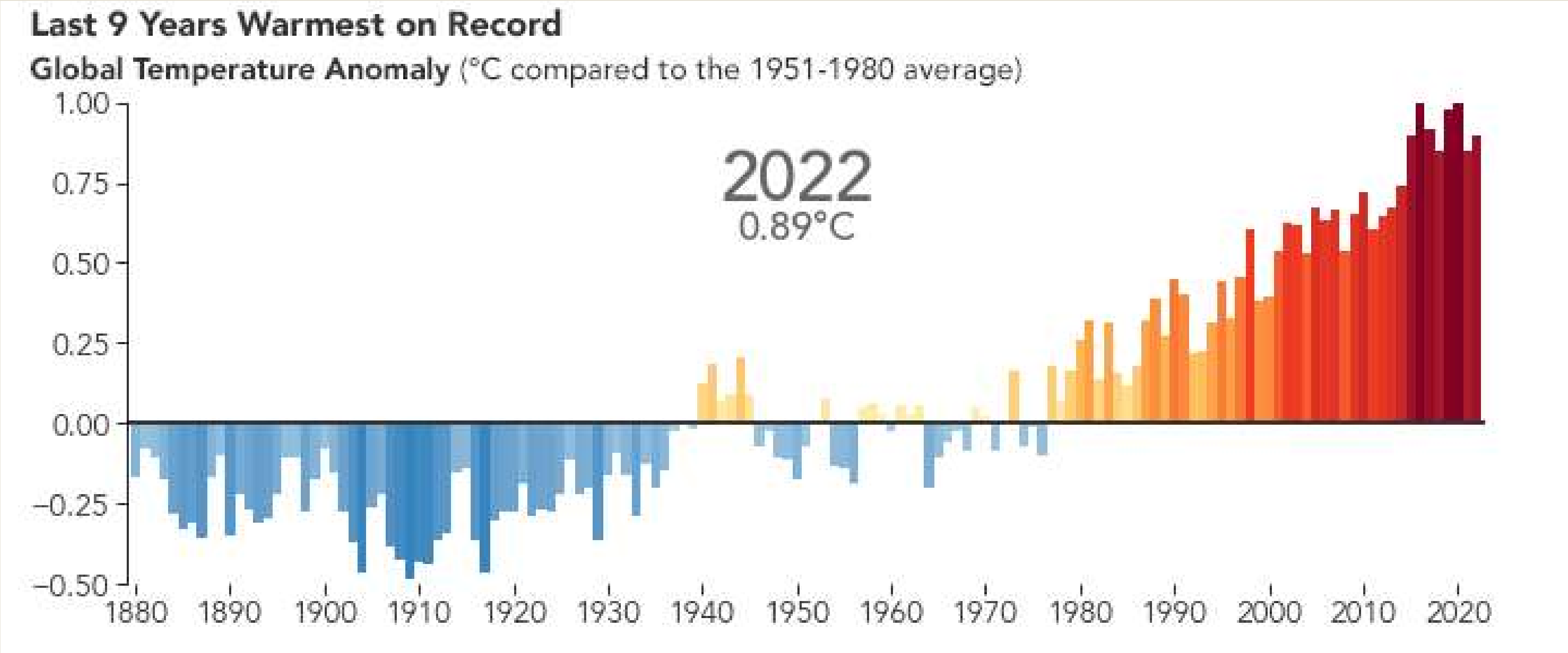
Lecture 6

- **Externalities**

NASA Earth Observatory



Externality Defined

- An <u>externality</u> is present when the activity of one entity (person or firm) directly affects the welfare of another entity in a way that is outside the market mechanism.
  - ***Negative externality***: These activities impose damages on others.
  - ***Positive externality***: These activities benefits on others.

Examples of externalities

- ***Negative Externalities***
  - Pollution
  - Cell phones in a movie theater
  - Congestion on the internet
  - Drinking and driving
  - Student cheating that changes the grade curve

- ***Positive Externalities***
  - Research & development
  - Vaccinations
  - A neighbor's nice landscape
  - Students asking good questions in class
  - *Not* Considered Externalities
  - Land prices rising in urban area.
  - Known as "pecuniary" externalities.

Nature of externalities

- Arise because there is no market price attached to the activity.
- Can be produced by people or firms.
- Can be positive or negative.
- Public goods are special case.
  - Positive externality's full effects are felt by everyone in the economy.

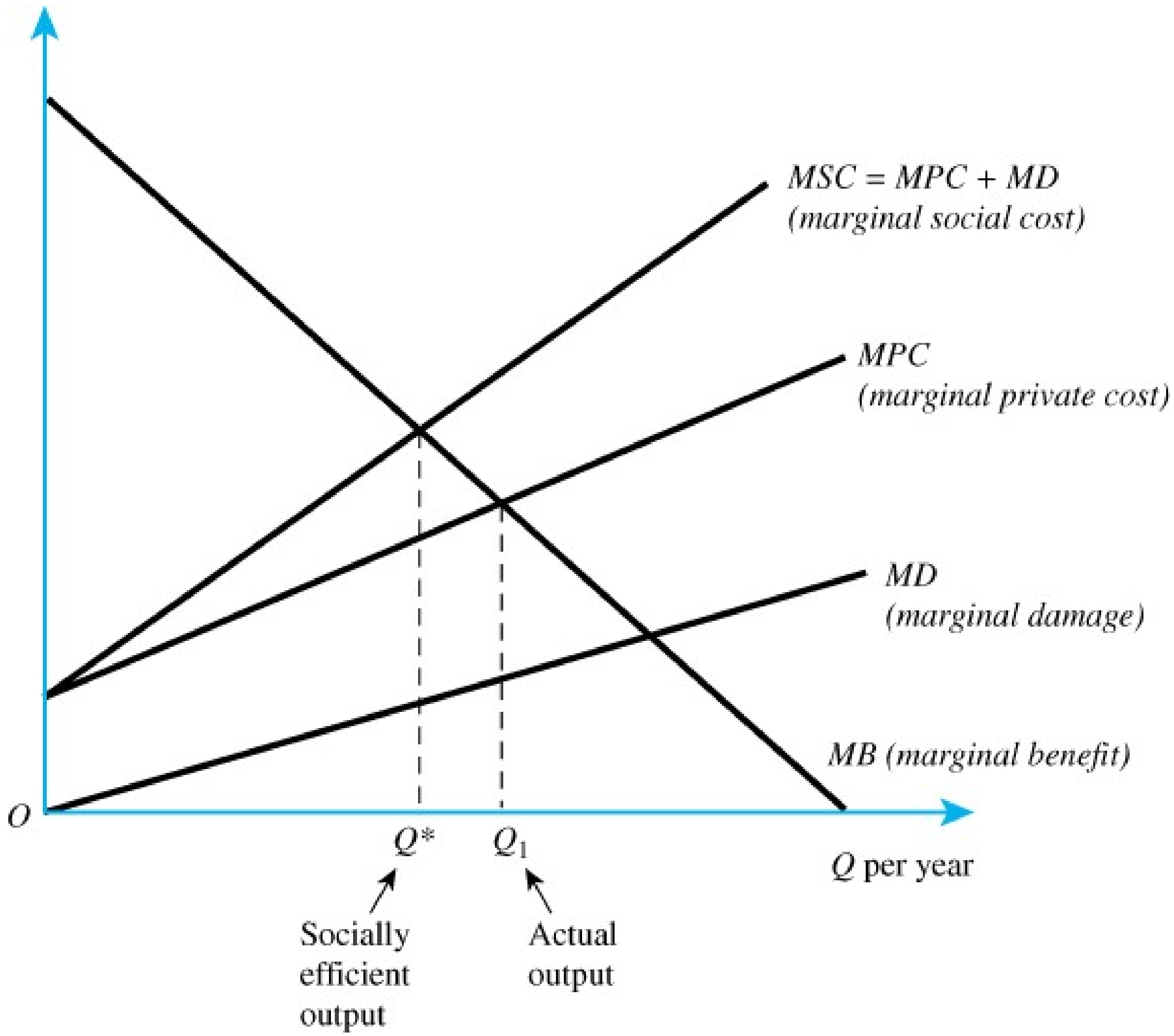
Graphical analysis: Negative externalities

- For simplicity, assume that a steel firm dumps pollution into a river that harms a fishery downstream.
- Competitive markets, firms maximize profits
  - Note that steel firm only care's about its own profits, not the fishery's
  - Fishery only cares about its profits, not the steel firm's.

