Professional Career Program

Environmental Economic Theory No. 10

(18 December 2018)

Chapter 12. Incentive-based strategies: Emission charges and subsidies

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Textbook: Barry .C. Field & Martha K. Fields (2009) ***Environmental Economics - an introduction***, McGraw-Hill, International Edition

PCP Environmental Economic Theory (Hosoda)
Homework 10
18 December 2018

- Theme: *"What is the Montreal Protocol on Substances that Deplete the Ozone Layer work? Explain how it works or not?"*
- Language: English.
- Volume: A4 two pages. Single space. 12 points.
- Submission period: 9 a.m. 24 December 2018 - 9 a.m. 25 December 2018.
- Submission: Submit your paper in a pdf file. A file name must be "HW10.xxx.pdf" (xxx=your name). Send your file to hosoda@econ.keio.ac.jp.

The purpose of this lecture

We study emission charges (subsidies) approaches, where, in order to bring about socially desirable circumstances*, authorities charge (pay) on the amount of discharged (reduced) pollutants. These approaches utilize incentives of dischargers, and are considered more flexible than command-and-control approaches. We study (1) emission charges, and (2) abatement subsidies in order.

The purpose of this lecture (cont.)

* Socially desirable circumstances imply those in which resources including environmental elements are allocated efficiently in terms of social welfare. In other words, socially optimum allocation of resources including environmental elements are attained in those circumstances.

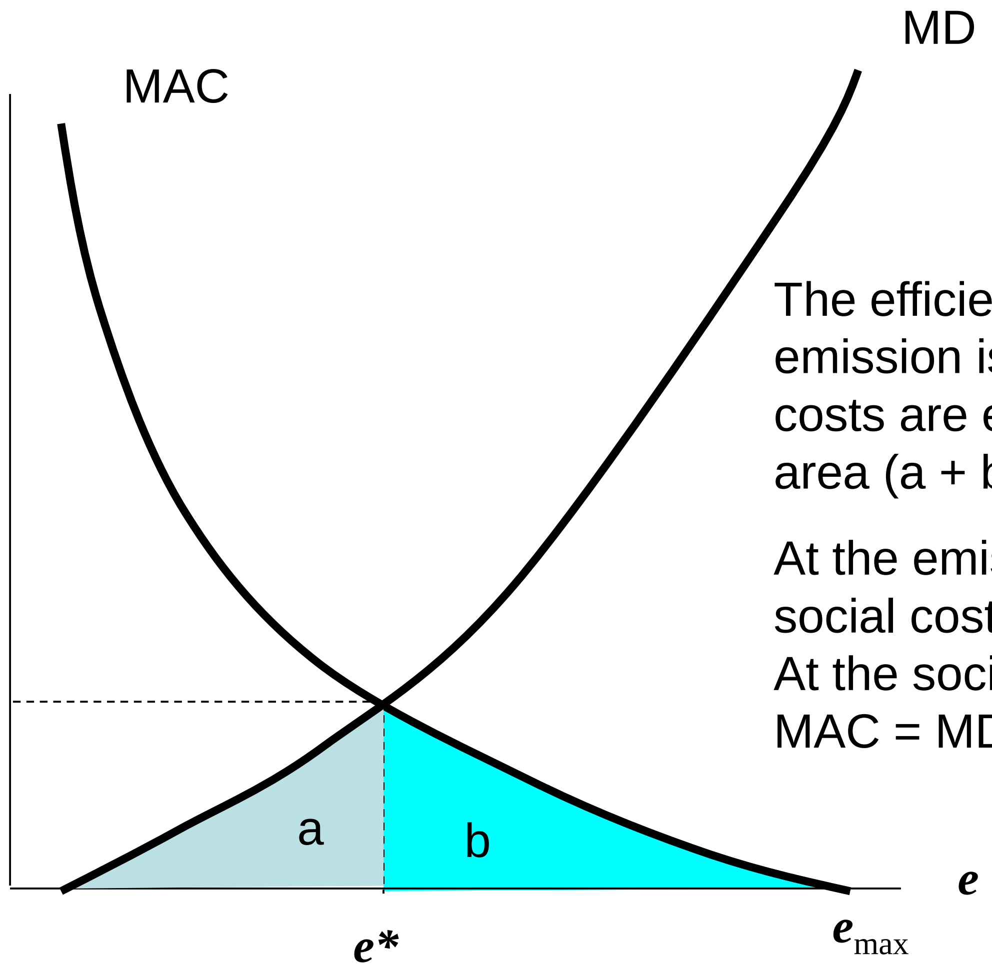
The purpose of this lecture (cont.)

- There are mainly two ways for expressing the social optimality.
- One is the Pareto optimality, and the other the maximization of the social surplus.
- Although the former is more rigorous and more general, the latter is easier to handle.
- We have utilized the latter expression so far.

The purpose of this lecture (cont.)

- Then, the social optimality is expressed by the equality MAC = MD.
- Moreover, the equi-marginal principle holds, so that marginal abatement costs are equal among dischargers of pollutants.

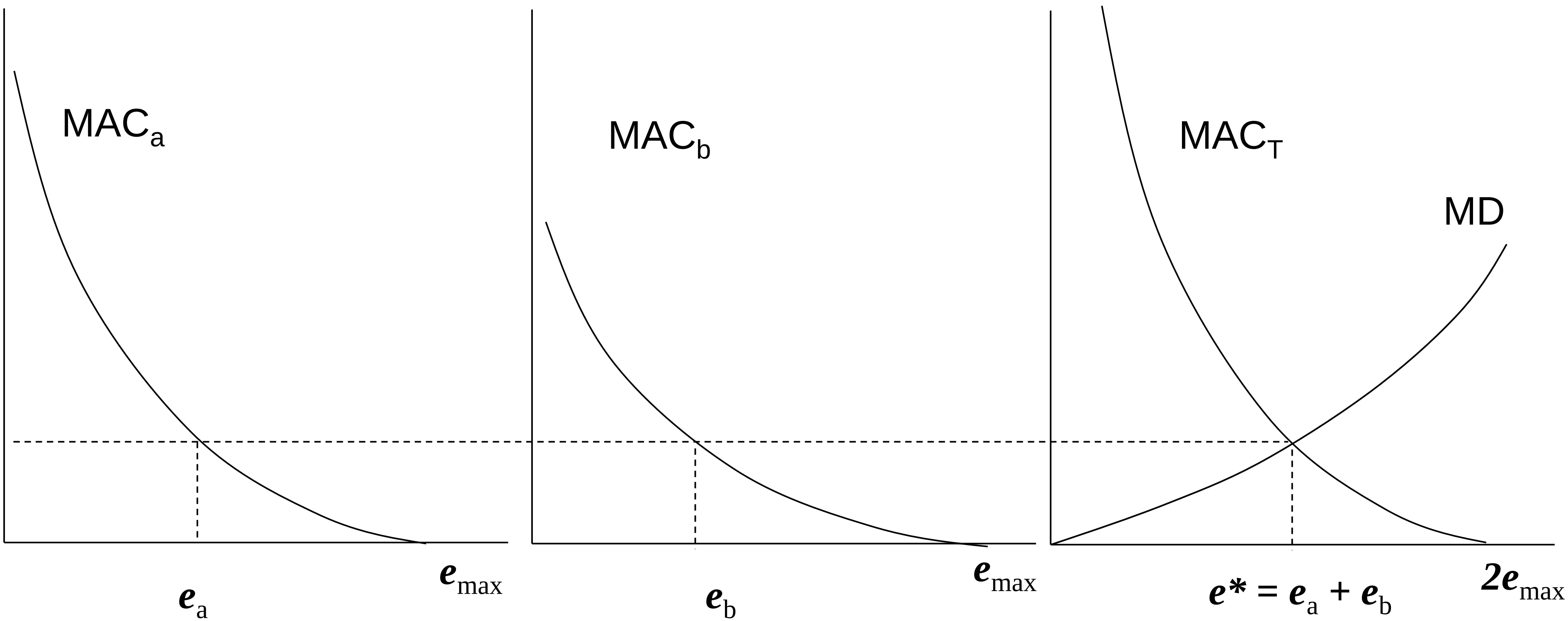
By means of a figure



The efficient level of the emission is e^*, and the social costs are expressed by the area (a + b).

