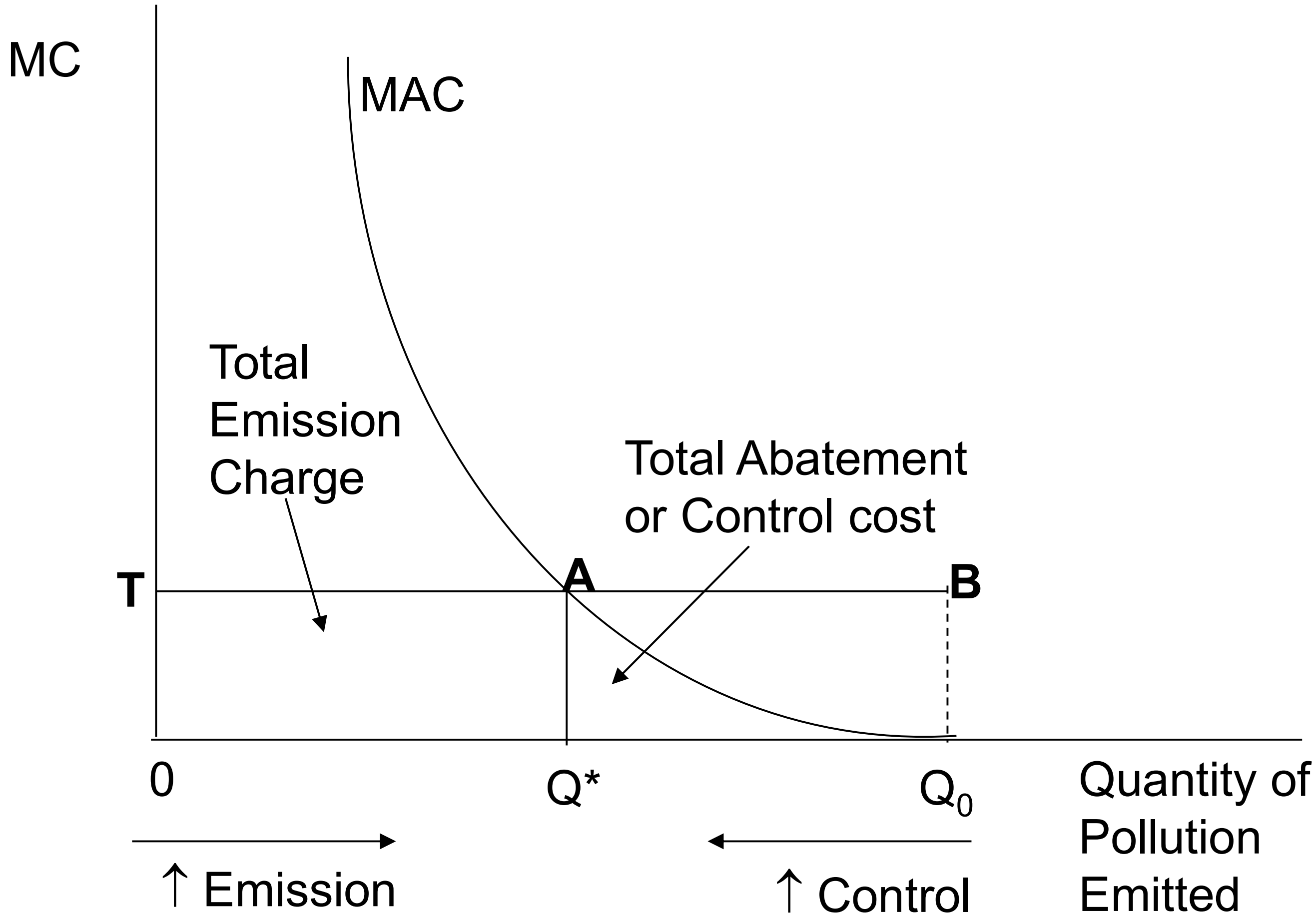
Note: MDC= f(Q) and MAC = F(Q), where Q is the amount of pollution or emission.

- To obtain the efficient (cost-minimizing level of pollution) Q*, solve for Q by equating MDC and MAC
- To obtain amount of pollution abated or controlled, subtract the efficient amount of pollution from the total amount of pollution that would be emitted without any abatement,
  - i.e. $Q_A = Q_0 - Q^*$,
- Q_A = the amount of abated or controlled pollution.
- Q* = efficient pollution
- Q_0 = total pollution if there is no abatement or pollution control

3. Environmental Policy Instruments

i) Emission charges or taxes

- An emission charge is a per-unit tax on emissions of pollutant.
- A firm responsible for emissions pays a tax for each unit of emission.
- Total emission charge a firm pays is the tax times the amount of pollution emitted.
- Thus, pollution costs the firm money
- Therefore, the firm has an incentive to reduce pollution
- To save money the firm seeks ways to reduce pollution.



- The firm emits a total of Q_0 units pollution without any abatement.
- If the firm decides not to control any emission, it would have to pay a total emission charge equal to T times Q_0, represented by area $OTBQ_0$.