Graphical analysis, continued

- MB = marginal benefit to steel firm
- MPC = marginal *private* cost to steel firm
- MD = marginal damage to fishery
- MSC = MPC+MD = marginal *social* cost

Figure 6.1


MSC = MPC + MD
(marginal social cost)
MPC
(marginal private cost)
MD
(marginal damage)
MB (marginal benefit)
O
Q*
Q1
Q per year
Socially efficient output
Actual output

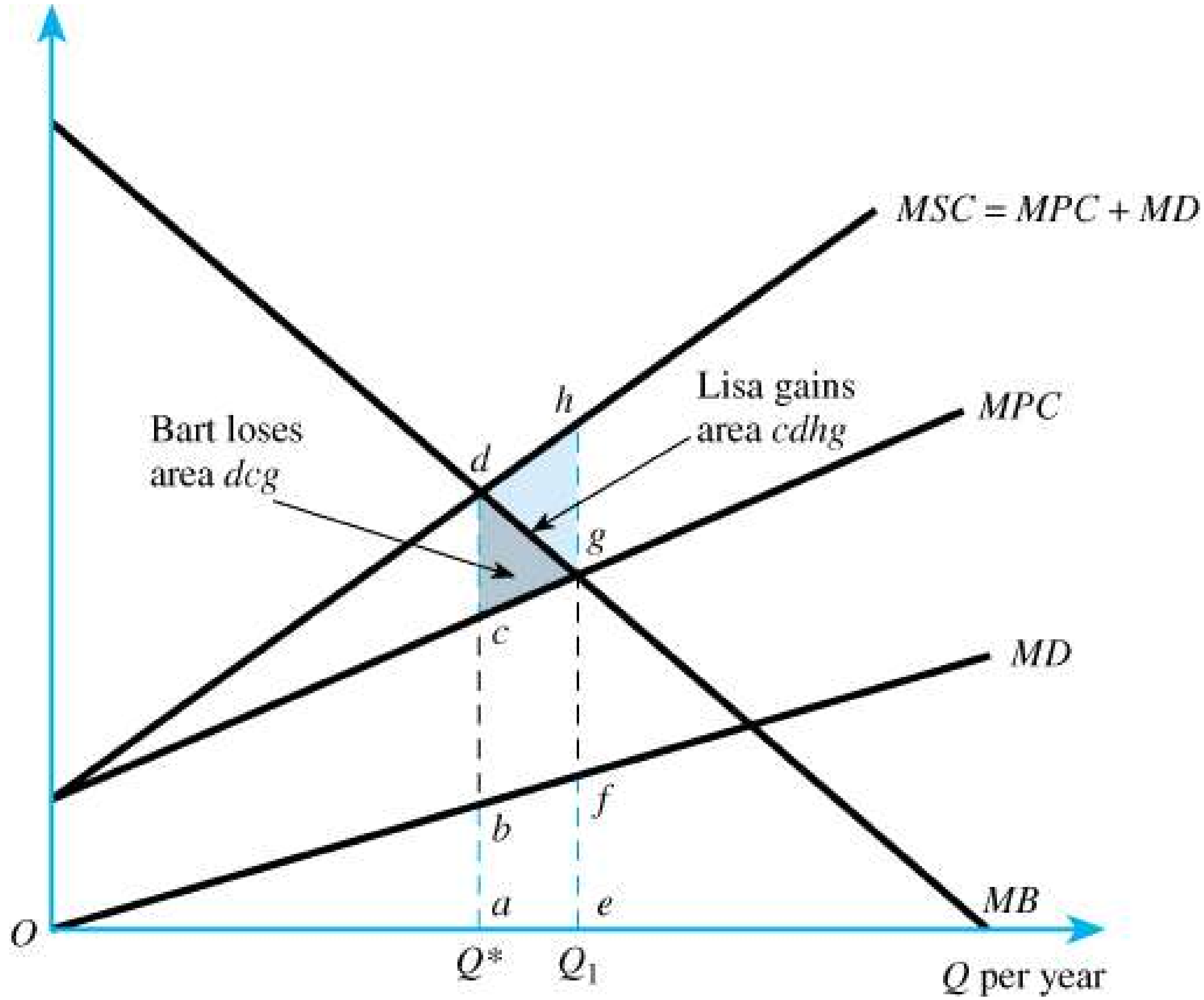
Graphical analysis, continued

- From figure 6.1, as usual, the steel firm maximizes profits at ***MB=MPC***. This quantity is denoted as Q_1 in the figure.
- Social welfare is maximized at ***MB=MSC***, which is denoted as Q^* in the figure.

Graphical analysis: Implications

- ***Result 1***: $Q_1 > Q^*$
  - Steel firm privately produces "*too much*" steel, because it does not account for the damages to the fishery.
- ***Result 2***: Fishery's preferred amount is 0.
  - Fishery's damages are minimized at MD=0.
- ***Result 3***: Q^* is not the preferred quantity for either party, but is the best compromise between fishery and steel firm.
- ***Result 4***: Socially efficient level entails some pollution.
  - Zero pollution is not socially desirable.

Figure 6.2



MSC = MPC + MD
MPC
MD
MB
Bart loses
area dcg
Lisa gains
area cdhg
h
d
g
c
f
b
a
e
O
Q*
Q1
Q per year

Graphical analysis: Intuition

- In Figure 6.2, loss to steel firm of moving to Q^* is shaded triangle ***dcg***.
  - This is the area between the MB and MPC curve going from Q_1 to Q^*.
- Fishery gains by an amount ***abfe***.
  - This is the area under the MD curve going from Q_1 to Q^*. By construction, this equals area ***cdhg***.
- Difference between fishery's gain and steel firm's loss is the efficiency loss from producing Q_1 instead of Q^*.

Numerical example: Negative Externalities

- Assume the steel firm faces the following MB and MPC curves:

$$MB = 300 - Q$$

$$MPC = 20 + Q$$

Assume the fishery faces the following MD curve:

$$MD = 40 + 2Q$$

Numerical example, continued

- The steel firm therefore chooses Q_1:

$$MB = MPC \Rightarrow 300 - Q = 20 + Q \Rightarrow Q_1 = 140$$

The socially efficient amount is instead Q^*:

$$MB = MSC = MPC + MD$$

$$\Rightarrow 300 - Q = (20 + Q) + (40 + 2Q) \Rightarrow Q^* = 60$$

Numerical example, continued

- The deadweight loss of steel firm choosing Q_1=140 is calculated as the triangle between the MB and MSC curves from Q_1 to Q^*.

$$DWL = \frac{1}{2}\left(Q_1 - Q^*\right)\left(MSC\big|_{Q_1} - MB\big|_{Q_1}\right)$$

$$DWL = \frac{1}{2}\left(140 - 60\right)\left(480 - 160\right) = 12800$$

In Figure 6.2, this corresponds to area ***dhg***.

Numerical example, continued

By moving to Q^* the fishery reduces its damages by an amount equal to the trapezoid under the MD curve from Q_1 to Q^*.

$$GAIN = \frac{1}{2}\left(Q_1 - Q^*\right)\left(MD\Big|_{Q^*} + MD\Big|_{Q_1}\right)$$

$$GAIN = \frac{1}{2}(140-60)(160+320) = 19200$$

- By moving to Q^* the steel firm loses profits equal to the triangle between the MB and MPC curve from Q_1 to Q^*.

$$LOSS = \frac{1}{2}\left(Q_1 - Q^*\right)\left(MB\Big|_{Q^*} - MC\Big|_{Q^*}\right)$$

$$LOSS = \frac{1}{2}(140-60)(240-80) = \$6400$$

Calculation of gains & losses raises practical questions

- What activities produce pollutants?
  - With acid rain it is not known how much is associated with factory production versus natural activities like plant decay.
- Which pollutants do harm?
  - Pinpointing a pollutant's effect is difficult. Some studies show very limited damage from acid rain.
- What is the value of the damage done?
  - Difficult to value because pollution not bought/sold in market. Housing values may capitalize in pollution's effect.