At the emission level e^*, the social costs are minimized. At the socially optimal point, MAC = MD holds.

By means of a figure

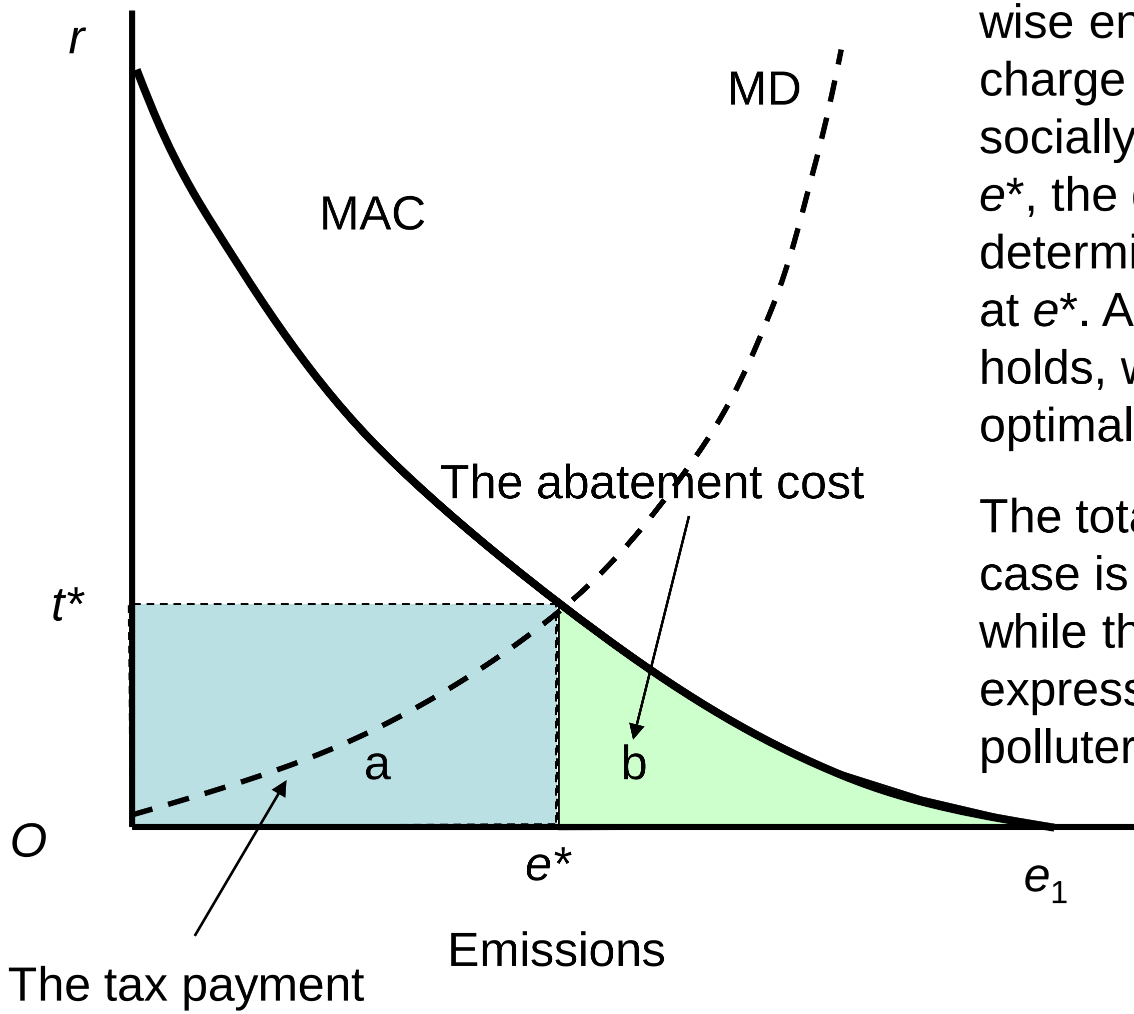


At the emission level e^*, the social costs are minimized. At the socially optimal point, the equi-marginal principle holds.

1. Emission charges

Emission charges are imposed on the dischargers of pollutants, according to the discharged amount, so that they can take the environmental costs into account when they are involved in productive activities. By so-doing, incentives of producers are wisely utilized, and the efficient level of abatement can be attained once the optimal charge rate is determined and imposed on dischargers.

Basic Economics: How emission charges work.

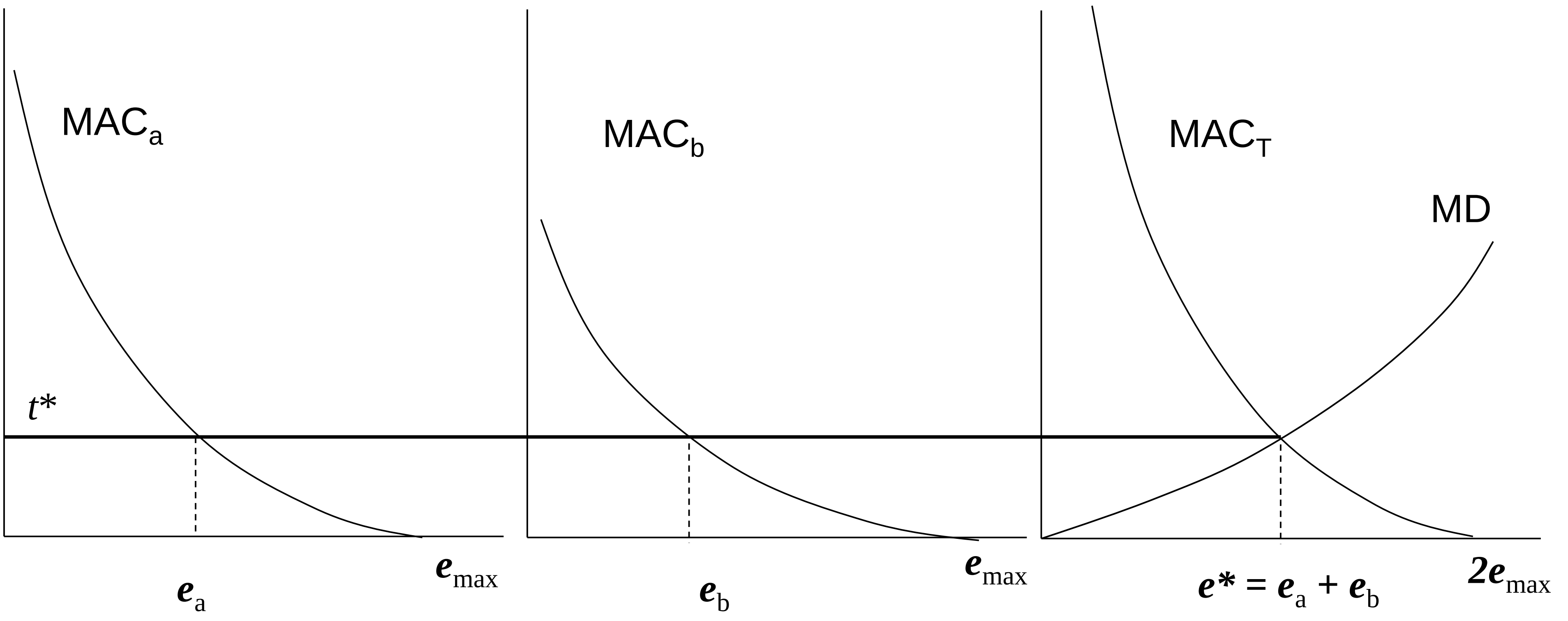


Provided that the authority is wise enough to be able to set the charge rate which attains the socially efficient level of emission *e**, the discharger voluntarily determines the amount emission at *e**. At *e**, clearly, MAC = *t** holds, where *t** denotes the optimal emission tax rate.

