Lecture 16: Market Instruments in Practice

Prof. Austin
Environmental Economics
Econ 4075

Roadmap

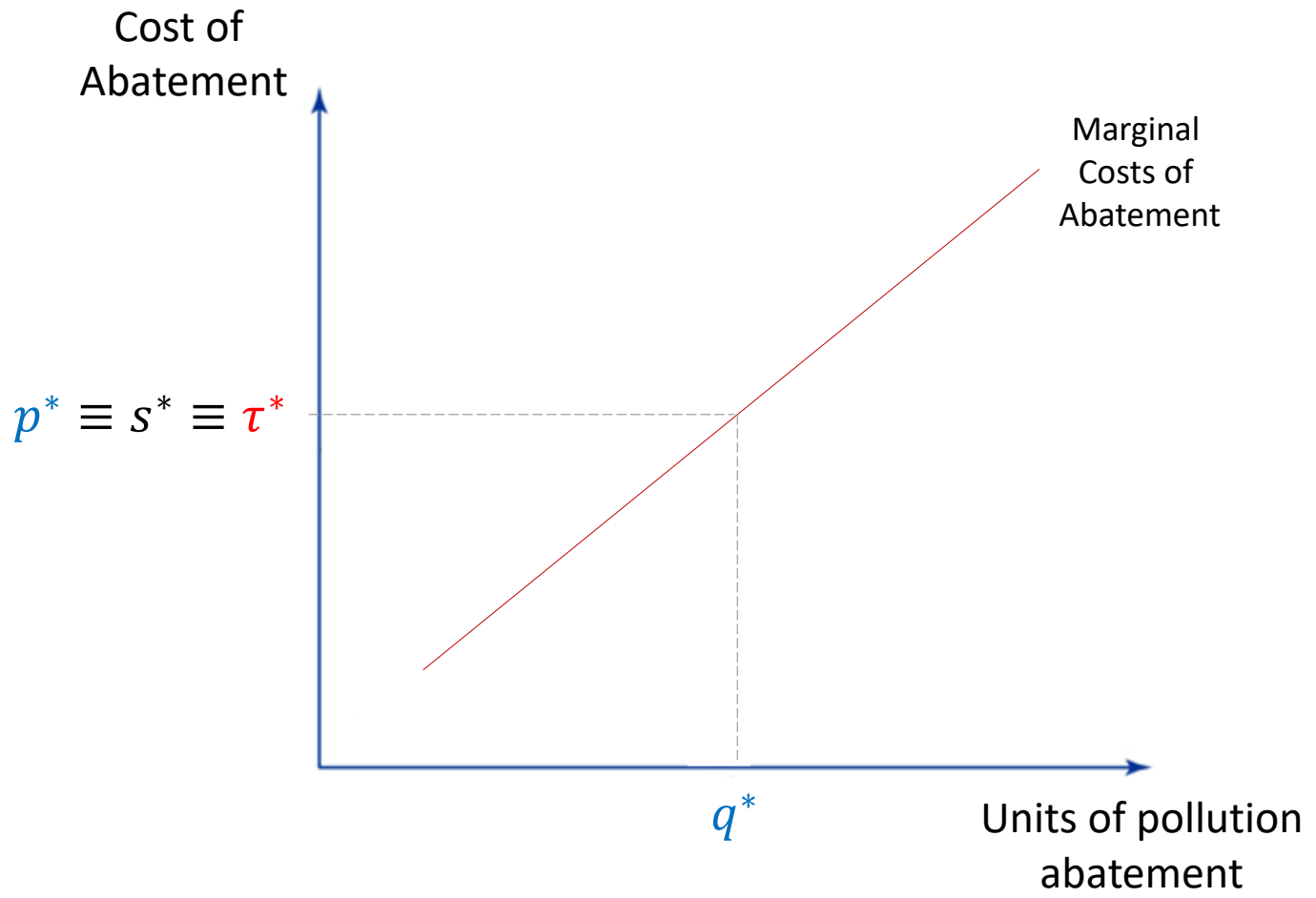
Market instruments in practice:

- Quantities with Pigouvian taxes
- Price formation in cap-and-trade
- Cap-and-trade game
- Prices vs. Quantities (Weitzman Rule)

Part 1: Quantities with Pigouvian Taxes

Recap from Last Time

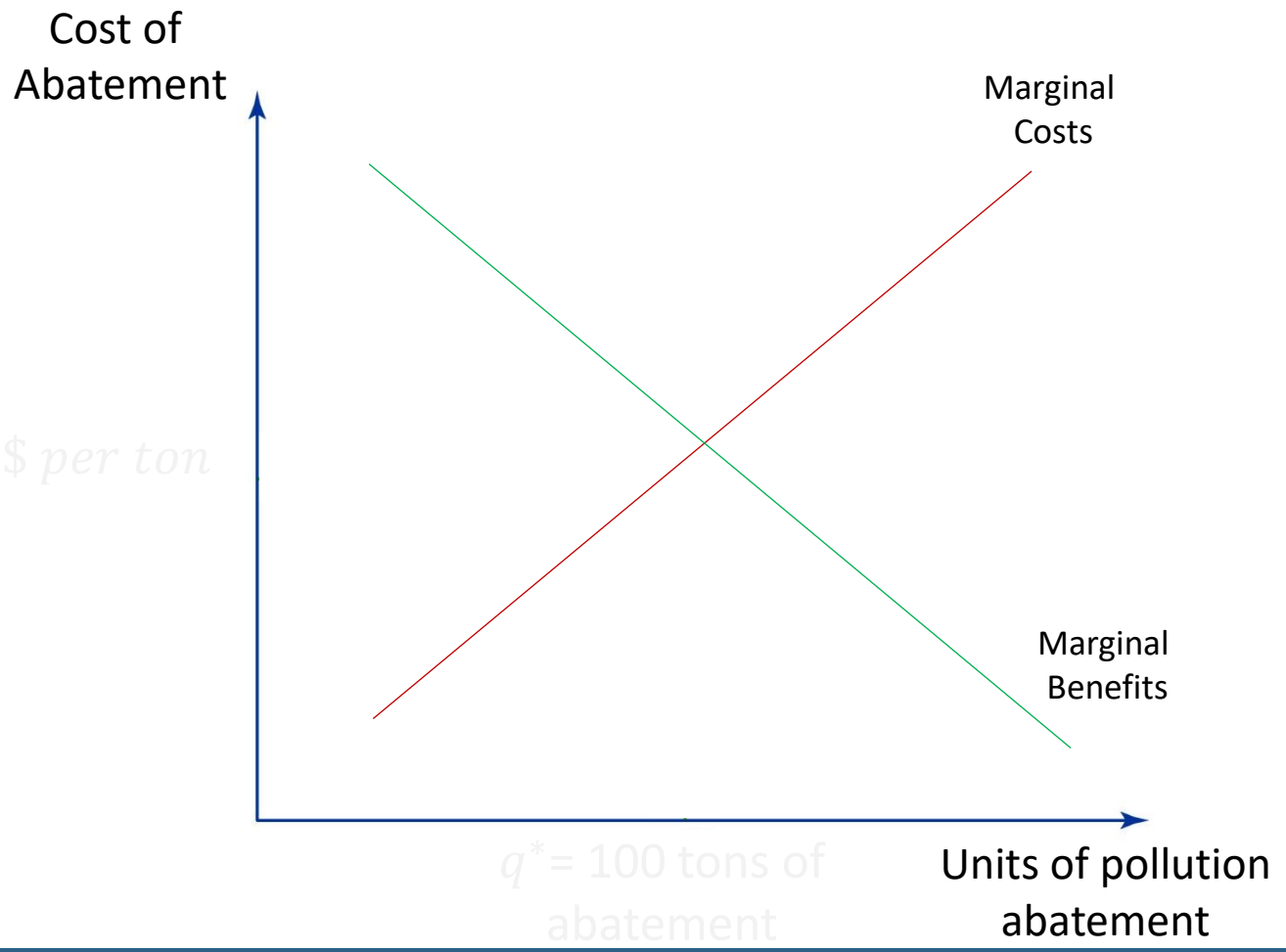
Previously, we discussed how a quantity control at q^* in a cap-and-trade policy will lead to allowance prices p^* that are equal to the Pigouvian Tax, τ^*.



Quantities Under a Pigouvian Tax

Let's start with a Pigouvian tax.

- The regulator determines the optimal tax level.
- τ^* is the resulting emissions fee.
- q^* is the quantity of pollution abated.



$\tau^* = 10\$ \, per \, ton$

$q^* = 100$ tons of abatement

Quantities Under a Pigouvian Tax

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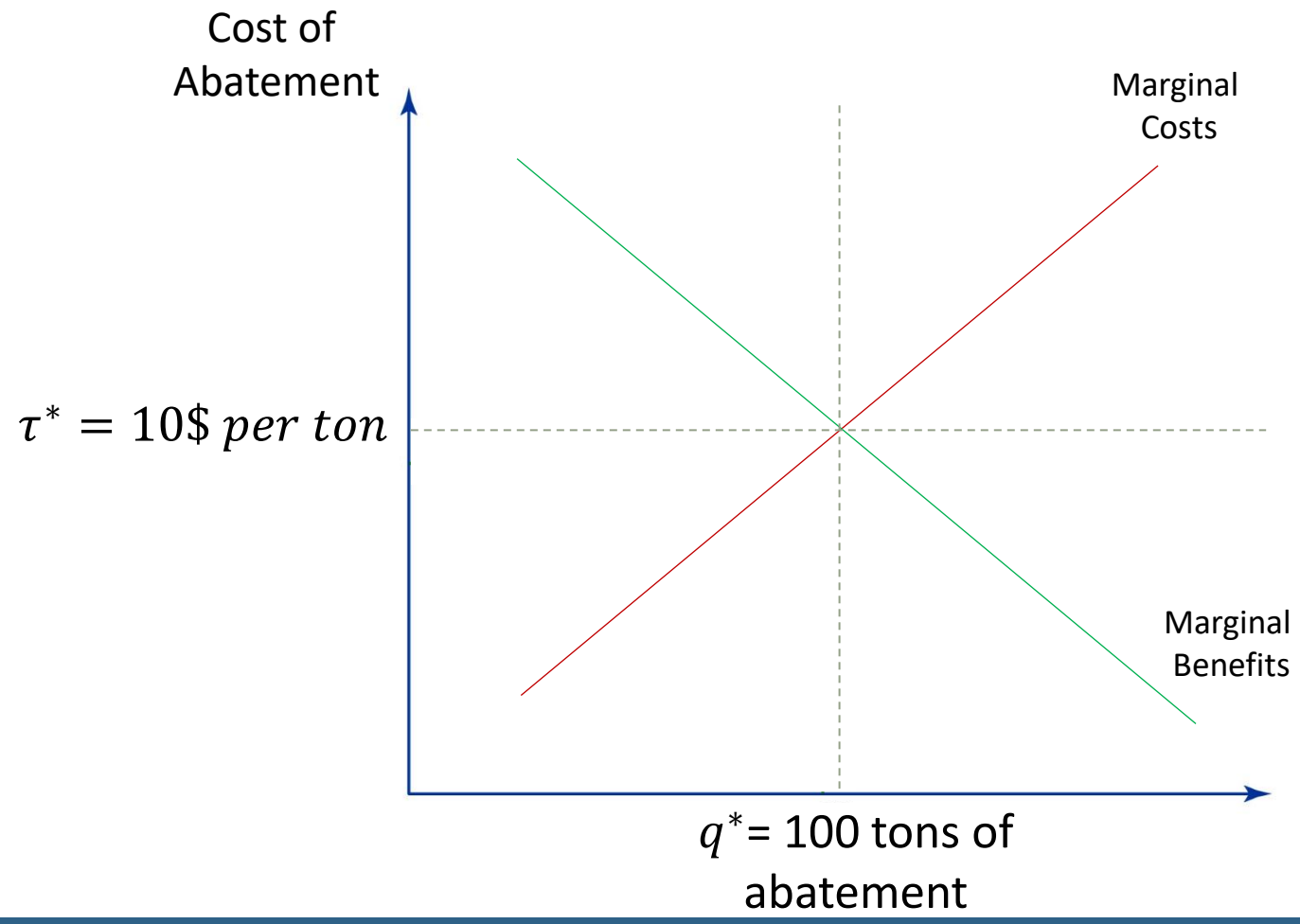
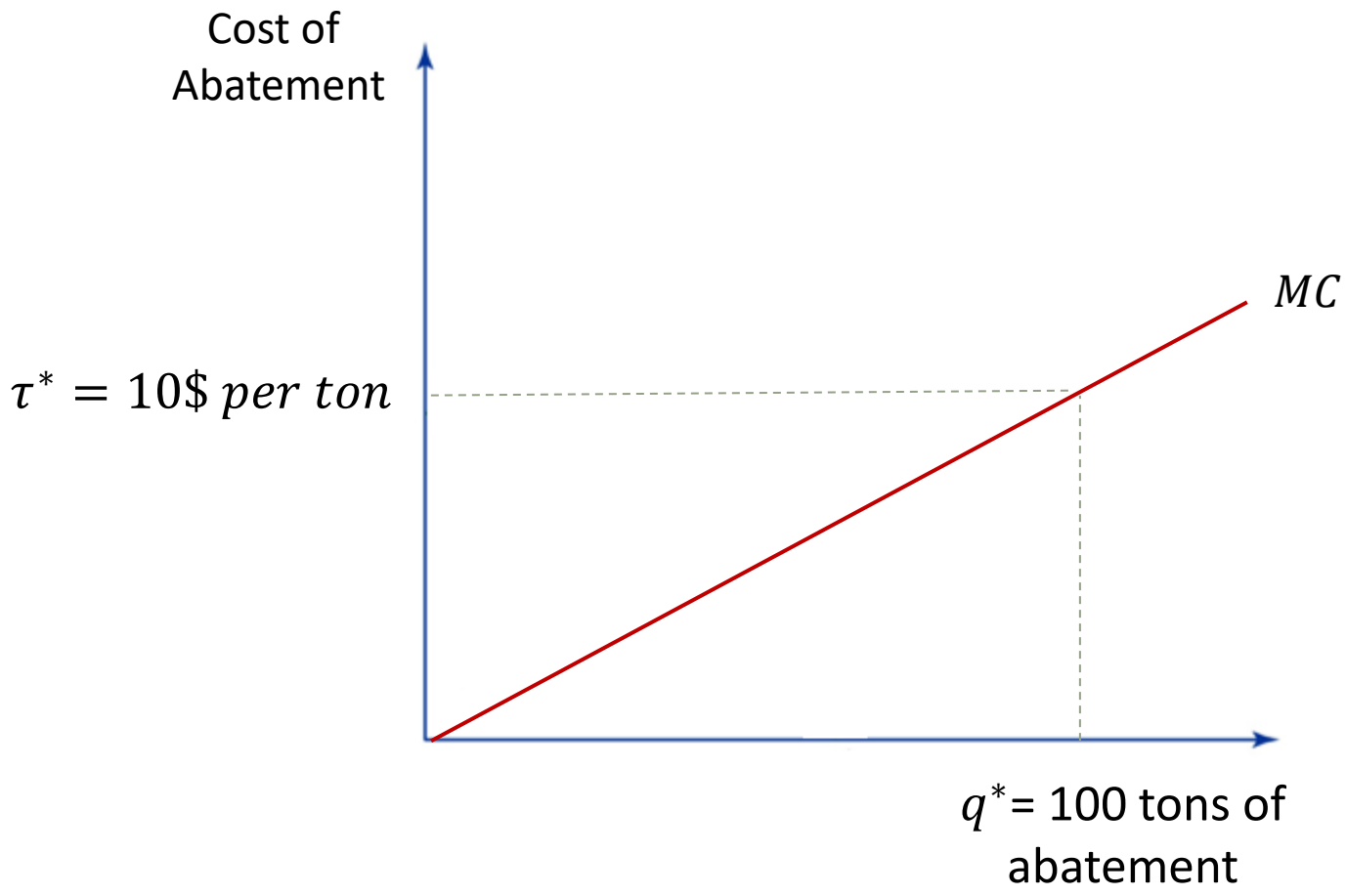


Marginal Costs Across Firms

In this example, the marginal cost of abatement curve represents the marginal costs across many polluting firms.