Private responses

- Coase theorem
- Mergers
- Social conventions

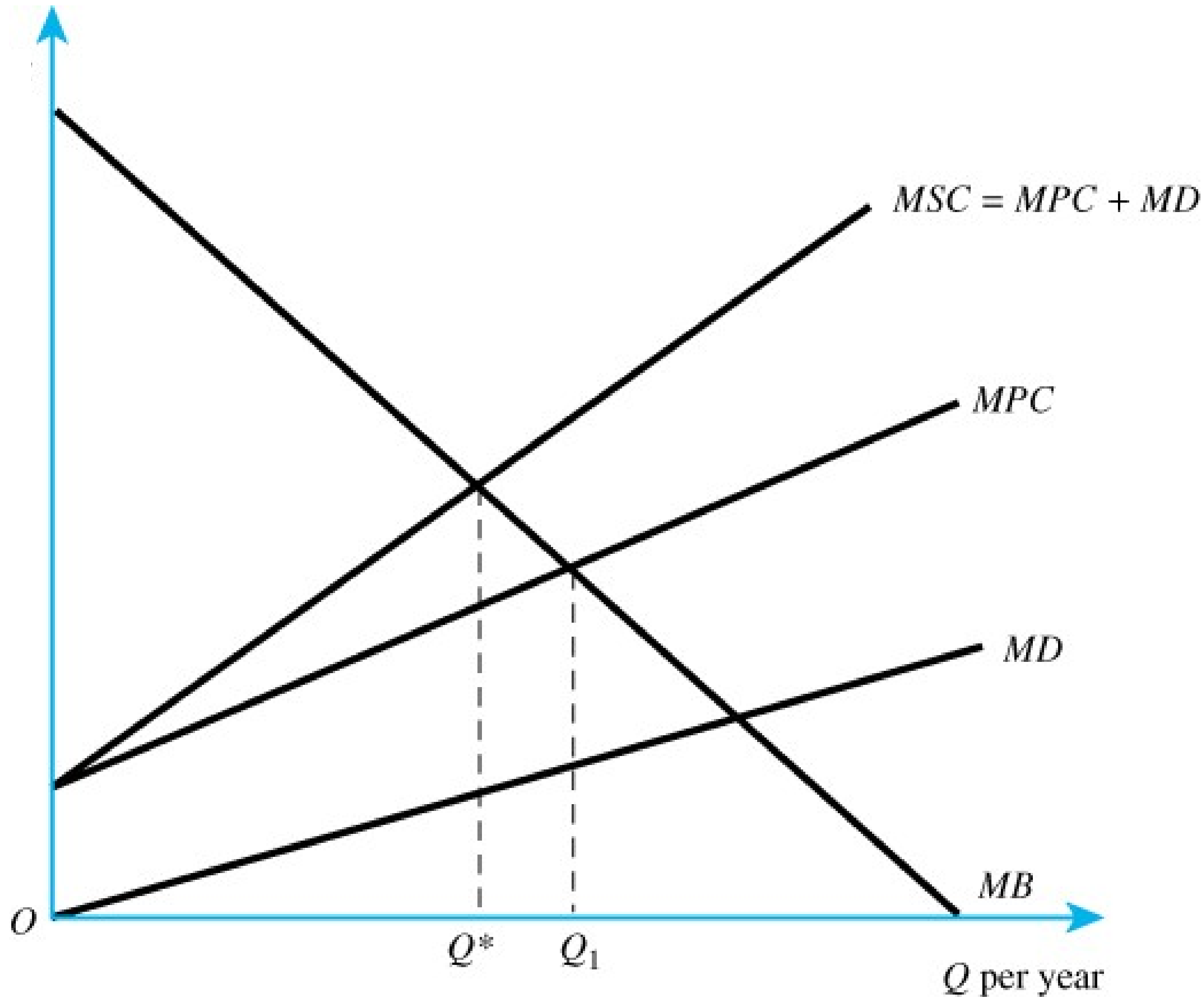
Coase Theorem

- Insight: root of the inefficiencies from externalities is the absence of property rights.
- The ***Coase Theorem*** states that once property rights are established and transaction costs are small, then one of the parties will bribe the other to attain the socially efficient quantity.
- The socially efficient quantity is attained *regardless* of whom the property rights were initially assigned.

Illustration of the Coase Theorem

- Recall the steel firm / fishery example. If the steel firm was assigned property rights, it would ***initially produce Q_1***, which maximizes its profits.
- If the fishery was assigned property rights, it would ***initially mandate zero production***, which minimizes its damages.

Figure 6.3



Coase Theorem – assign property rights to steel firm

- Consider the effects of the steel firm reducing production in the direction of the socially efficient level, Q^*. This entails a cost to the steel firm and a benefit to the fishery:
  - The steel firm (and its customers) would lose surplus between the MB and MPC curves between Q_1 and Q_1-1, while the fishery's damages are reduced by the area under the MD curve between Q_1 and Q_1-1.
  - Note that the marginal loss in profits is extremely small, because the steel firm was profit maximizing, while the reduction in damages to the fishery is substantial.
  - A bribe from the fishery to the steel firm could therefore make all parties better off.

Coase Theorem – assign property rights to steel firm

- When would the process of bribes (and pollution reduction) stop?
  - When the parties no longer find it beneficial to bribe.
  - The fishery will not offer a bribe larger than it's MD for a given quantity, and the steel firm will not accept a bribe smaller than its loss in profits (MB-MPC) for a given quantity.
  - Thus, the quantity where MD=(MB-MPC) will be where the parties stop bribing and reducing output.
  - Rearranging, MC+MPC=MB, or MSC=MB, which is equal at Q^*, the socially efficient level.

Coase Theorem – assign property rights to fishery

- Similar reasoning follows when the fishery has property rights, and initially allows zero production.
  - The fishery's damages are increased by the area under the MD curve by moving from 0 to 1. On the other hand, the steel firm's surplus is increased.
  - The increase in damages to the fishery is initially very small, while the gain in surplus to the steel firm is large.
  - A bribe from the steel firm to the fishery could therefore make all parties better off.

Coase Theorem – assign property rights to fishery

- When would the process of bribes now stop?
  - Again, when the parties no longer find it beneficial to bribe.
  - The fishery will not accept a bribe smaller than it's MD for a given quantity, and the steel firm will not offer a bribe larger than its gain in profits (MB-MPC) for a given quantity.
  - Again, the quantity where MD=(MB-MPC) will be where the parties stop bribing and reducing output. This still occurs at Q^*.

When is the Coase Theorem relevant or not?

- Low transcation costs
  - Few parties involved
- Source of externality well defined
- Example: Several firms with pollution

- Not relevant with high transaction costs or ill-defined externality
- Example: Air pollution

Private responses, continued

- Mergers
- Social conventions

Mergers

- Mergers between firms "internalize" the externality.
- A firm that consisted of both the steel firm & fishery would only care about maximizing the *joint* profits of the two firms, not either's profits individually.
- Thus, it would take into account the effects of increased steel production on the fishery.

Social Conventions

- Certain social conventions can be viewed as attempts to force people to account for the externalities they generate.
- Examples include conventions about not littering, not talking in a movie theatre, etc.

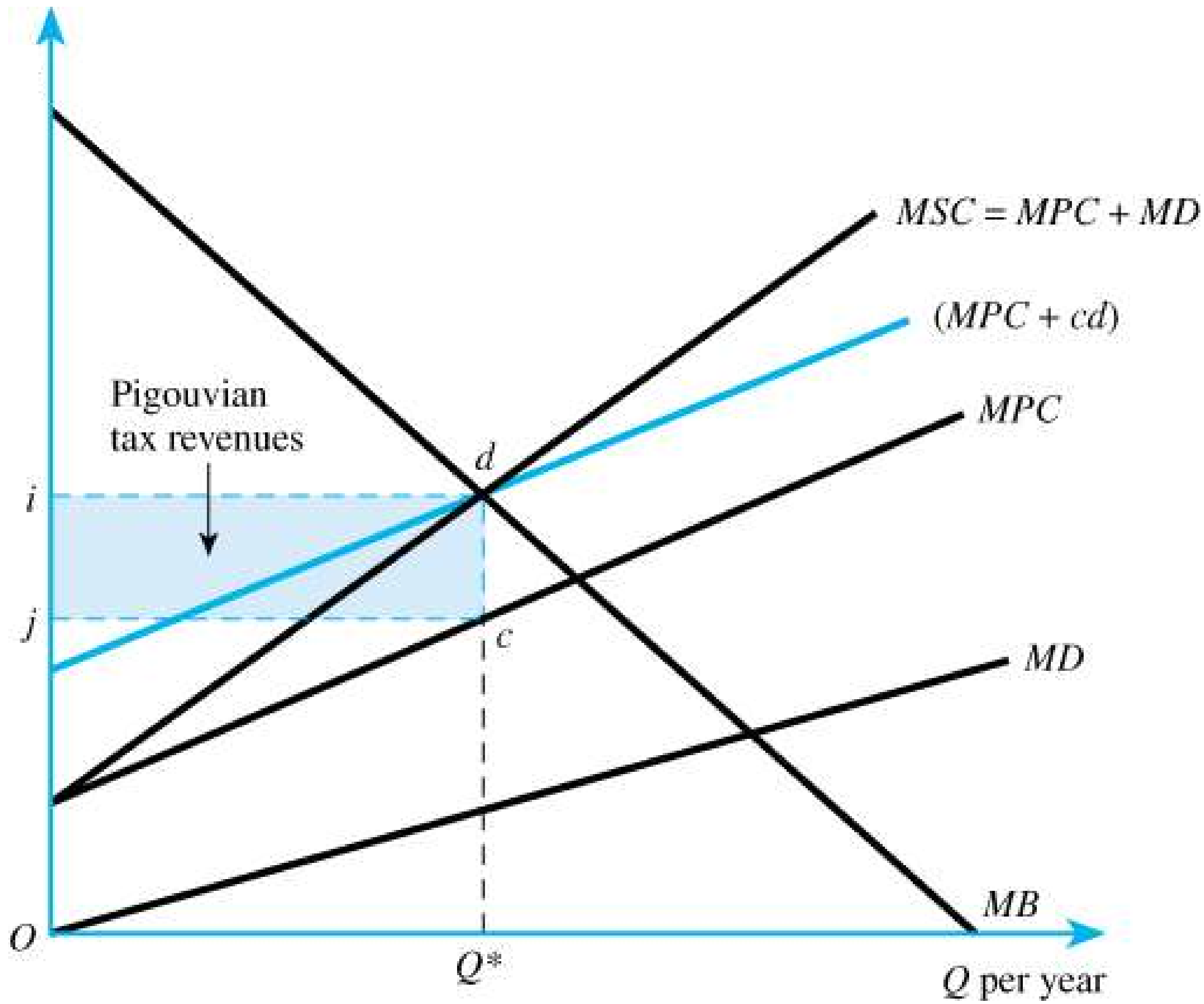
Public responses

- Taxes
- Subsidies
- Creating a market
- Regulation

Taxes

- Again, return to the steel firm / fishery example.
- Steel firm produces inefficiently because the prices for inputs incorrectly signal social costs. Input prices are too low. Natural solution is to levy a tax on a polluter.
- A ***Pigouvian tax*** is a tax levied on each unit of a polluter's output in an amount just equal to the marginal damage it inflicts at the efficient level of output.