The total abatement cost in this case is expressed by the area b, while the tax payment is expressed by a. Thus, the polluter has to pay (a + b).

Equi-marginal principle again!

Once *t** is given, the optima allocation of emission to each plant is automatically determined. The equi-marginal principle appears again!



A remark

- For the optimal allocation of emission to be attained, an important proviso must hold; the authority is wise enough to be able to set the charge rate which attains the socially efficient level of emission e^*.

Pigouvian (Pigovian) tax

- In the economic theory, emission charges are not differentiated from emission tax.
- Thus, they are often used interchangeably.
- Such tax is called Pigouvian (Pigovian) tax, since Pigou first put forward the idea.

Basic Economics: How emission charges work. (cont.)

- Suppose the total abatement cost is expressed as TAC = $f(e_0 - e)$ where $f'(e_0 - e) > 0$ and $f''(e_0 - e) > 0$ hold. Clearly, $f'(e_0 - e)$ is the marginal abatement cost.
- If the authority imposes t^* on the amount of the emission, the total cost for a firm is TC = $f(e_0 - e) + t^*e$, which must be minimized.
- Thus, MAC = $f'(e_0 - e) = t^*$ must hold.

Question

- If there are plural number of firms or plants, how the above mathematical expression is modified?

Basic Economics: How emission charges work. (cont.)

- How is t^* determined?
- Notice that the optimal point is determined by the quality MAC(e^*) = MD(e^*).
- Set t^* = MAC(e^*) = MD(e^*).
- The, by definition, the optimal condition is satisfied.

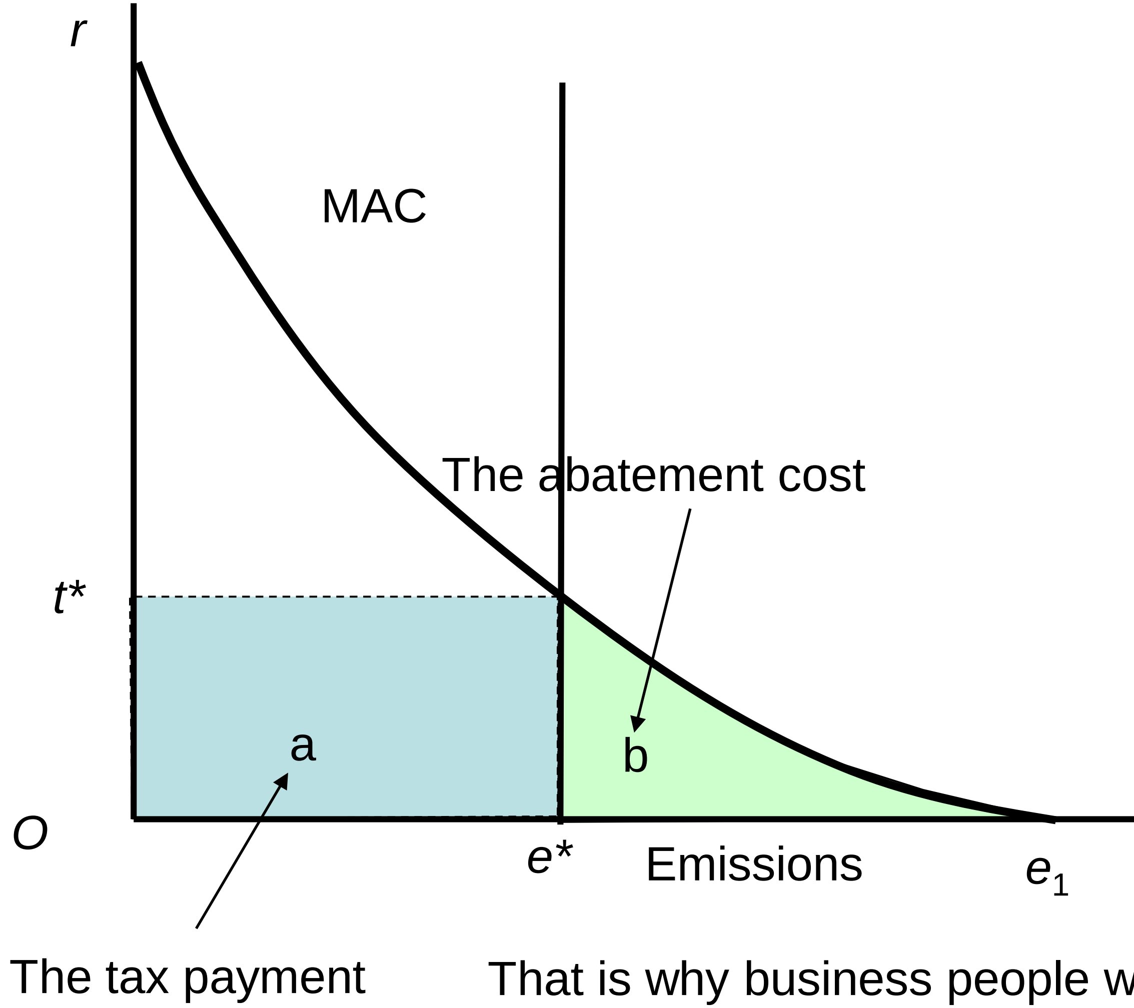
A remark

- For the authority to determine the optima tax rate, it must have correct information on marginal damages and marginal abatement costs of firms.
- It is often so costly to collect such information that the authority must *estimate* those costs with limited amount of information.

Difference in income distribution between emission charges and CAC

- What is the difference between emission charges and CAC, when the authority sets the target emission at e^*?
- It seems that the same amount of reduction of emission is obtained by the two methods, and actually so.
- Apart from an issue of cost effectiveness mentioned later, there is a difference in income distribution.