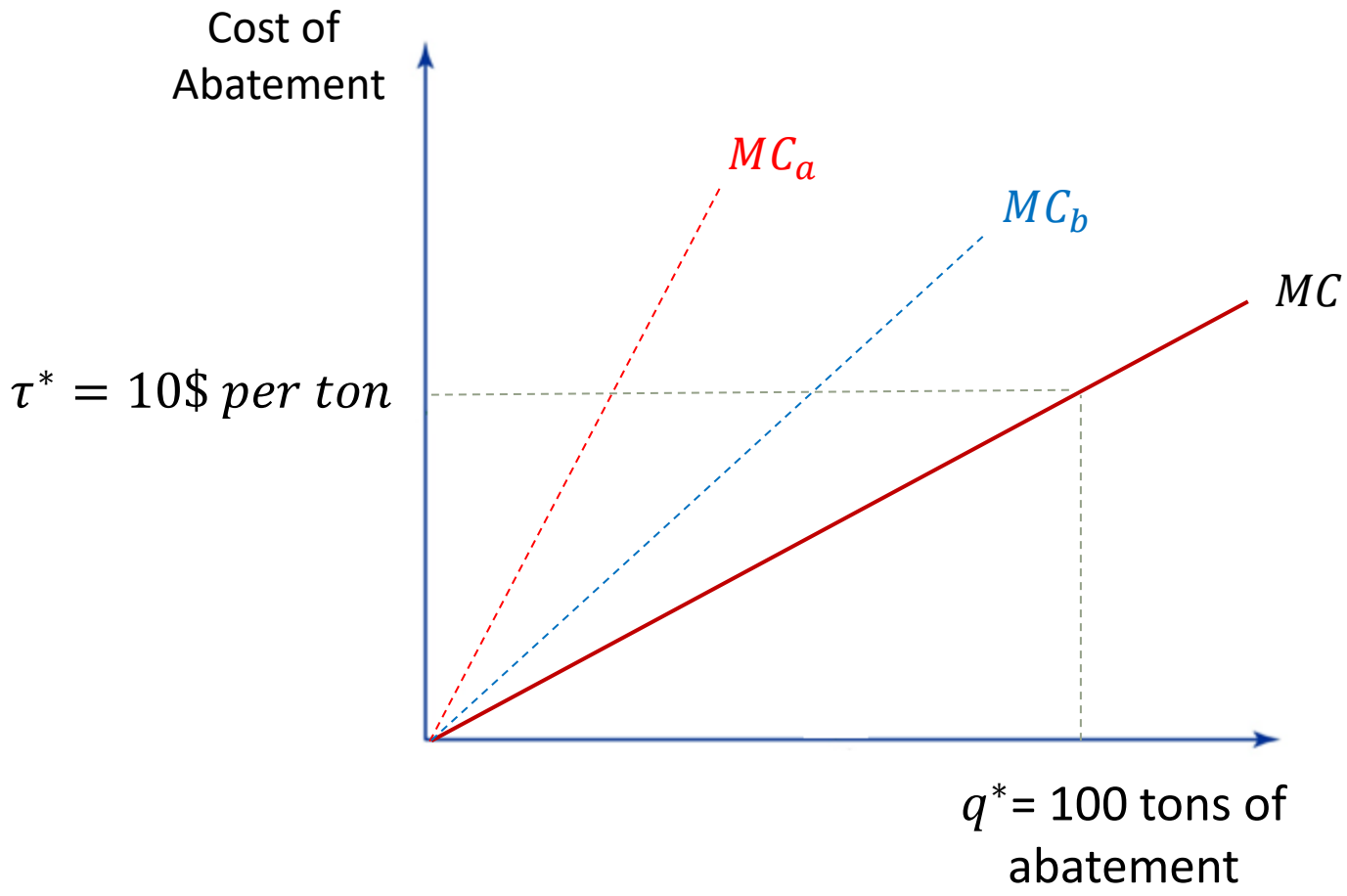


Marginal Costs Across Firms

For simplicity, let's assume there are two firms, A and B. These firms have the following marginal cost curves.

$$MC_a = \frac{1}{4} * q_a$$

$$MC_b = \frac{1}{6} * q_b$$



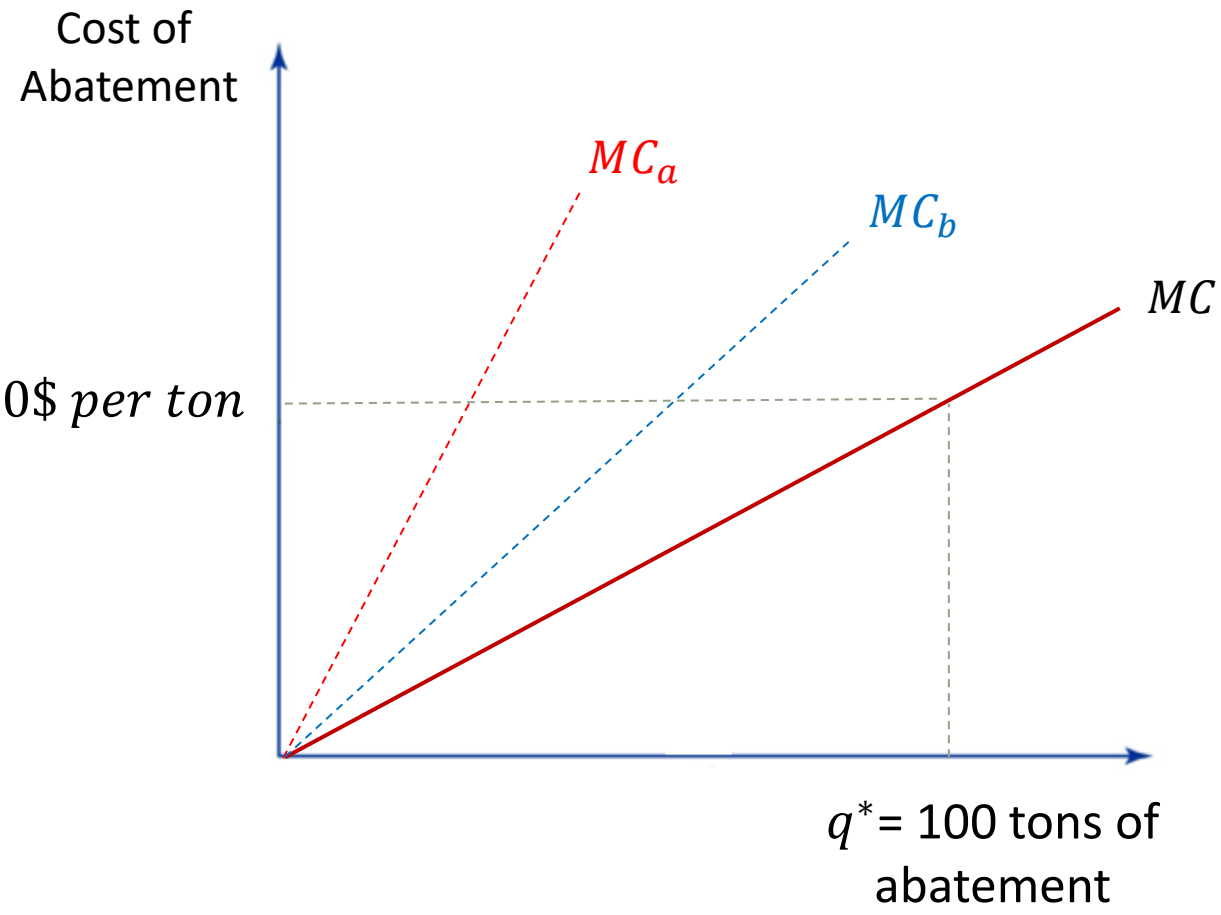
Quantities Under a Pigouvian Tax

How much would each firm abate with a Pigouvian tax of $10 per ton?

$$MC_a = \frac{1}{4} * q_a$$

$$MC_b = \frac{1}{6} * q_b$$

$$\tau^* = 10\$ \; per \; ton$$



Quantities Under a Pigouvian Tax

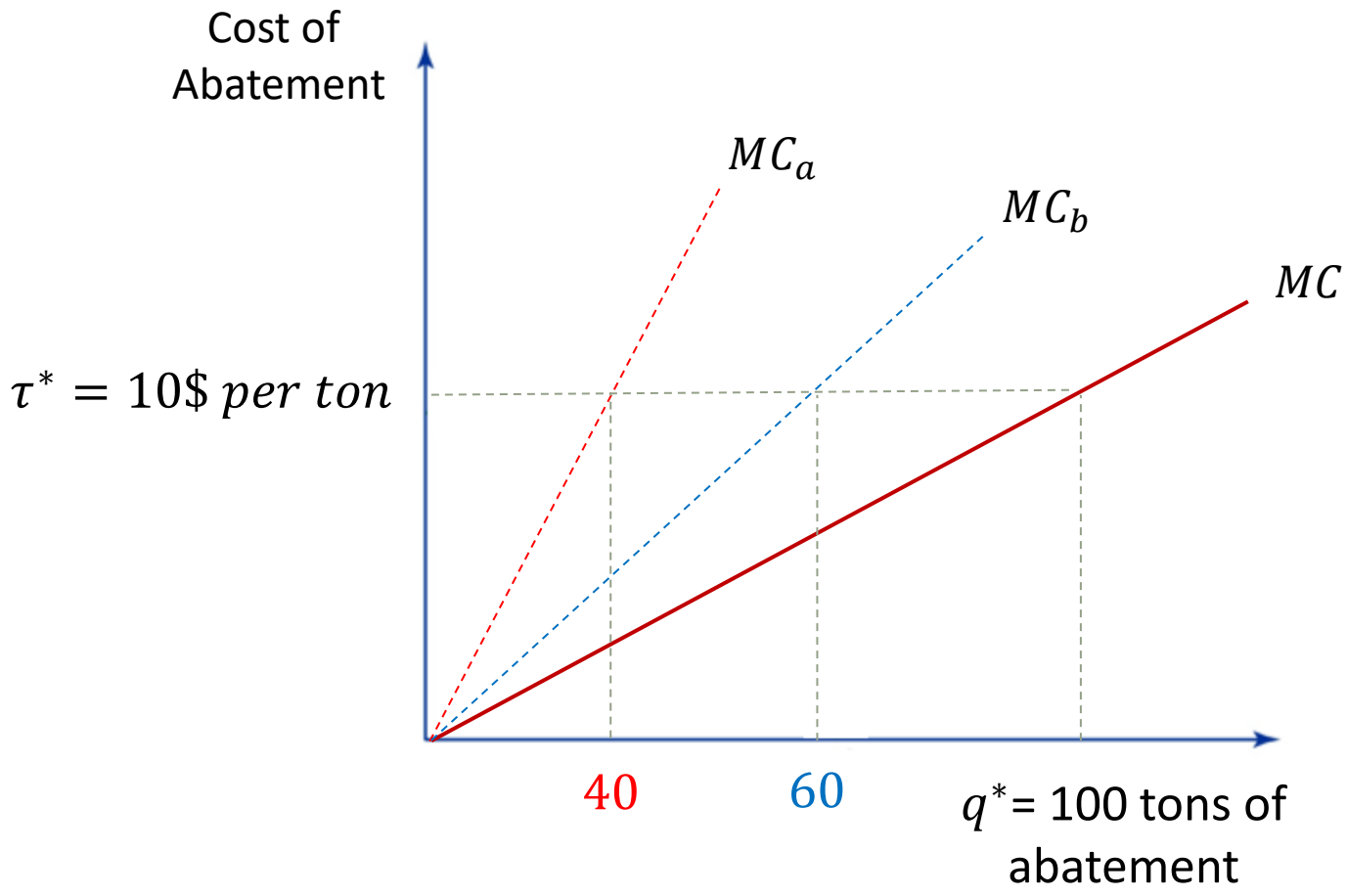
How much would each firm abate with a Pigouvian tax of $10 per ton?

$$MC_a = \frac{1}{4} * q_a$$

$$MC_b = \frac{1}{6} * q_b$$

10*4 = 40

10*6 = 60



Quantities Under a Pigouvian Tax

We already know that the economy-wide abatement quantity will be 100 (60+40).

We can also re-construct the sector-wide marginal abatement cost curve.

$$\tau^* = 10\$ \; per \; ton$$

$$MC_a = \frac{1}{4} * q_a$$

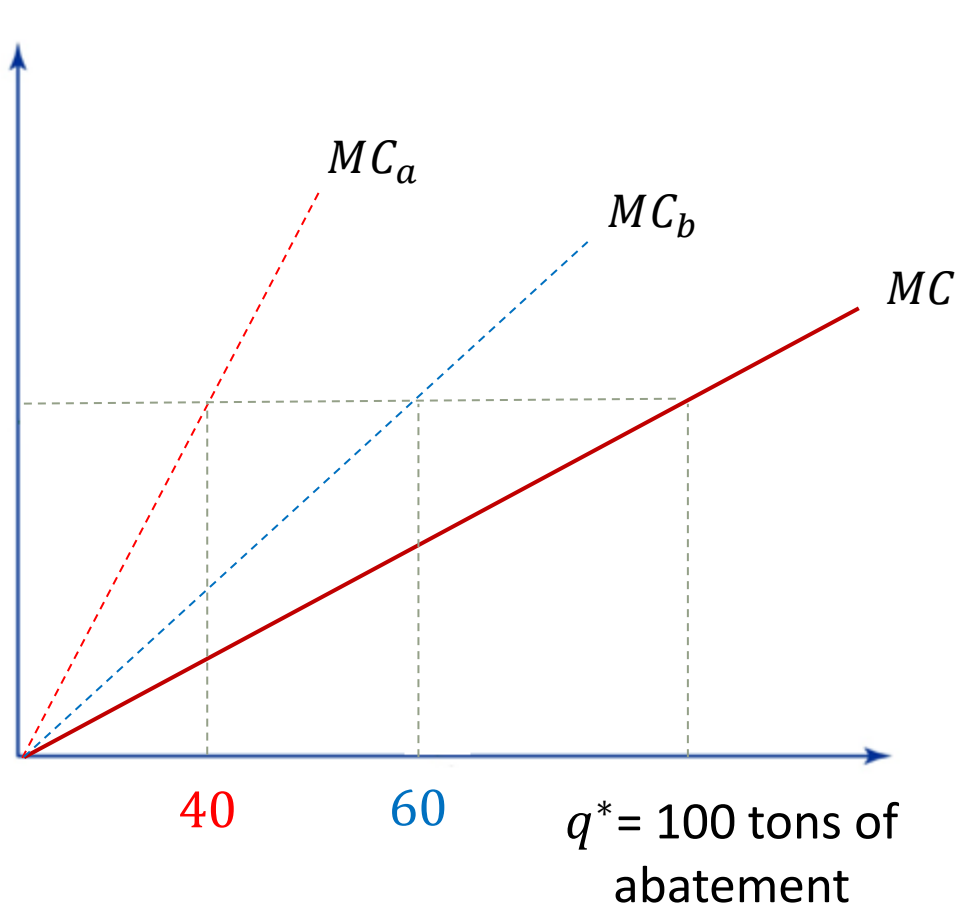
$$MC_b = \frac{1}{6} * q_b$$

$$MC_a + MC_b = \mathrm{MC}$$

$$4p^* + 6p^* = q_a + q_b$$

$$\rightarrow 10p^* = q^*$$

$$\rightarrow p^* = \frac{1}{10} q^*$$



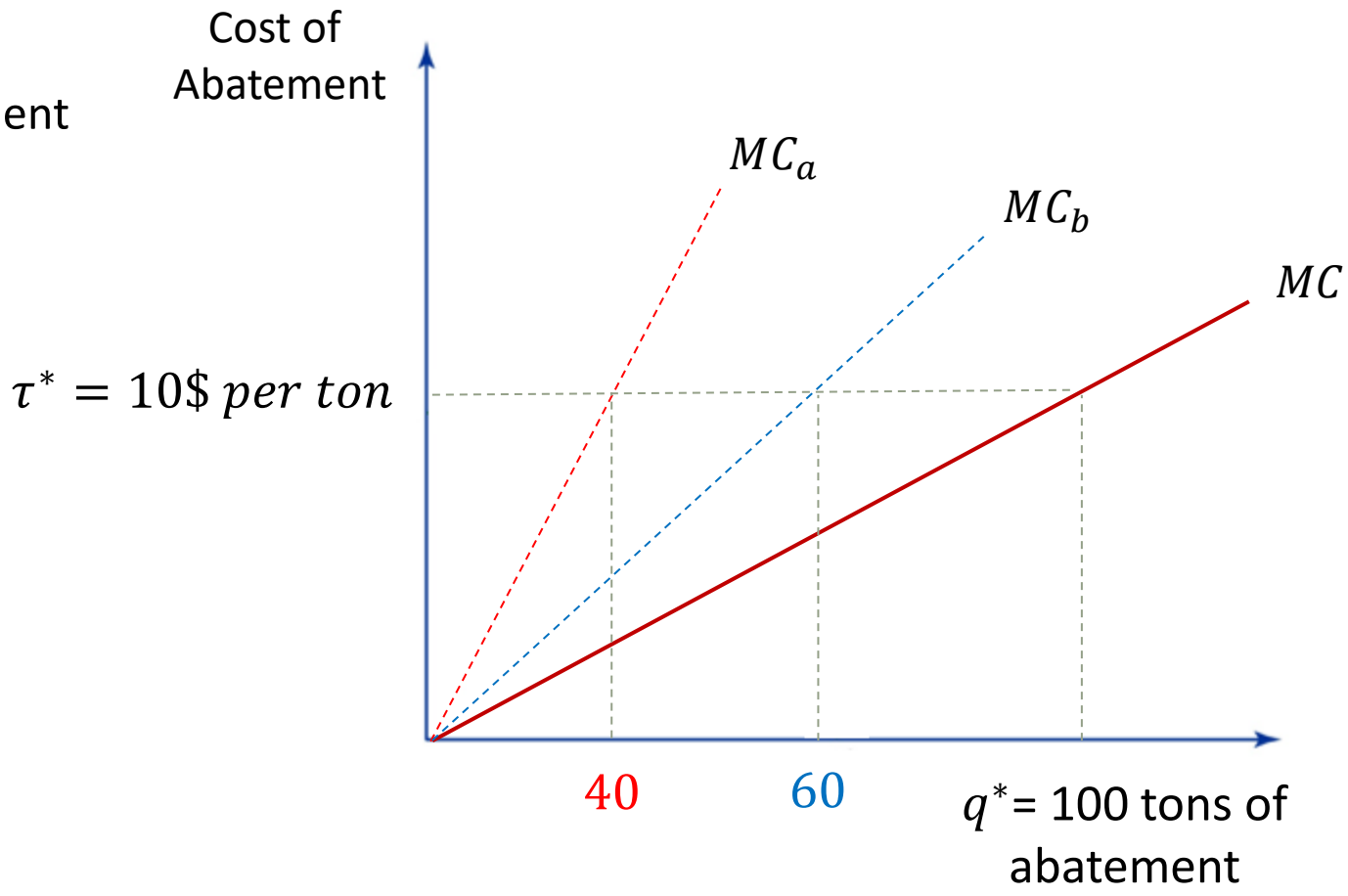
Quantities Under a Pigouvian Tax

Now we have the following marginal abatement curves and the known abatement quantities at a \$10 Pigouvian tax.

