# Lecture 13: Economics of Environmental Regulation 2

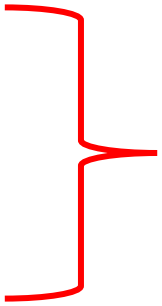
Prof. Austin
Environmental Economics
Econ 475

# Part 1: Cap and Trade Instruments

# Refresher: Regulatory Instruments

Many regulatory instruments are available. These need not be implemented in isolation:

- Information approaches
  - Toxic Releases Inventory and the Emergency Planning and Community Right-to-Know Act
  - Behavioral Nudges
- Liability approaches
  - CERCLA and the Superfund program
- Prescriptive Regulations (Command-and-Control)
  - Technology and performance-based standards.
- Emission Fees or Abatement Subsidies
  - Pigouvian taxes
- Quantity Control and Allowance Trading
  - Cap-and-trade systems



Market-based instruments.

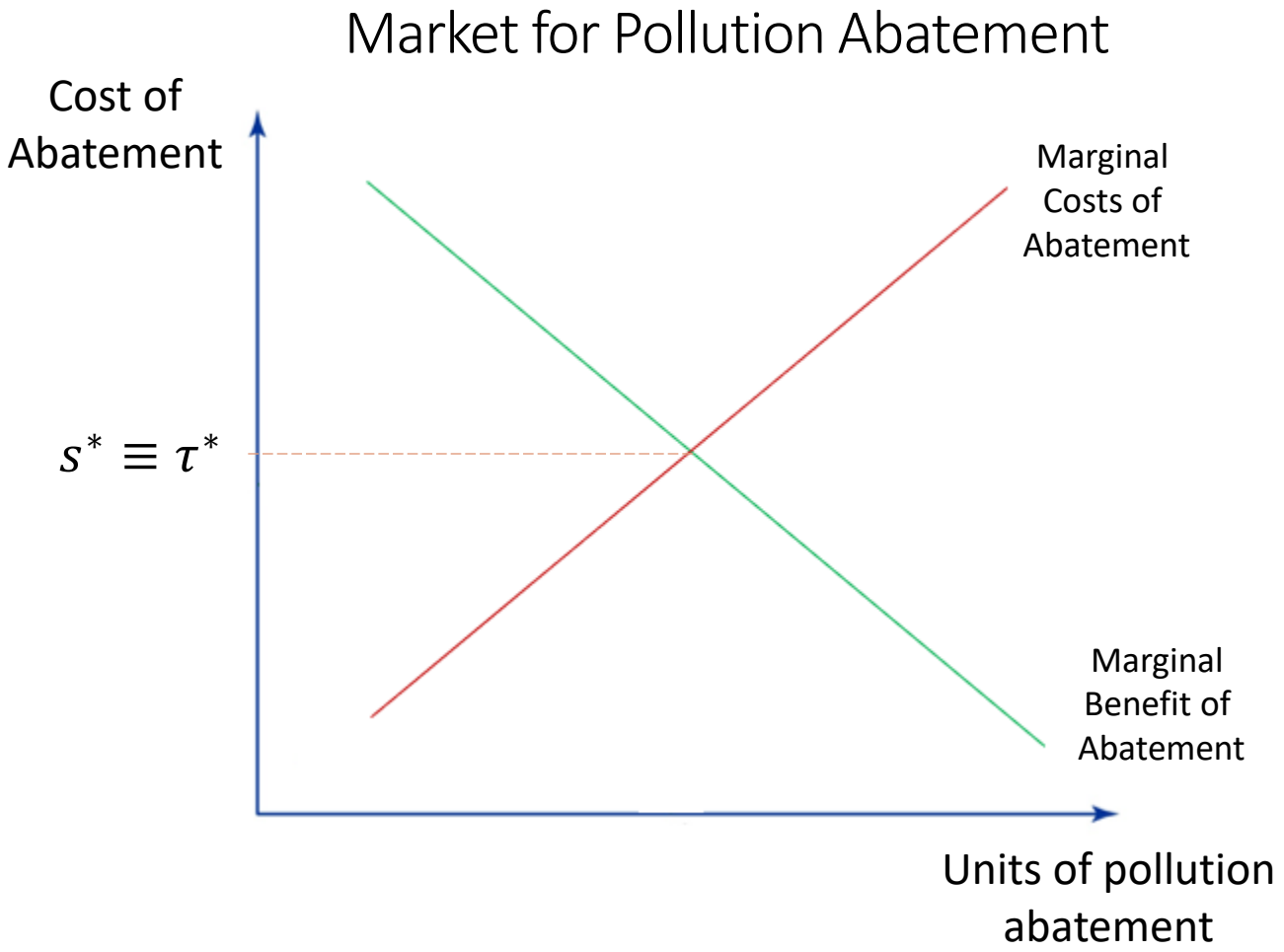
# Quantity Control and Allowance Trading

What is a cap-and-trade regulatory instrument?

- Quantity control ("cap") places a restriction on the total quantity of emissions for a given pollutant by distributing allowances that sum to that quantity.
- Allowance trading ("and trade") is the subsequent market for pollution allowances. Trading creates an incentive for firms to abate, buy, and/or sell allowances to save money. Supply and demand ensures firms abate or trade in a cost-effective way.

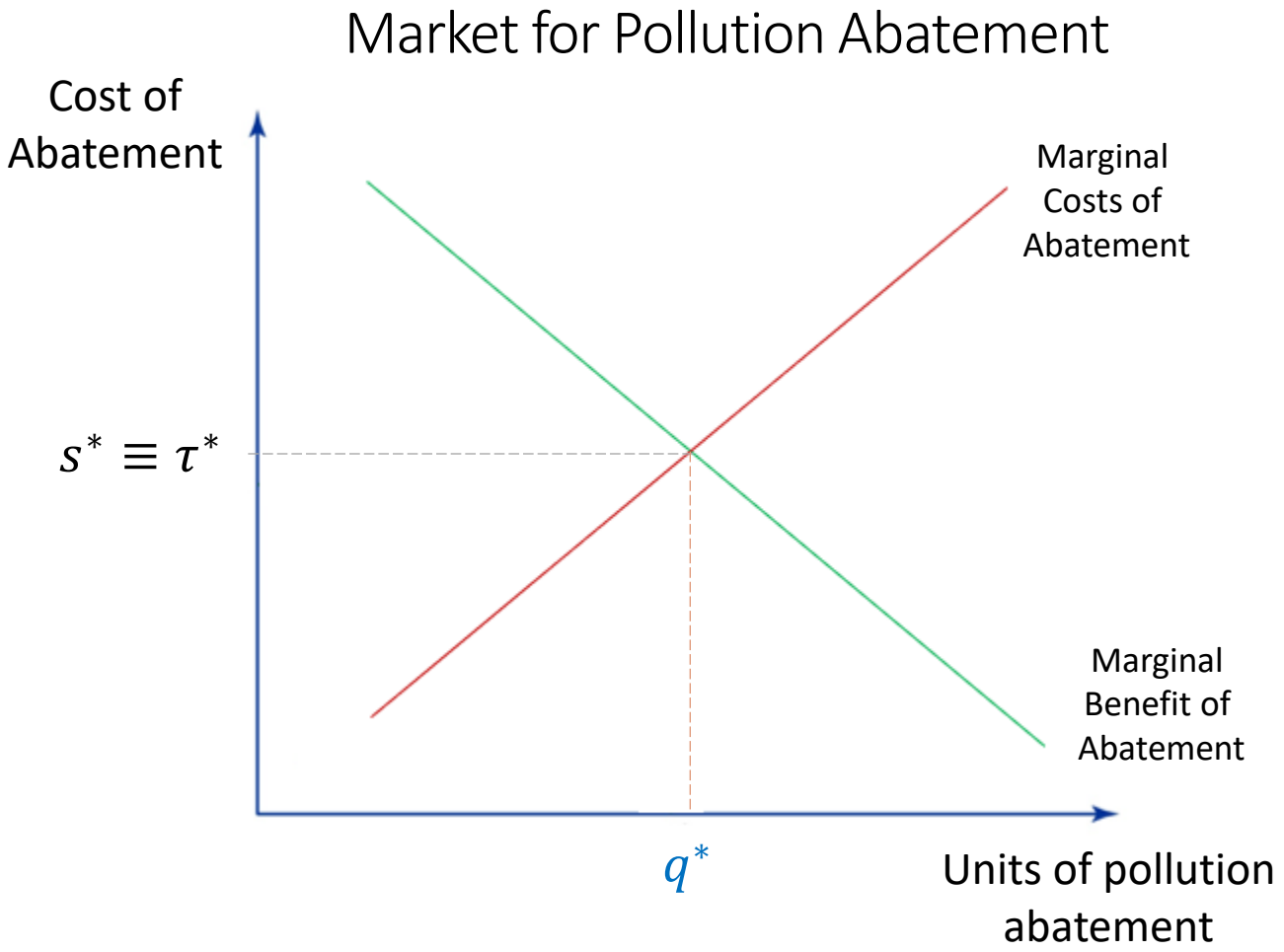
# Recall the Optimal Emissions Tax and Abatement Subsidy

The optimal emissions tax or abatement subsidy is the price where the marginal cost of abatement equals the marginal benefit of abatement.



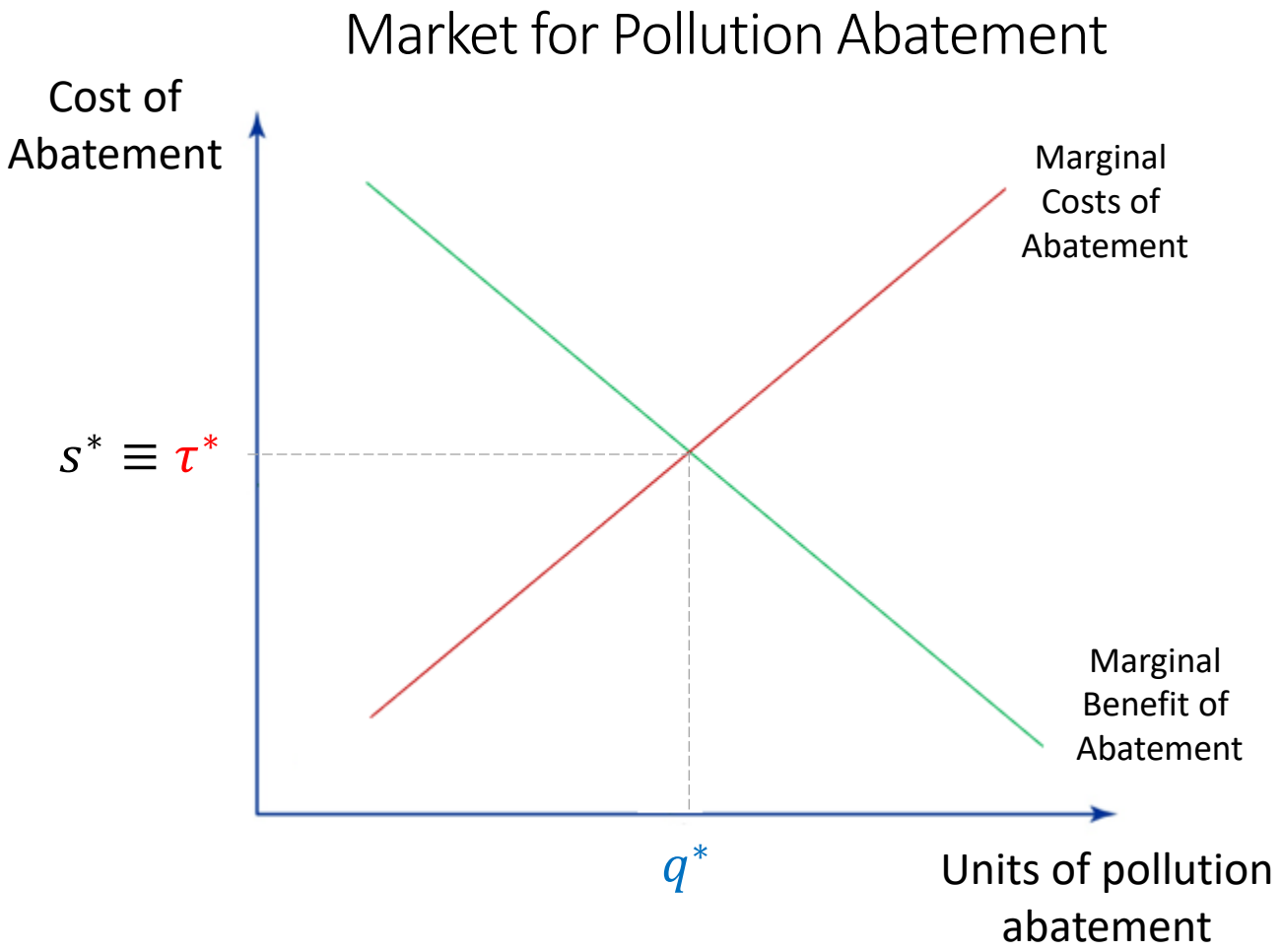
# The Optimal Quantity of Pollution Abatement

The tax/subsidy where the marginal cost of abatement equals the marginal benefit of abatement is also associated with a specific quantity of abatement, $q^*$.