Explanation by means of a figure

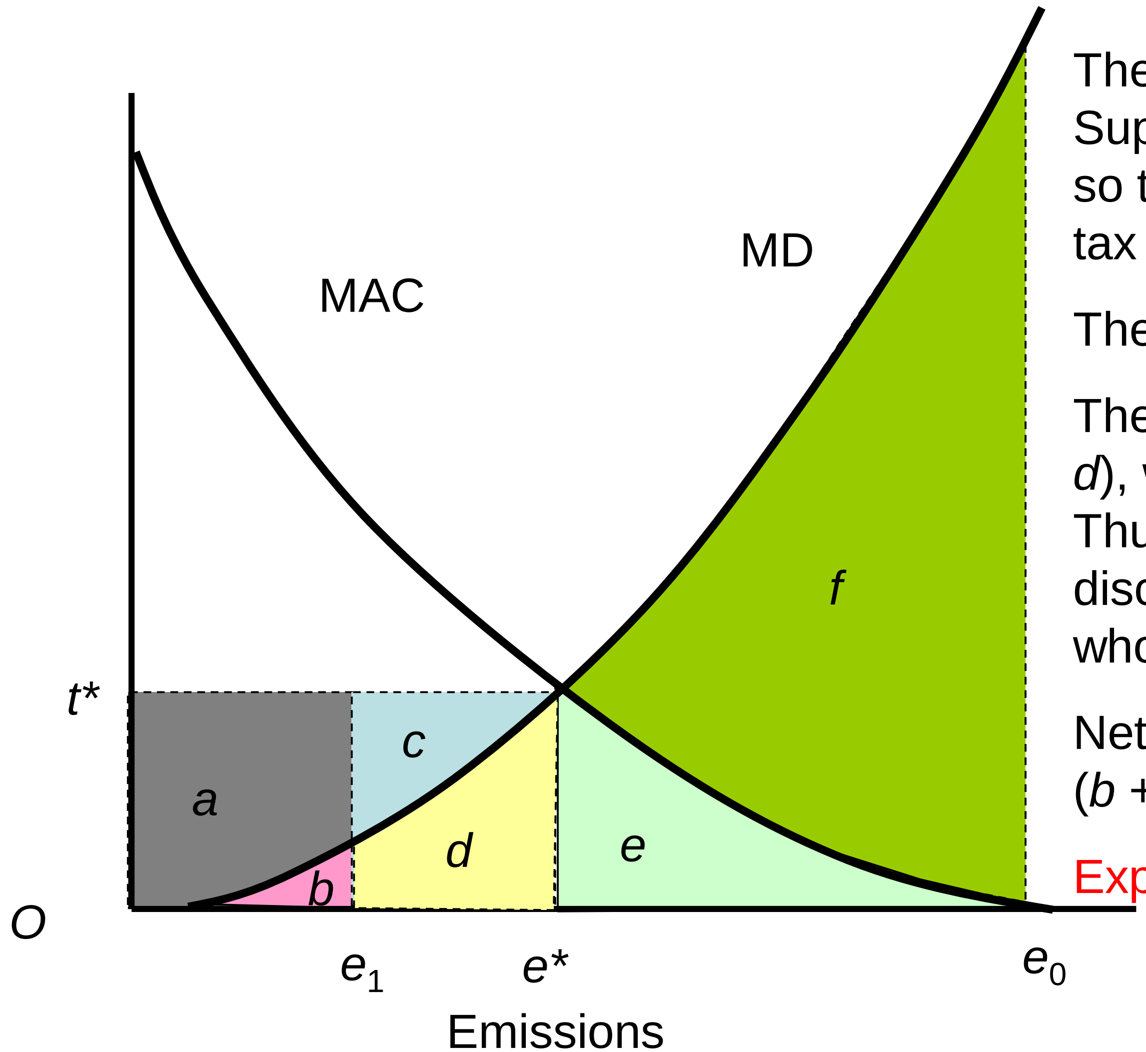


In the case of CAC, the costs for a discharger are expressed by the area *b* when the emission restriction is given at *e**. The abatement costs only.

On the other hand, in the case of emission charges, the costs for a discharger are expressed by the area (*a* + *b*), namely the abatement costs plus the tax payment, when the tax rate is given at *t**.

That is why business people would prefer CAC to emission charge scheme, if they were forced to choose one of them.

The costs for polluters and a society



The optimal emission level is *e**. Suppose that the authority is clever so that it knows *e** and imposes the tax *t** on emission.

The total abatement costs: *e*

The total tax payments: (*a* + *b* + *c* + *d*), which are transfer payments. Thus, these are costs for the discharger, but not costs for the whole society.

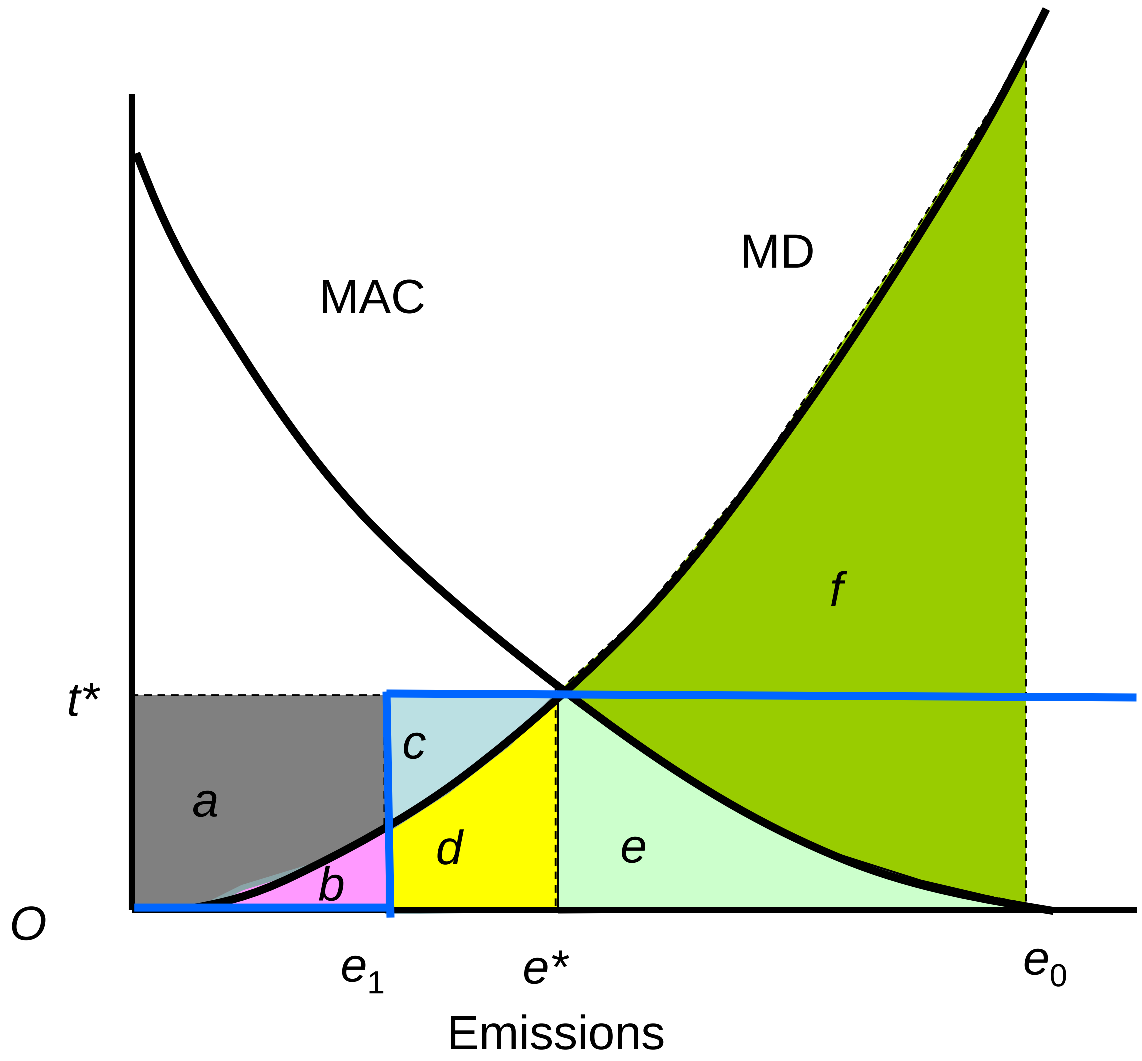
Net costs for the whole society are (*b* + *d* + *e*).

Explain why?

Two-part of emission charge

- To avoid heavy cost burden on firms by emission charges, two-part emission charges may be adopted.
- According to this idea, tax exemption is applied to some amount of emission, and charges are imposed on the amount which is larger than a certain level.

