Externalities*

*We thank Harvey Rosen for the useful material.

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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
  - The "Club" anti-theft device for automobiles
- Positive Externalities
  - Research & development
  - Vaccinations
  - A neighbor's nice landscape
  - Students asking good questions in class
  - The "LoJack" anti-theft device for automobiles
- *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 cares about its own profits, not the fishery's profits.
  - Fishery only cares about its profits, not the steel firm's profits.

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 5.1

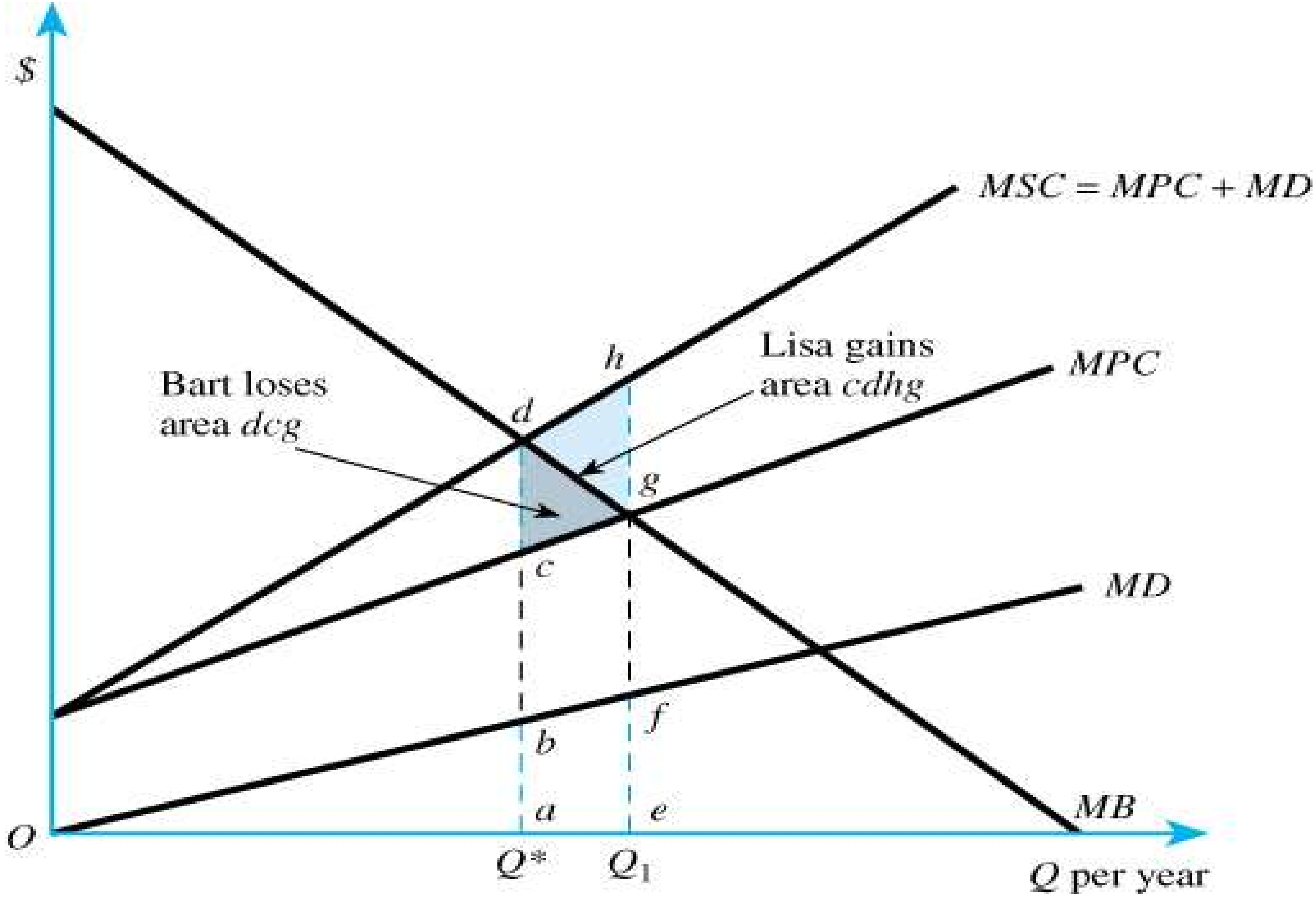
Graphical Analysis, continued

- From Figure 5.1, 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 5.2



$
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 5.2, 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 5.2, 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^*.