Figure 6.4


MSC = MPC + MD
(MPC + cd)
MPC
Pigouvian
tax revenues
d
i
j
c
MD
MB
O
Q*
Q per year

Taxes

- This tax clearly raises the cost to the steel firm and will result in a reduction of output.
- Will it achieve a reduction to Q^*?
  - With the tax, *t*, the steel firm chooses quantity such that MB=MPC+*t*.
  - When the tax is set to equal the MD evaluated at Q^*, the expression becomes MB=MPC+MD(Q^*).
  - Graphically it is clear that MB(Q^*)-MPC(Q^*)=MD(Q^*), thus the firm produces the efficient level.

Numerical example: Pigouvian taxes

- Returning to the numerical example:

$$MB = 300 - Q$$

$$MPC = 20 + Q$$

$$MD = 40 + 2Q$$

Recall that Q_1=140 and Q^*=60.

Numerical example: Pigouvian taxes

- Setting t=MD(60) gives t=160. The firm now sets MB=MPC+t, which then yields Q^*.

$$
\begin{aligned}
& MB = MPC + t \\
& \Rightarrow 300 - Q = 20 + Q + t \\
& \Rightarrow 300 - Q = 20 + Q + 160 \\
& \Rightarrow 120 = 2Q \\
& \Rightarrow Q = 60
\end{aligned}
$$

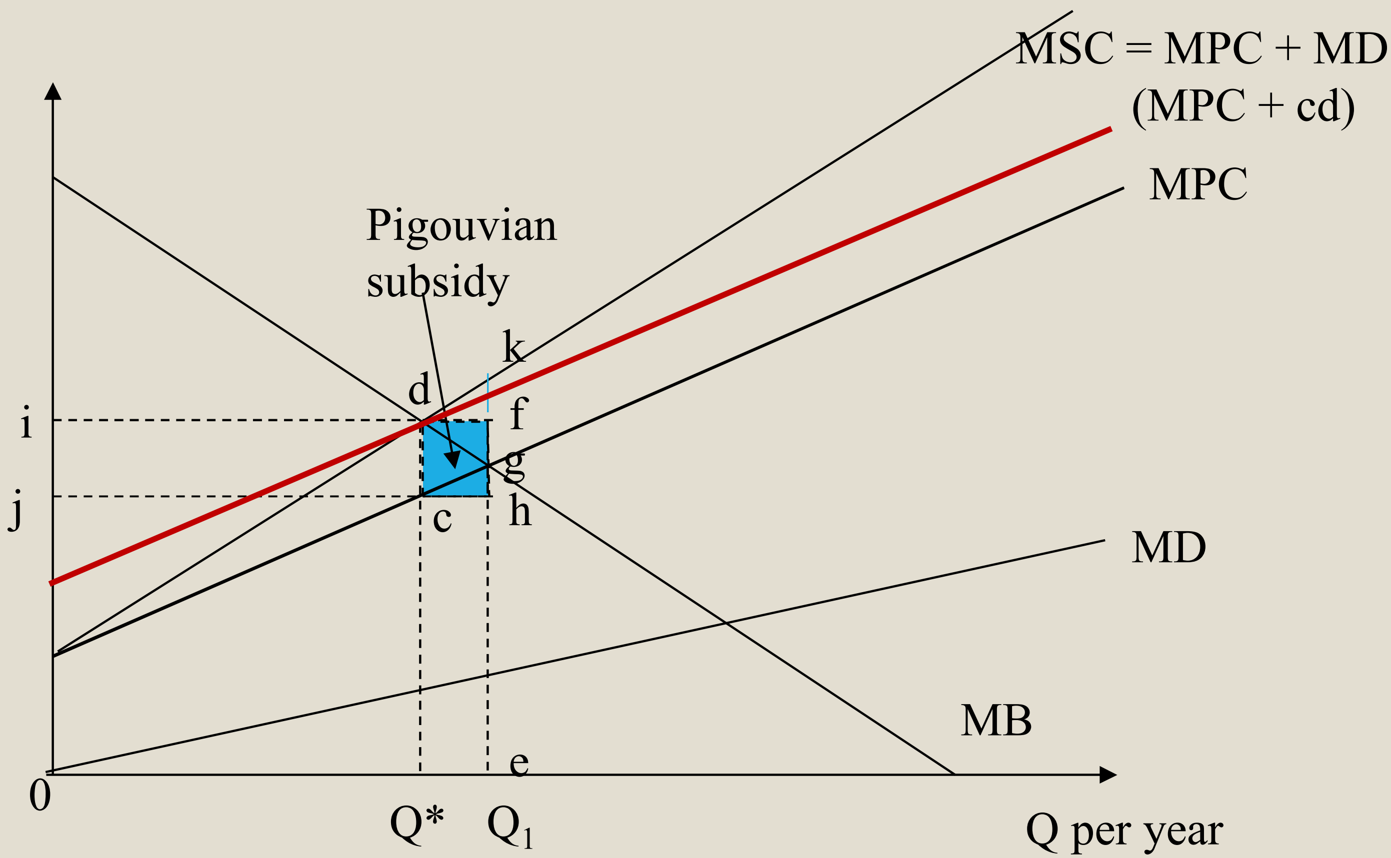
Public responses

- Subsidies
- Creating a market
- Regulation
- Emission fees
- Cap and trade programs

Subsidies

- Another solutions is *paying* the polluter to *not pollute*.
- Assume this subsidy was again equal to the marginal damage at the socially efficient level.
- Steel firm would cut back production until the loss in profit was equal to the subsidy; this again occurs at Q^*.
- Subsidy could induce new firms to enter the market, however.

Subsidies



MSC = MPC + MD
(MPC + cd)
MPC
Pigouvian
subsidy
k
d
f
g
i
j
c
h
MD
MB
e
0
Q*
Q1
Q per year

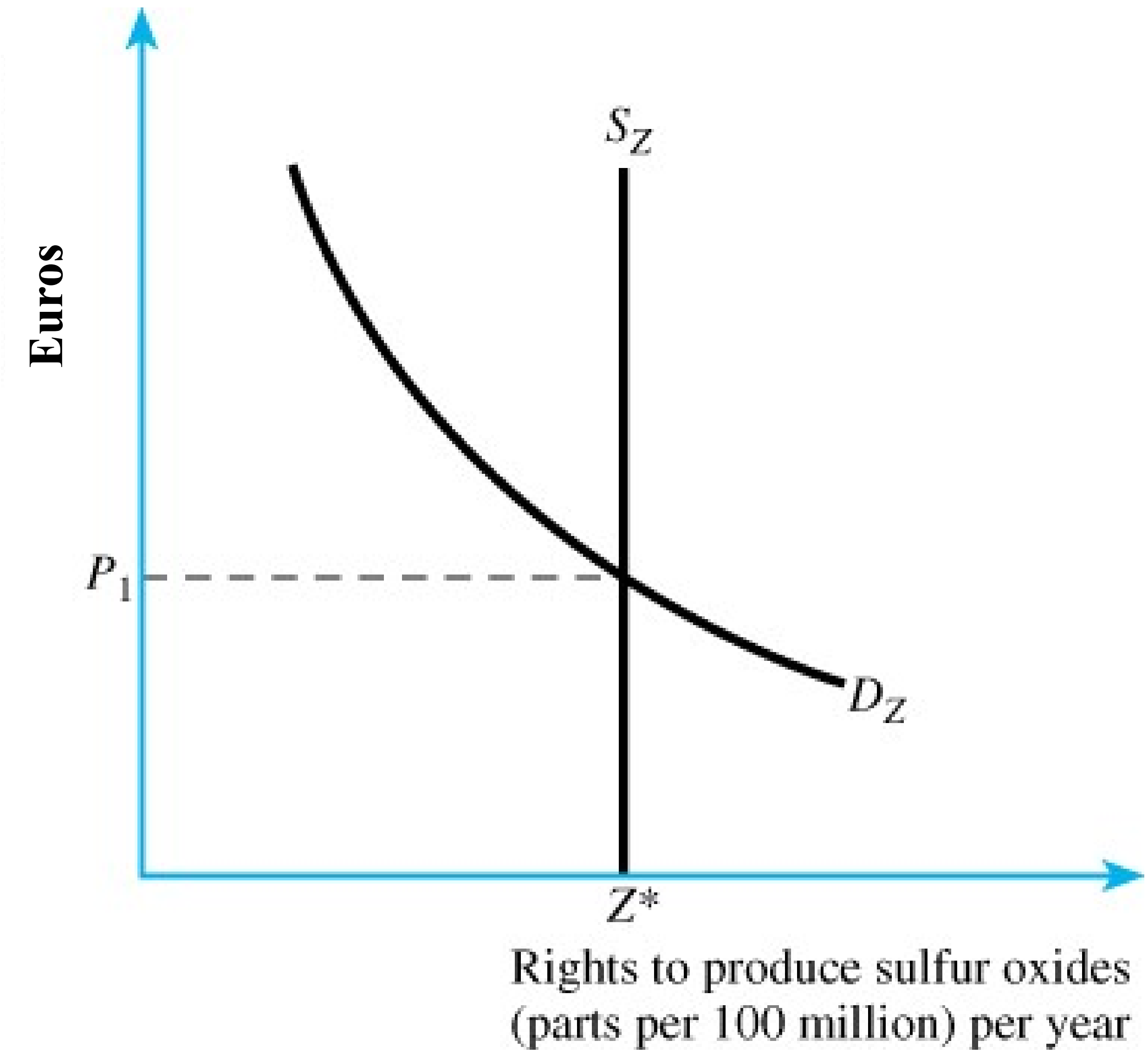
Public responses

- Creating a market
- Regulation

Creating a market

- Sell producers permits to pollute. Creates market that would not have emerged.
- Process:
  - Government sells permits to pollute in the quantity Z^*.
  - Firms bid for the right to own these permits, fee charged clears the market.
- In effect, supply of permits is inelastic.

