

**PINDYCK & RUBINFELD
MICROECONOMICS
7TH ED, © 2009**

Electronically reproduced by permission of Pearson Canada.

1. A number of firms have located in the western portion of a town after single-family residences took up the eastern portion. Each firm produces the same product and in the process emits noxious fumes that adversely affect the residents of the community.

a. Why is there an externality created by the firms?

The noxious fumes emitted by the firms impose costs on the town's residents, and the residents have no control over the quantity of the fumes. Costs may include reduced visibility, difficulty breathing, foul-smelling air, increased health problems, and reduced property values. The firms, however, do not have to pay to release the fumes, so the costs borne by the town's residents are not reflected in the firms' costs or the prices of their products. Thus, there is a negative externality created by the firms.

b. Do you think that private bargaining can resolve the problem? Explain.

If residents anticipated the location of the firms when the eastern part of the town was developed, housing prices would have reflected the disutility of the fumes, and the externality would have been internalized by the housing market in housing prices. In this case there is no problem. If the noxious fumes were not anticipated, private bargaining could resolve the problem of the externality only if there are a relatively small number of parties (both firms and families). Private bargaining would rely on each family's willingness to pay for air quality, but truthful revelation might not be possible. All this will be complicated by the adaptability of the production technology known to the firms and the employment relations between the firms and families. It is unlikely that private bargaining will resolve the problem.

c. How might the community determine the efficient level of air quality?

The community could determine the economically efficient level of air quality by aggregating the families' willingness to pay and equating it with the marginal cost of pollution reduction. Both steps involve the acquisition of truthful information, which is likely to be quite difficult.

3. Assume that scientific studies provide you with the following information concerning the benefits and costs of sulfur dioxide emissions:

Benefits of abating (reducing) emissions: $MB = 500 - 20A$

Costs of abating emissions: $MC = 200 + 5A$

where A is the quantity abated in millions of tons and the benefits and costs are given in dollars per ton.

a. What is the socially efficient level of emissions abatement?

To find the socially efficient level of emissions abatement, set marginal benefit equal to marginal cost and solve for A :

$$500 - 20A = 200 + 5A$$

A = 12 million tons.

- b. What are the marginal benefit and marginal cost of abatement at the socially efficient level of abatement?

Plug A = 12 into the marginal benefit and marginal cost functions to find the benefit and cost:

$$MB = 500 - 20(12) = 260$$

$$MC = 200 + 5(12) = 260.$$

- c. What happens to net social benefits (benefits minus costs) if you abate one million more tons than the efficient level? One million fewer?

Net social benefits are the area under the marginal benefit curve minus the area under the marginal cost curve. At the socially efficient level of abatement this is equal to area a+b+c+d in the figure below, or

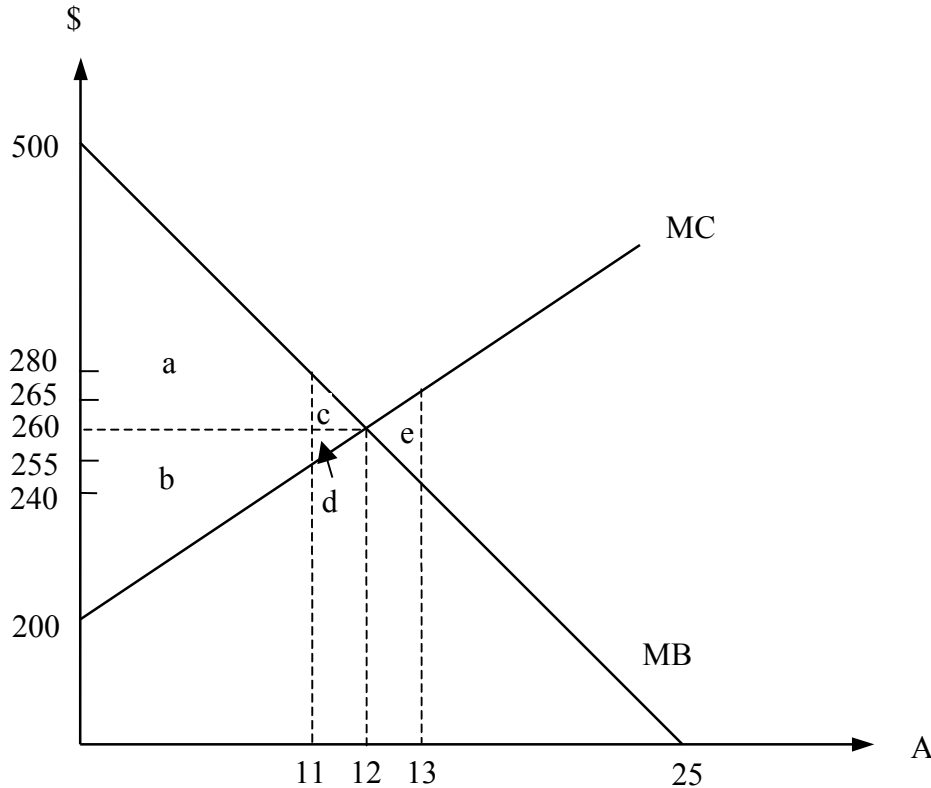
$$0.5(500 - 200)(12) = \$1800 \text{ million.}$$