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

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

Calculating 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

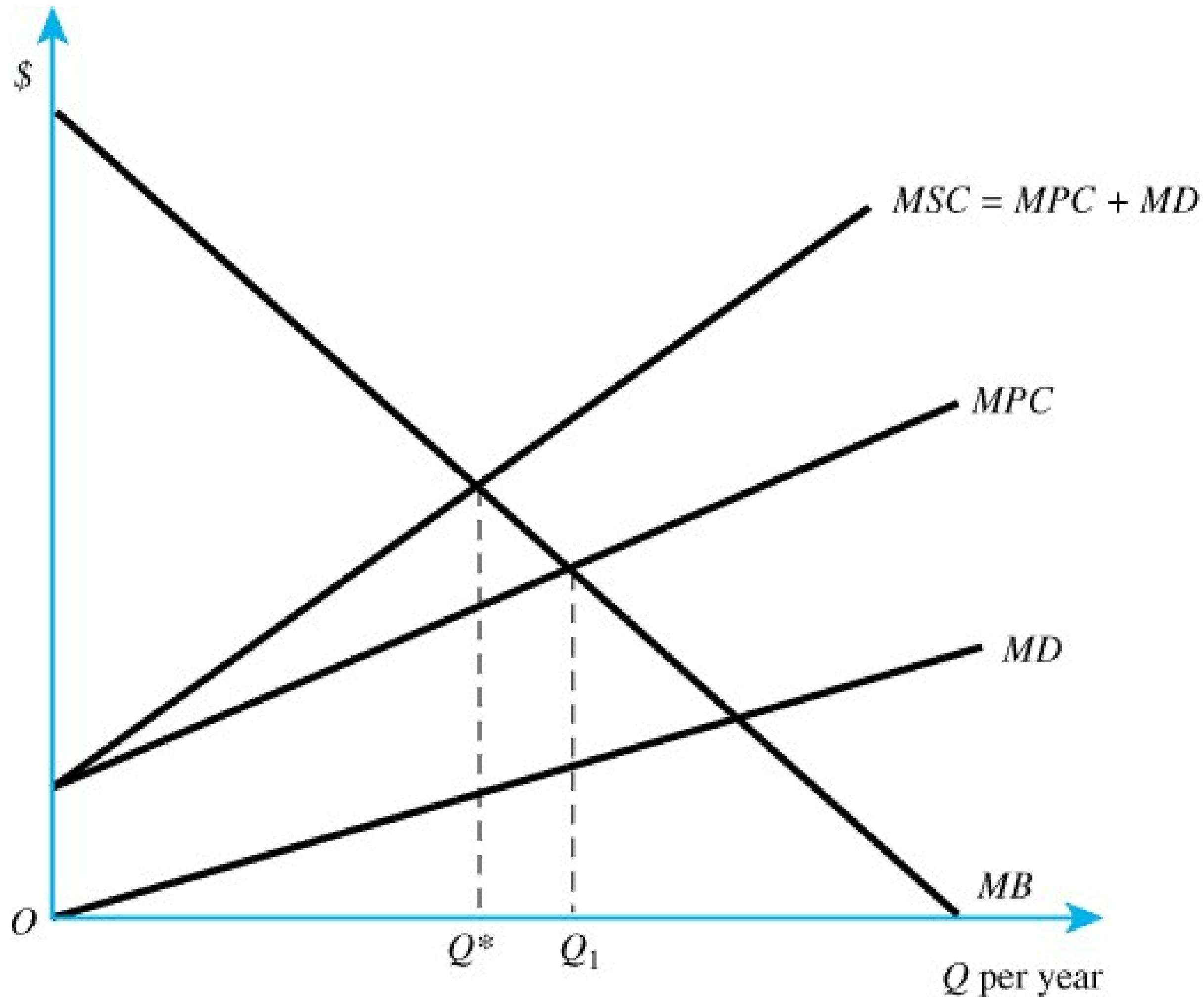
Coase Theorem

- Insight: root of the inefficiencies from externalities is the <u>absence of property rights</u>.
- 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 to whom the property rights were initially assigned.