$$MC_a = \frac{1}{4} * q_a$$

$$MC_b = \frac{1}{6} * q_b$$

$$MC = \frac{1}{10} * q$$

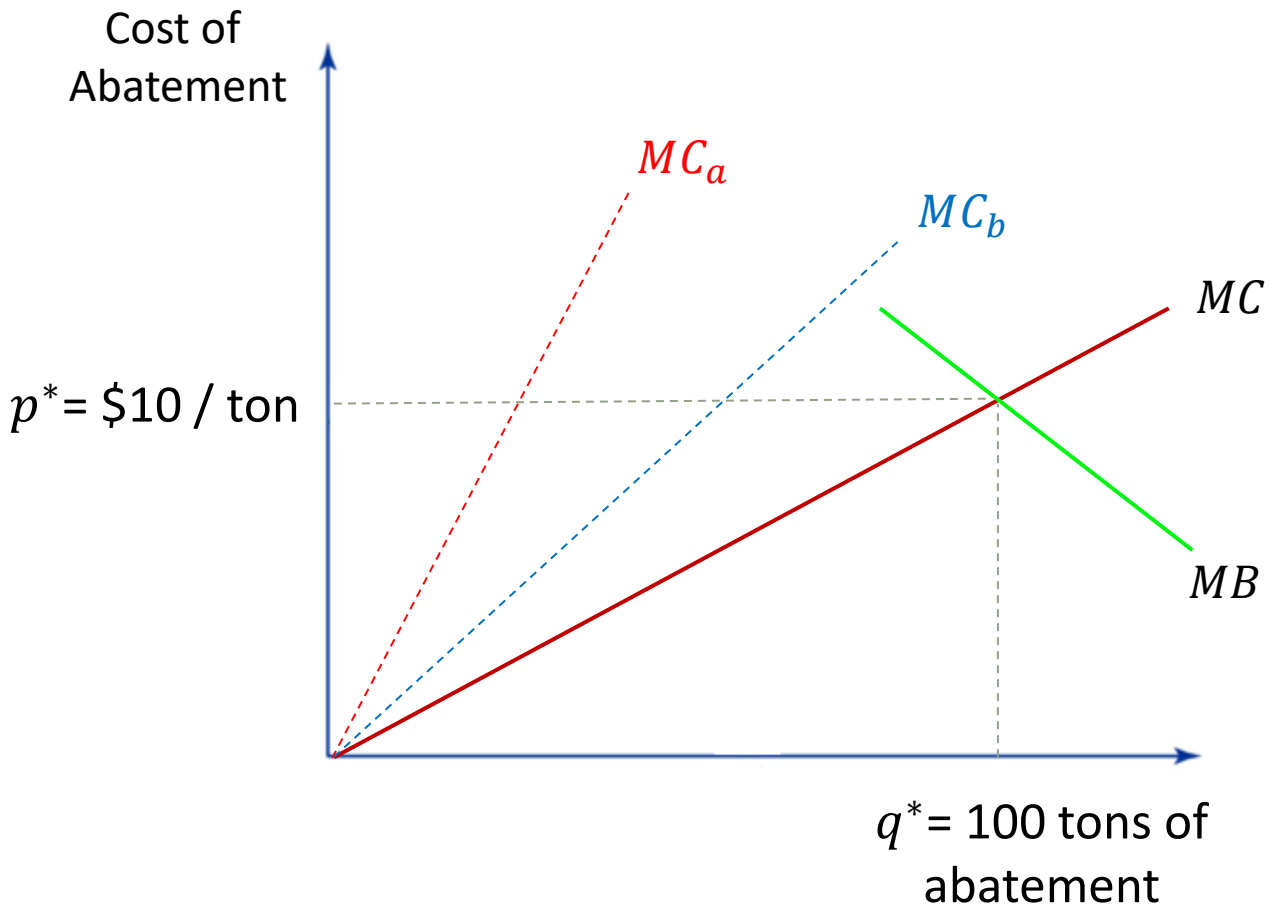


Part 2: Price Formation in Cap and Trade

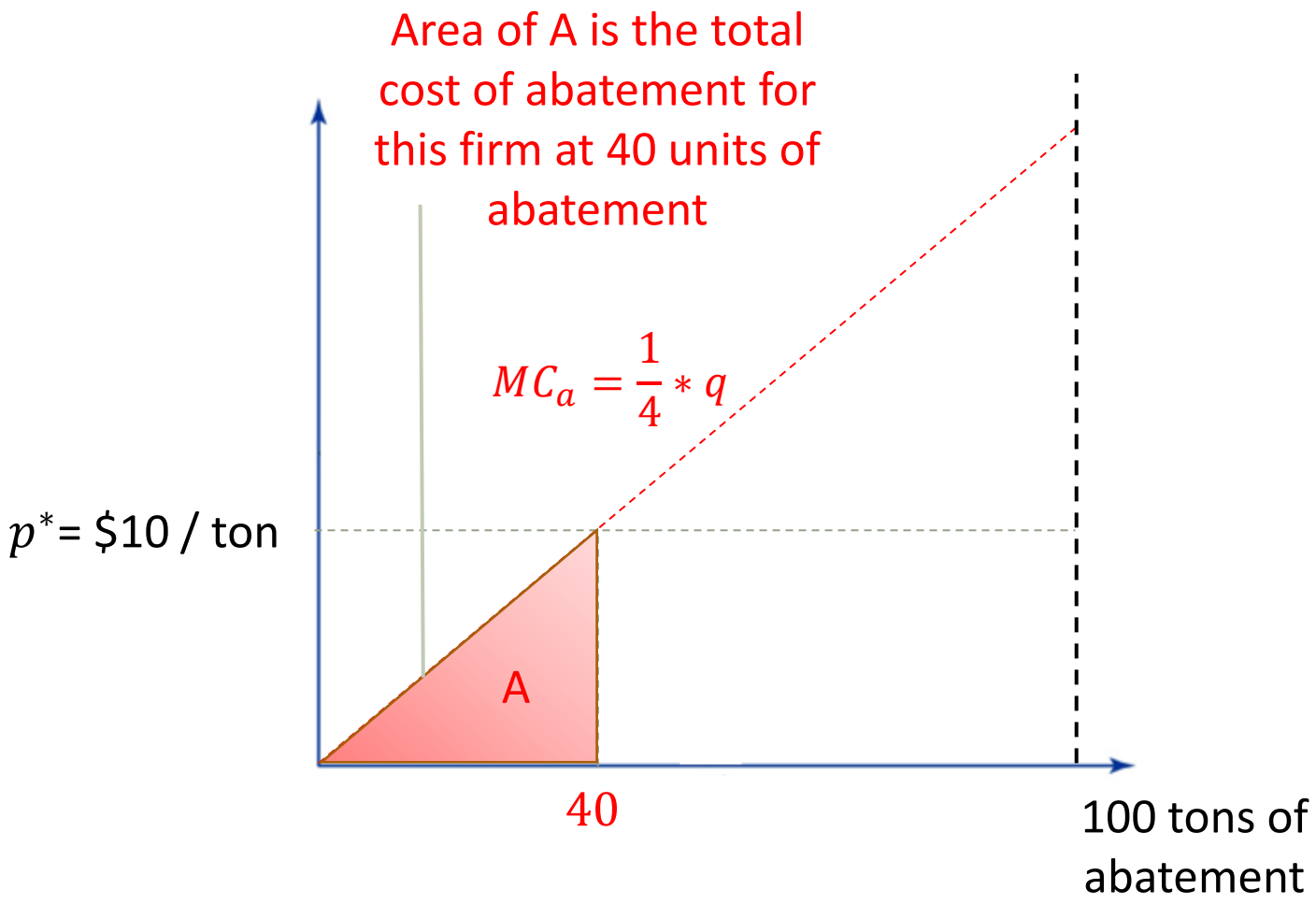
Allowance Price Formation in Cap and Trade

Let's see why the price of an emissions allowance p^* should be the same as the efficient Pigouvian tax. We have two facilities, a and b, and marginal abatement cost functions MC_a and MC_b.

Suppose total pollution is 150, firms have equal pollution quantities at 75, and the regulator distributes 50 allowances. So, **the cap is 50 tons,** and 100 tons must be abated.



Allowance Price Formation in Cap and Trade



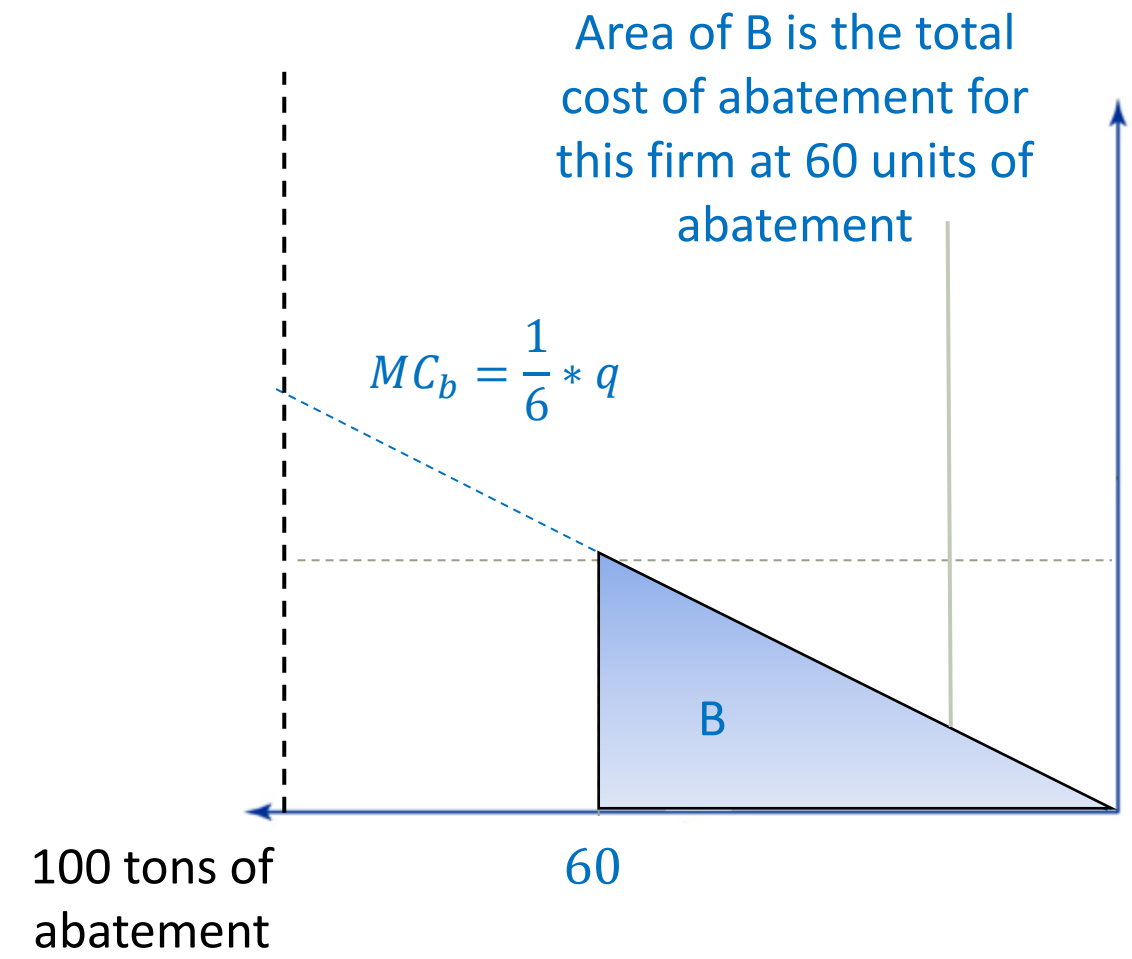
Under the prior tax, A would have abated 40 units.

- Abatement cost for the 40 units is 10*40/2 = $200.
- Taxes paid on the remaining 35 units of pollution are $350.
- Total cost of the policy for A is $550.

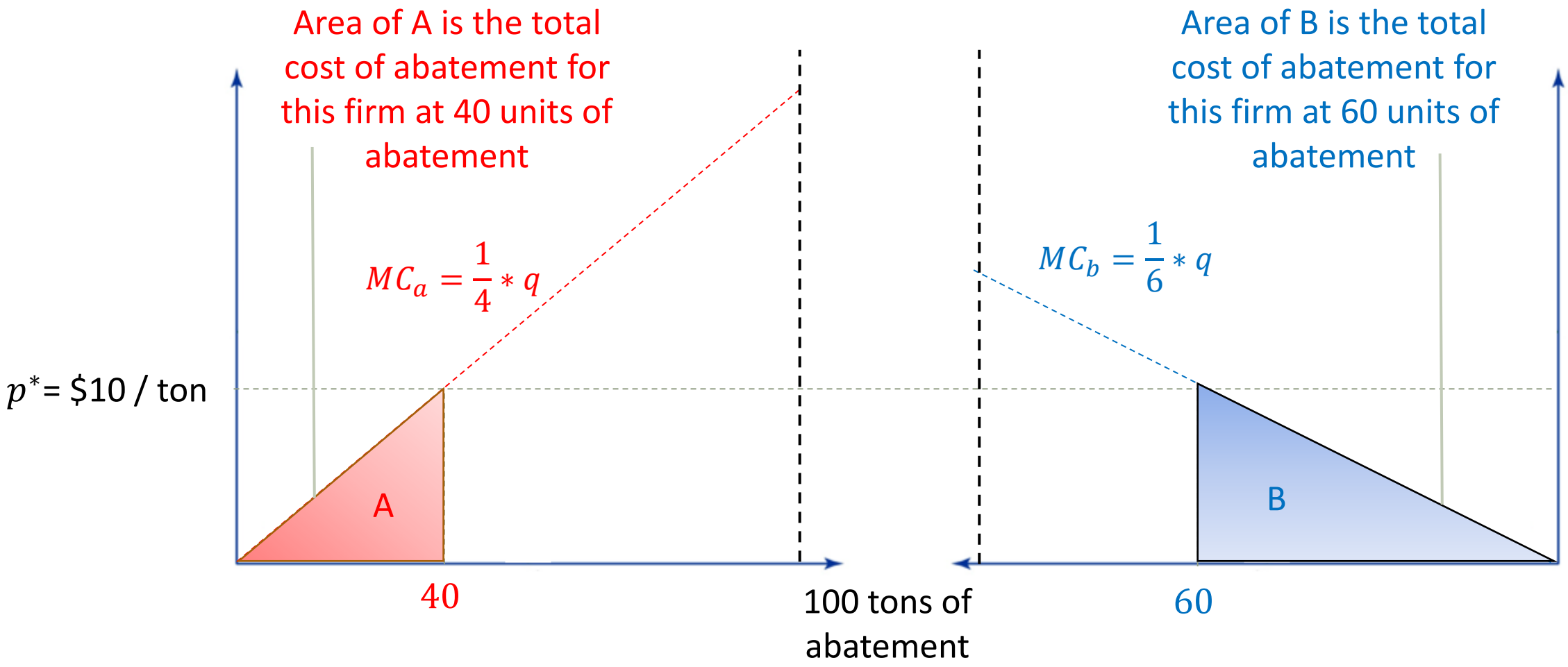
Allowance Price Formation in Cap and Trade

What about firm B? Under the prior tax:

- Abatement cost for the 60 units is 10*60/2 = $300.
- Taxes paid on the remaining 15 units of pollution are $150.
- Total cost for B is $450.

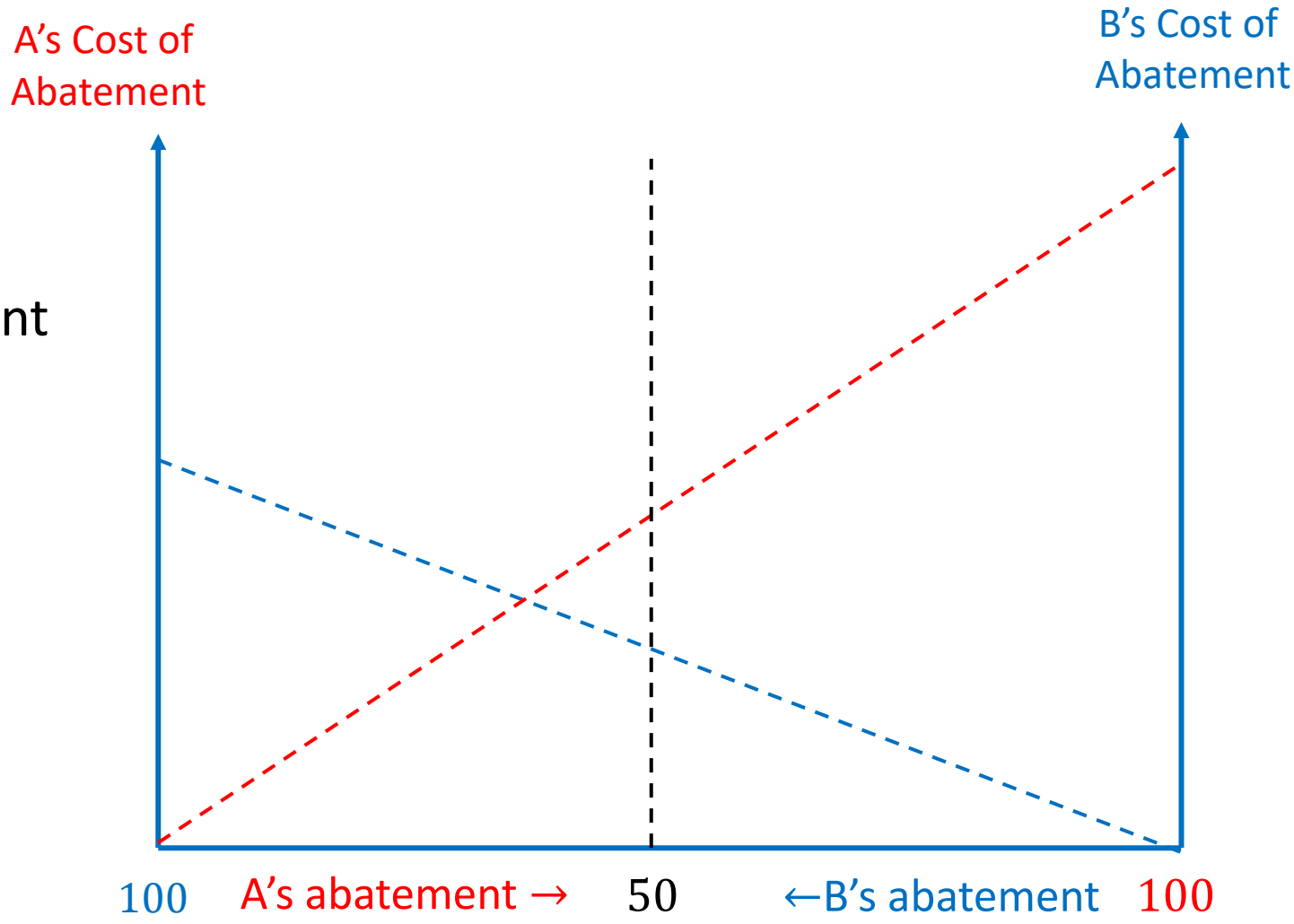


Allowance Price Formation in Cap and Trade



Allowance Price Formation in Cap and Trade

What are abatement costs if the firms each have 25 allowances and do not trade?