If you abate one million tons too many, the net social benefit is area a+b+c+d-e, or

$$1800 - 0.5(265 - 240)(1) = 1800 - 12.5 = \$1787.5 \text{ million.}$$

If you abate 1 million too few tons, then the net social benefit is area a+b or

$$0.5(500 - 280)(11) + (280 - 255)(11) + 0.5(255 - 200)(11) = \$1787.5 \text{ million.}$$



- d. Why is it socially efficient to set marginal benefits equal to marginal costs rather than abating until total benefits equal total costs?

It is socially efficient to set marginal benefit equal to marginal cost rather than total benefit equal to total cost because we want to maximize net benefits, which are total

benefit minus total cost. Maximizing total benefit minus total cost means that at the margin, the last unit abated will have an equal cost and benefit. Choosing the point where total benefit is equal to total cost would mean that net benefits equal zero, and would result in too much abatement. This would be analogous to choosing to produce where total revenue was equal to total cost. If total revenue was always equal to total cost by choice, then there would never be any profit. In the case of abatement, the more we abate, the costlier it is. Given that funds will tend to be scarce, dollars should be allocated to abatement only so long as the benefit of the last unit of abatement is greater than or equal to the cost of the last unit of abatement.

5. Medical research has shown the negative health effects of “secondhand” smoke. Recent social trends point to growing intolerance of smoking in public areas. If you are a smoker and you wish to continue smoking despite tougher anti-smoking laws, describe the effect of the following legislative proposals on your behavior. As a result of these programs, do you, the individual smoker, benefit? Does society benefit as a whole?

Since smoking in public areas is similar to polluting the air, the programs proposed here are similar to those examined for air pollution. A bill to lower tar and nicotine levels is similar to an emissions standard, and a tax on cigarettes is similar to an emissions fee. Requiring a smoking permit is similar to a system of emissions permits, assuming that the permits would not be transferable. The individual smoker in all of these programs is being forced to internalize the externality of “second-hand” smoke and will be worse off. Society will be better off if the benefits of a particular proposal outweigh the cost of implementing that proposal. Unfortunately, the benefits of reducing second-hand smoke are uncertain, and assessing those benefits is costly.

a. A bill is proposed that would lower tar and nicotine levels in all cigarettes.

Some smokers might actually smoke more in an effort to maintain a constant level of consumption of nicotine, although the total amount of tar and nicotine released into the air would probably be reduced. The smoker is worse off because he or she will spend more on cigarettes and consume less tar and nicotine. Nonsmokers would be better off because less tar and nicotine would be in the air. It is difficult to know whether society as a whole would be better or worse off.

b. A tax is levied on each pack of cigarettes.

If the tax is levied on producers, producers will pay some of the tax but consumers (i.e., smokers) will also pay a portion. The price of cigarettes would therefore increase, and smokers might turn to substitutes such as cigars and pipes, or start rolling their own cigarettes. The extent of the effect of a tax on cigarette consumption depends on the elasticity of demand for cigarettes. Again, it is unclear whether society as a whole will benefit.

c. A tax is levied on each pack of cigarettes sold.

If the tax is levied on consumers, the tax will be shared between consumers and producers in exactly the same proportions as in part (b), so the effect will be the same as in part (b).

d. Smokers would be required to carry government-issued smoking permits at all times.

Smoking permits would effectively transfer property rights to clean air from smokers to non-smokers. The main obstacle to society benefiting from such a proposal would be the high cost of enforcing a smoking permit system. In addition, the cost of the permit

raises the effective price of smoking, and the resulting affect on quantity smoked will depend on the elasticity of demand.

7. In a market for dry cleaning, the inverse market demand function is given by $P = 100 - Q$ and the (private) marginal cost of production for the aggregation of all dry-cleaning firms is given by $MC = 10 + Q$. Finally, the pollution generated by the dry-cleaning process creates external damages given by the marginal external cost curve $MEC = Q$.