Illustration of the Coase Theorem

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

Figure 5.3



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 its 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 its 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?

- Low transaction 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 and 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 theater, etc.

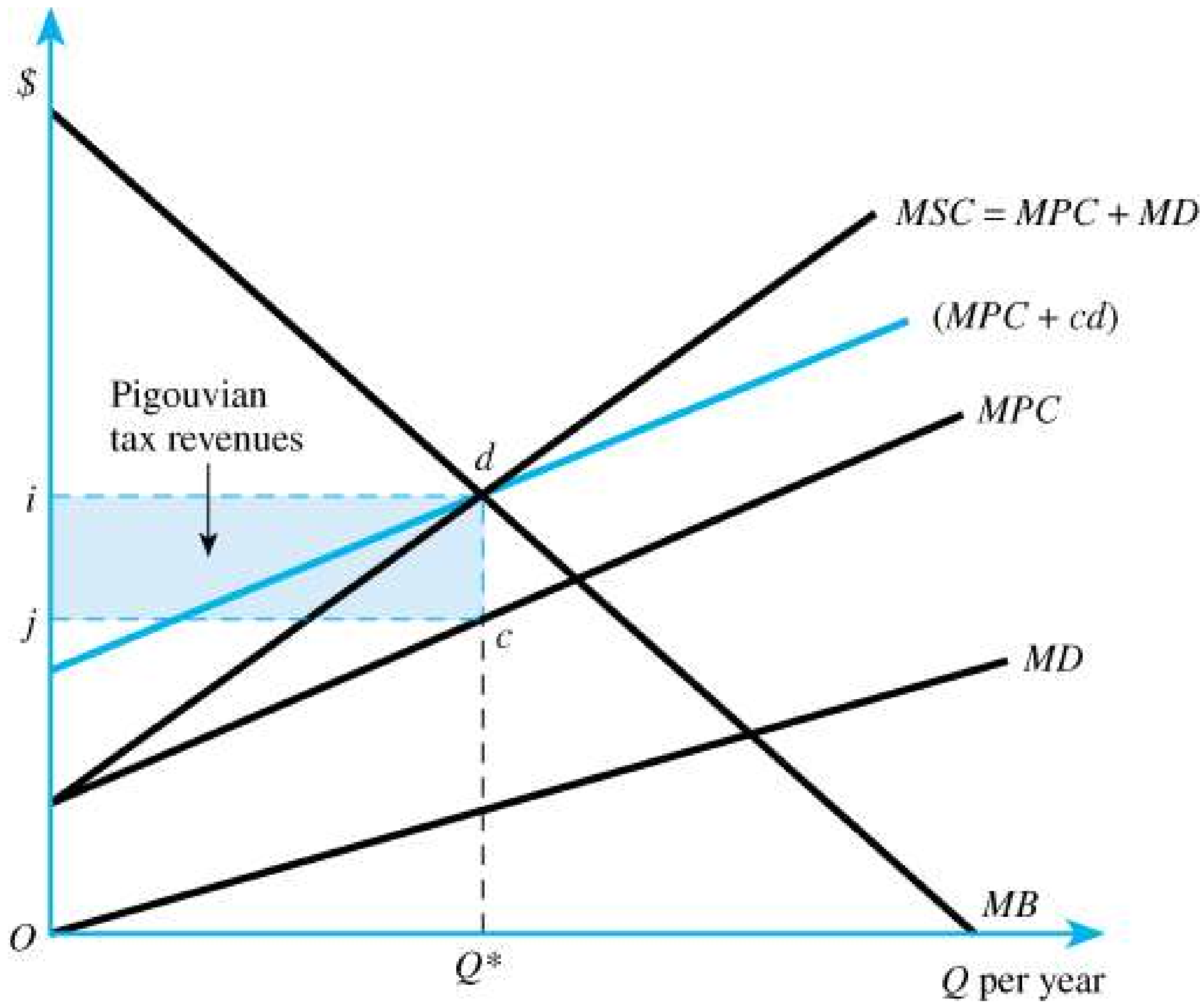
Public Responses

- 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 5.4



$
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^*.

$$MB = MPC + t$$

$$\Rightarrow 300 - Q = 20 + Q + t$$

$$\Rightarrow 300 - Q = 20 + Q + 160$$

$$\Rightarrow 120 = 2Q$$

$$\Rightarrow Q = 60$$

Public Responses

- Subsidies
- Creating a market
- Regulation

Subsidies

- Another solution 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.