Explanation by means of a figure

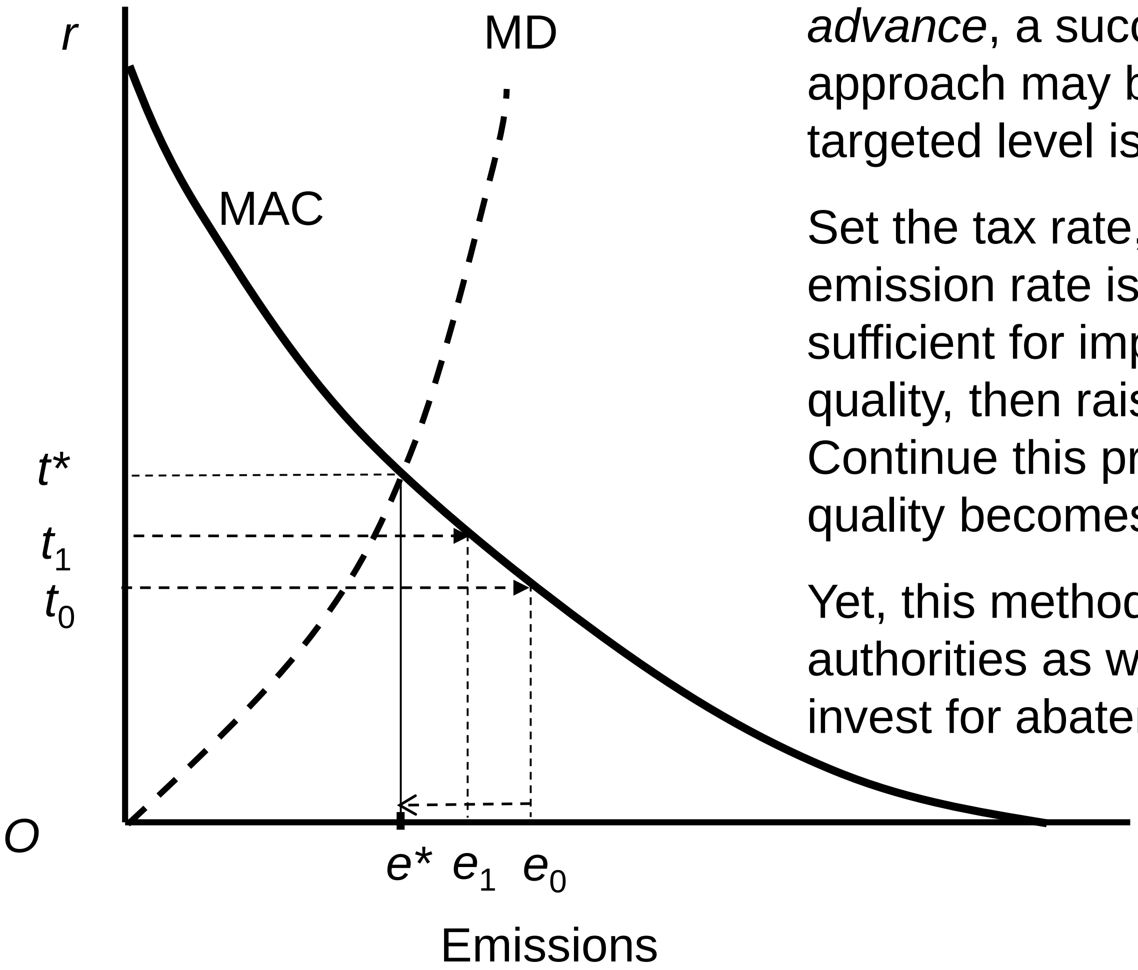


Two-part emission charge: $t = 0$ if $e < e_1$, and $t = t^*$ if $e = e_1$ or $e > e_1$.

Then, the tax payment is only (c + d), while the optimal emission level e^* is attained.

This two-part charge scheme is preferable to discharges, compared to the flat emission charge scheme.

What if the damage function is unknown.



When the damage function is not known *in advance*, a successive approximation approach may be required until the socially targeted level is attained.

Set the tax rate, say, at t_0. Then, the emission rate is e_0. If the reduction is not sufficient for improvement of the ambient quality, then raise the tax rate, say to t_1. Continue this process until the ambient quality becomes the targeted level e^*.

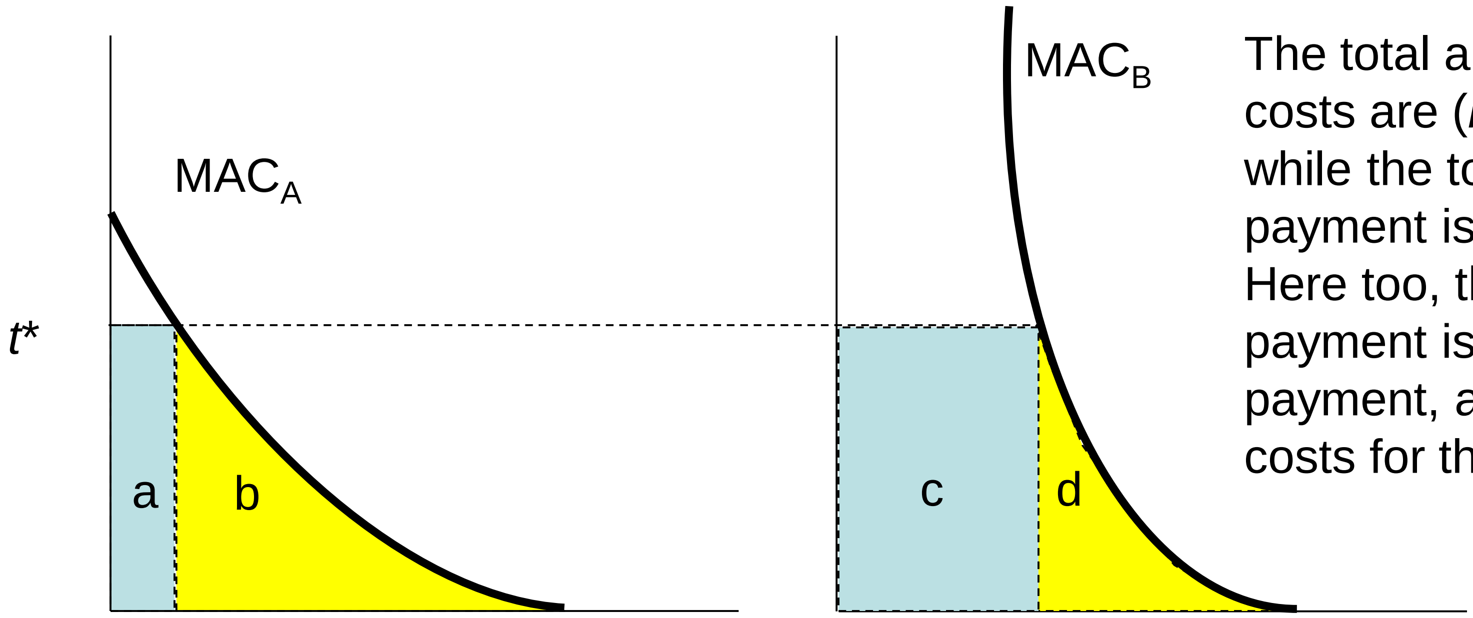
Yet, this method is very costly for the authorities as well as for dischargers, who invest for abatement of pollutants.

Emission charges and cost-effectiveness

- Emission charge approaches realize the *equi-marginal* principle, so that the cost-effectiveness is fulfilled.
- That is, $t^* = MAC_A = MAC_B$ holds.
- Thus, these approaches are cost effective. This cannot be made by CAC.

Emission charges and cost-effectiveness

Emission charge approaches realize the *equi-marginal* principle, since each firm tries to equalize its marginal abatement costs and the tax rate. That is, $t^* = MAC_A = MAC_B$ holds. This equation implies that these approaches are cost effective.



The total abatement costs are (*b* + *d*), while the total tax payment is (*a* + *c*). Here too, the tax payment is transfer payment, and not costs for the society.