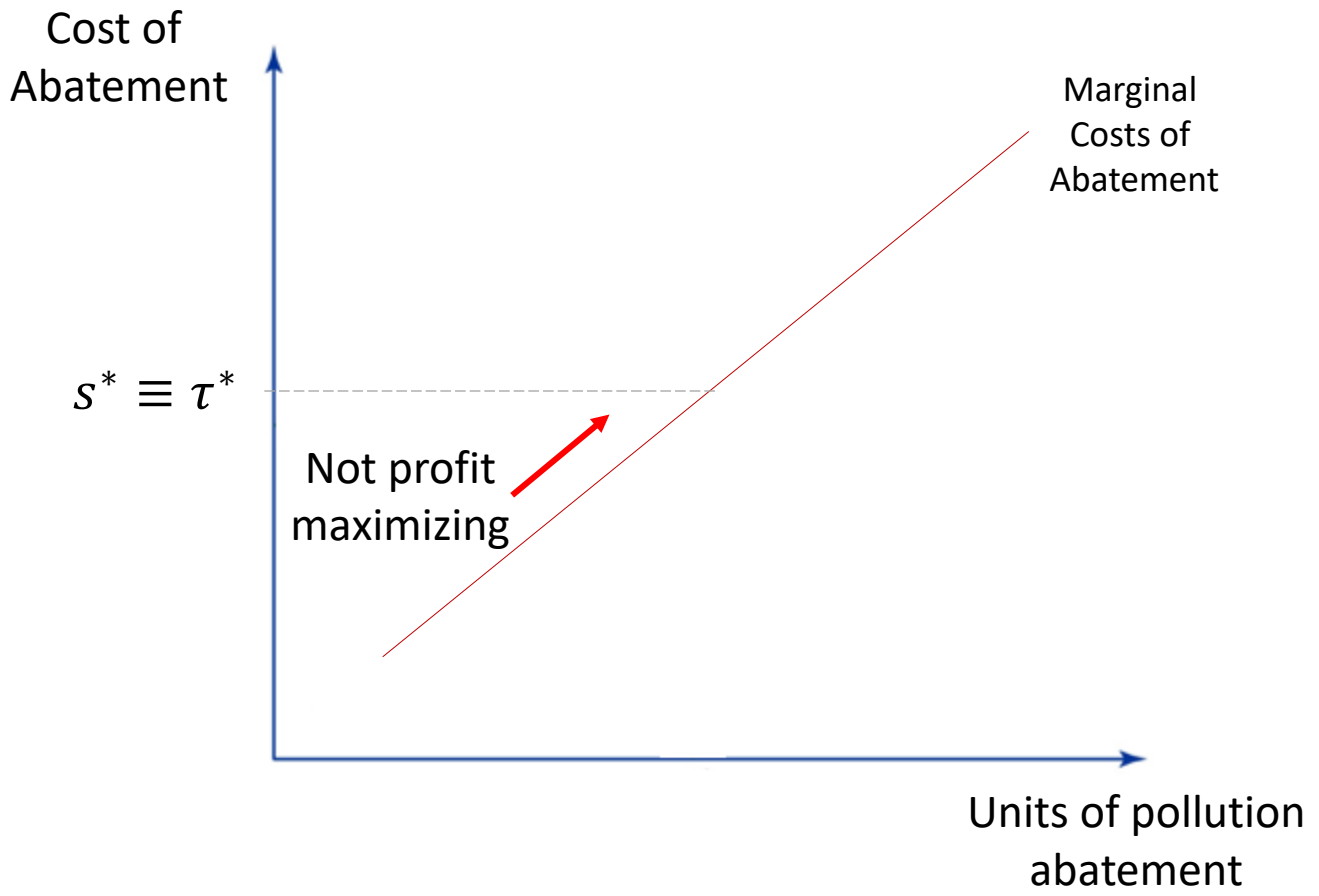
# Combining Price and Quantity Regulatory Instruments

In a theoretical competitive market with known pollution abatement costs, a regulator could achieve the same optimal pollution abatement with a Pigouvian tax at $\tau^*$ as they could with a quantity control at $q^*$.



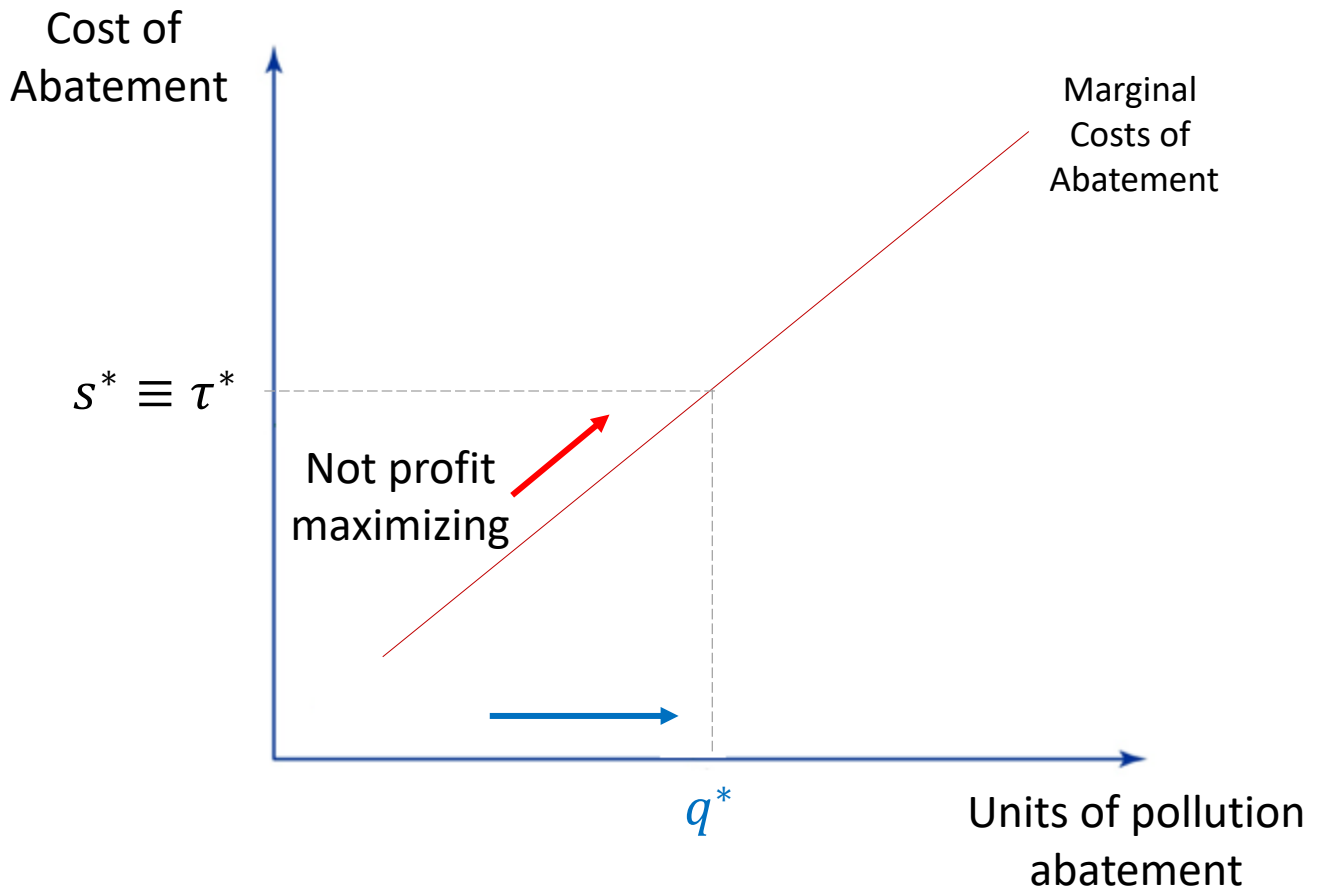
# Equivalence of Market-based Incentives

A tax or subsidy pushes firms to the optimal quantity because it is more profitable to abate than to pay the tax for emitting a unit of pollution.



# Equivalence of Market-based Incentives

A quantity control mandates the quantity by creating $q^*$ pollution allowances and distributing them to regulated entities for free or by auction.

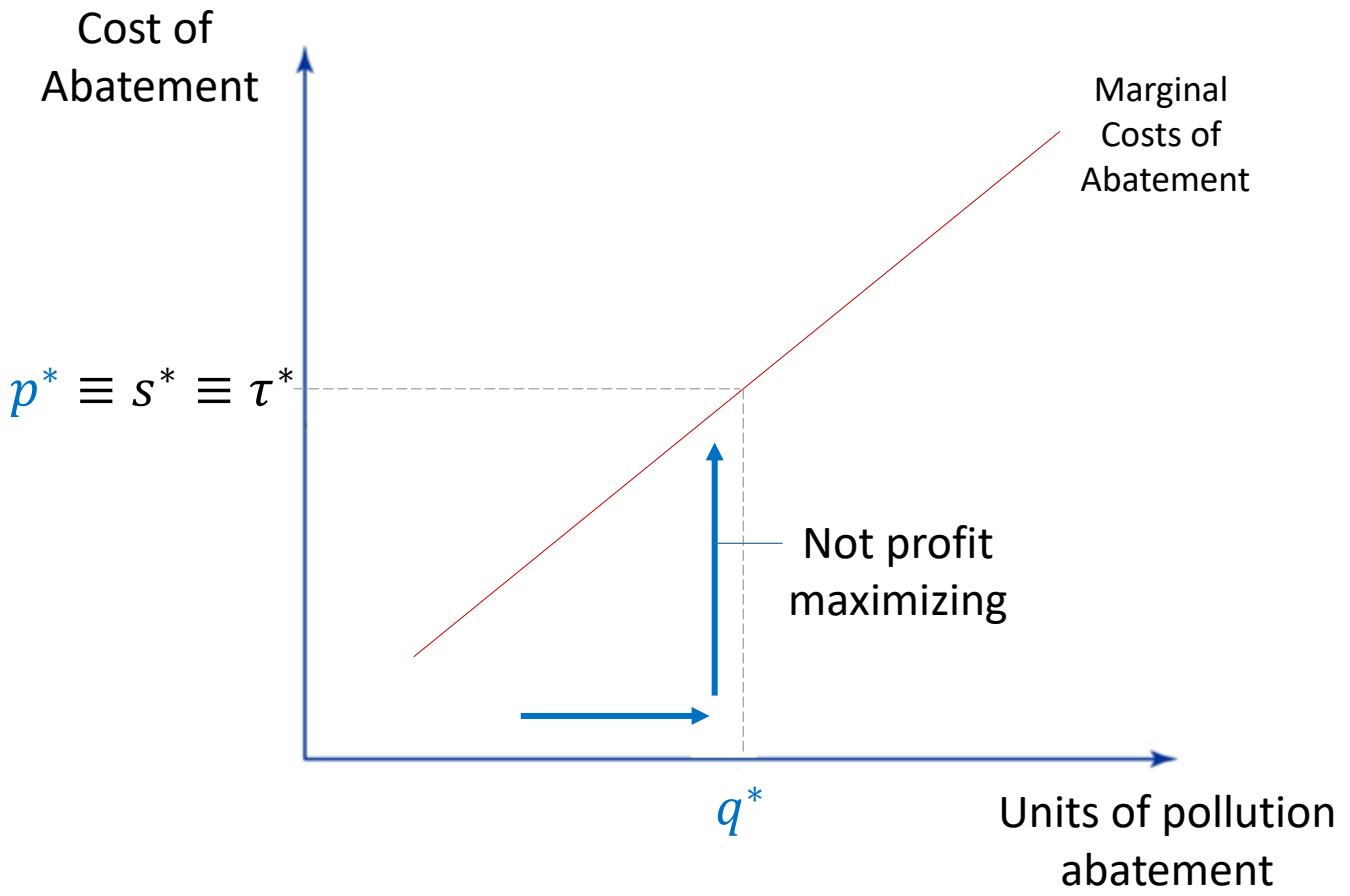


# Equivalence of Market-based Incentives

Firms buy and sell (i.e., trade) allowances if it is profitable.

