

# Externalities\*



\*We thank Harvey Rosen for the useful material.

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# Externality Defined

- An **externality** 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.

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# 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

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## 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

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## 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.

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## 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

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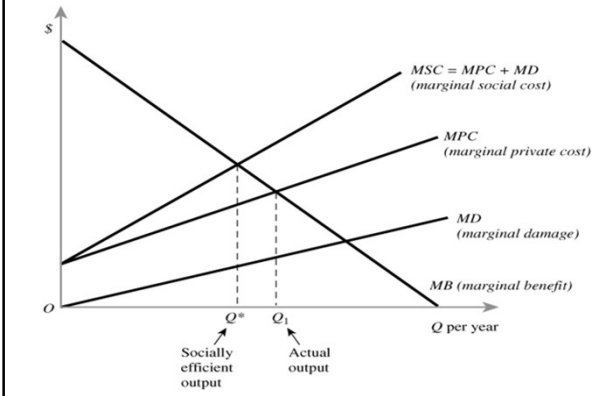
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Figure 5.1




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### 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.

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### 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.

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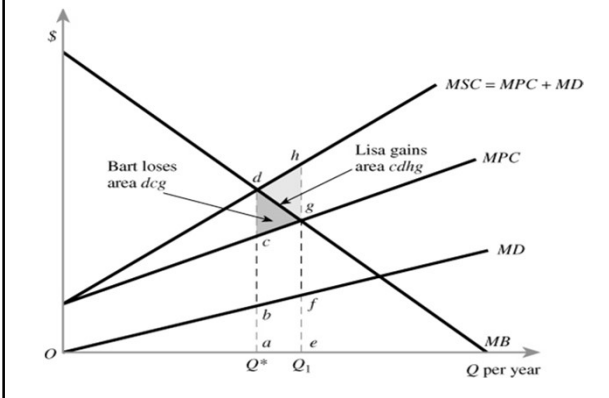
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Figure 5.2




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### 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  $Q^*$ .

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### 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:

$$MD = 40 + 2Q$$

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## 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  $Q^*$ :

$$MB = MSC = MPC + MD$$

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

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## 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  $Q^*$ .

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

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

- In Figure 5.2, this corresponds to area **dhg**.

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## 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  $Q^*$ .

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

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

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

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

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

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## 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.

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## Private Responses

- Coase Theorem
- Mergers
- Social conventions

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## 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 to whom the property rights were initially assigned.

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## 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.

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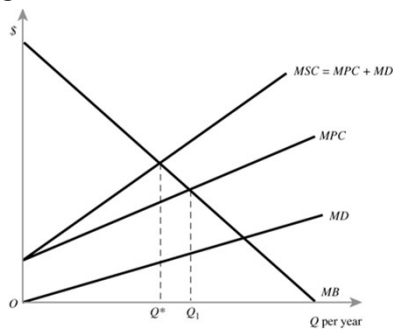
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Figure 5.3




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## 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.

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## 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.

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## 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.

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## 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  $Q^*$ .

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## 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

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## Private Responses, continued

- Mergers
- Social conventions

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## 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.

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## 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.

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## Public Responses

- Taxes
- Subsidies
- Creating a market
- Regulation

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## 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.

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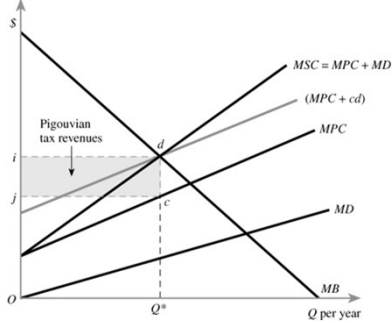
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Figure 5.4




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## 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.

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## Numerical Example: Pigouvian Taxes

- Returning to the numerical example:

$$MB = 300 - Q$$

$$MPC = 20 + Q$$

$$MD = 40 + 2Q$$

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

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## Numerical Example: Pigouvian Taxes

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

$$MB = MPC + t$$

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

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

$$\Rightarrow 120 = 2Q$$

$$\Rightarrow Q = 60$$

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## Public Responses

- Subsidies
- Creating a market
- Regulation

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## 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.

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## Public Responses

- Creating a market
- Regulation

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## 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.

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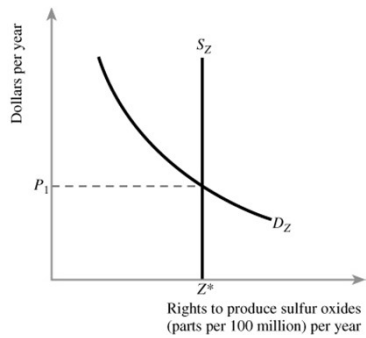
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Figure 5.6



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## 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.

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## Public Responses

- Regulation

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## 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.

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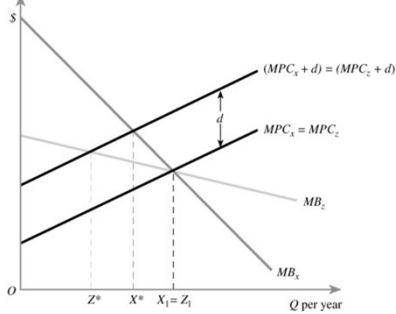
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Figure 5.7




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### 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.

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### 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

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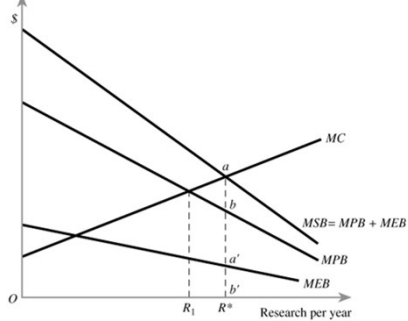
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Figure 5.8




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### 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.

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### 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.

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## 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  $R^*$ .

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## Recap of Externalities

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

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