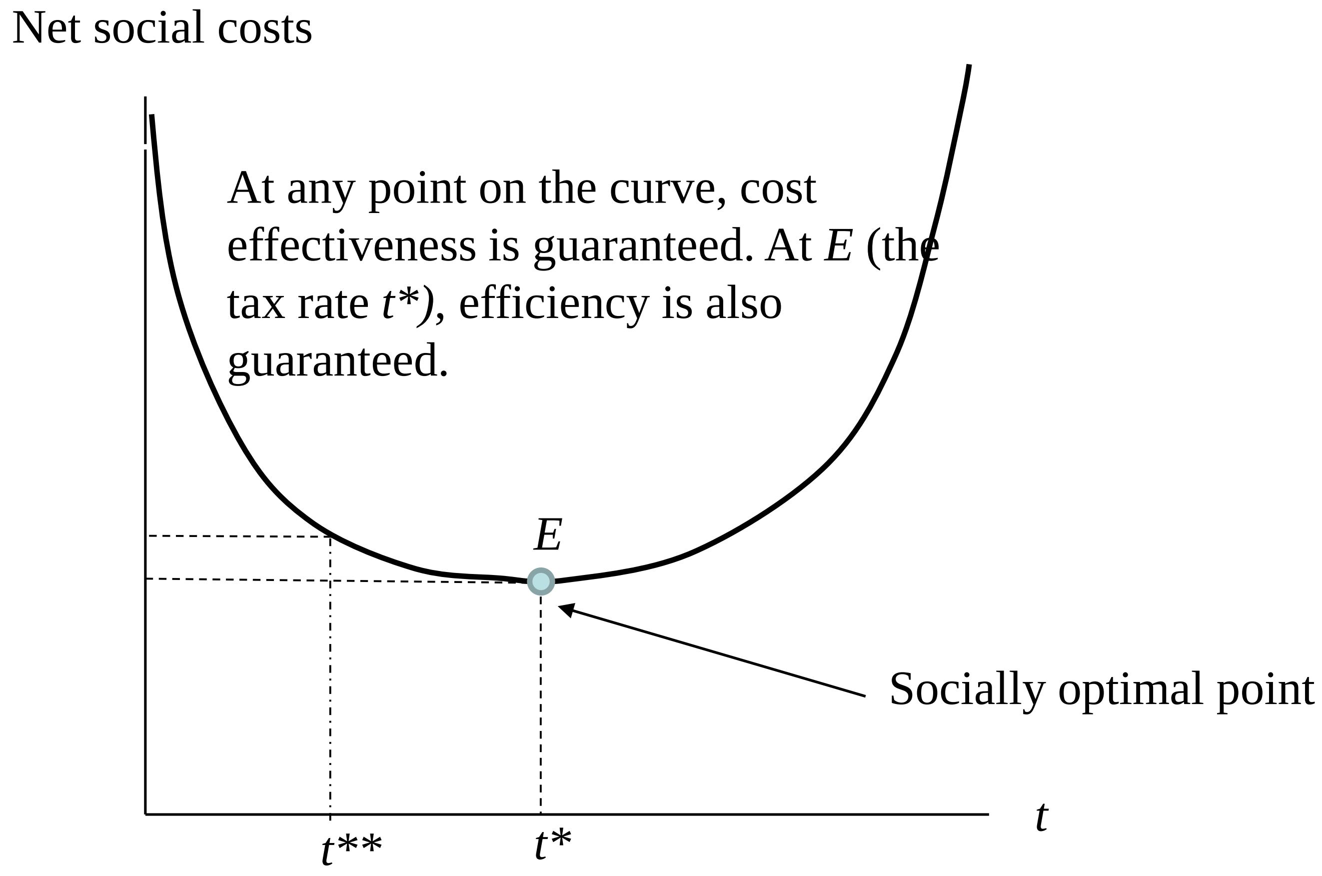
Cost-effectiveness: mathematics

- Suppose the total amount of emission is given as a policy target. Namely, $e_A + e_B = e$ (given).
- Minimize the total abatement costs.
- Minimize $\mathrm{AC_A}(e_{A0} - e_A) + \mathrm{AC_B}(e_{B0} - e_B) + \lambda\,(e_A + e_B - \mathrm{e}\,)$.
- Then, we have $\mathrm{MAC_A} = \mathrm{MAC_B} = \lambda$.
- If we set $t^* = \lambda$, we can minimize the total abatement costs.
- Clearly, this tax rate minimizes the total costs, namely, the total abatement costs and tax payment, given the total emission amount.

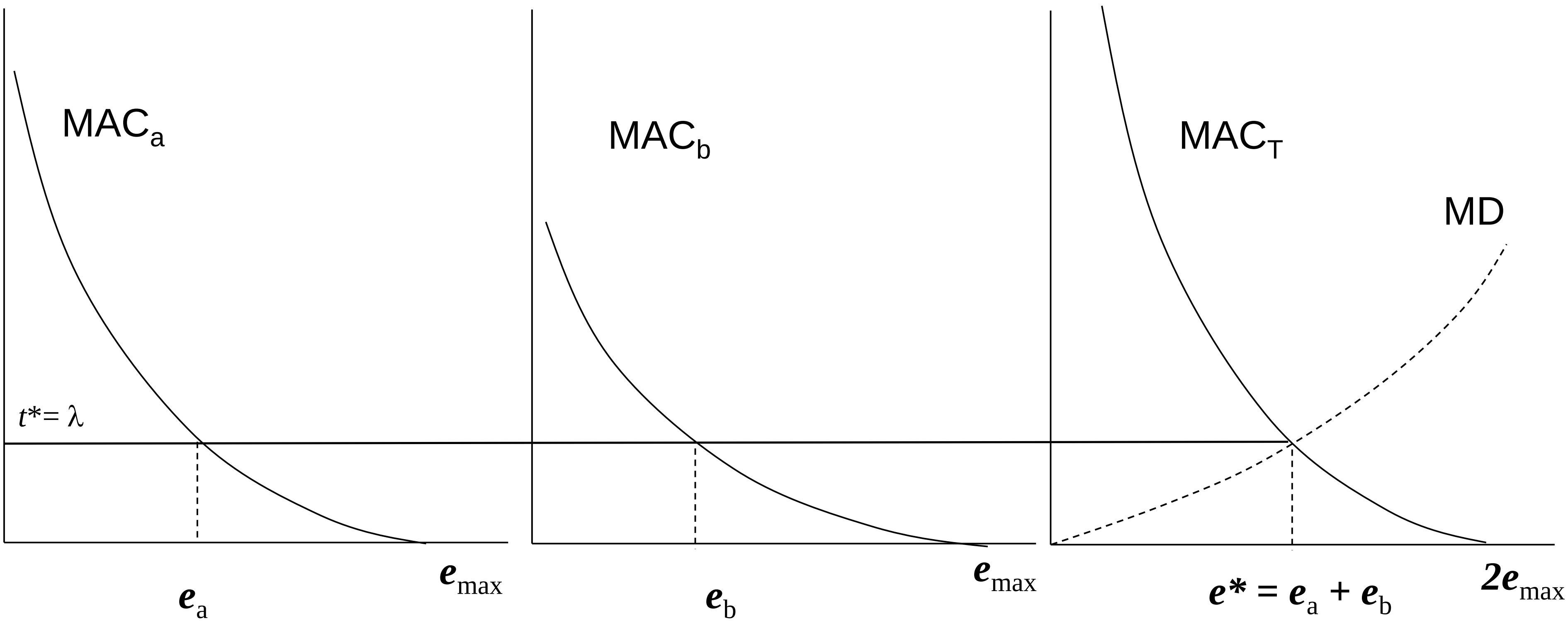
Important remarks

- Authorities are not always so clever to determine the optimal tax; *t* may not equal λ.
- Yet, notice that $MAC_A = MAC_B = t$ holds, implying that the equi-marginal principle still holds.
- What does this mean?
- If the tax rate is determined at *t*, the maximum amount of the emission e^{**} (may not be efficient level) is determined.
- Hence, for attaining the level e^{**} , the total abatement costs are minimized, since the equi-marginal principle holds.