- Buy if allowance price < cost of abatement
- Sell if allowance price > cost of abatement

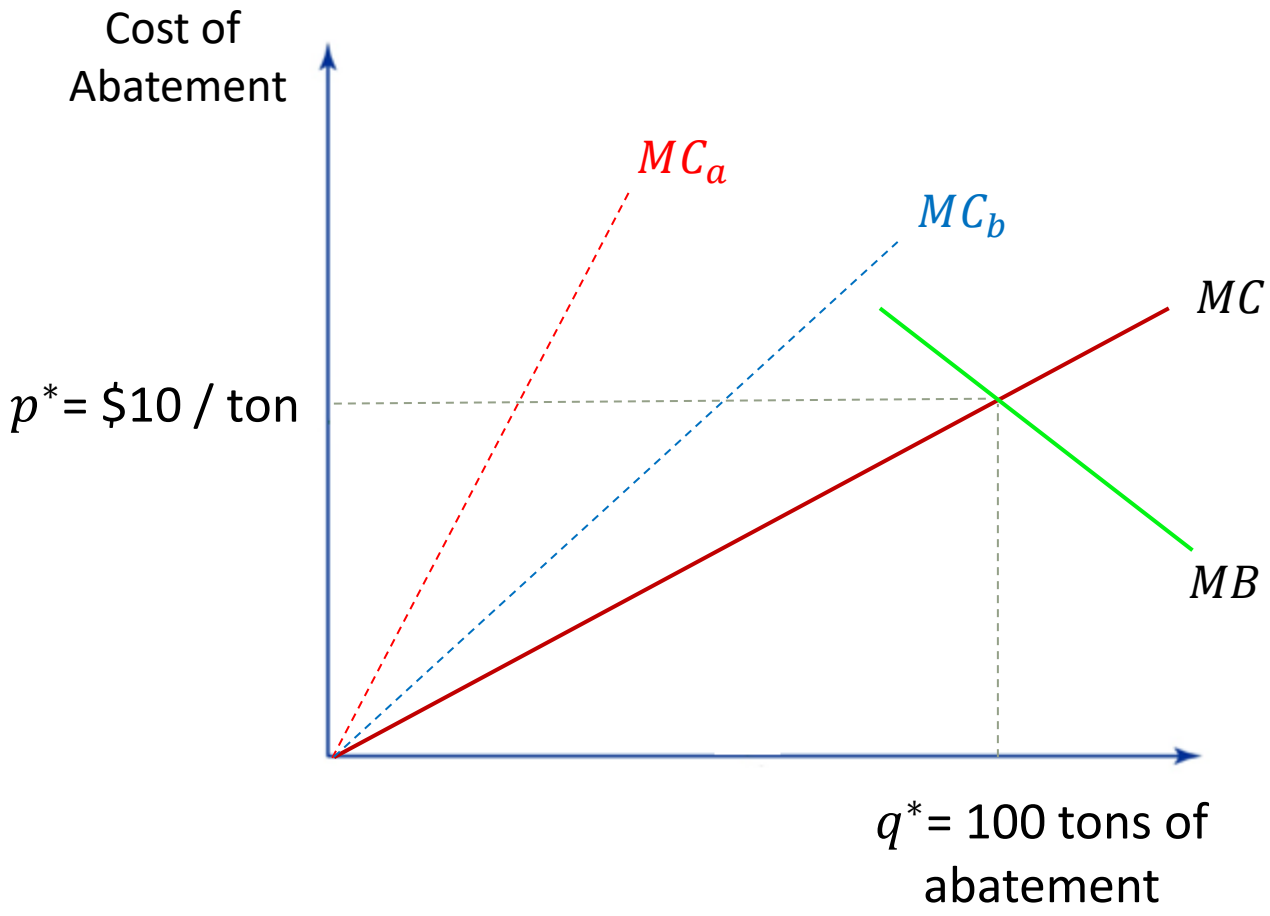
In a competitive market, this pushes the price of an allowance $p^*$ to the level of an efficient tax/subsidy.



# Allowance Price Formation in Cap and Trade

To see why the price of an emissions allowance $p^*$ should be the same as the efficient Pigouvian tax, let's take the example at right where we have two facilities, a and b, each with their own marginal cost of abatement function $MC_a$ and $MC_b$.

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



# Allowance Price Formation in Cap and Trade

Cap is 50 tons total. Each firm currently pollutes 75 tons, so 100 must be abated.

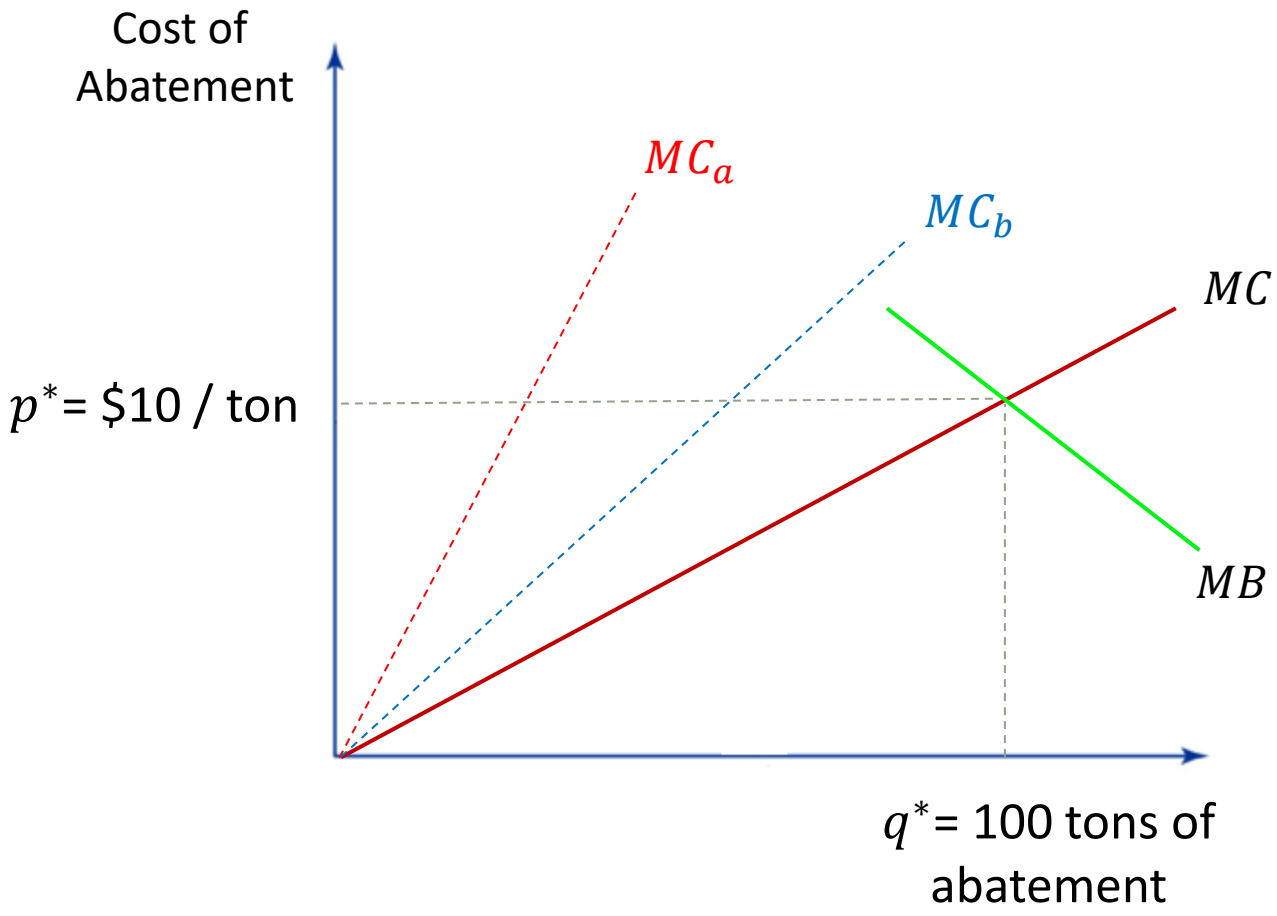
Let:

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

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

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

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



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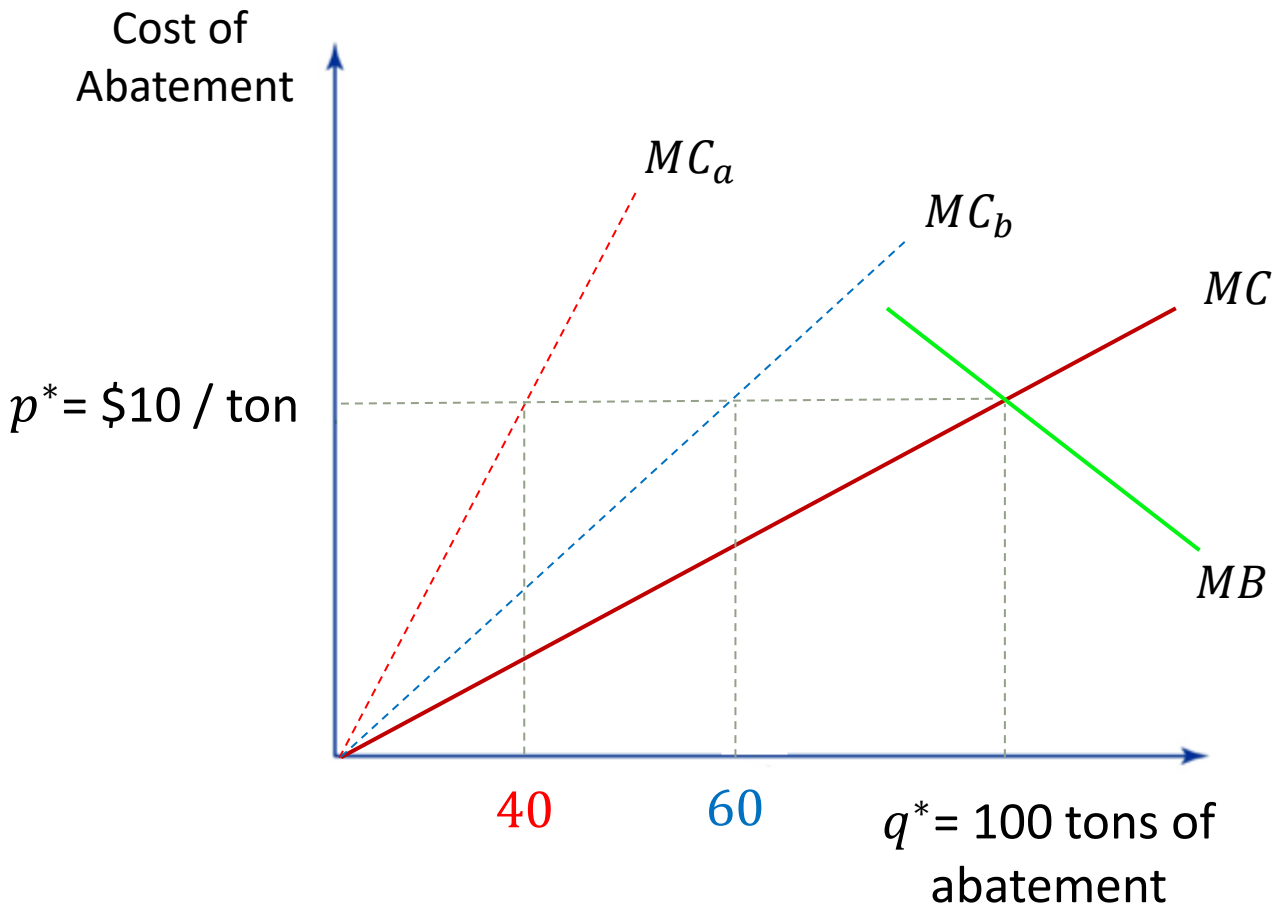