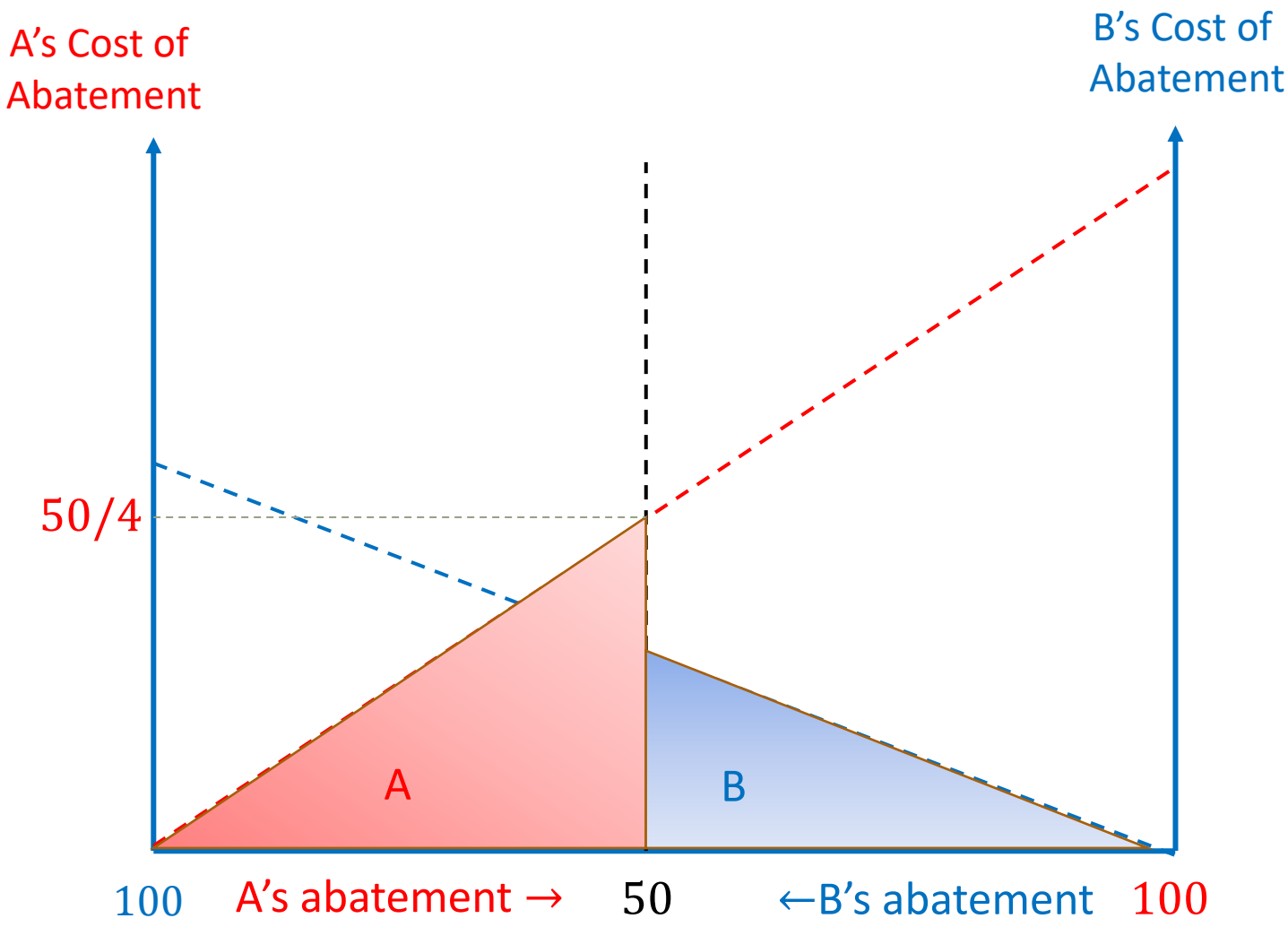


Allowance Price Formation in Cap and Trade

$MC_a = \frac{1}{4} * q$

Costs for A:

- 50/4 = MC
- (50/4)*(50/2)= 312.5



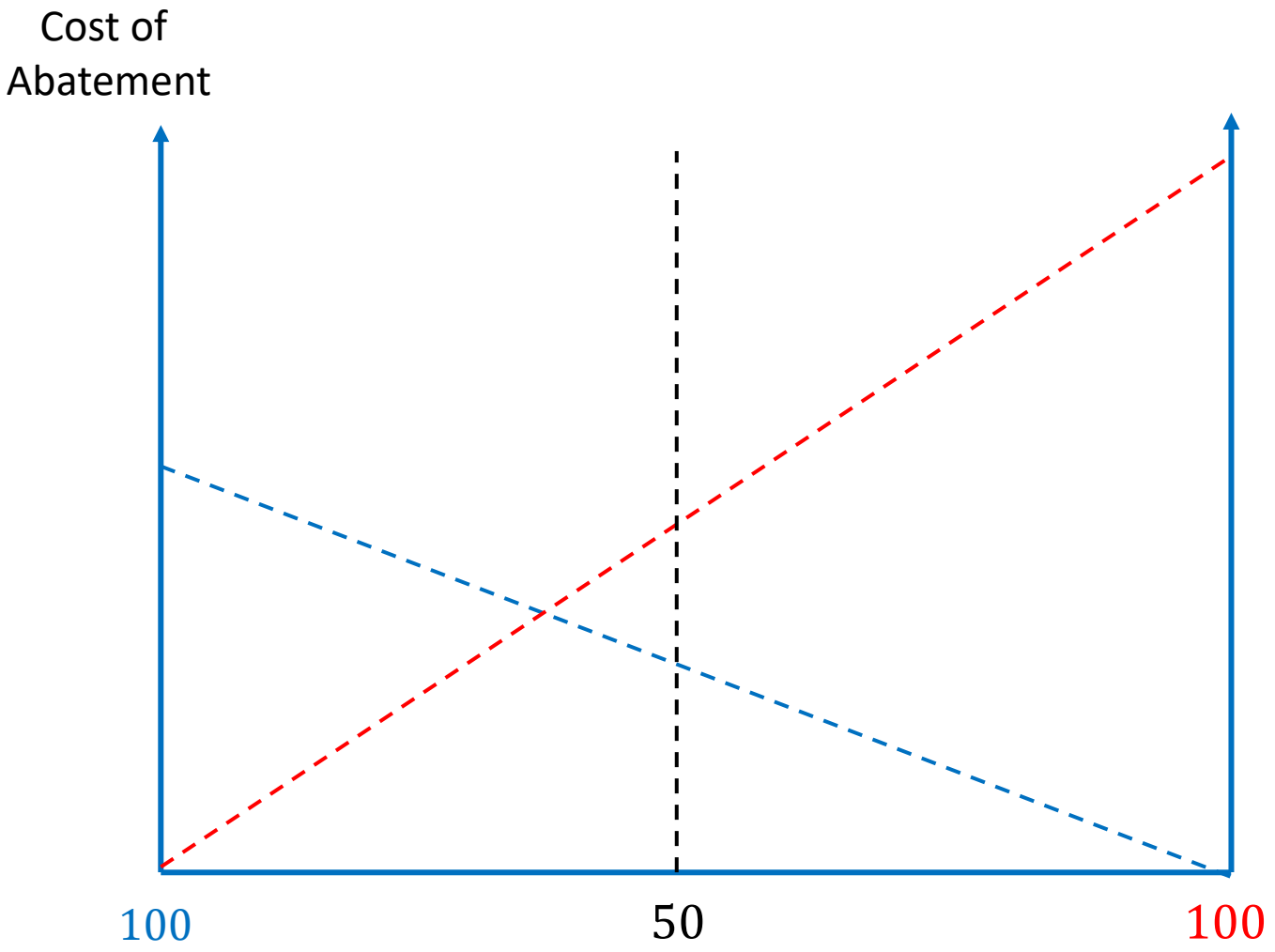
$MC_b = \frac{1}{6} * q$

Costs for B:

- 50/6 = MC
- (50/6)*(50/2)= 208.3

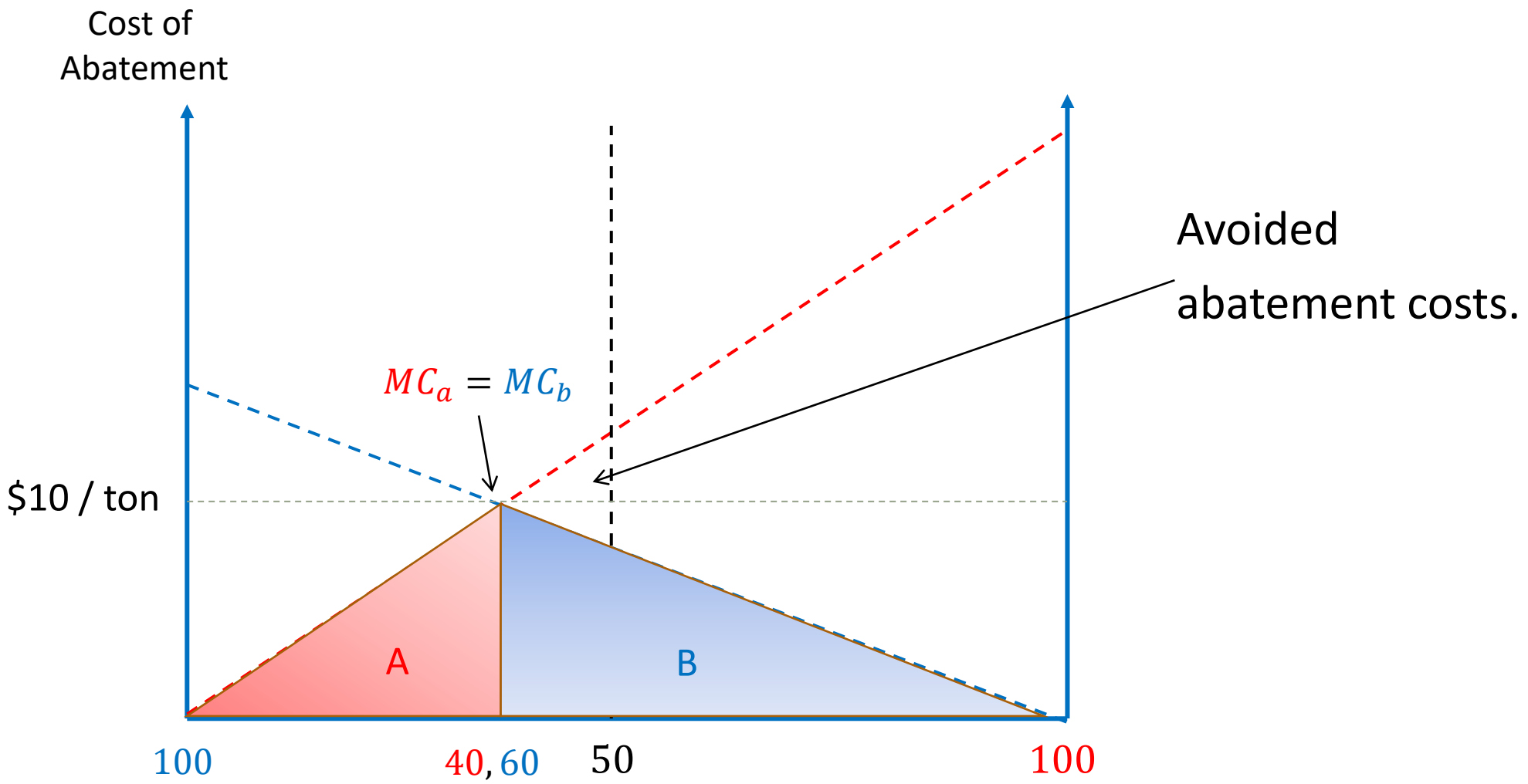
Allowance Price Formation in Cap and Trade

How could abatement be assigned to minimize costs?



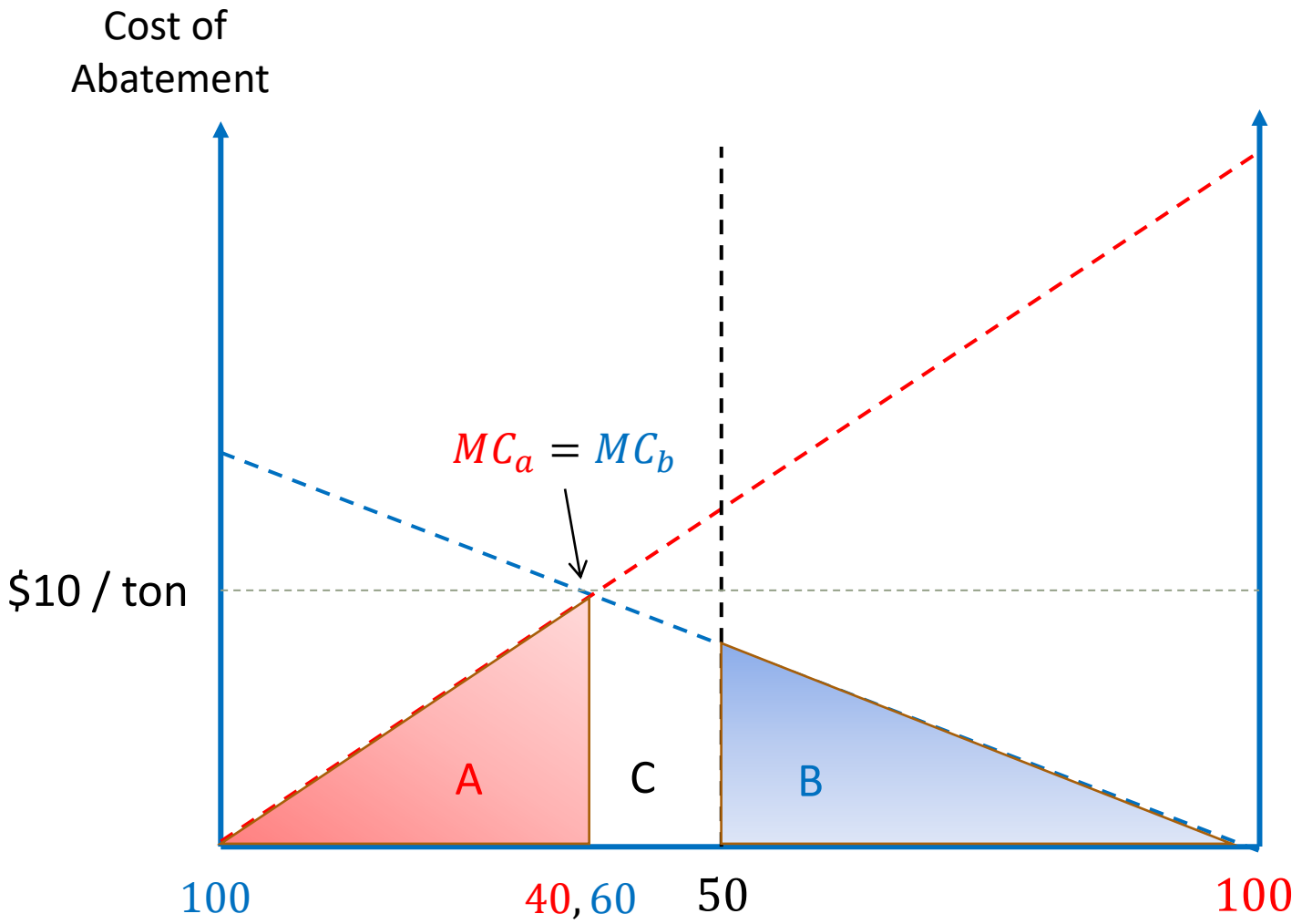
Allowance Price Formation in Cap and Trade

How could abatement be assigned to minimize costs?