Creating a market



Creating a market, continued

- Process would also work if the government initially assigned permits to firms, and then allowed firms to sell permits.
  - Distributional consequences are different – firms that are assigned permits initially now benefit.
- One advantage over Pigouvian taxes: permit scheme ***reduces uncertainty*** over ultimate level of pollution when costs of MB, MPC, and MD are unknown.

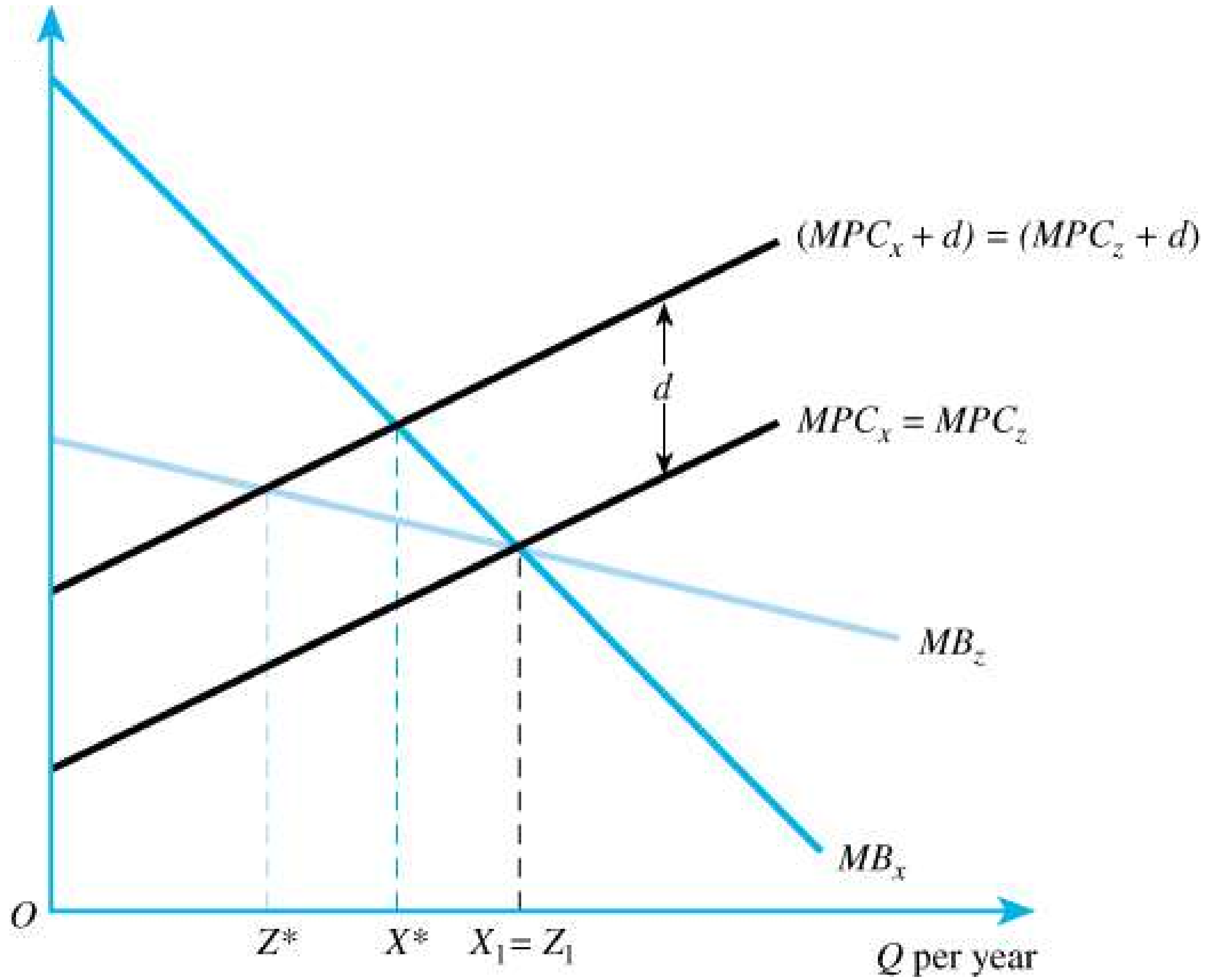
Public responses

- Regulation

Regulation

- Each polluter must reduce pollution by a certain amount or face legal sanctions.
- Inefficient when there are multiple firms with different costs to pollution reduction. Efficiency does not require equal reductions in pollution emissions; rather it depends on the shapes of the MB and MPC curves.