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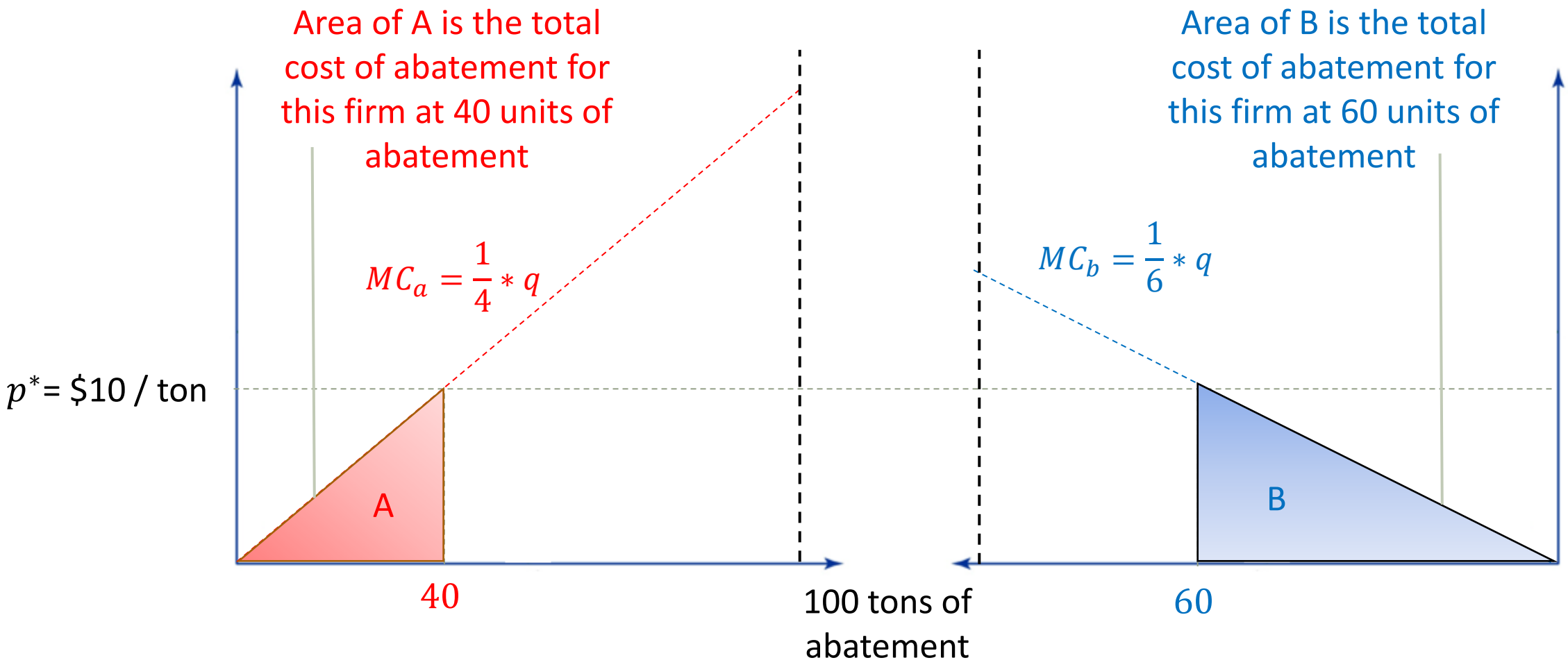

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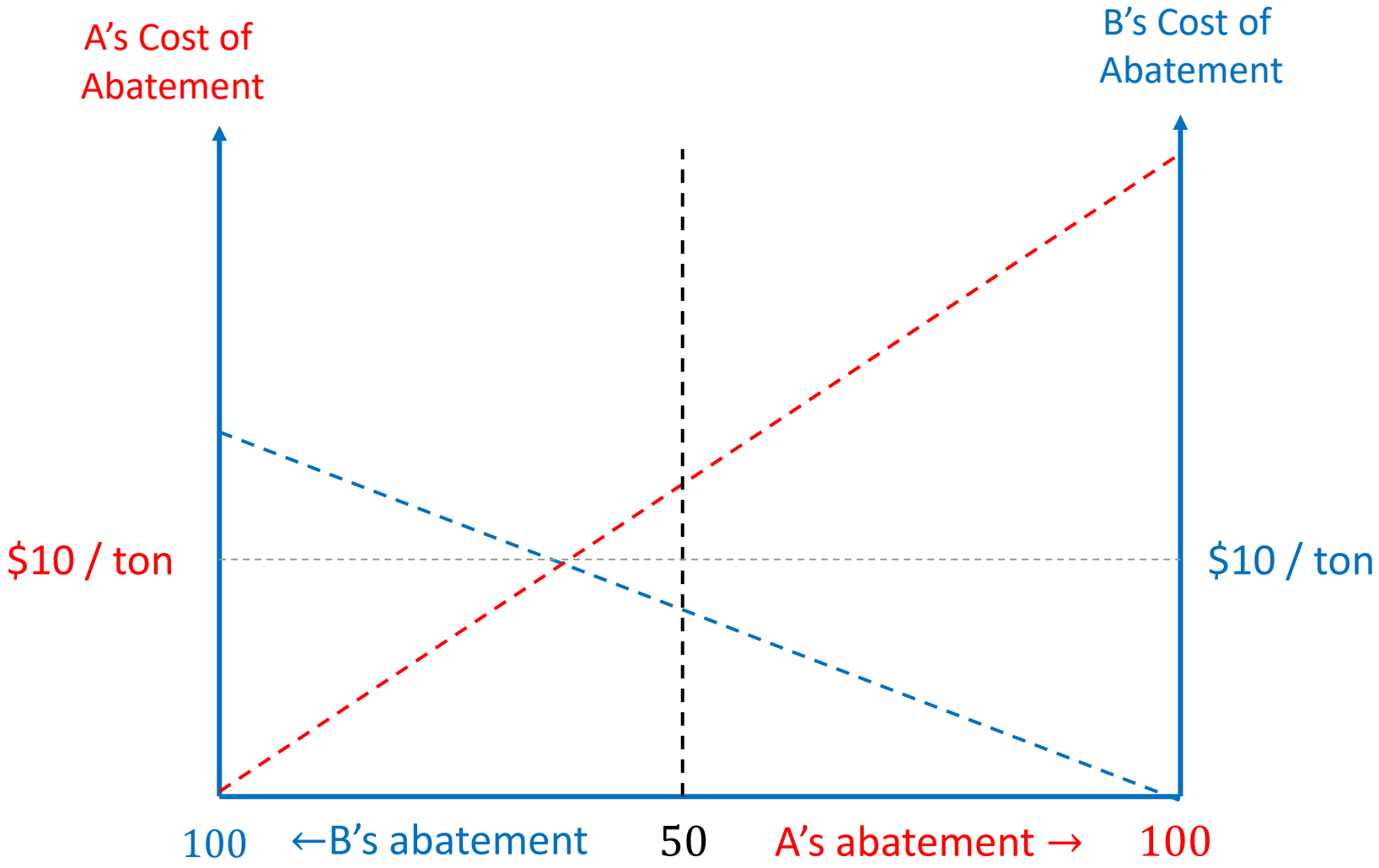
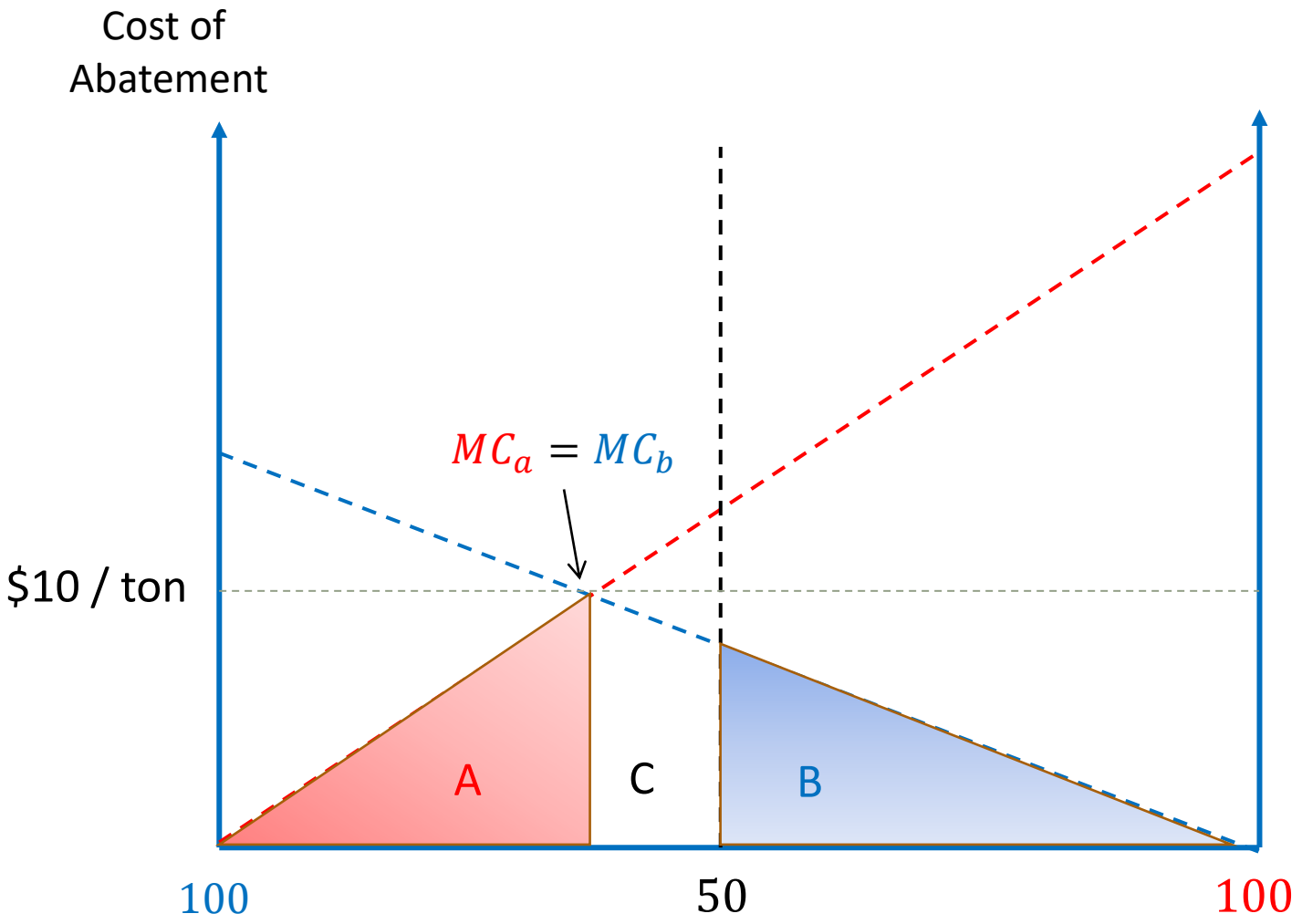


# Allowance Price Formation in Cap and Trade

How could abatement be assigned to minimize costs?