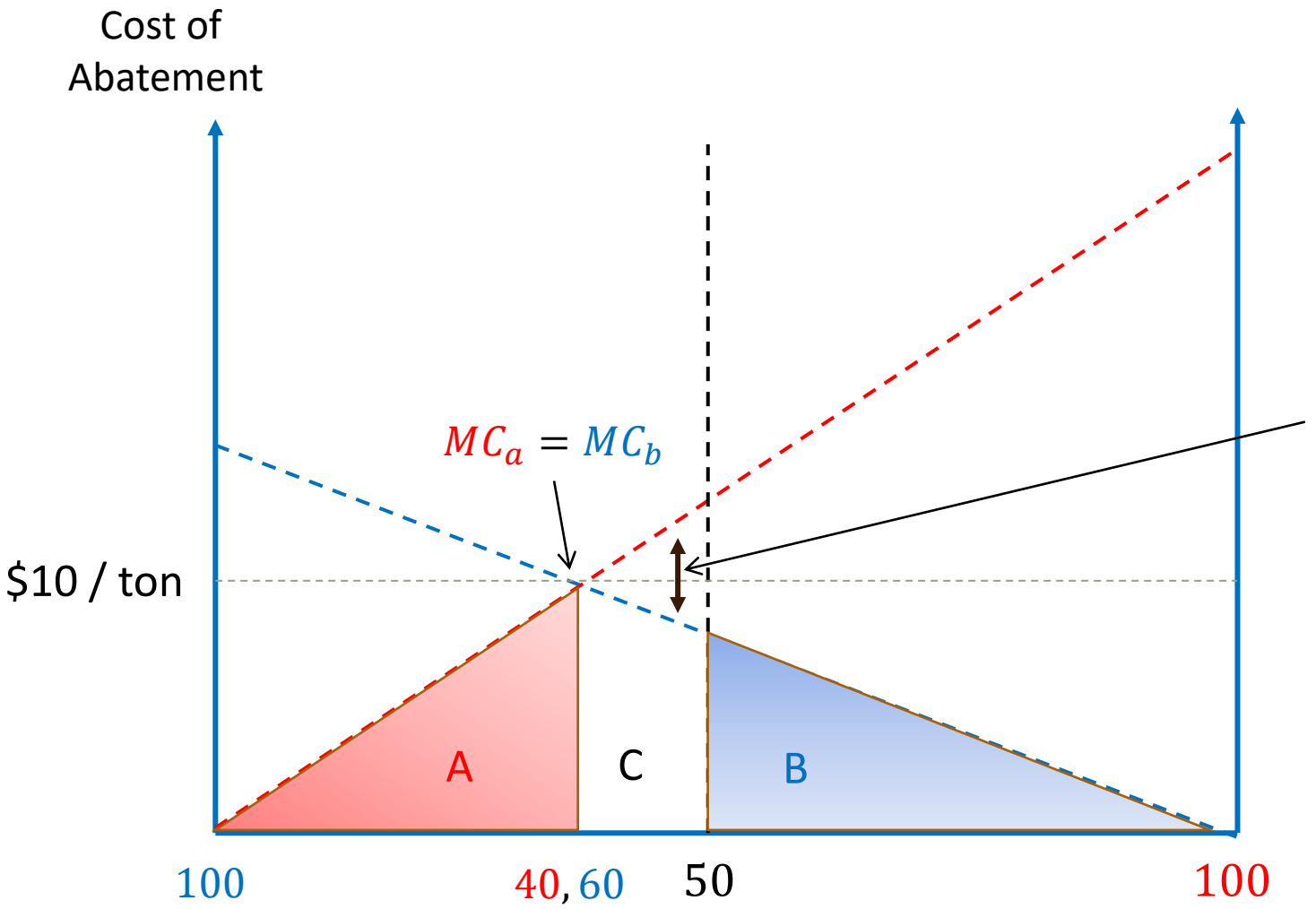


Allowance Price Formation in Cap and Trade

How can the firms trade to reach this efficient least-cost point?



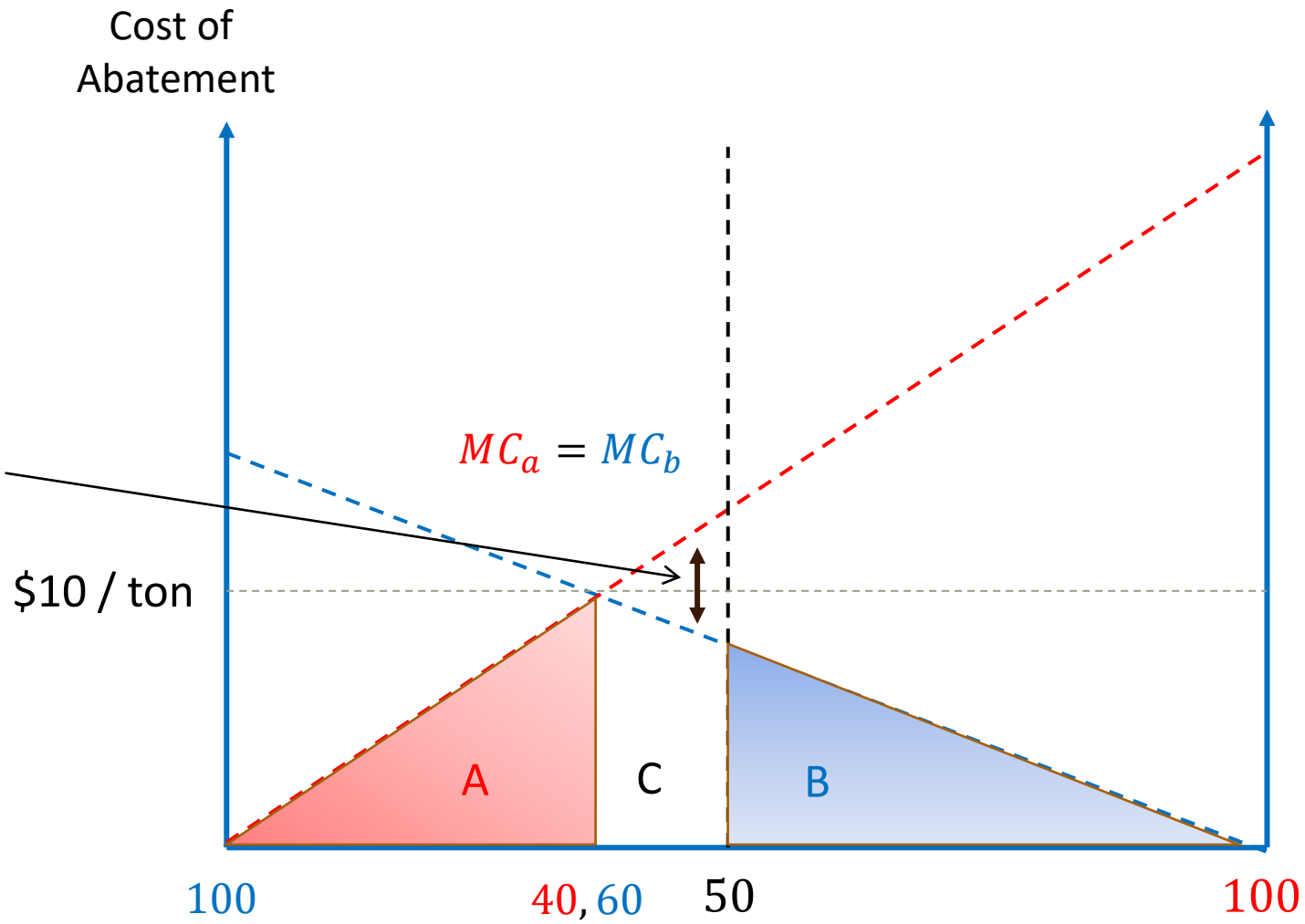
Allowance Price Formation in Cap and Trade



For the entire region to the right of $(40, 60)$, it is in B's best interest to sell allowances to A at some price greater than MC_b.

Allowance Price Formation in Cap and Trade

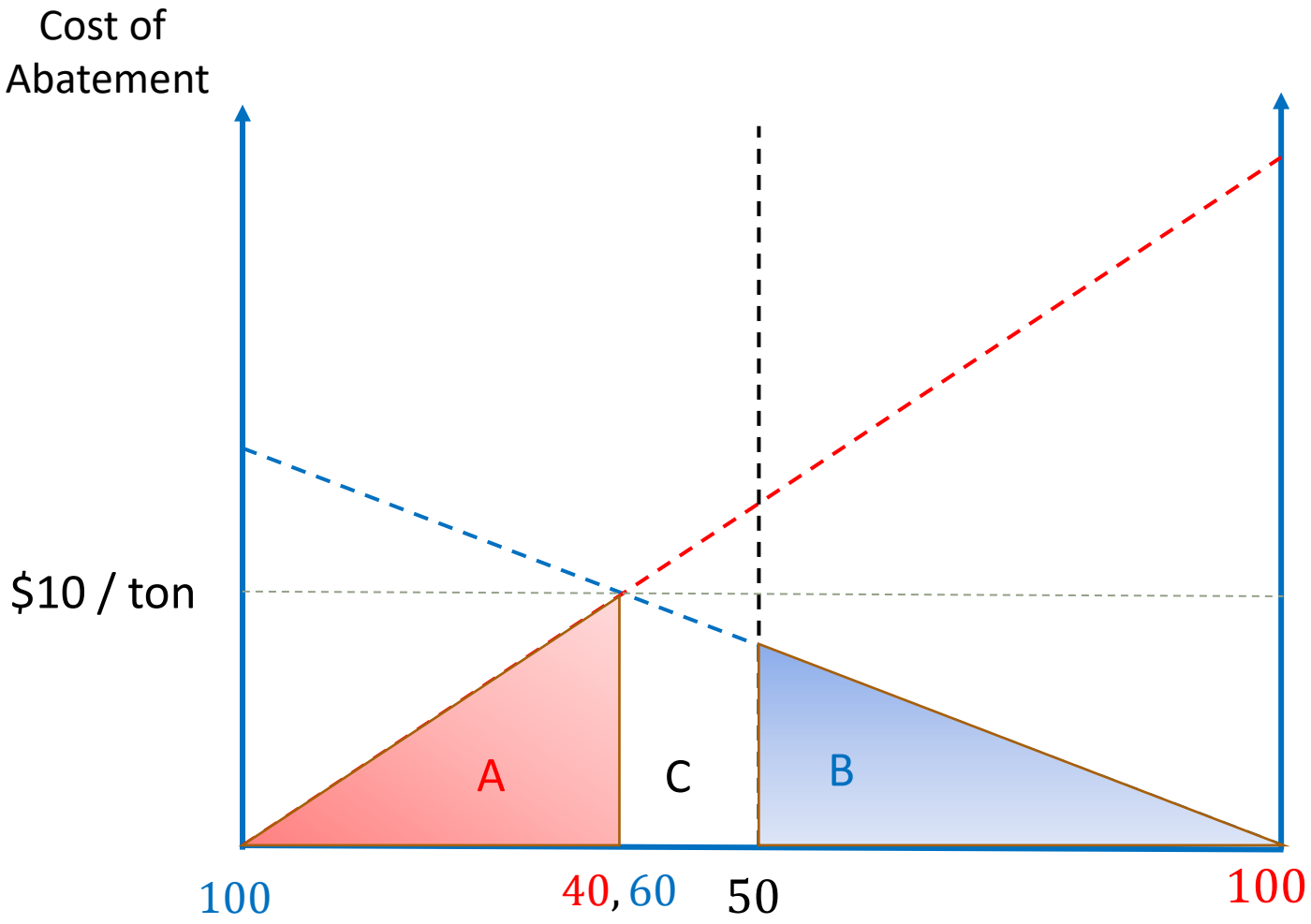
For the entire region to the right of $(40, 60)$, it is in A's best interest to buy allowances from B at some price lower than MC_a.



Allowance Price Formation in Cap and Trade

How will these firms trade:

- If each firm is assigned 25 pollution allowances?
- If A is assigned all 50 pollution allowances?
- If B is assigned all 50 pollution allowances?



Allowance Price Formation in Cap and Trade

Conclusion: Efficient allocation of abatement occurs where all firms have equal marginal abatement costs at their quantity of abatement, i.e. $MC_a = MC_b$.

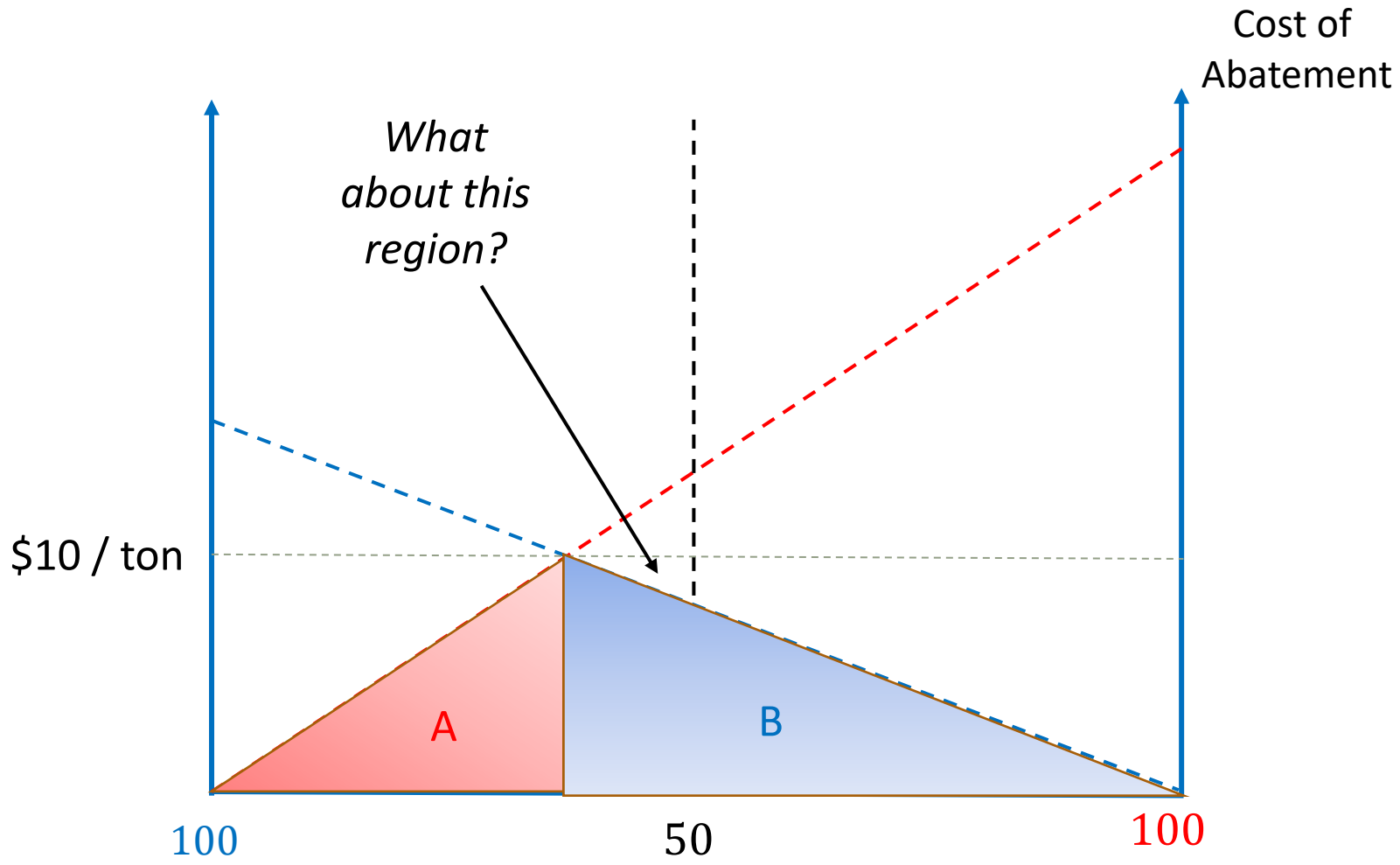
Otherwise, firms could buy or sell allowances to arbitrage their excess costs, re-allocating abatement to minimize the entire industry's total costs.

At the last sale of an allowance, $MC_a = MC_b = 10 = \tau^*$.

Quick Caveat on Price Formation

Short aside:

- With equal allowance allotments at 25, B could charge A $10 for their 10 allowances and actually make revenue from the sales.
- Total cost of abatement would still be minimized, but B is made better off by these trades.
- We'll return to this later today.



Part 3: For Want of A Chair

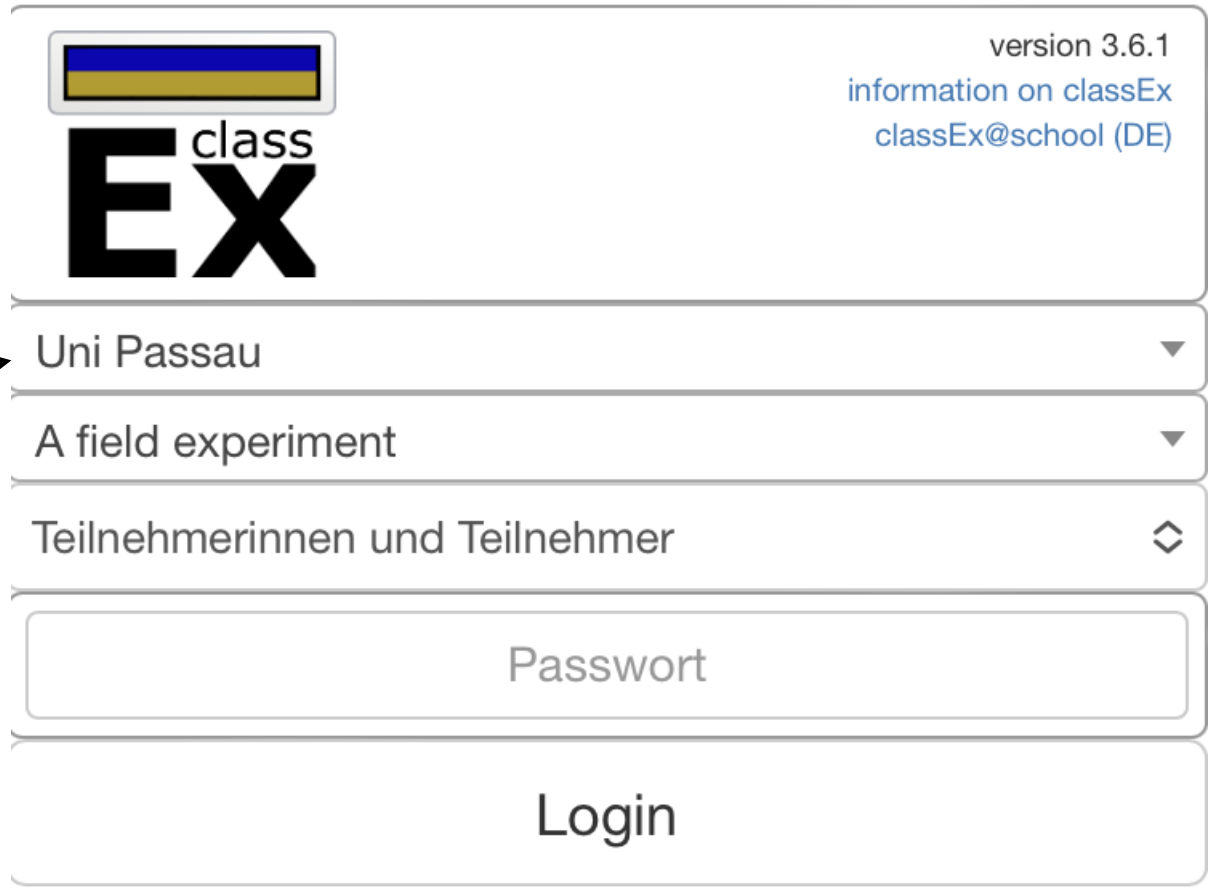
For Want of a Chair:
How to Play

1. Please navigate to the following web-page:

https://classEx.uni-passau.de

2. Type in “Environmental Protection Agency”

3. Enter the password: m5GK



For Want of a Chair: How it Works

1. Each of you is now a polluting facility, and each chair represents one allowance to pollute.
2. We will play musical chairs to determine the initial allowance of pollution across firms.
3. If you have a chair, you have an allowance to pollute. If you are standing, then you have abated your pollution at some cost that is unique to you.