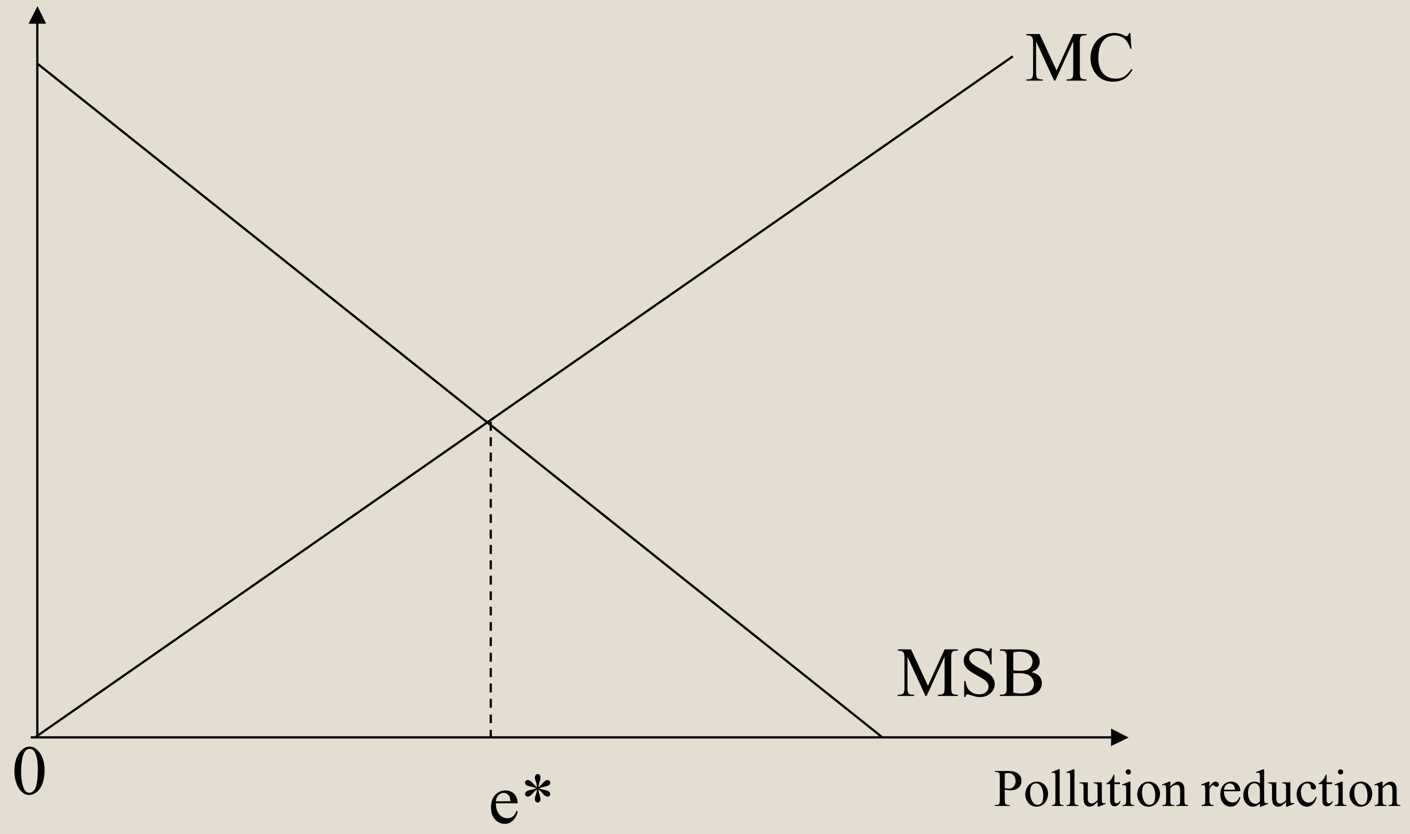
Regulation



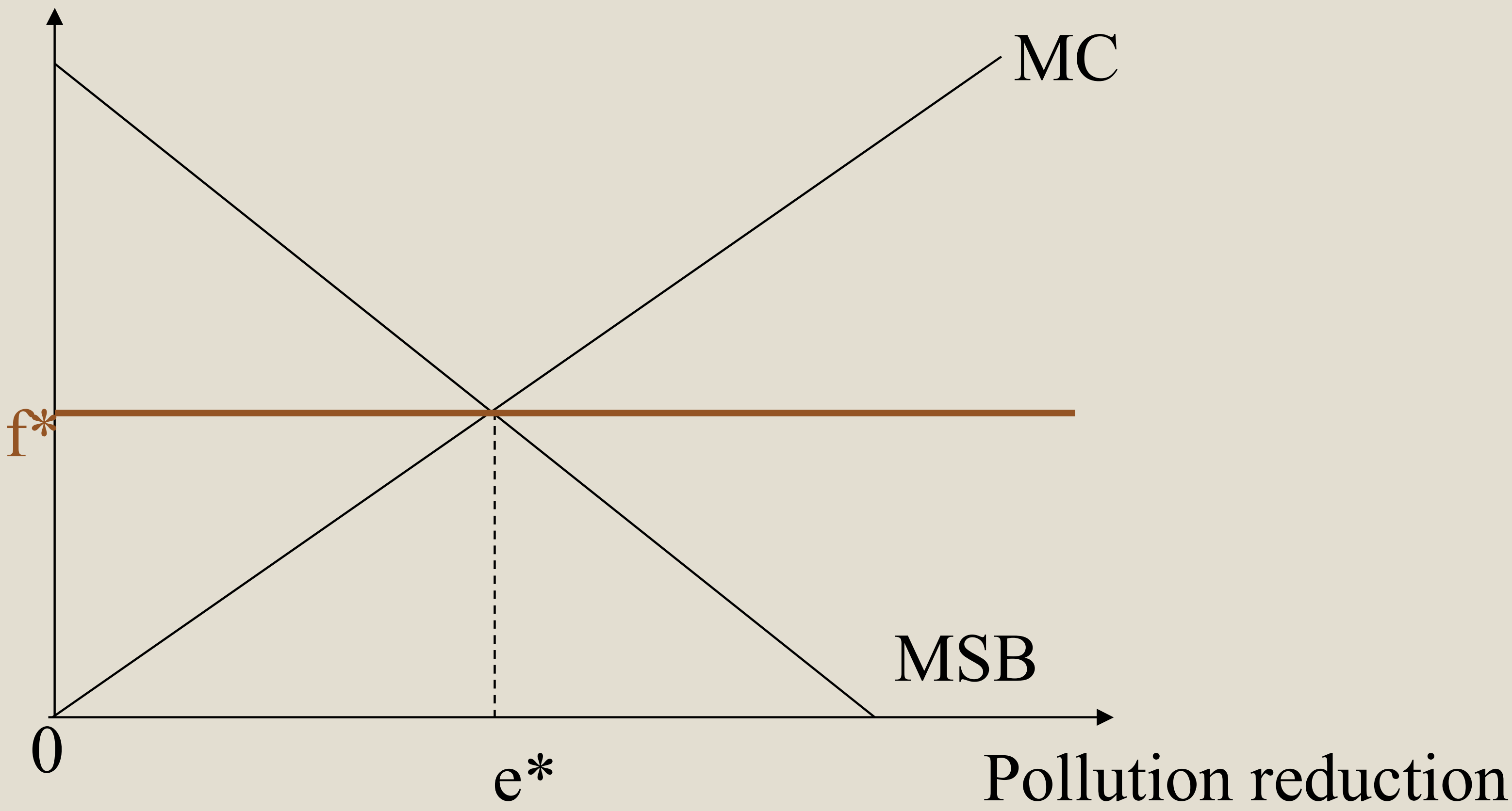
Emission fees

- One way to address the problem of pollution is to levy a Pigouvian tax on each unit of emissions rather than on each unit of output. This is called an ***emission fee.***
- Consider the following figure, which shows Bart's level of pollution reduction on the horizontal axis. The curve MSB shows the msb to Lisa of each unit reduction in Bart's pollution. The curve MC shows the mc to Bart of reducing each unit of pollution (e.g install new technology)