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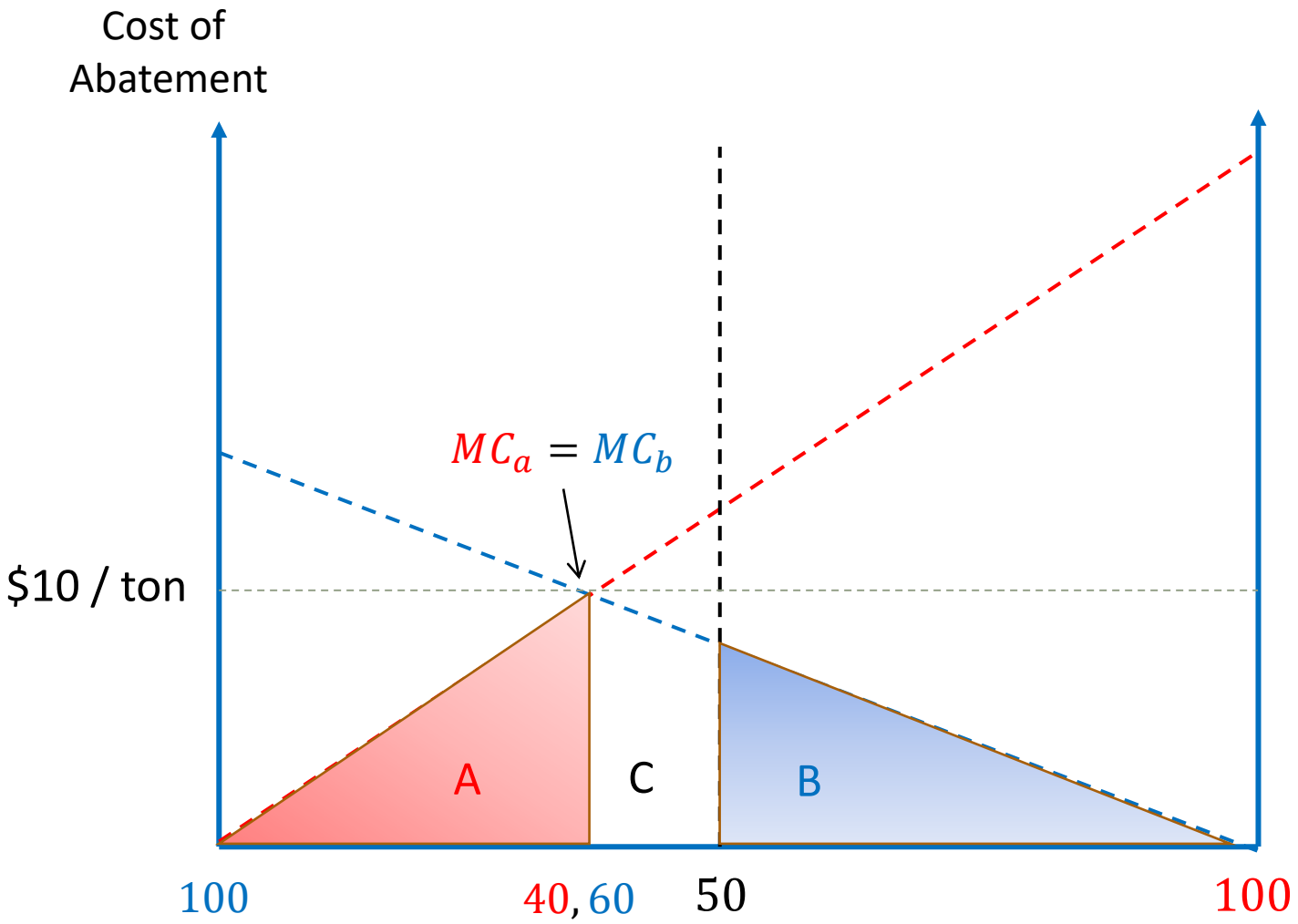
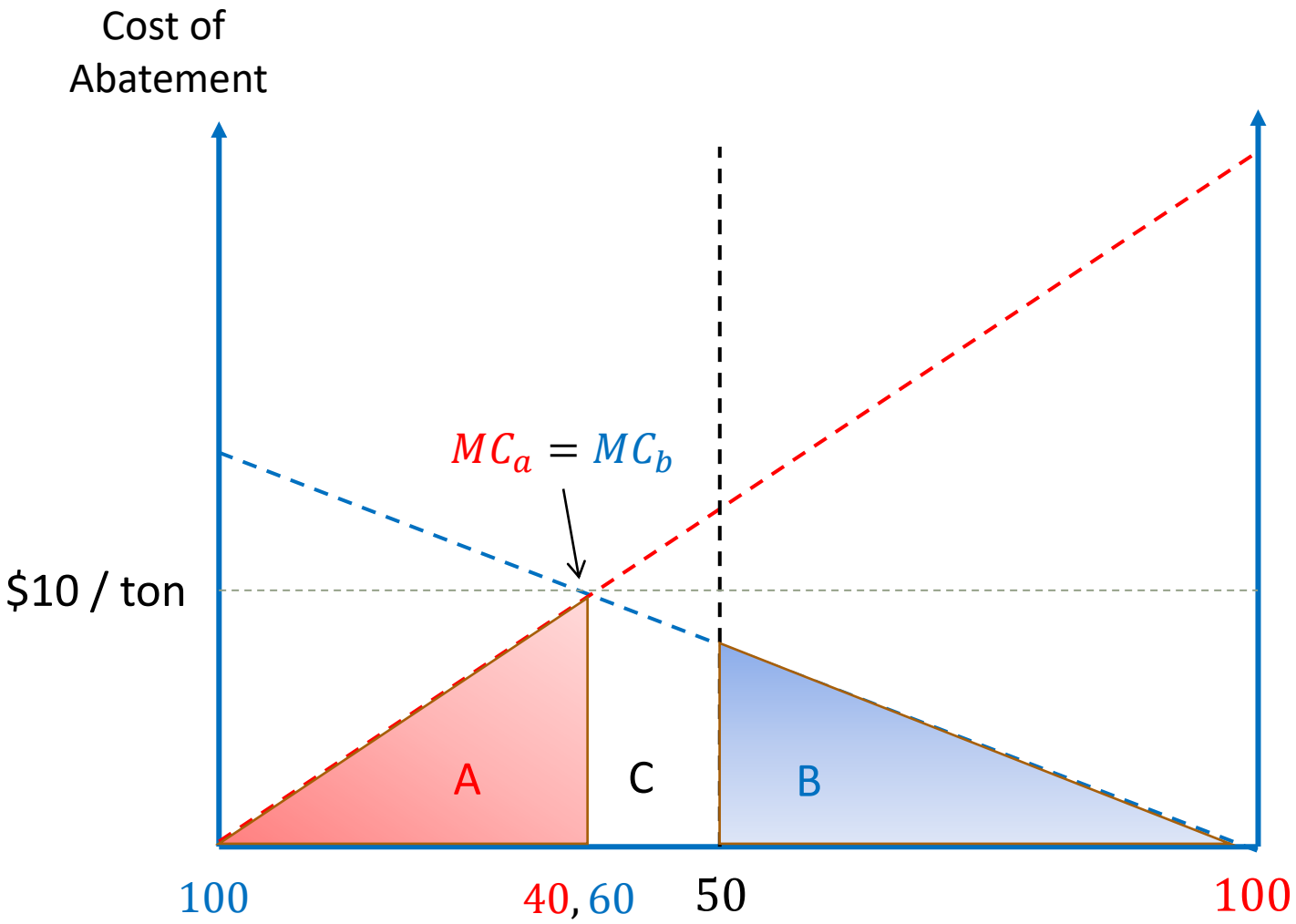


# Allowance Price Formation in Cap and Trade

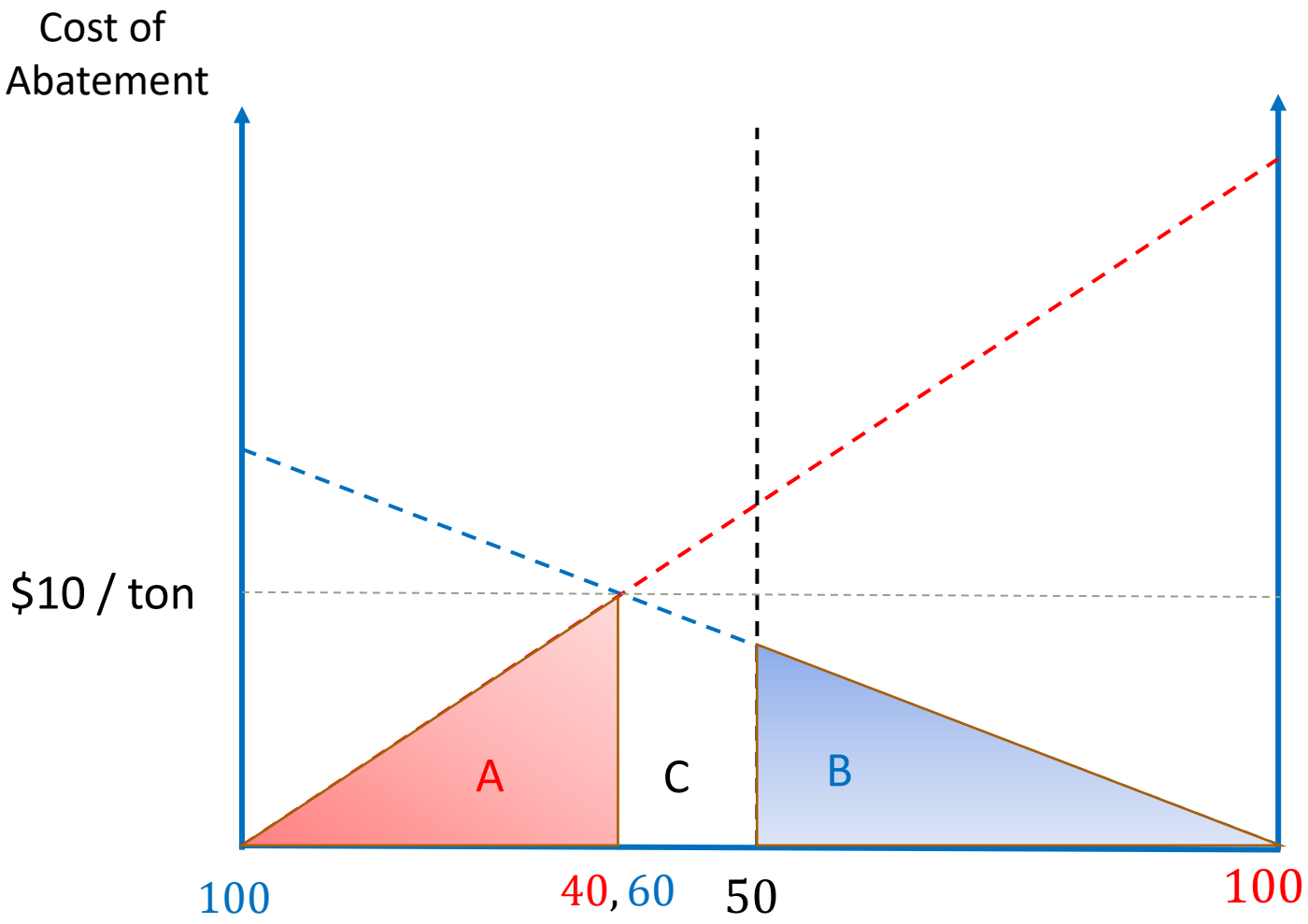
How will these firms trade allowances to achieve the lowest-cost allocation of pollution abatement?



# Allowance Price Formation in Cap and Trade

How will these firms trade:

- If each facility 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

How will these firms trade:

- If each facility is assigned 25 pollution allowances?
  - Both will pollute 25 tons and need to abate 50 tons in the absence of trading. However, at the point where A reaches 40 units of abatement, A and B can come to an agreement where A purchases 10 of B's allowances because A is willing to pay B more for these allowances than it costs B to abate. This will push B to 60 units of abatement, where $MC_a = MC_b$.
- If A is assigned all 50 pollution allowances?
  - A can pollute 50 units and only needs to abate 25. B needs to abate 75. Once B abates 60, however, B is willing to compensate A more for their allowances than it costs A to abate. A will agree because this trade is also worthwhile for them, as their MC is less than B's offer price.
- If B is assigned all 50 pollution allowances?
  - A would need to abate 75 in the absence of trading, but they will find it worthwhile to pay B for their allowances over the entire region where $MC_a > MC_b$. This is the region to the right of $q_a = 40$

# Allowance Price Formation in Cap and Trade

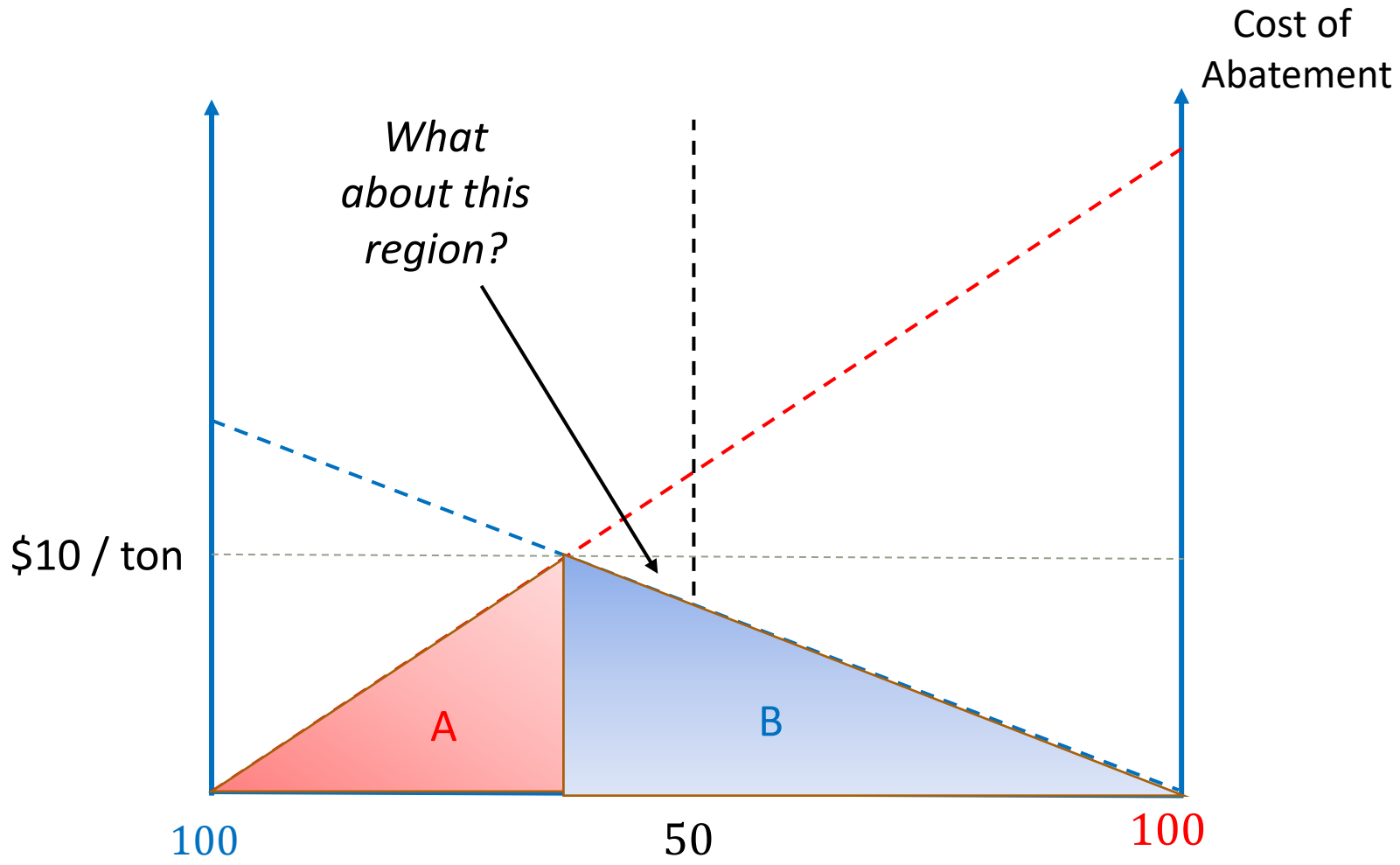
Conclusion: Allocation of abatement occurs only when all firms that abate pollution have equal marginal abatement costs at their quantity of abatement, i.e. $MC_a = MC_b$.