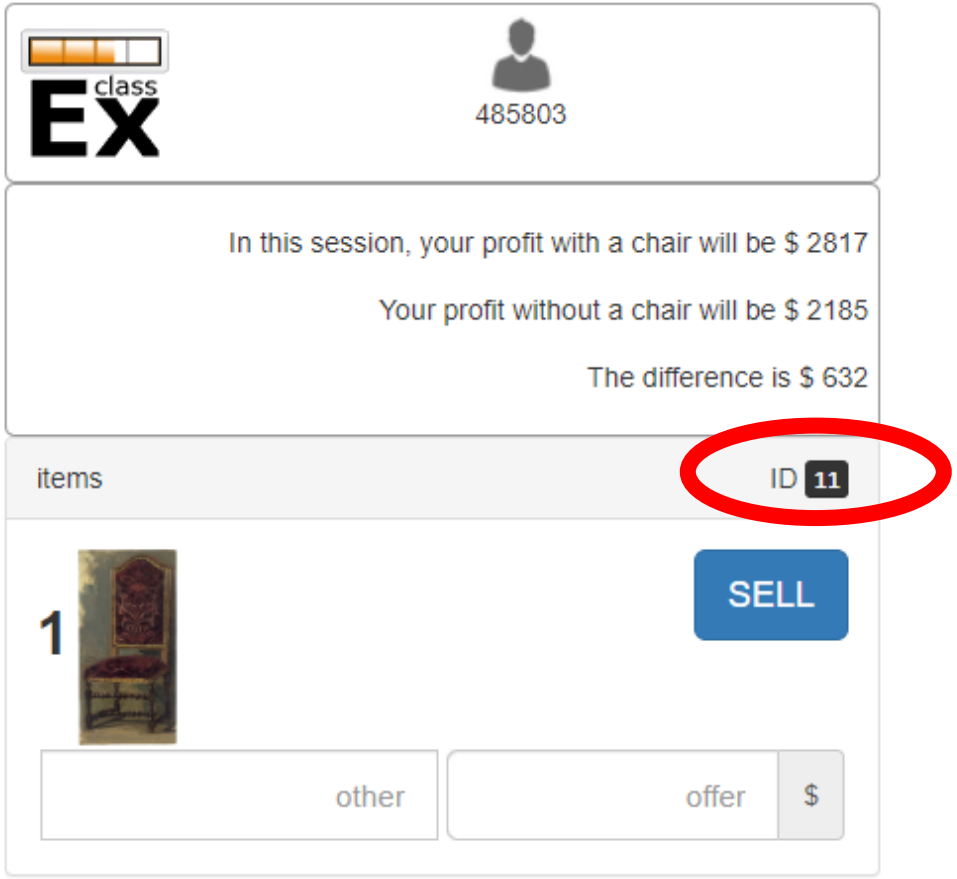
For Want of a Chair: How it Works

If you are seated, you may want to sell your right to pollute if the allowance sale price is greater than your cost of abating.

For player 11, the cost of abatement is $632.

They are better off selling their seat if:

Sale Price > $632



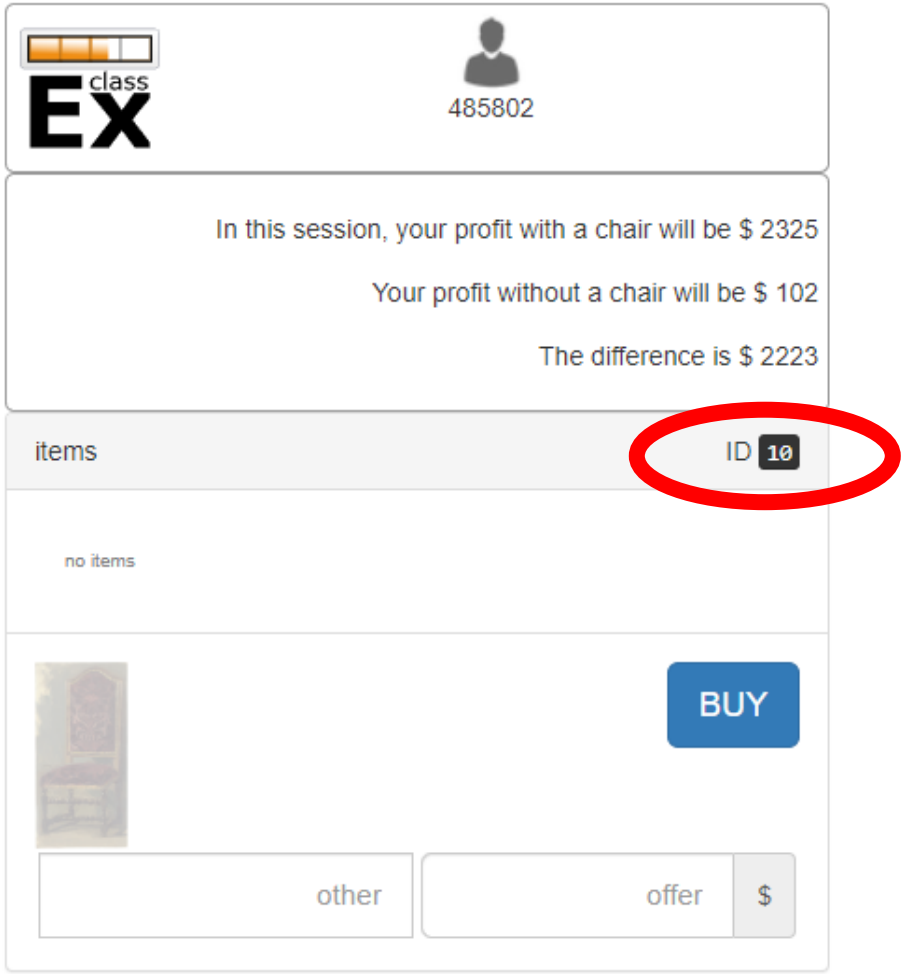
For Want of a Chair: How it Works

If you are standing, you may want to buy the right to sit if the offer price for a pollution allowance is less than the cost of abating.

For player 10, the cost of abatement is $2,223.

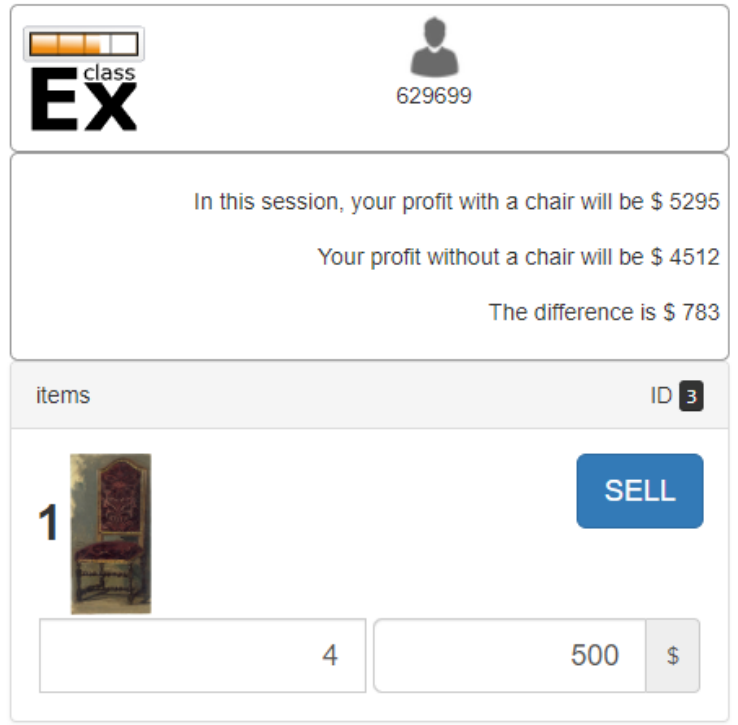
They are better off purchasing a seat if:

Purchase Price < $2,223

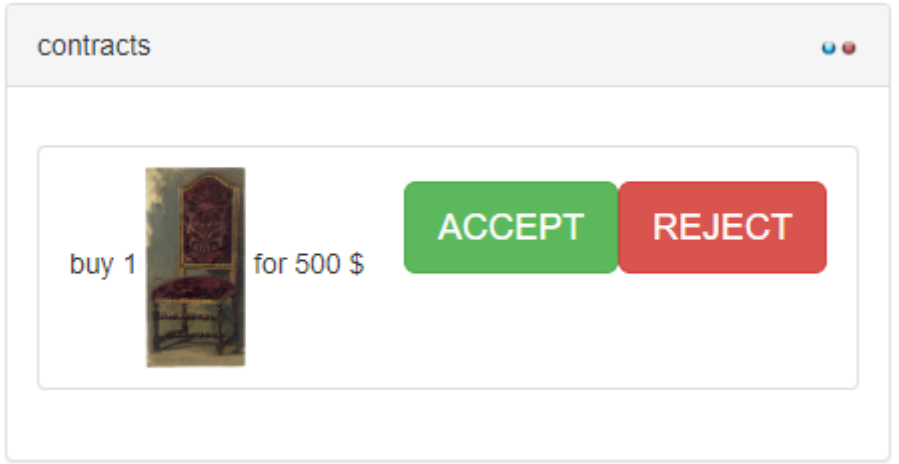


For Want of a Chair: How it Works

If you are sitting and you want to sell your pollution allowance (i.e., chair), you need to figure out the other player's ID number and send them an offer.

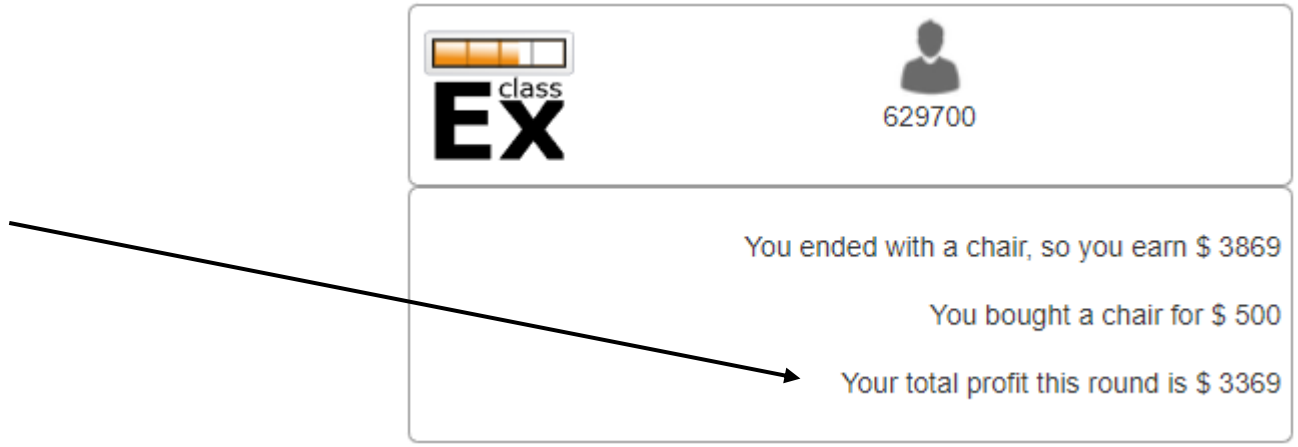


They then have the option to accept your offer.



For Want of a Chair: How it Works

Keep track of your total profit and sum it across rounds. The top three players will receive a prize.



Part 4: Prices vs. Quantities

Equivalence between Pigouvian Taxes and Quantity Controls

We spent the first part of class showing how emissions taxes and cap-and-trade systems have theoretical similarities. Specifically:

- Emissions taxes (or abatement subsidies) set the price of pollution and push firms to the optimal quantity of abatement.
- Cap-and-trade set the quantity of pollution, and the price of an allowance is pushed to the marginal cost of abatement at that quantity through trades.
- In theory, the quantity and price of pollution abatement is equivalent in both systems.

How Pigouvian Taxes and Quantity Controls Differ

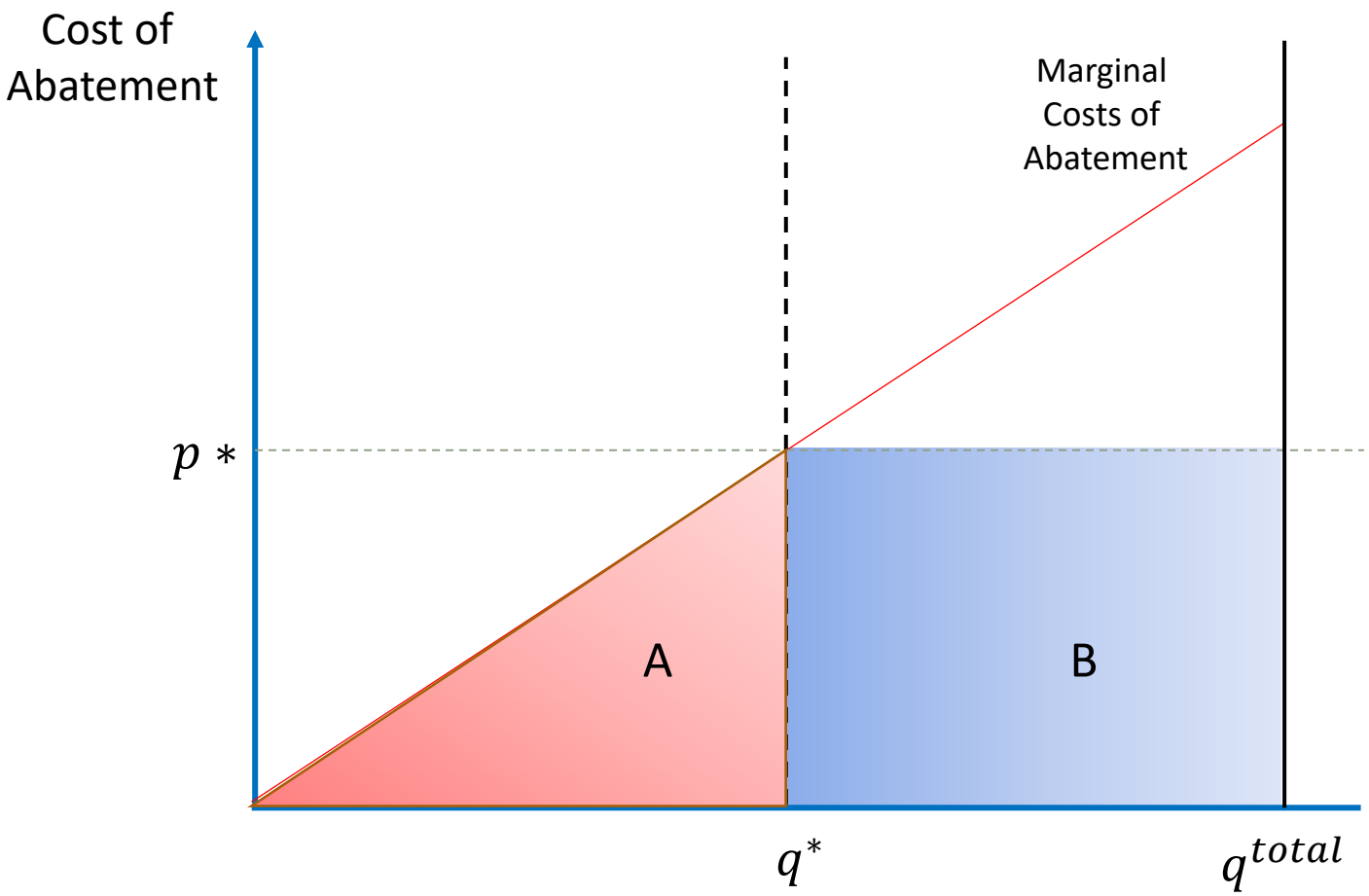
Two key differences:

1) Tax revenue (or subsidy cost) vs. allowance value.
2) When the abatement cost curve is not known with certainty, the quantity reduced and the marginal cost of abatement at that quantity are not the same for each regulatory instrument.

1) Tax Revenue vs. Allowance Value

q^{total} is the total amount of potential pollution, such that $q^{total} - q^*$ is the quantity of actual emissions.