Emission fees



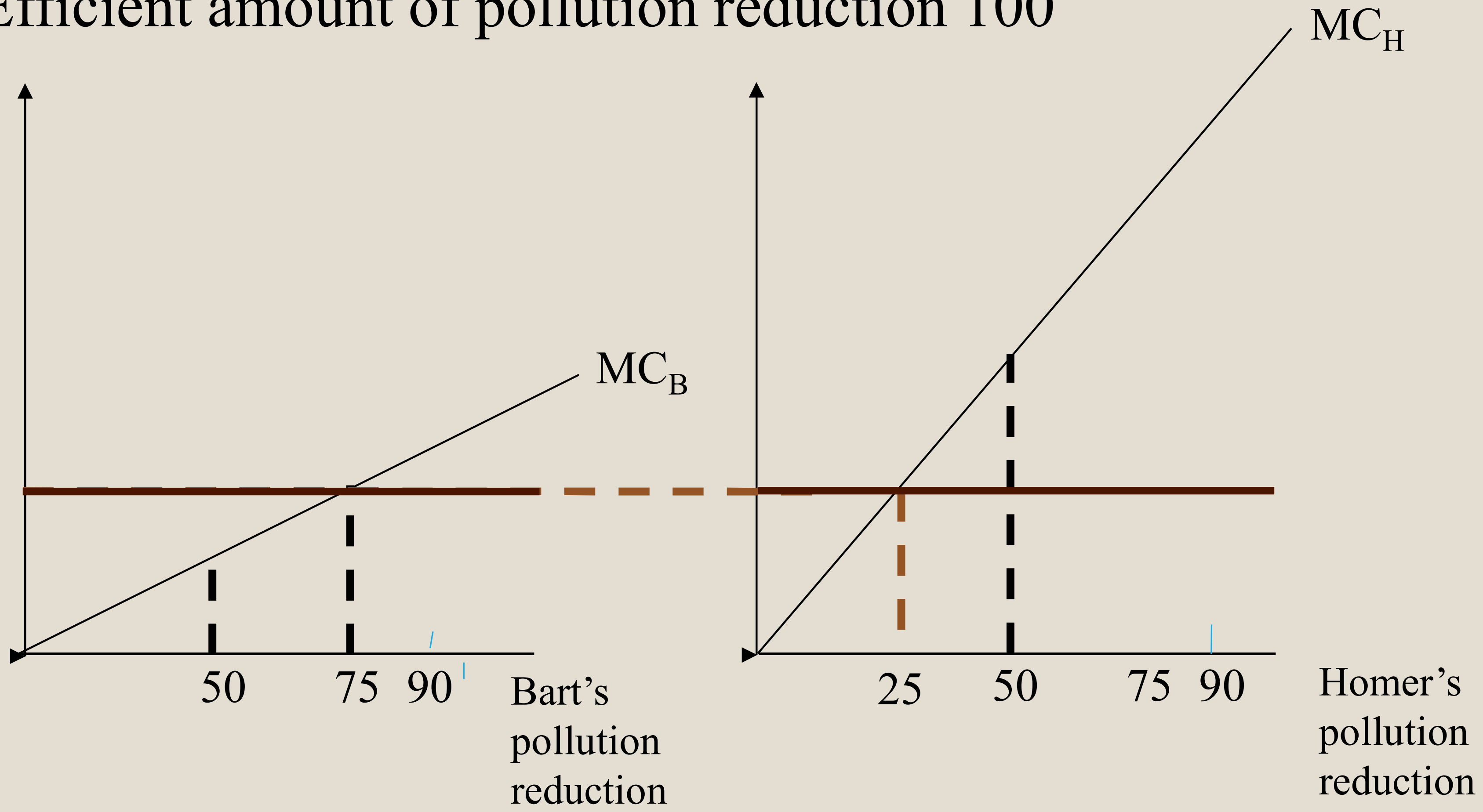
Emission fees



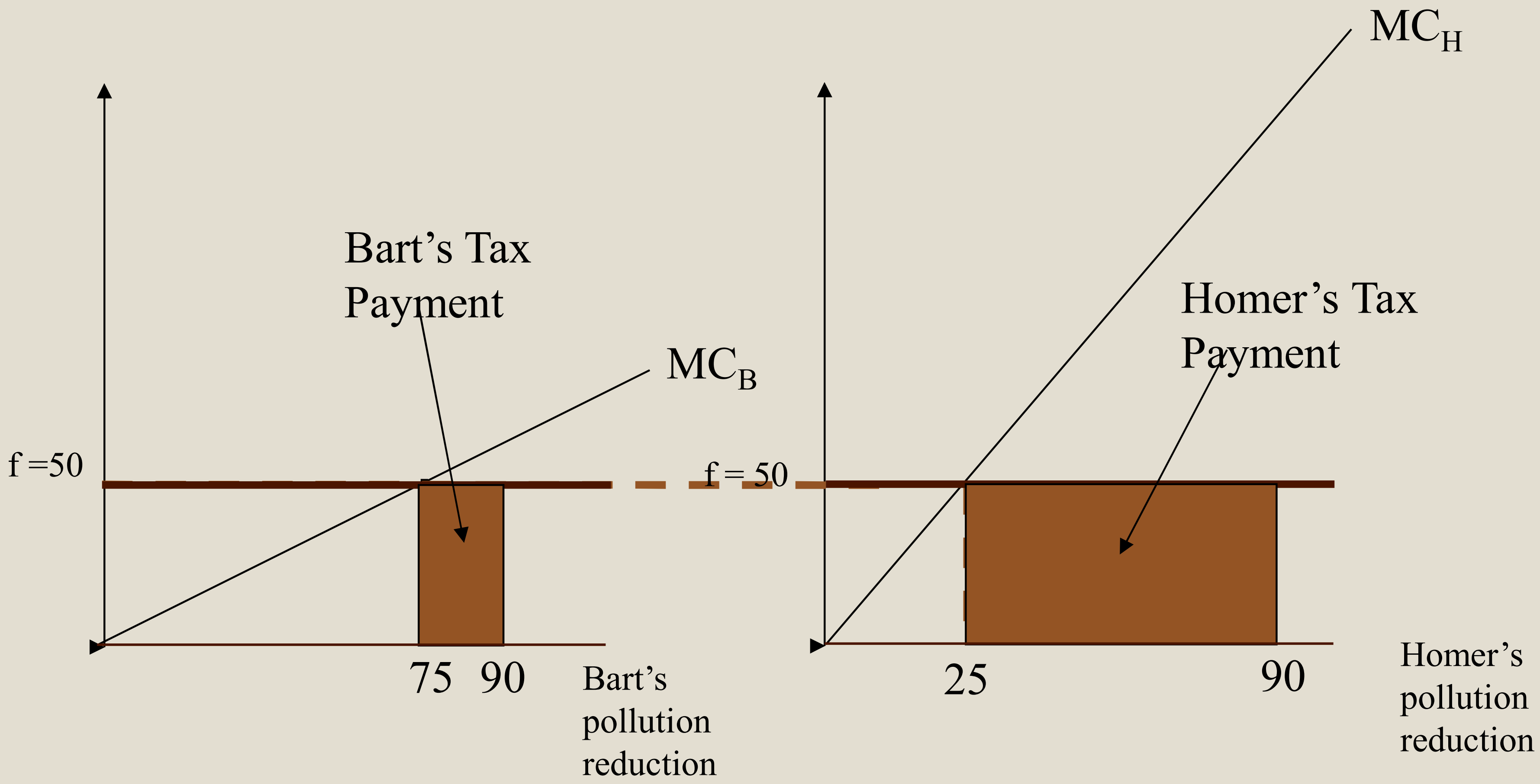
Emission fees

Initially each emits 90 units of pollution

Efficient amount of pollution reduction 100

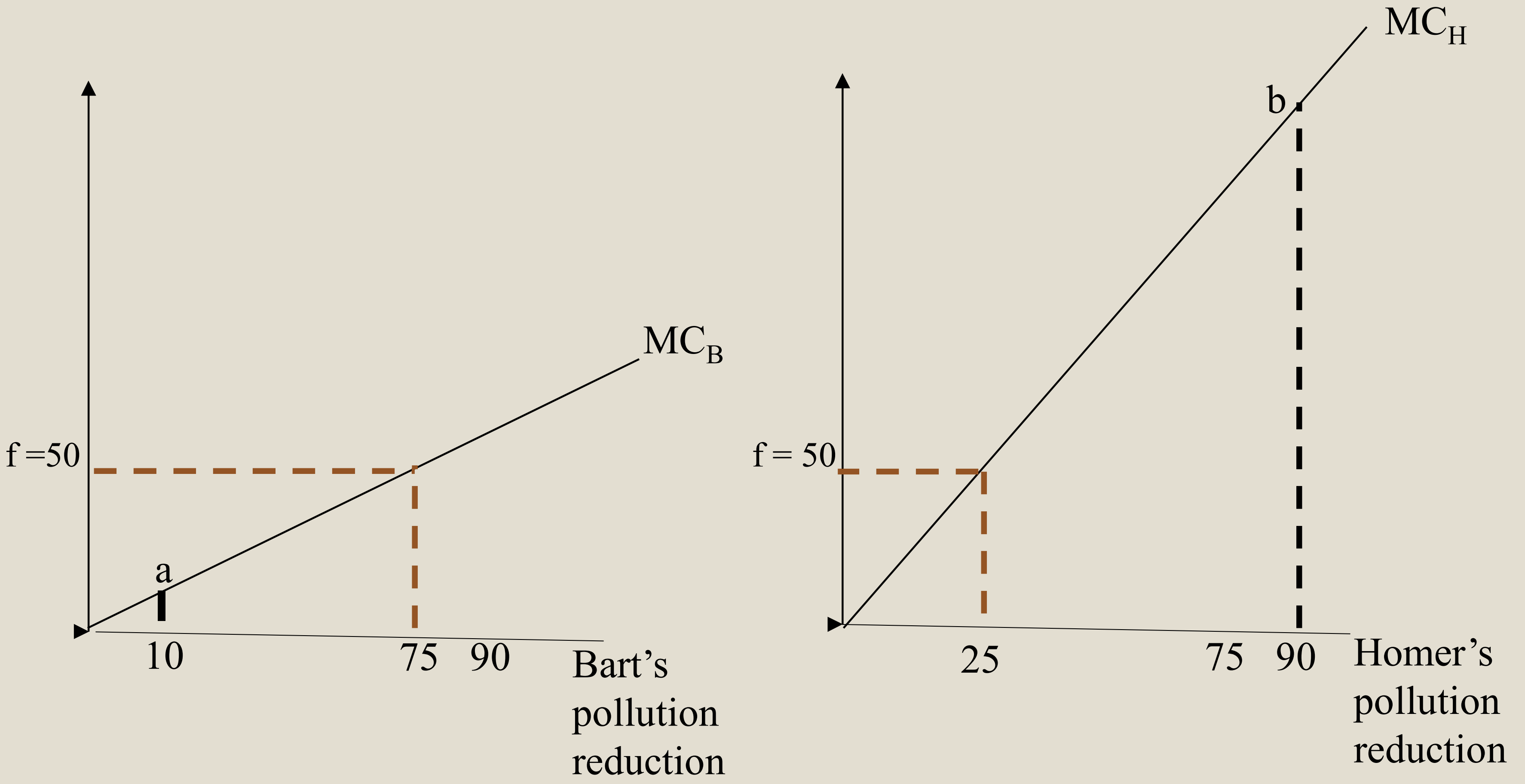


Uniform Pollution Reductions



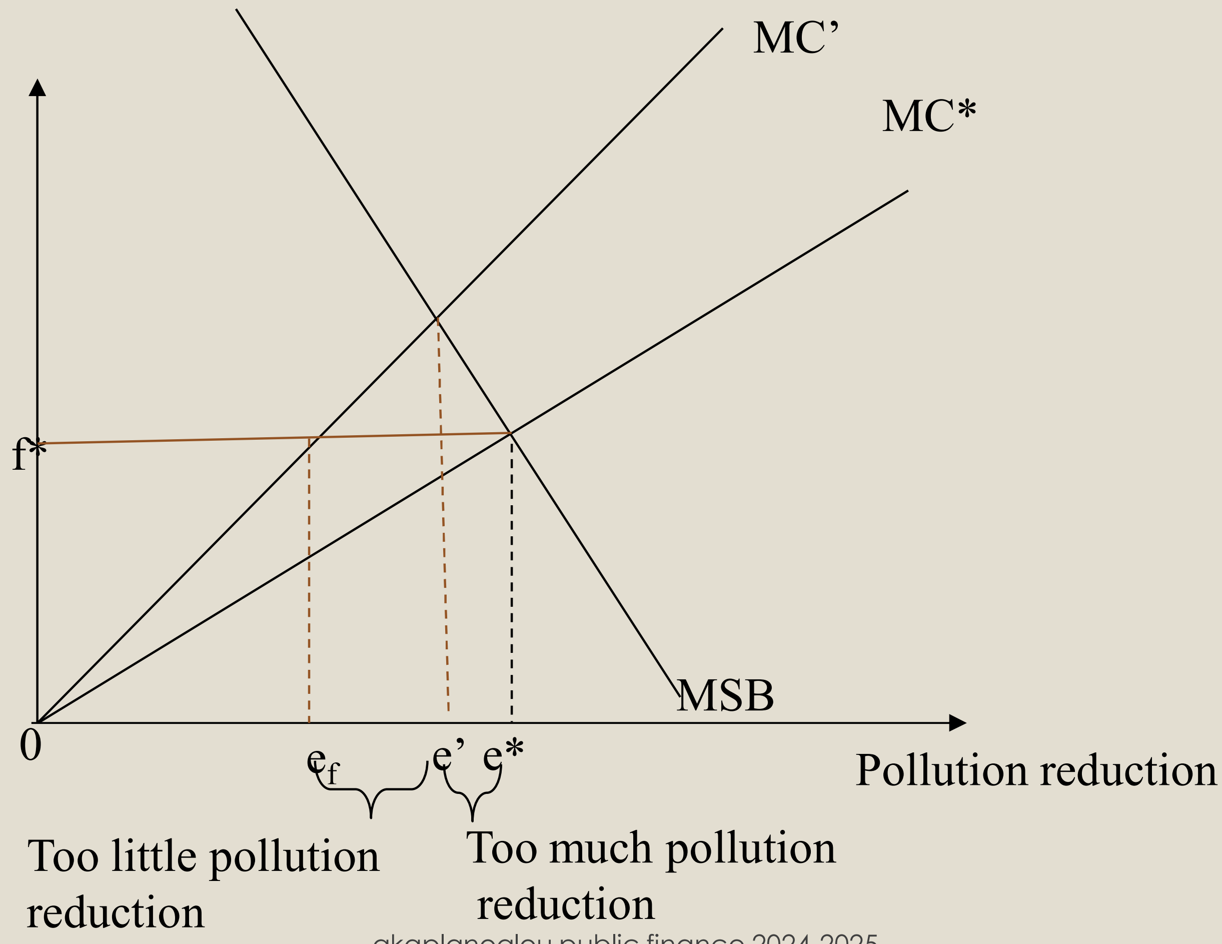
Cap and trade

Government issues 80 permits



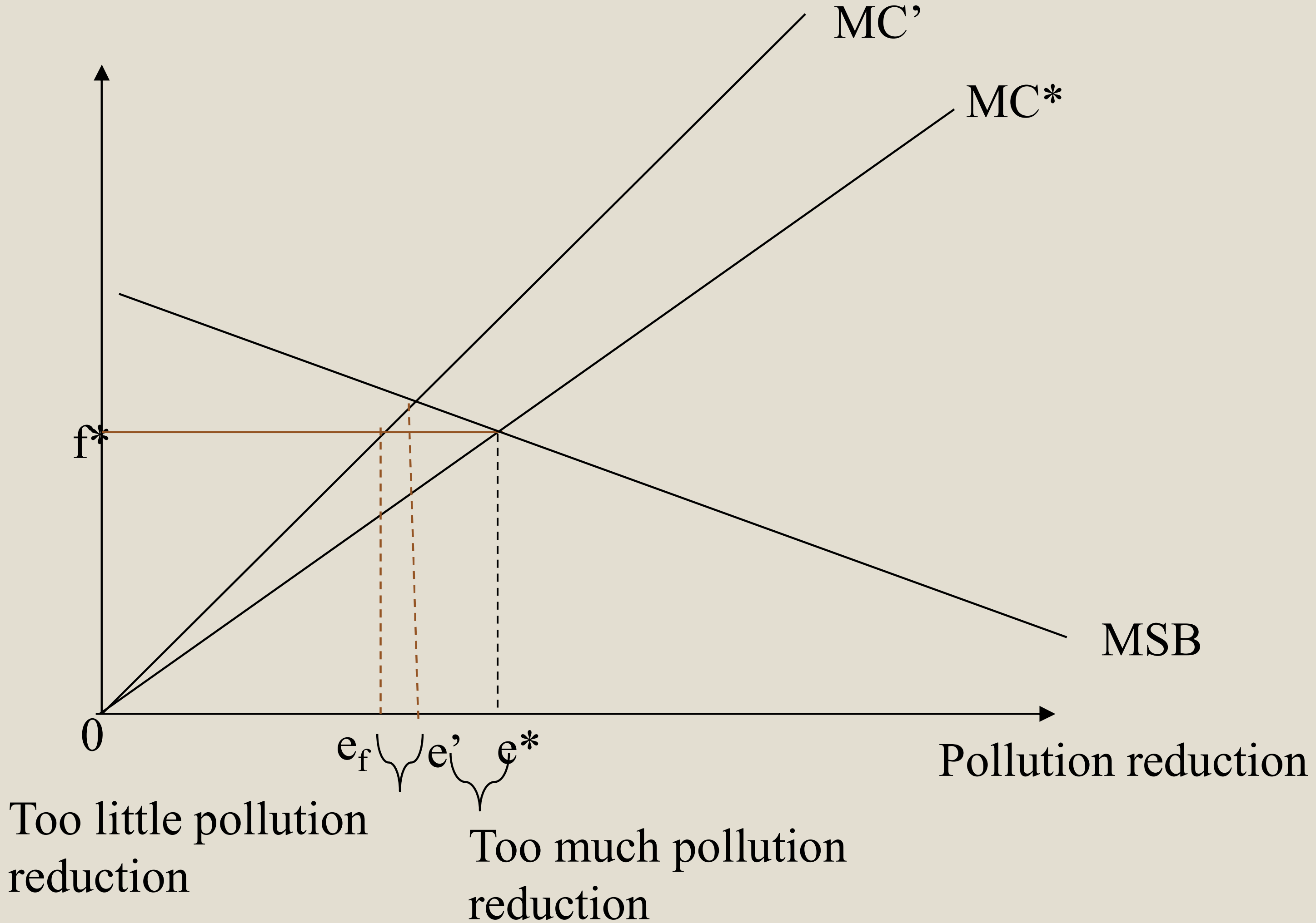
Cap and trade

MSB inelastic, costs uncertain



Cap and trade

MSB elastic, costs uncertain



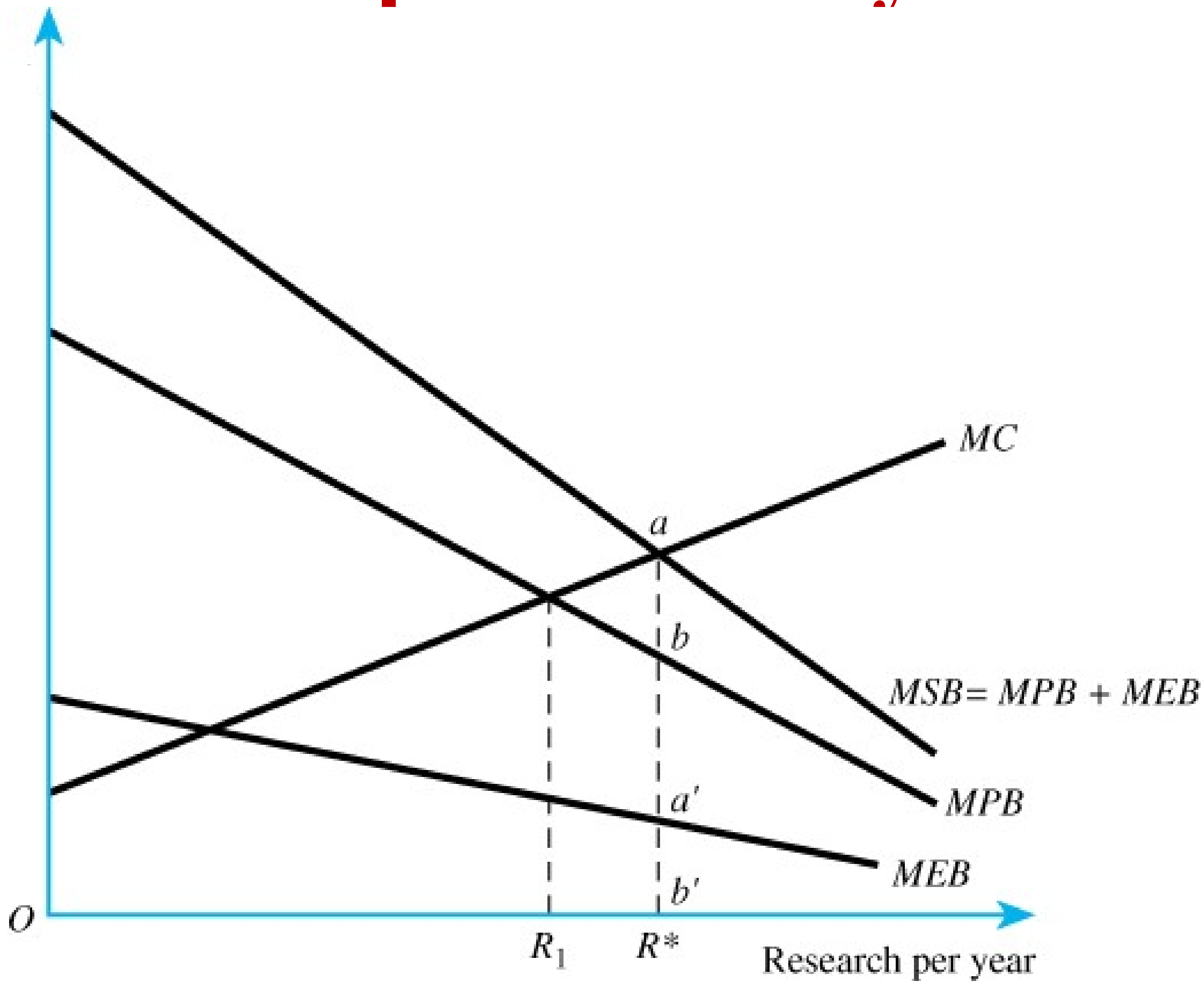
Positive externalities: Graphical Analysis

- For simplicity, assume that a university conducts research that has spillovers to a private firm.
- Competitive markets, firms maximize profits
  - Note that university only care’s about its own profits, not the private firm’s.
  - Private firm only cares about its profits, not the university’s.

Graphical Analysis, continued

- MPB = marginal *private* benefit to university
- MC = marginal cost to university
- MEB = marginal external benefit to private firm
- MSB = MPB+MEB = marginal *social* benefit

Graphical Analysis



Graphical Analysis, continued

- From the above figure, as usual, the university maximizes profits at ***MPB=MC***. This quantity is denoted as R_1 in the figure.
- Social welfare is maximized at ***MSB=MC***, which is denoted as R^* in the figure.

Graphical Analysis, Implications

- ***Result 1***: $R_1 < R^*$
  - University privately produces "*too little*" research, because it does not account for the benefits to the private firm.
- ***Result 2***: Private firm's preferred amount is where the MEB curve intersects the x-axis.
  - Firm's benefits are maximized at MEB=0.
- ***Result 3***: R^* is not the preferred quantity for either party, but is the best compromise between university and private firm.

Graphical Analysis, Intuition

- In above Figure, loss to university of moving to R^* is the triangle area between the MC and MPB curve going from R_1 to R^*.
- Private firm gains by the area under the MEB curve going from R_1 to R^*.
- Difference between private firm's gain and university's loss is the efficiency loss from producing R_1 instead of R^*.

Recap of externalities

- Externalities definition
- Negative externalities – graphical & numerical examples
- Private responses
- Public responses
- Positive externalities