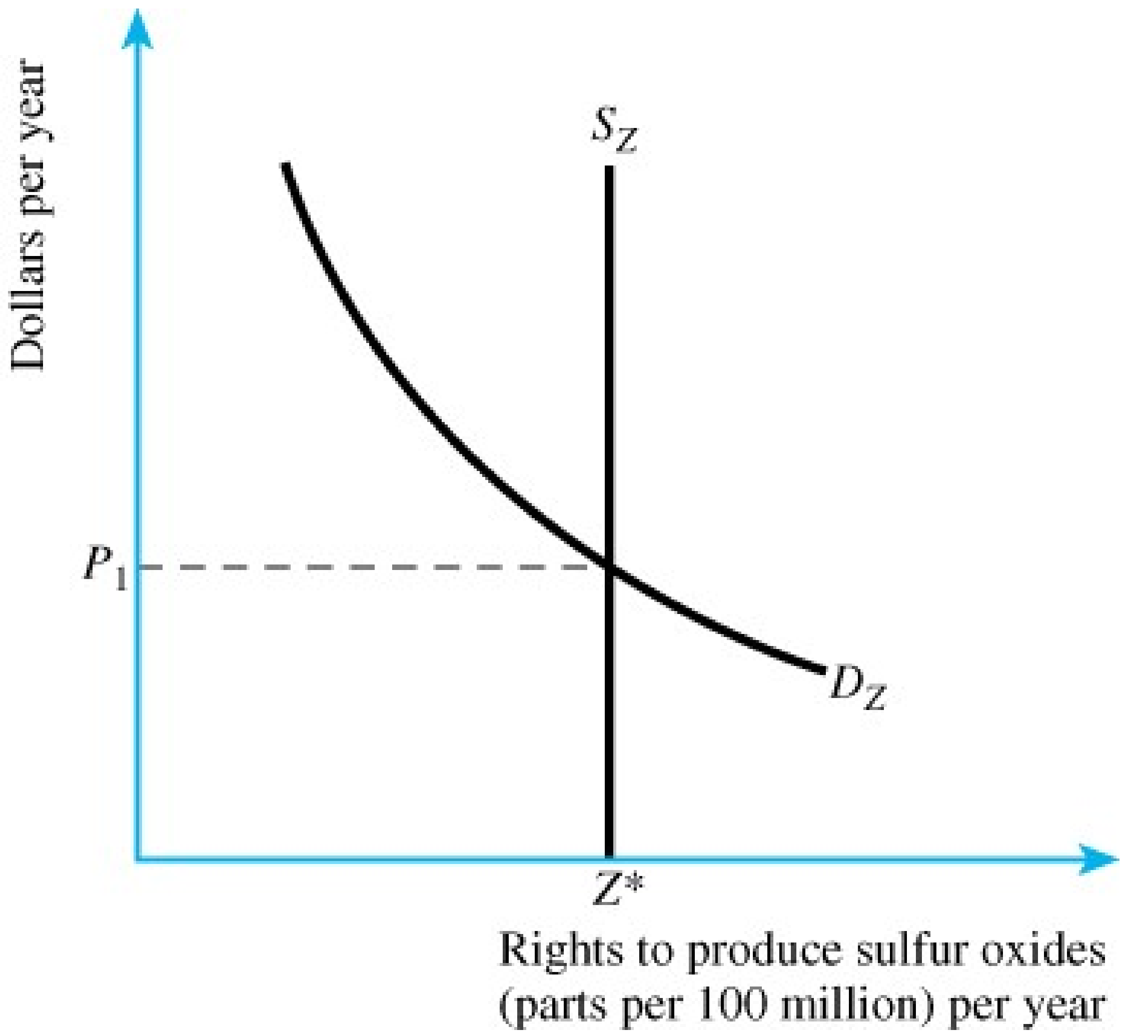
Public Responses

- 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.