The relationship between a tax rate and the net social costs



The case where $t^* = \lambda$: By means of a figure



When emissions are non-uniform.

- There are cases that emissions of sources are not uniformly mixed.
- A unit of discharge from one source may give different impacts from other sources.
- Then, the principle of the uniform tax rate does not hold any more, since different sources give different impacts.
- Suppose emission from the source 1 (source 2) has an emission coefficient h_1 (h_2).

Modification of the equi-marginal principle

- The total costs are expressed as

$AC_1(e_{10} - e_1) + AC_2(e_{20} - e_2) + D(h_1 e_1 + h_2 e_2)$.

- From minimization of this, the following is obtained:

$$MAC_1 = h_1 D' \text{ and } MAC_2 = h_2 D'.$$

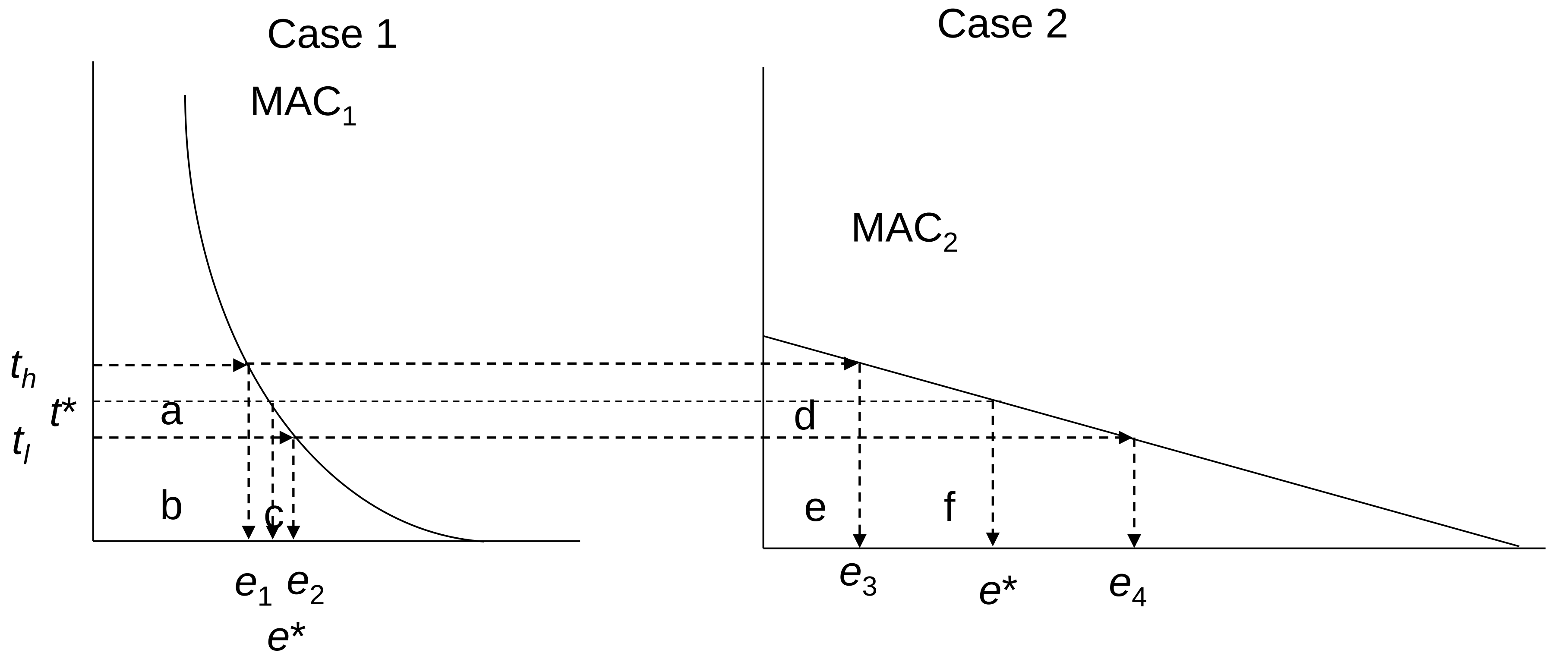
- Thus, we have

$$MAC_1/h_1 = D' = MAC_2/h_2.$$

Modification of the equi-marginal principle (cont.)

- Set the tax rate for source 1 and 2 as $t_1 = h_1 D'$ and $t_2 = h_2 D'$ respectively.
- Clearly, if $h_1 = h_2$ holds, the basic equi-marginal principle applies.

Emission charges and uncertainty

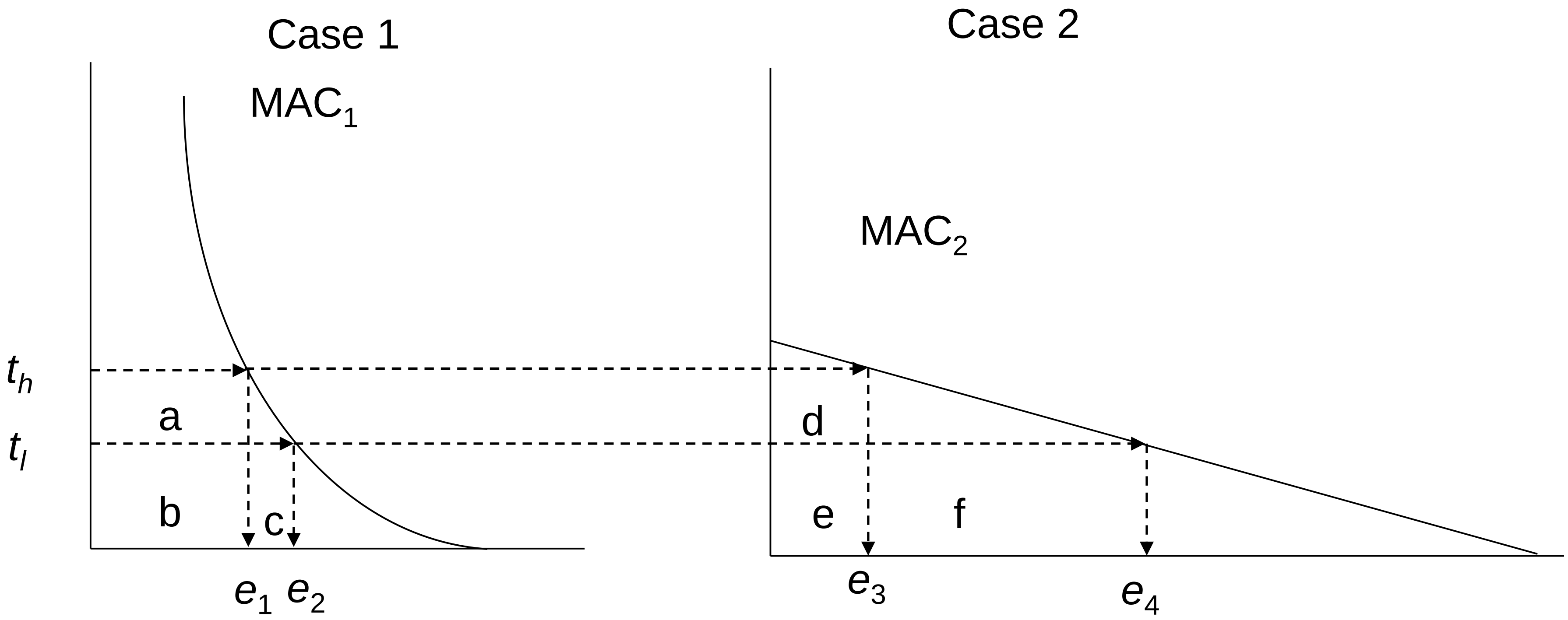


When there is uncertainty, the authority may not be able to set the optimal tax rate. But In Case 1, even if the higher or lower tax rate is applied, the emission rates obtained are very close to the optimal one. In Case 2, non-optimal tax rate may possibly realize the emission rates which are very different from the optimal emission rate. The elasticity of MAC curve does matter when there is uncertainty.