Otherwise, firms could buy or sell allowances to arbitrage away excess costs, hence re-allocating abatement to minimize the entire industry's marginal cost.

# 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 concern of allotment values later today.



# Part 2: For Want of A Chair

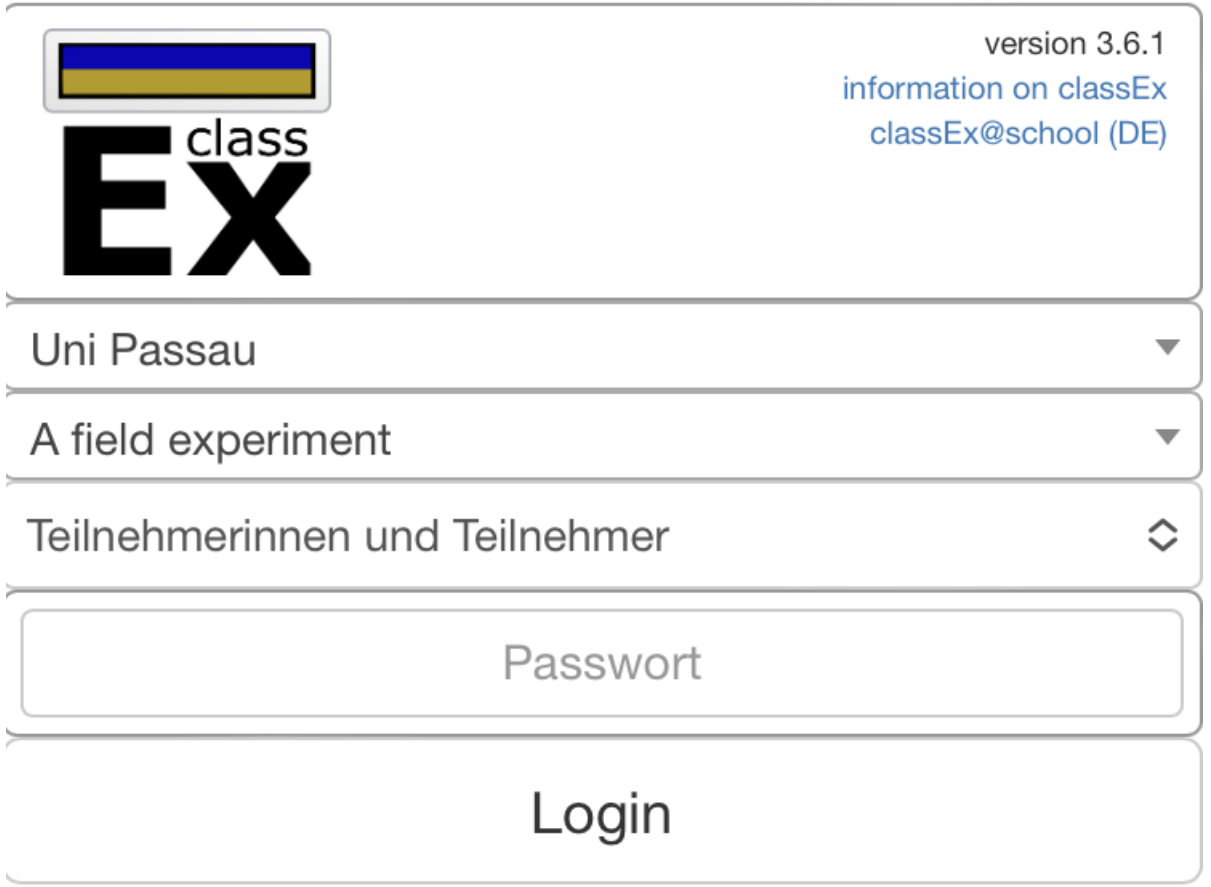
# For Want of a Chair: How to Play

1. Please navigate to the following web-page:

https://classEx.uni-passau.de

2. Type in “US- Environmental Protection Agency”

3. Enter the password: m5GK



# For Want of a Chair: How it Works

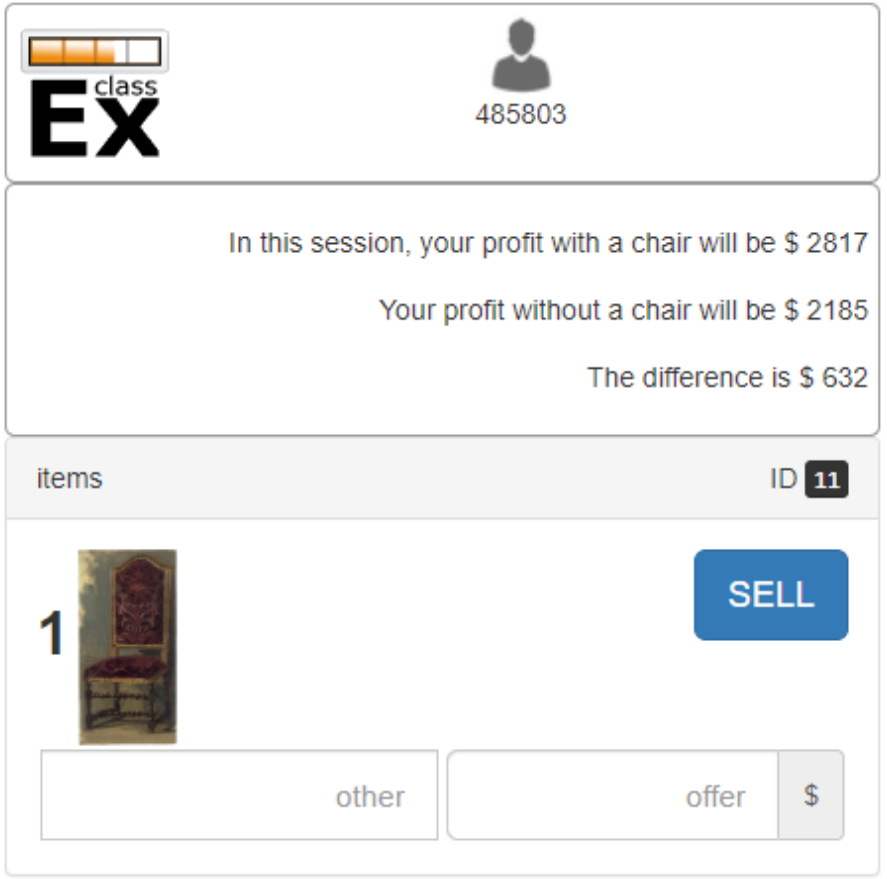
1. Each of you is now a polluting facility, and each chair represents one allowance to pollute.
2. We will play the classic game of musical chairs to determine the initial allowance of pollution across firms.
3. If you have a chair, you have an allowance to pollute. If you are standing, then you have 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 485803, the cost of abatement is $632. They are better off selling their seat if:

Sale Price > $632

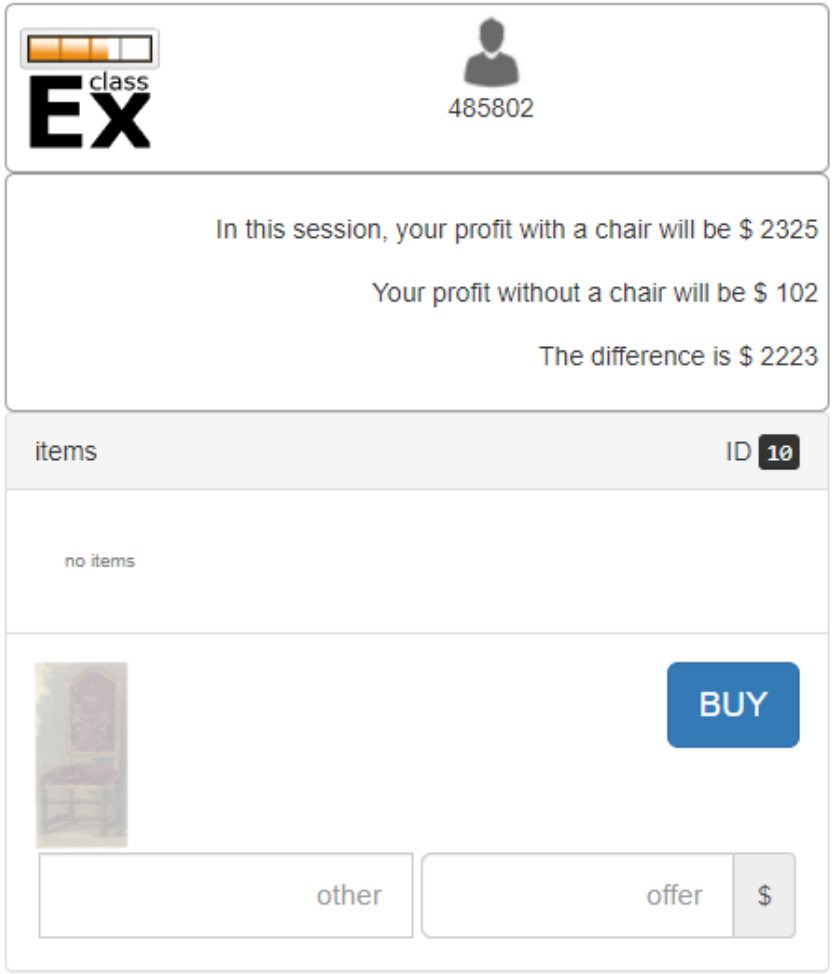


# For Want of a Chair: How it Works

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 485802, the cost of abatement is $2,223. They are better off purchasing a seat if:

Purchase Price < $2,223



# Part 3: Other Considerations

# 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 level of a Pigouvian tax through trades.
- In theory, the quantity and price of pollution abatement is equivalent in both systems.

# How Pigouvian Taxes and Quantity Controls Differ

Two ways in which Pigouvian taxes and quantity controls are not the same:

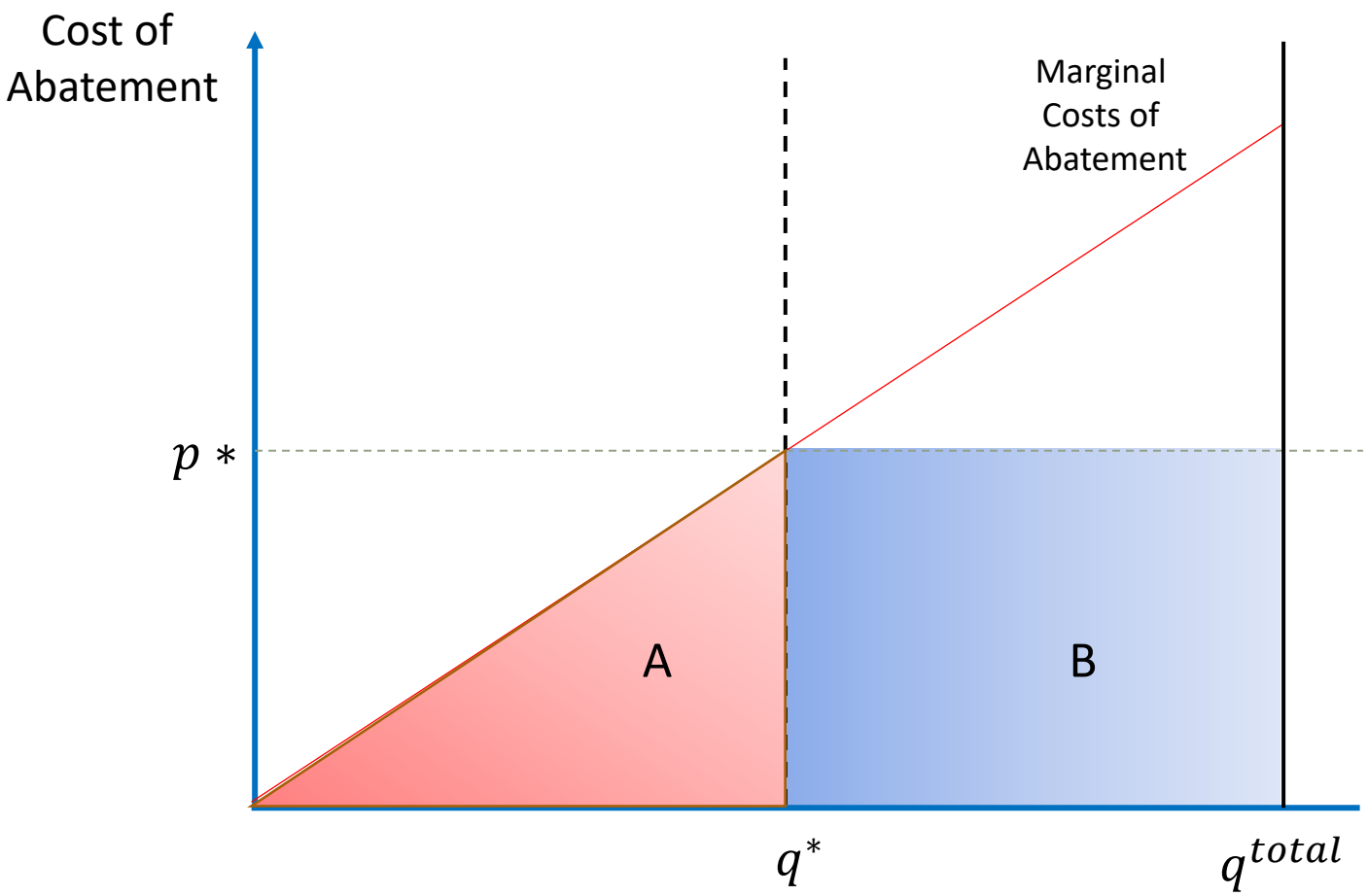
1) Tax revenue (or subsidy cost) vs. allowance value.
2) When the abatement cost curve is not known with certainty, the quantity reduced and the marginal cost of abatement at that quantity are not the same for each regulatory instrument.