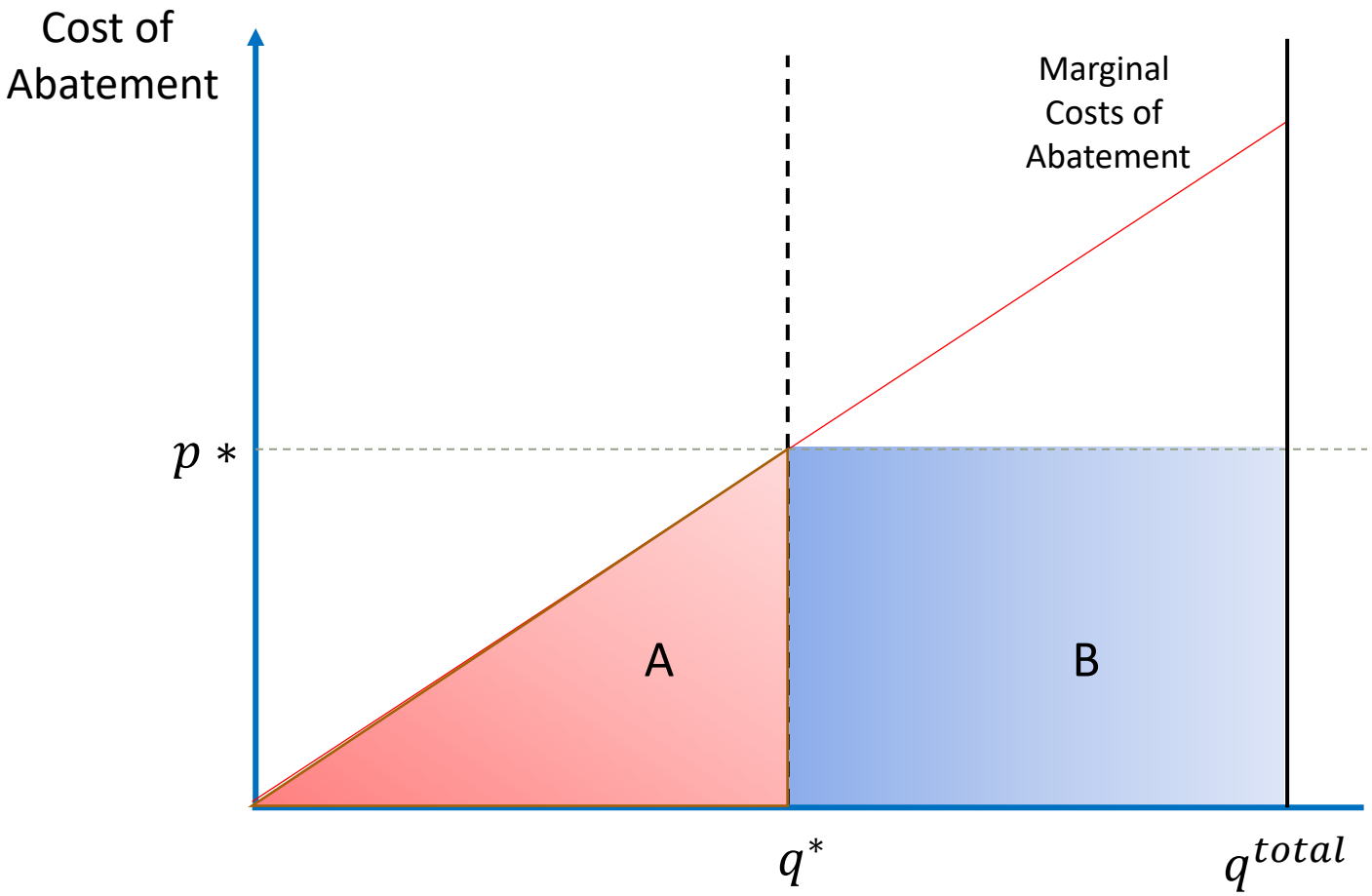
What are A and B?



1) Tax Revenue vs. Allowance Value

What are A and B?

- The area of A is total abatement cost.
- The area of B is the tax revenue ***or*** the value of allowances.
- In cap-and-trade, can recoup B through an allowance auction or assign allowances for equity.



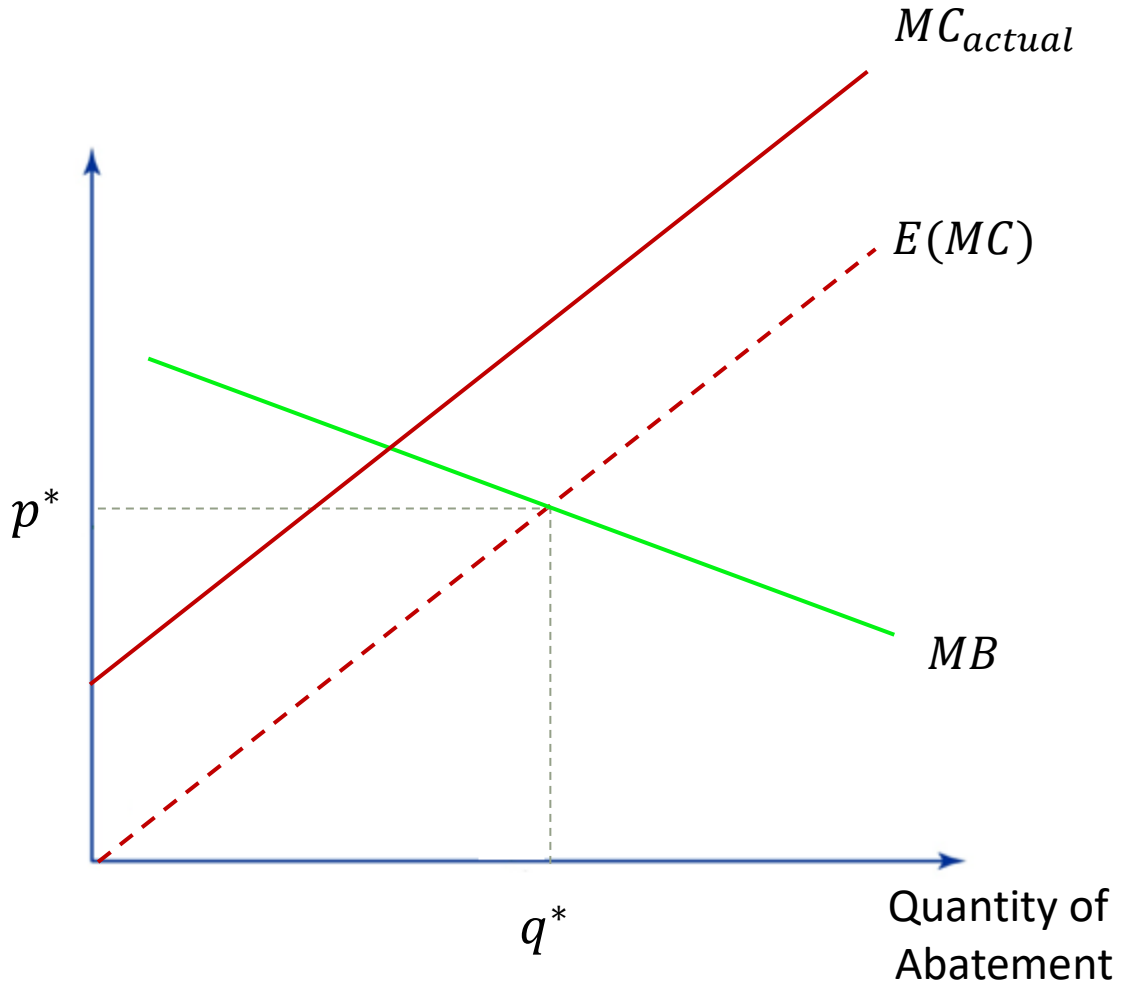
2) Prices vs. Quantities

When the abatement cost curve is not known with certainty, the quantity reduced and the marginal cost of abatement at that quantity are not the same for each regulatory instrument (setting prices vs. setting quantities).

Why might industry-wide marginal abatement costs not be known with certainty?

2) Prices vs. Quantities

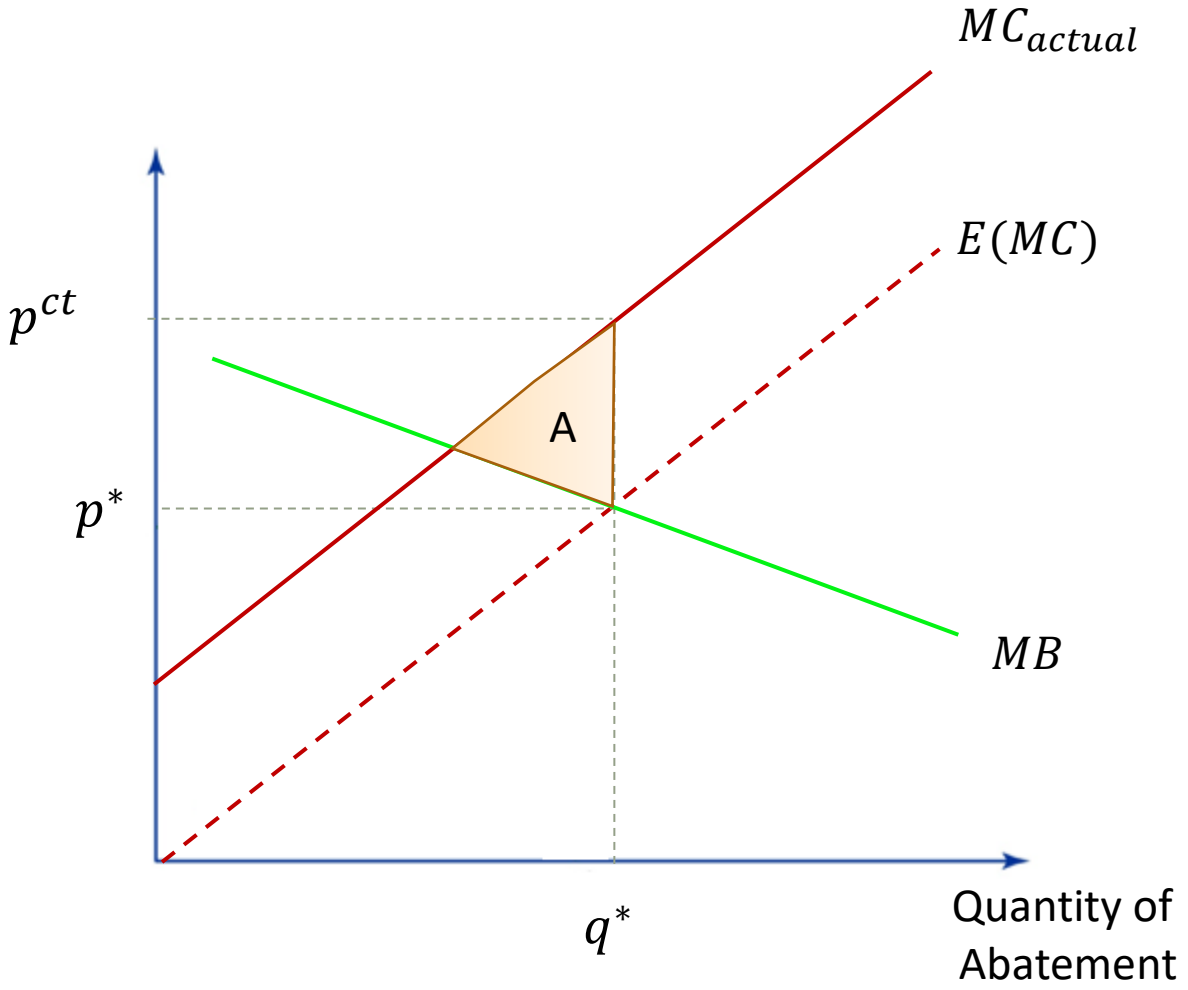
Let $E(MC)$ represent the expected marginal costs, however MC_{actual} is the actual marginal cost of abatement for the industry.



2) Prices vs. Quantities

Let $E(MC)$ represent the expected marginal costs, however MC_{actual} is the actual marginal cost of abatement for the industry.

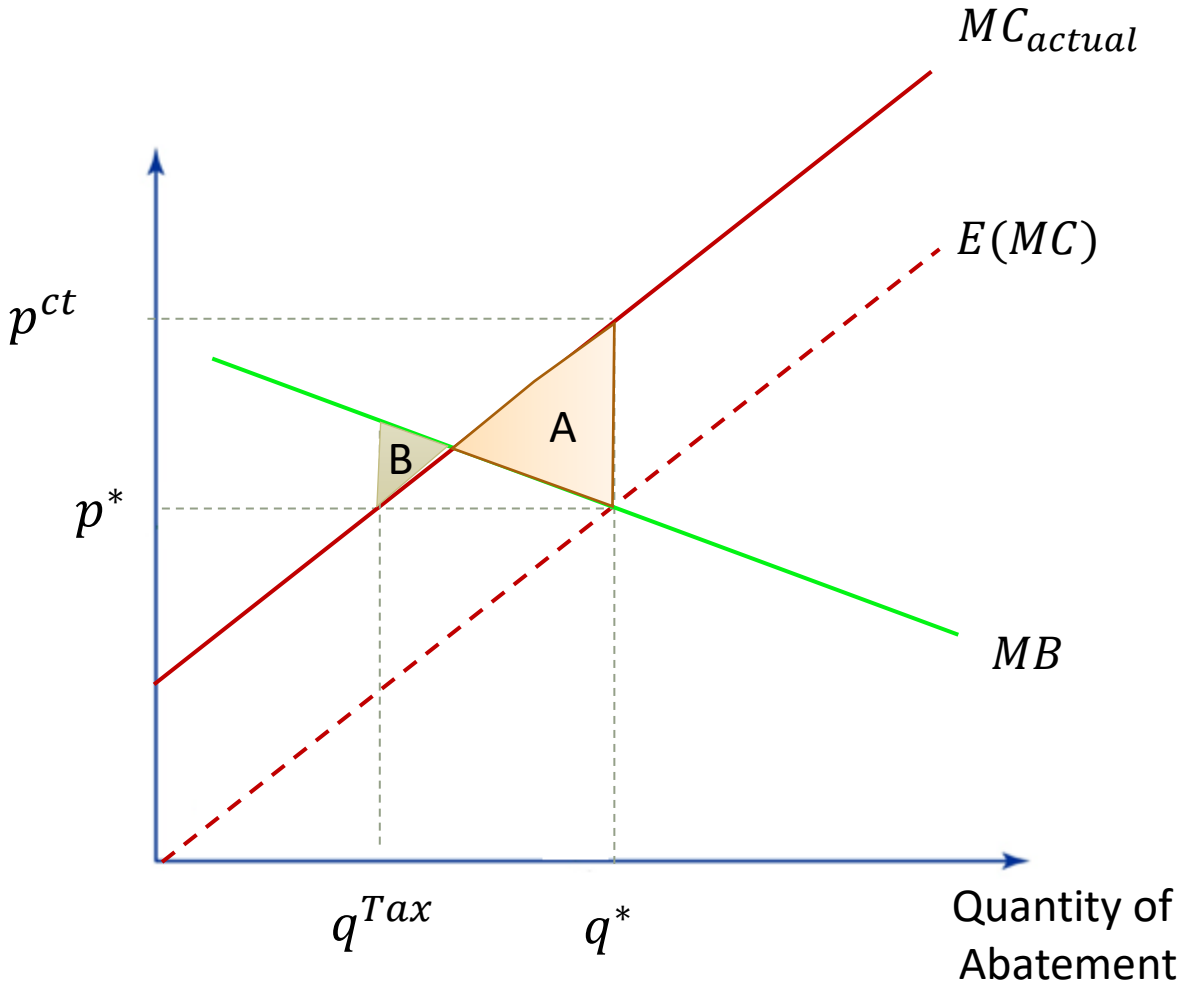
- A cap-and-trade program will still abate to q^*, even though the marginal costs will be p^{ct}.
- The marginal benefits will be less than the marginal abatement cost at this quantity, leading to deadweight loss of region A.



2) Prices vs. Quantities

Let $E(MC)$ represent the expected marginal costs, however MC_{actual} is the actual marginal cost of abatement for the industry.

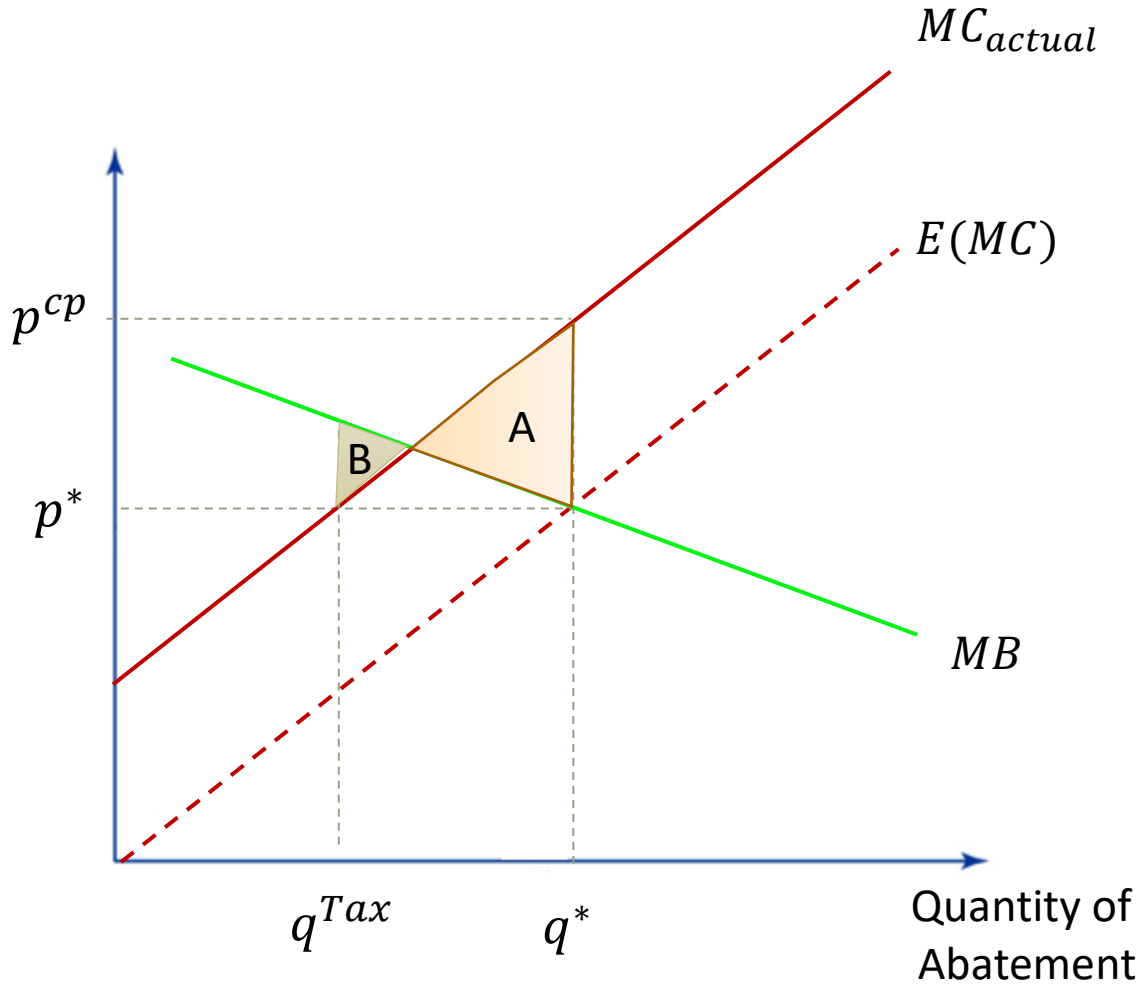
- With a tax set at p^*, firms will only abate up to q^{Tax}.
- Marginal benefits are higher than marginal costs at q^{Tax}, leading to deadweight loss of region B.