Double dividends

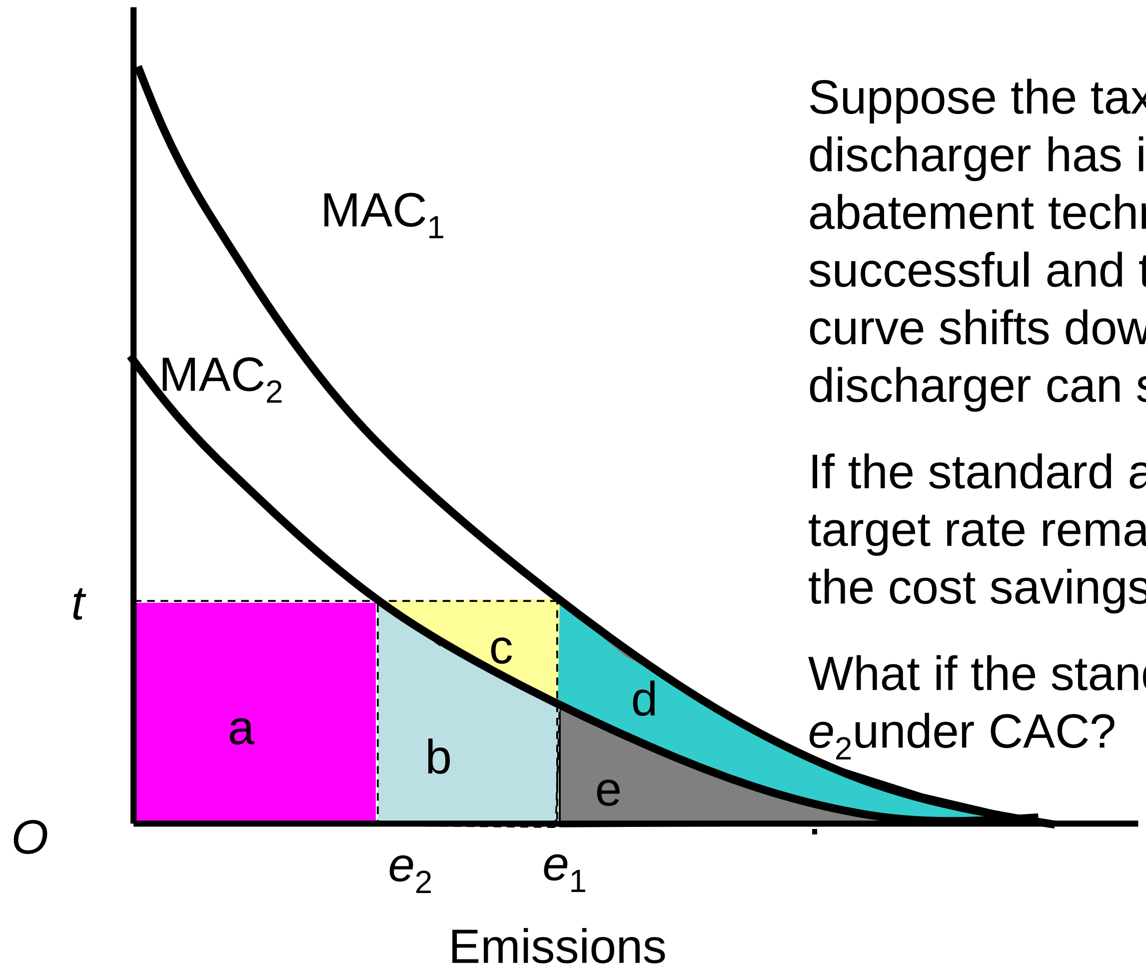
- How can tax revenues be used?
- It is often argued that they can be used to reduce the conventional tax burden, i.e., employment taxes.
- Then, the environmental burden is reduced on one hand, while the employment could be increased. $\rightarrow$ A win-win solution!
- Thus, there are two good things, which are often called *double dividends*.

Really such merits?



Suppose the tax rate is increased from t_l to t_h, the tax revenues are also increased from (b + c) to (a + b) in Case 1. In Case 2, however, the tax revenues are decreased from (e + f) to (d + e). Then, the employment tax cannot be reduced.

Dynamics: Emission charges and innovation



Suppose the tax rate is set at *t*. Then, the discharger has incentives for R&D for new abatement technology. If the innovation is successful and the marginal abatement curve shifts down as in the figure, the discharger can save the cost (c + d).

If the standard approach is taken and the target rate remains e_1 after the innovation, the cost savings are only d.

What if the standard is changed from e_1 to e_2 under CAC?

Enforcement

- To implement emission charges approach, the authority must measure or monitor the emission rates from all the sources.
- Otherwise, fair charges could not be imposed on the dischargers, who may oppose this approach in such a case.
- Yet, the same argument can be applicable to the command-and-control approaches, since the compliance must be checked by the authority.

The second best approaches

- It may be difficult to charge on dischargers according to the amount of emission, since monitoring is not easy in some cases.
- Pollution which comes from non-point sources, say pollution of agricultural fertilizer, is a good example.
- Then, alternative ways of charging may be adopted.
- Input charges may be adopted. Yet, generally speaking, this method is second best and not optimal.

Distributional impacts

- Emission charges give impacts on relative prices and outputs, as well as distribution.
- If the charge is imposed on a single firm in a competitive circumstances, the firm cannot shift the cost increase, and must reduce outputs.
- If the charge is imposed on the entire industry, the social MC curve or the social supply curve shifts up, so that the price increases, depending upon the elasticity of demand.
- If the demand is not elastic, consumers are affected also.

2. Abatement subsidies

- The same effects as emission charges are brought about by abatement subsidies on emission reduction in the short run.
- This is so, because the subsidies are the opportunity costs for dischargers.
- Distributional effects are, however, different, since dischargers are given subsidies, and their profits are increased.
- Thus, in the long run, there may be entry of firms, and the number of firms may be increased.
- The optimal condition may not be satisfied.

Why so?

- Suppose the subsidy rate is s^* which is equal to the optimal tax rate (t^* = MD = MAC).
- The firms minimize the total costs TAC($e_0 - e$) – s^* ($e_0 - e$).
- Thus, we have MAC = s^*.
- But this is true, insofar as there is no entry to the relevant market.
- If there is entry of other firms, the optimal condition is not satisfied.

If there is entry of other firms, . . .

- If there is entry of other firms, why isn't the optimal condition satisfied?
- To consider this, we have to remember how the social (aggregate) abatement cost function is deduced?
- See Lecture No. 3, p.26: It is obtained by the minimization of $\{TAC_1(\boldsymbol{e}_{\max} - \boldsymbol{e_a}) + TAC_2(\boldsymbol{e}_{\max} - \boldsymbol{e_b}) - \lambda (\boldsymbol{e} - \boldsymbol{e_a} - \boldsymbol{e_b})\}$
- If, say, firm *c* enters the market, the above equation is changed, and so the social abatement cost function is also changed. (How should the above be modified?)
- Hence, the optimal point is affected by the entry.

Application of subsidies

- A deposit-refund system is the combination of a tax and a subsidy.
- When consumers buy some drinks, they are charged on bottles or containers (a deposit = a tax or a charge).
- If they return the bottles or containers, they are refunded (a subsidy).
- If they do not return the bottles or containers, they remain charged.
- Yet, for the deposit-refund to be successful, a collection system must be prepared carefully.