# 1) Tax Revenue vs. Allowance Value

What are we looking at?

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

What are A and B?



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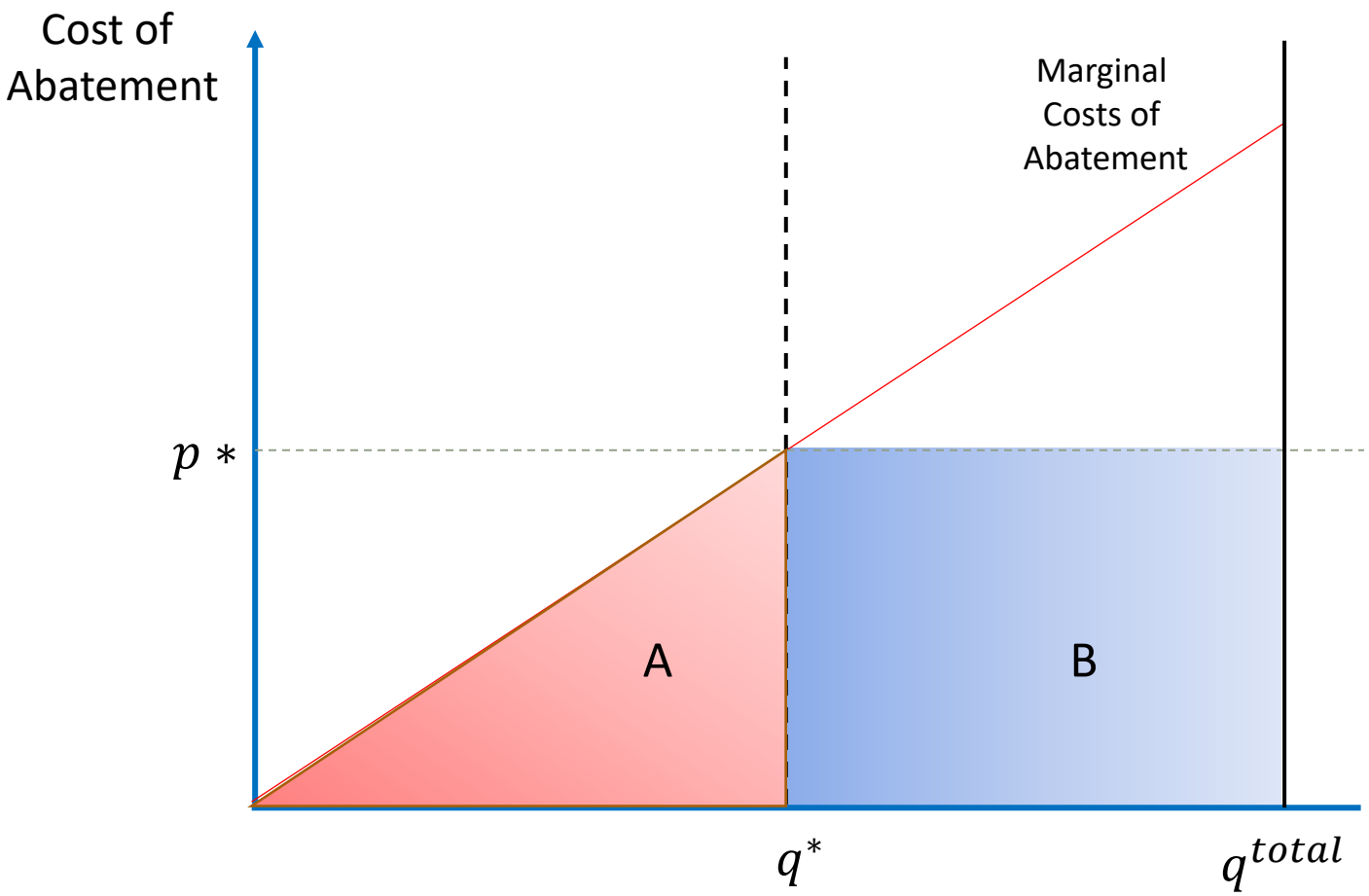
What are A and B?

- 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.



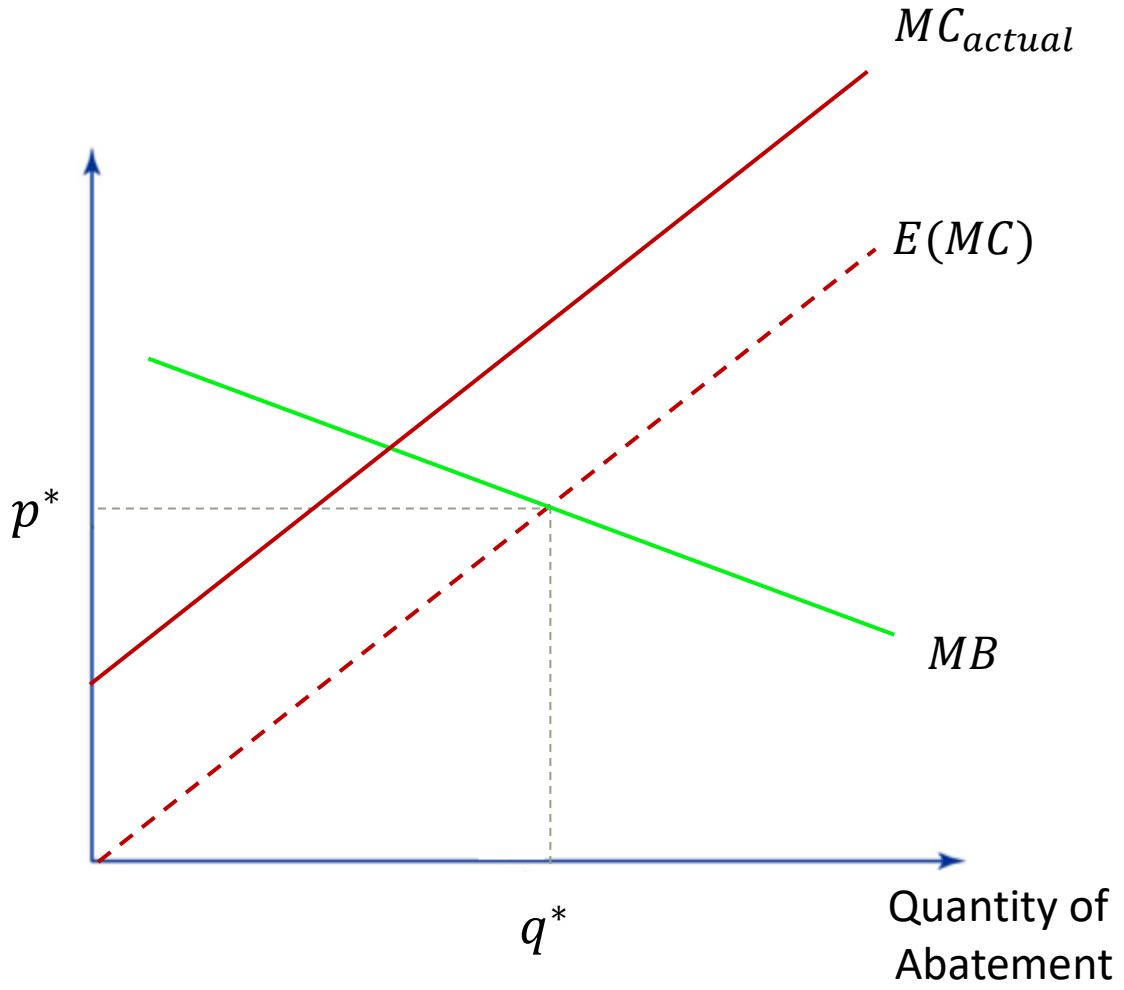
# 2) Prices vs. Quantities

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

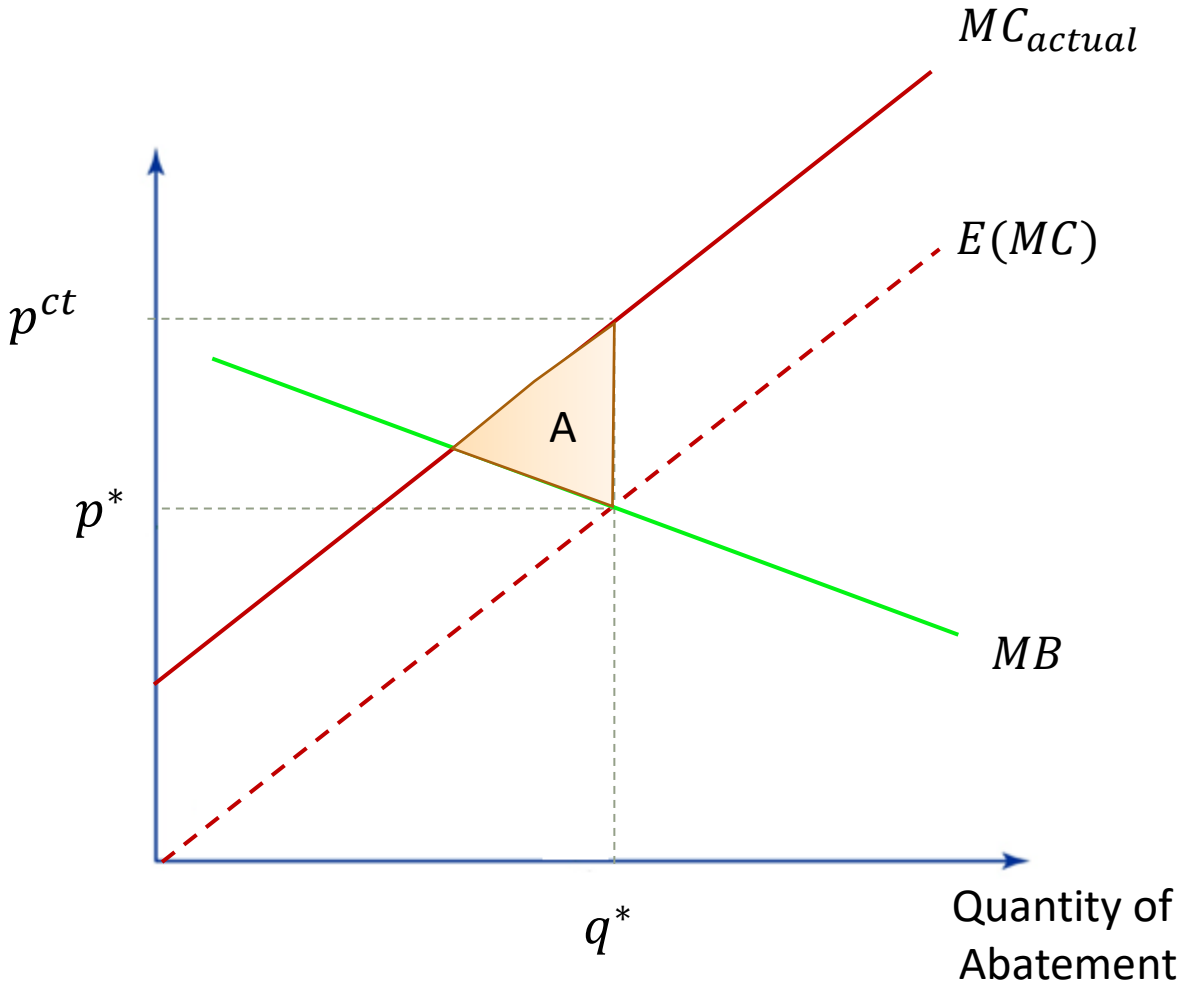
Let $E(MC)$ represent the expected marginal costs, however $MC_{actual}$ is the actual marginal cost of abatement for the industry.