Figure 5.6



Dollars per year
S_Z
P_1
D_Z
Z^*
Rights to produce sulfur oxides
(parts per 100 million) per year

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.

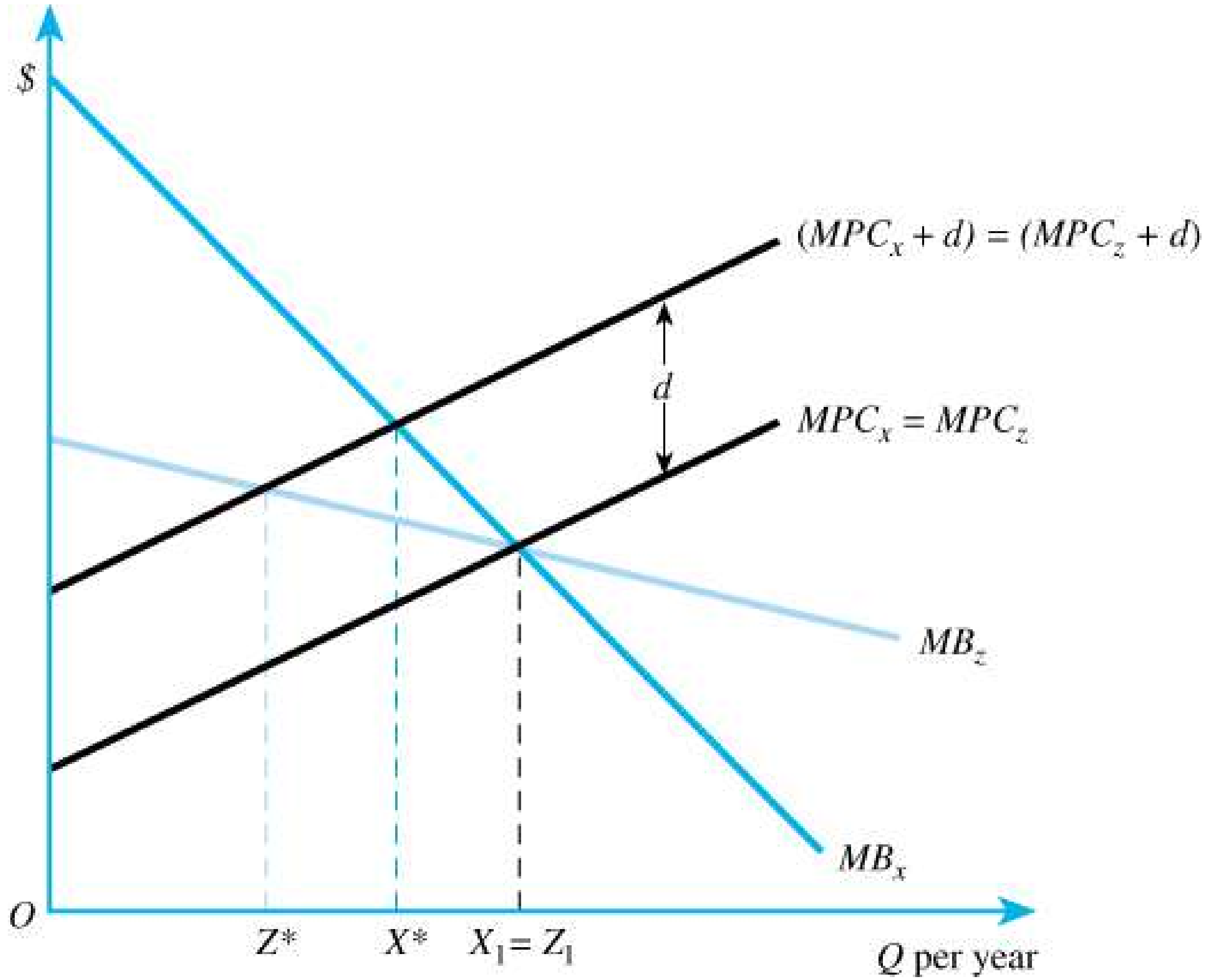
Public Responses

- 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.