→ **Is this efficient (cost-minimizing)? Obviously not.**

- As long as MAC < T
  - It cost the firm less to reduce emissions by one more unit than pay the tax
  - Therefore, the firm will reduce emissions.
- The firm can minimize cost by reducing pollution until its MAC=T (the emission charge/tax)
- The firm minimizes its costs by reducing emission to Q* units.
- At this allocation:
  - Total abatement cost of the firm = area AQ^*Q_0
  - Total emission charge payments = OTAQ*

→ **Does the firm save money by reducing pollution?**

- Total cost of the firm without pollution control = $T^* Q_0$ or area OTB Q_0

- Total cost of the firm if it reduces/controls pollution = AQ^*Q_0 + OTAQ*

- Clearly, the firm saves money by controlling pollution

NOTE:

- MAC = f(Q) = a –bQ , where Q is the amount of emission.
  - Inverse relationship between MAC and emission
- MAC = f(QA) = bQ_A, where Q_A is abated or controlled pollution.
  - Direct or positive relationship between MAC and controlled pollution

⇒ **Cost effective allocation of abatement or control responsibility: The case of more than one firm (source of pollution)**

- The cost of achieving a given reduction in emissions is minimized if and only if the MACs are equalized for all firms or emitters.

→ **Consider two firms. Initially,**

- Firm 1 emitting 20 units of pollution and
- firm 2 emitting 50 units of pollution

- We want to reduce the pollution down to a total of 55 units from 70 units.

Question: How should the pollution control be allocated between the two firms?

- That is, how many unit of pollution should each firm reduce to achieve required pollution reduction?

- $E_1 = 20$; $E_2 = 50$
- Goal: reduce total emissions to 55 units.
- Marginal Abatement cost of pollution:
  - $MAC_1 = q_1$; $MAC_2 = 2q_2$,
  - Where q_1 and q_2 are quantity of pollution abated or controlled by firm 1 and 2, respectively.

$\rightarrow$ $(E1 - q_1) + (E_2 - q_2) = 55$

Or, $q_1 + q_2 = 15$

Or, $q_2 = 15 - q1$

$\rightarrow$ Cost effectiveness requires:

$MAC_1 = MAC_2$ or, $q_1 = 2q_2 = 2(15 - q_1) = 30 - 2q_1$

- Remember that:

$q_1 + q_2 = 15$

$q_1 = 30 - 2q_1$ and $q_2 = 15 - q_1$

$30 - 2q1 + 15 - q1 = 15$

***q1 = 10 and q2 = 5**

ii. Transferable emission permits

- Tradeable emissions permits is a system of marketable permits, allocated among firms, specifying the maximum level of emissions that can be generated.
- The control authority issues exactly the number of permits needed to produce the desired emissions level
- Under this system, each firm must have permits to generate emissions.
- Permits are allocated among firms, with the total number of permits chosen to achieve the desired maximum level of emissions.
- Each permit specifies the number of units of emissions that the firm is allowed to put out.
- Any firm that generates emissions not allowed by permit is subject to substantial monetary sanctions.
- Permits are marketable: They can be bought and sold.

- If there are enough firms and permits, a competitive market for permits will develop.
- In market equilibrium, the price of a permit equals the marginal cost of abatement for all firms.
- Those firms with relatively low marginal cost of abatement curves will be reducing emissions the most, and
- Those with relatively high marginal cost of abatement curves will be buying more permits and reducing emissions the least.
- Under this system, a transfer of permits would take place among firms until their marginal costs of control are equalized.
- The level of emissions chosen by the government will be achieved at minimum cost.

iii) Emission Standards (Command – and – control)

- An emission standard is a legal limit on the amount of pollution an individual firm (source) is allowed to emit.
- It is a traditional legal approach of imposing a separate emission standard on each firm.
- Historically, standards have been set on a plant – by – plant basis.
- Emission standards can be classified into two main types:
  - a) Performance standards
  - b) Design (technology) standards

a) Performance standards

- Performance standards place restrictions and conditions on the day – to – day performance of the firm. These include restrictions on:
  - the volume of emissions
  - the volume of emissions per unit of output
  - the volume of emissions per unit of a particular input

b) Design (technology) standards

- Design or technology standards impose requirements for:
  - the use of particular pollution control equipment,
  - Or a particular production technology.

Transboundry Environmental Problems

- Trans boundary environmental problems (TEP) are impacts of actions taken in one country on environment – related welfare in another country.
- The prime example of A TEP is global climate change caused by greenhouse gas emissions.
- Many TEPs involve the physical transportation of air – borne pollutants.
  - Example:
    - greenhouse gases: gases that contribute to the rise in temperature of the earth's atmosphere (e.g carbon dioxide)
    - sulfur dioxide
- TEPs are international externalities- a cost imposed on other countries for which the source country does not have to pay.
- **Consequences:**
  - Unilateral action leads to standards that are too low from the perspective of maximizing global welfare.
  - The only resolution to international externalities is through international agreements, like the Kyoto Protocol on GHGs.