# 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.

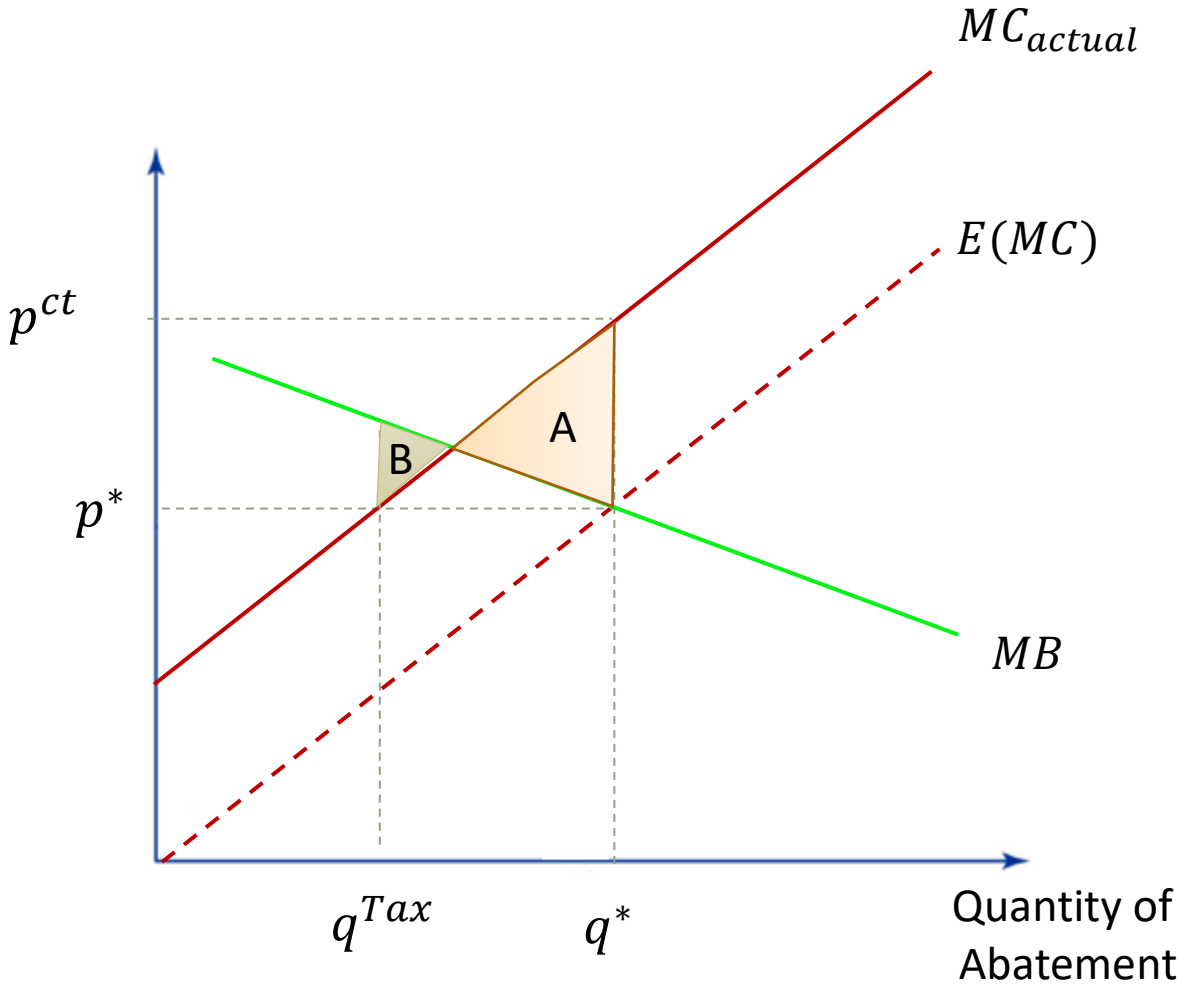
- A cap-and-trade program will still abate to $q^*$, even though the marginal costs will be $p^{ct}$.
- The marginal benefits will be less than the marginal abatement cost at this quantity, leading to deadweight loss of region A.



# 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.

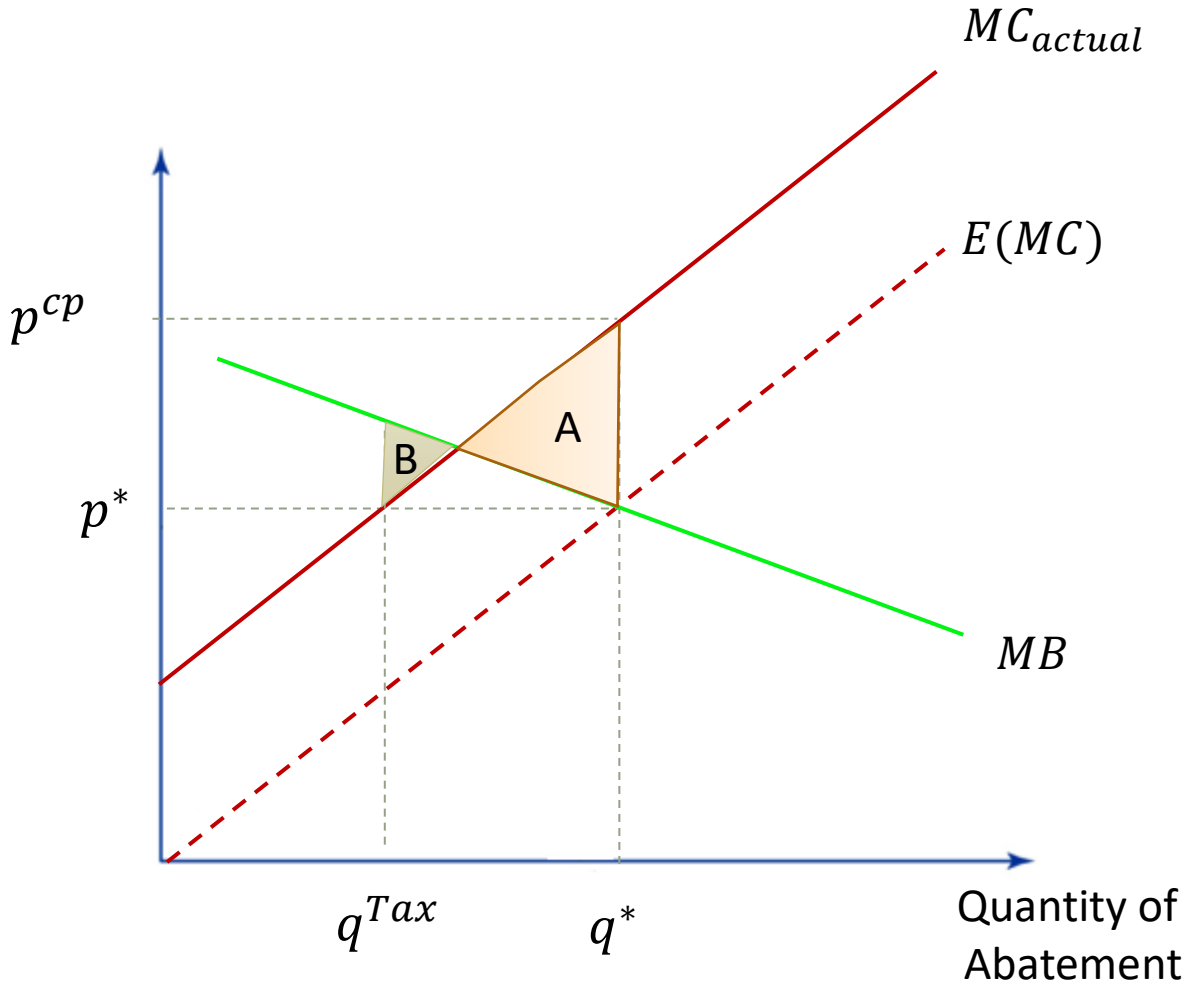
- With a tax set at $p^*$, firms will only abate up to $q^{Tax}$.
- Marginal benefits are higher than marginal costs at $q^{Tax}$, leading to deadweight loss of region B.



# 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

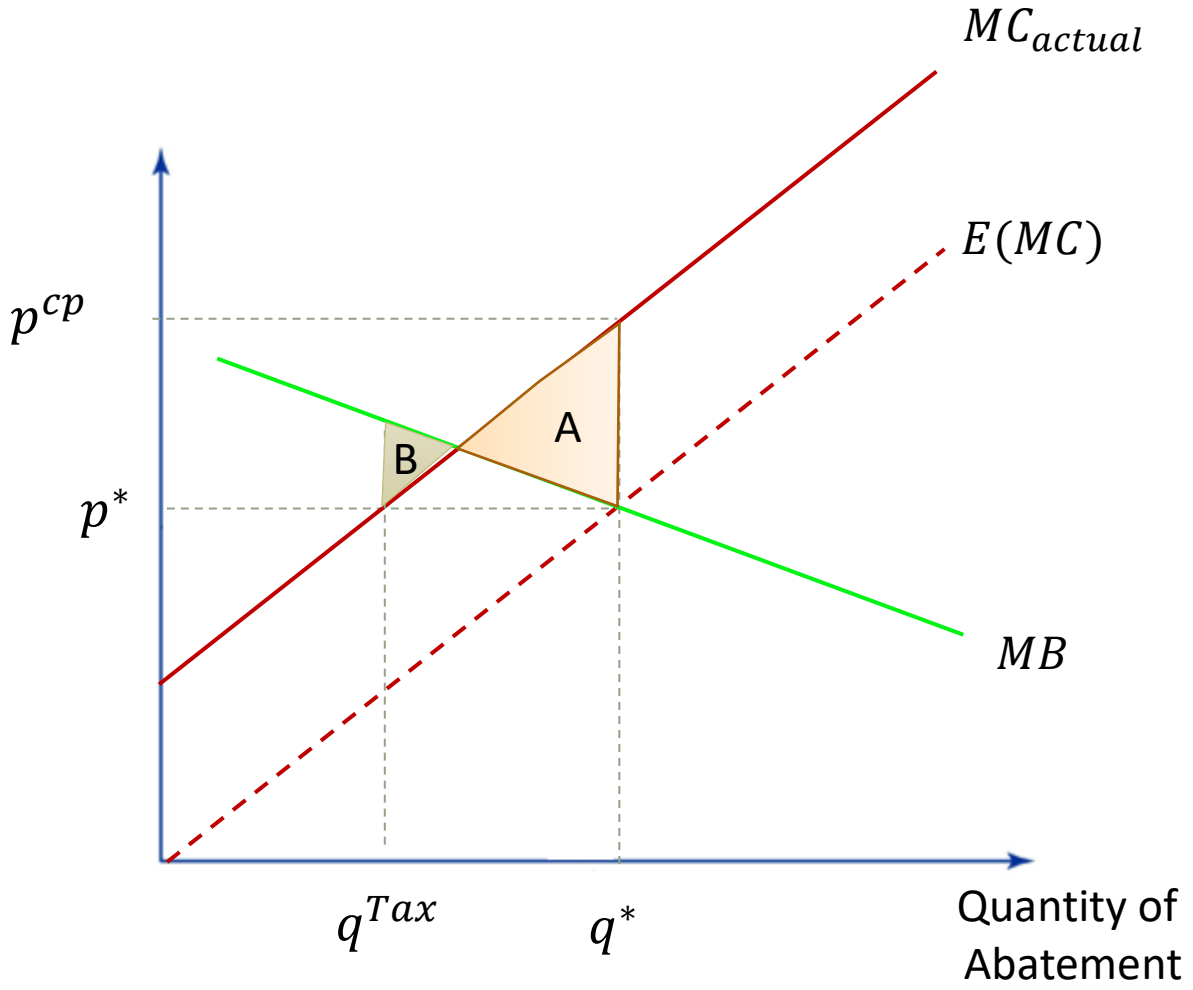
**The Weitzman Rule**

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 functions, cover a cap-and-trade system in Southern California, and discuss some prominent papers on the topic.

- Materials for Wednesday:

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

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