2) Prices vs. Quantities

In this example, visual inspection suggests that $A > B$. This suggests that the tax is preferable to the quantity control under uncertainty.

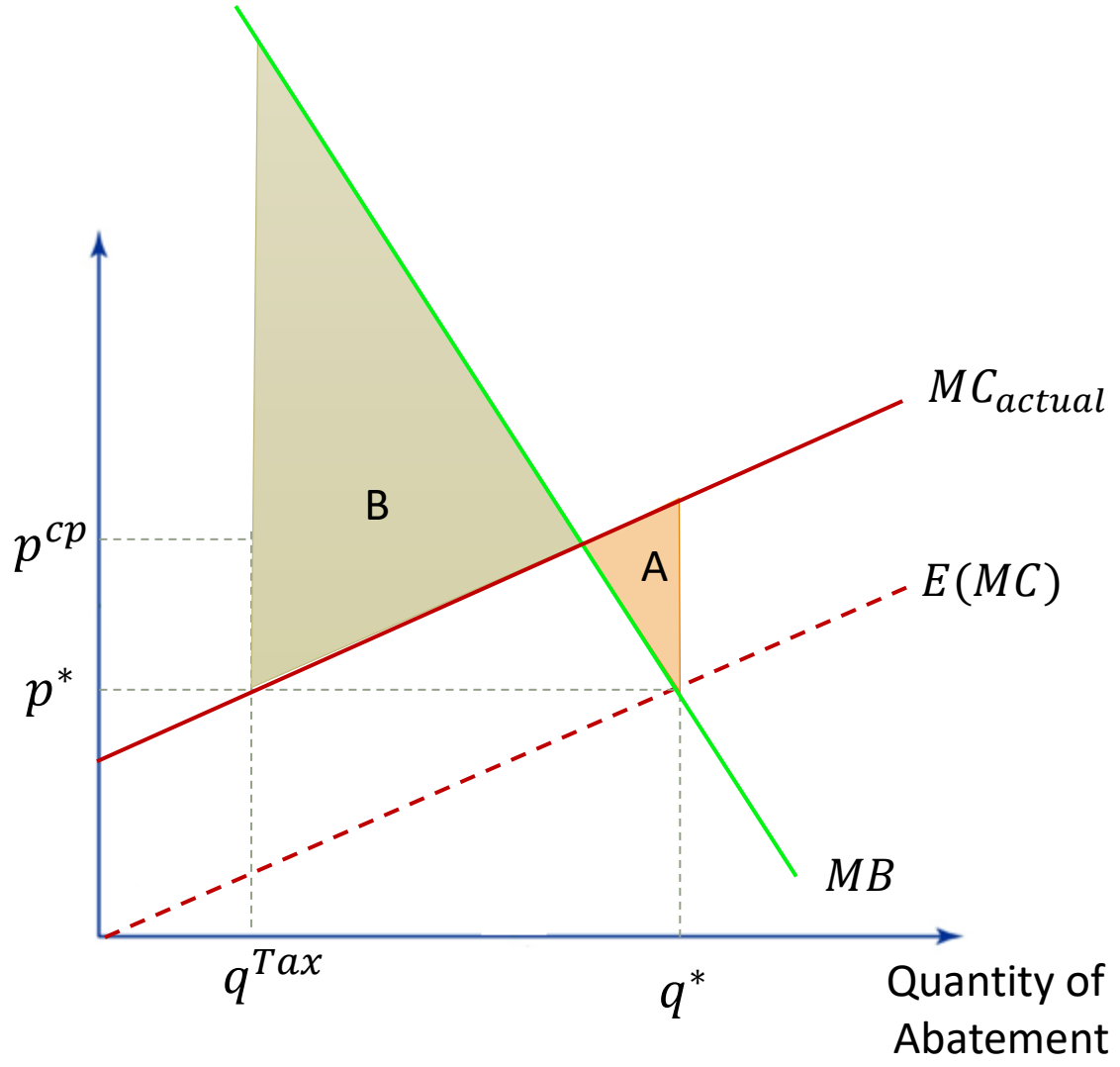
This finding is not universal. The preference of one instrument over another depends on the slope of the MC curve with respect to the MB curve.



2) Prices vs. Quantities

Let's look at another example where the slopes of MB vs. MC have different magnitude.

Here, we can observe that B>A, and hence in this situation we would prefer a quantity control to a tax.



2) Prices vs. Quantities

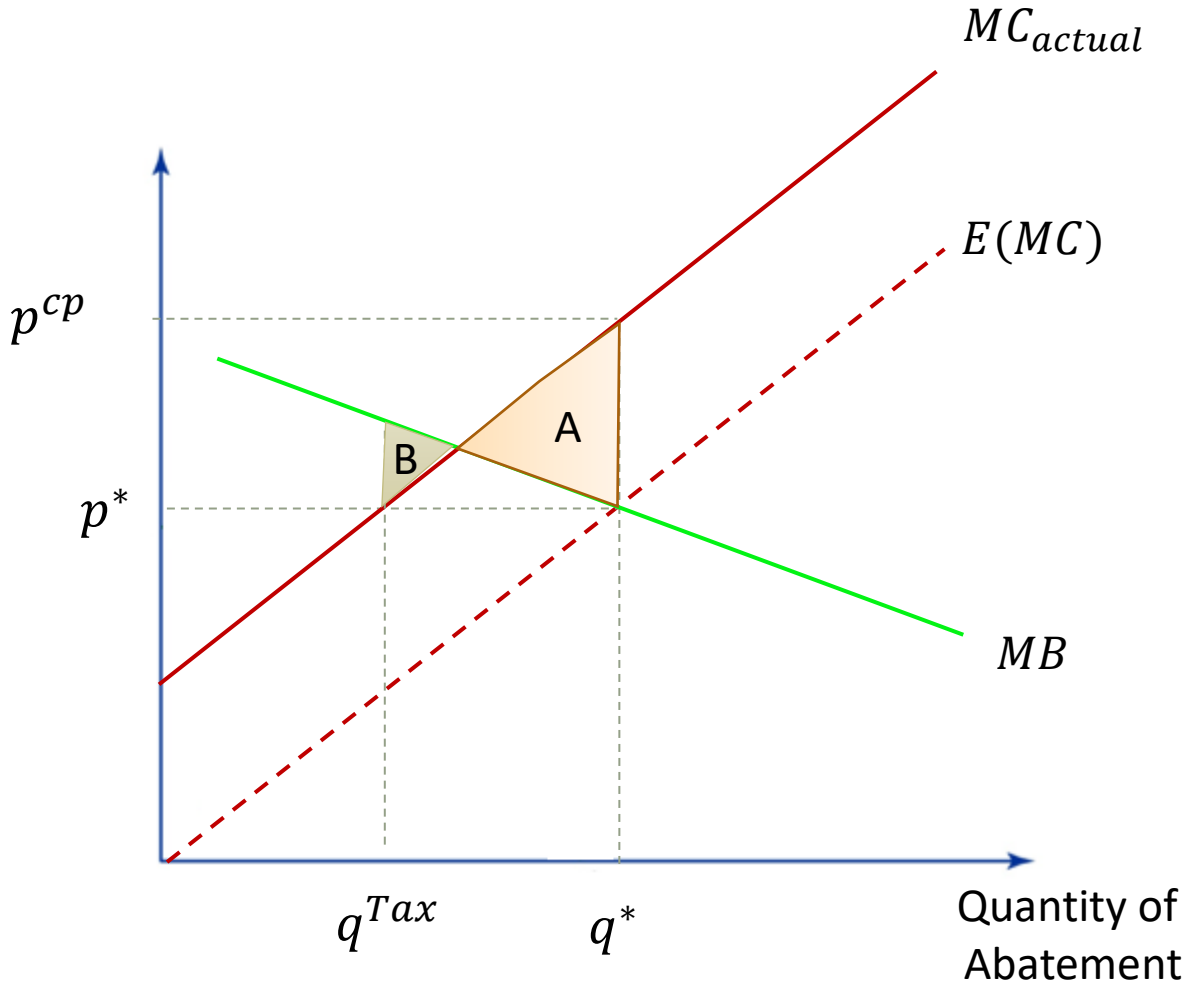
The Weitzman Rule

When marginal costs are uncertain, a tax instrument is preferred:

- If the absolute value of the slope of MC > MB (i.e., MB is flatter).

A quantity instrument is preferred:

- If the absolute value of the slope of MB > MC (i.e., MC is flatter).



Next class

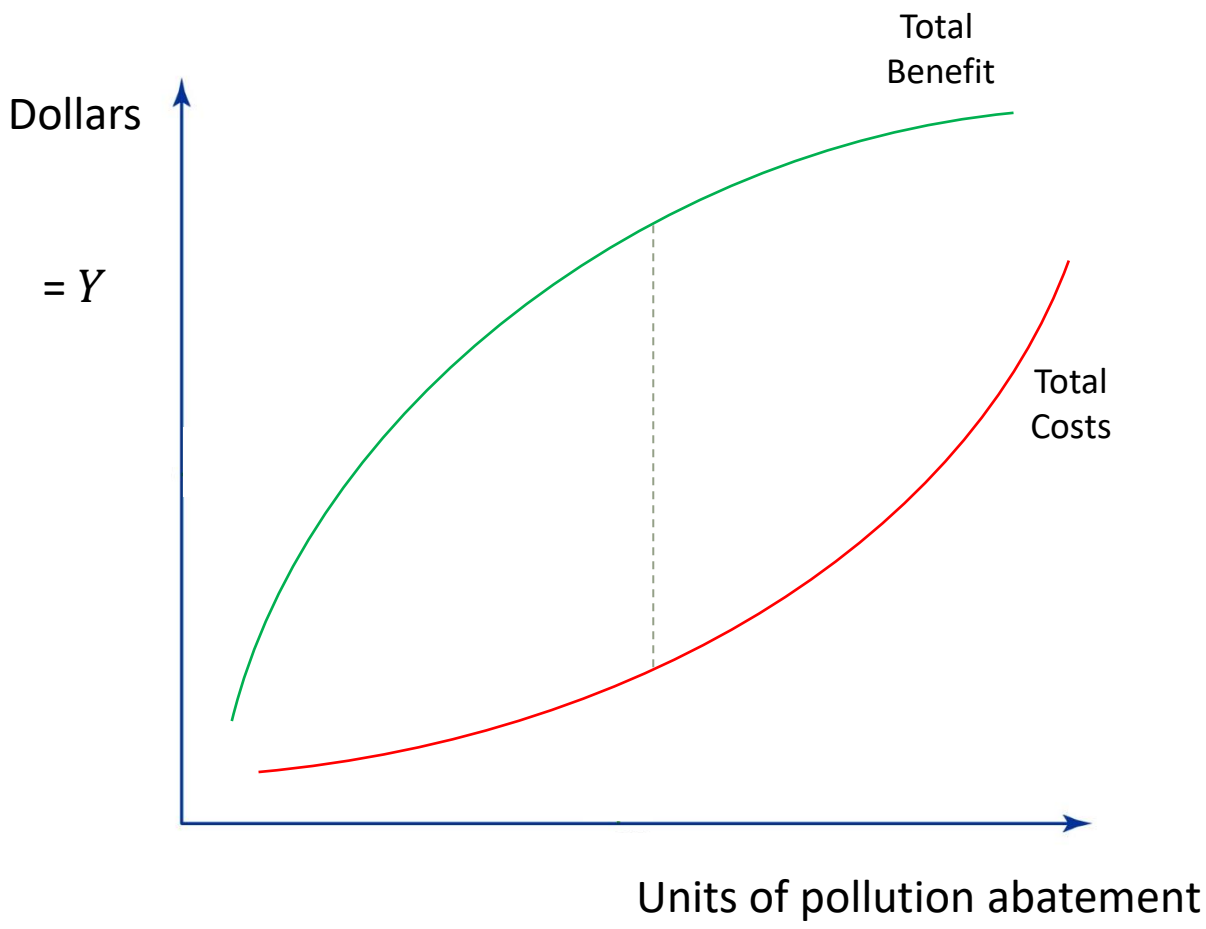
- Next class will cover the Clean Air Act. We'll discuss the background of the regulation and how it works, cover a cap-and-trade system in Southern California, and discuss some prominent papers on the topic**.**
- **Your third case study is due Sunday, 10/29.**

- Materials for Wednesday:

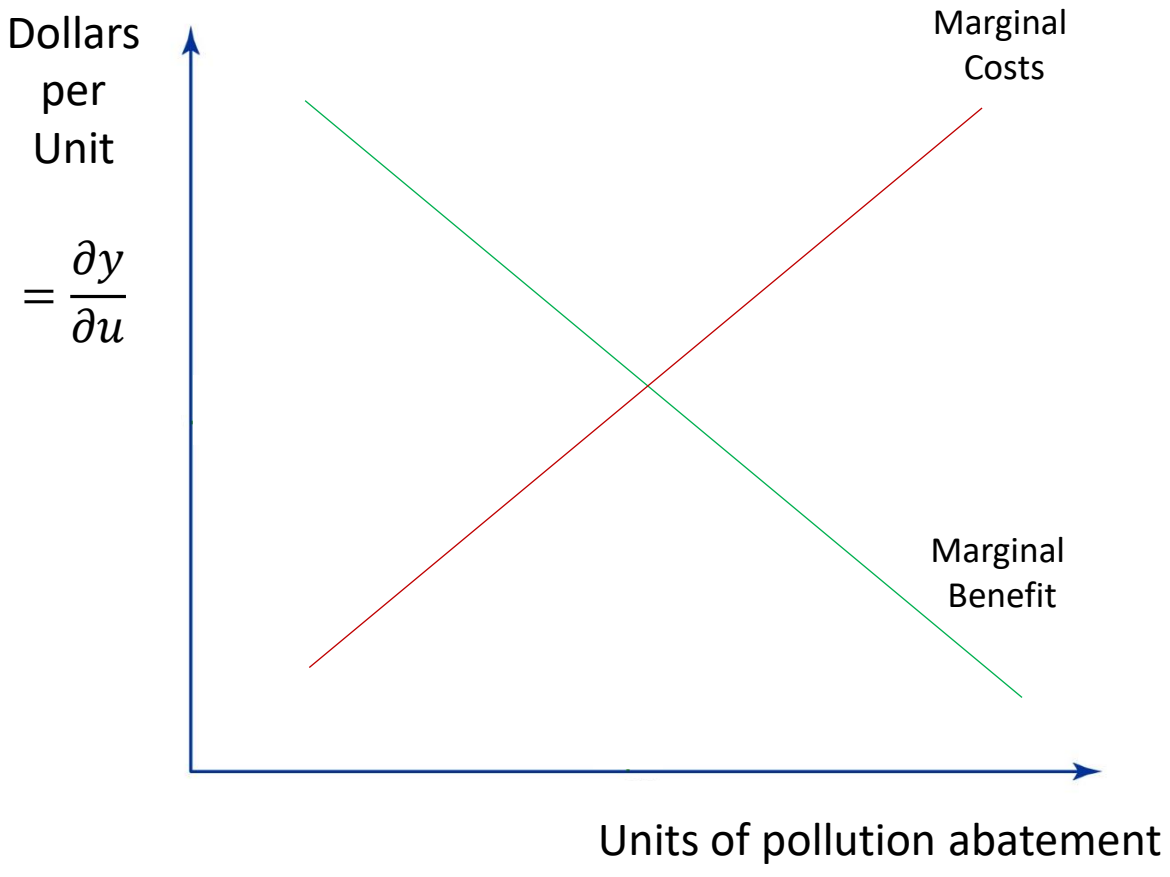
  - Hernandez-Cortes, Meng, and Weber (2022)
  - (*optional*) Chay and Greenstone (2005)

Recall Optimal Quantity

Total Benefits and Total Costs



Marginal Benefits and Marginal Costs



Proof $MC = \frac{1}{10} * q$

The aggregate marginal cost of abatement curve across all firms is the sum of each firm's abatement quantity at a given cost of abatement.

That is, $MC = q_1(p) + q_2(p)$.

In words, MC is the total quantity of abatement by both firms at any given cost of abatement, p^*. Therefore, we can substitute p^* for MC_a and MC_b →

$$\frac{1}{4} * q_1 = p^* \rightarrow 4p^* = q_1$$

$$\frac{1}{6} * q_2 = p^* \rightarrow 6p^* = q_2$$

Note aggregate quantity $q^* = q_1 + q_2$.

$$\rightarrow q^* = 4p^* + 6p^* = 10p^*$$

$$\rightarrow p^* = \frac{1}{10} q^*$$

Without loss of generality, $MC = \frac{1}{10} * q$