Figure 5.7



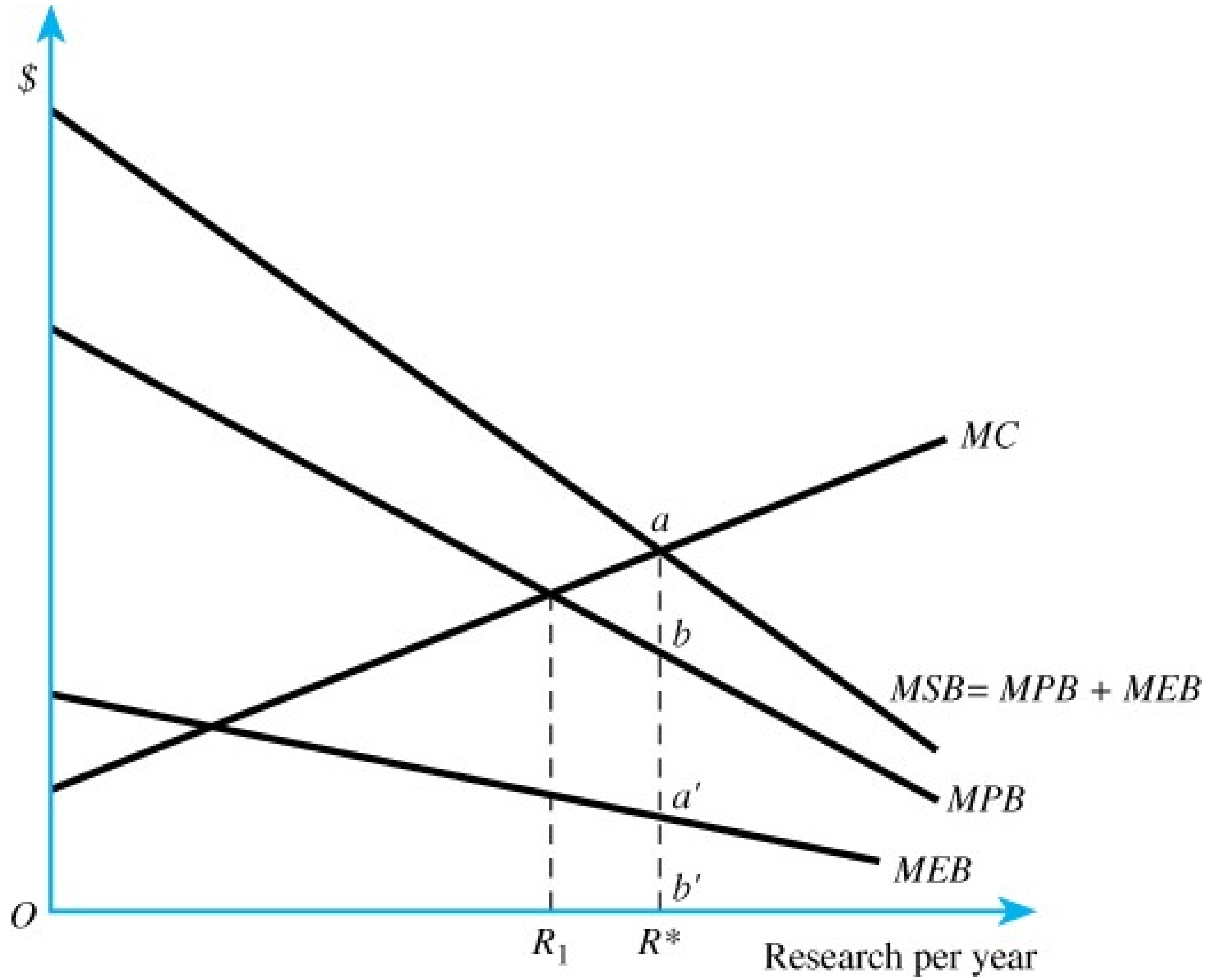
Graphical Analysis: Positive Externalities

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

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

Figure 5.8



Graphical Analysis, continued

- From Figure 5.8, 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 Figure 5.8, 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 and numerical examples
- Private responses
- Public responses
- Positive externalities