- a. Calculate the output and price of dry cleaning if it is produced under competitive conditions without regulation.**

Set demand equal to supply to find the competitive equilibrium. To do this, set price equal to marginal cost (which is the industry supply function):

$$\begin{aligned} 100 - Q &= 10 + Q, \\ Q &= 45, \text{ and } P = \$55. \end{aligned}$$

- b. Determine the socially efficient price and output of dry cleaning.**

To find the answer here, we must first calculate the marginal social cost (MSC), which is equal to the marginal external cost plus the private marginal cost. Next, set MSC equal to the market demand function to solve for price and quantity. When all costs are included, the quantity produced will fall and the price will rise:

$$\begin{aligned} \text{MSC} &= \text{MC} + \text{MEC} = (10 + Q) + Q = 10 + 2Q. \\ \text{Setting } \text{MSC} &= \text{MSB}: 10 + 2Q = 100 - Q, \text{ so} \\ Q &= 30, \text{ and } P = \$70. \end{aligned}$$

- c. Determine the tax that would result in a competitive market producing the socially efficient output.**

If there is a unit tax, t , then the new marginal private cost function is $\text{MCN} = (10 + Q) + tQ$. If we now set this new marginal cost function equal to the price of \$70 and substitute 30 for the quantity, we can solve for t :

$$\begin{aligned} 10 + Q + tQ &= 70 \\ Q(1+t) &= 60 \\ 1+t &= 2 \\ t &= \$1. \end{aligned}$$

The tax should be \$1 per unit of output. Note that with the tax equal to 1, the new private cost function is the same as the marginal social cost function.

- d. Calculate the output and price of dry cleaning if it is produced under monopolistic conditions without regulation.**

The monopolist will set marginal cost equal to marginal revenue. Recall that the marginal revenue curve has a slope that is twice the slope of the demand curve, so $\text{MR} = 100 - 2Q = \text{MC} = 10 + Q$. Therefore, $Q = 30$ and $P = \$70$.

- e. Determine the tax that would result in a monopolistic market producing the socially efficient output.**

The tax is equal to zero since the monopolist will produce at the socially efficient output in this case.

- f. Assuming that no attempt is made to monitor or regulate the pollution, which market structure yields higher social welfare? Discuss.**

In this case it is actually the monopolist that yields the higher level of social welfare compared to the competitive market, because the monopolist's profit maximizing price and quantity are the same as the socially efficient solution. Since a monopolist tends to produce less output than the competitive equilibrium, it may end up producing closer to the social equilibrium when a negative externality is present.

9. A beekeeper lives adjacent to an apple orchard. The orchard owner benefits from the bees because each hive pollinates about one acre of apple trees. The orchard owner pays nothing for this service, however, because the bees come to the orchard without his having to do anything. Because there are not enough bees to pollinate the entire orchard, the orchard owner must complete the pollination by artificial means, at a cost of \$10 per acre of trees.

Beekeeping has a marginal cost $MC = 10 + 5Q$, where Q is the number of beehives. Each hive yields \$40 worth of honey.

a. How many beehives will the beekeeper maintain?

The beekeeper maintains the number of hives that maximizes profits when marginal revenue is equal to marginal cost. With a constant marginal revenue of \$40 (there is no information that would lead us to believe that the beekeeper has any market power) and a marginal cost of $10 + 5Q$:

$$40 = 10 + 5Q, \text{ or } Q = 6.$$

b. Is this the economically efficient number of hives?

If there are too few bees to pollinate the orchard, the farmer must pay \$10 per acre for artificial pollination. Thus, the farmer would be willing to pay up to \$10 to the beekeeper to maintain each additional hive. So, the marginal social benefit, MSB , of each additional hive is \$50, which is greater than the marginal private benefit of \$40. Assuming that the private marginal cost is equal to the social marginal cost, we set $MSB = MC$ to determine the efficient number of hives:

$$50 = 10 + 5Q, \text{ or } Q = 8.$$

Therefore, the beekeeper's private choice of $Q = 6$ is not the socially efficient number of hives.

c. What changes would lead to a more efficient operation?

The most radical change that would lead to more efficient operations would be the merger of the farmer's business with the beekeeper's business. This merger would internalize the positive externality of bee pollination. Short of a merger, the farmer and beekeeper should enter into a contract for pollination services, with the farmer paying \$10 per hive to the beekeeper.

11. Reconsider the common resource problem given in Example 18.7. Suppose that crawfish popularity continues to increase, and that the demand curve shifts from $C = 0.401 - 0.0064F$ to $C = 0.50 - 0.0064F$. How does this shift in demand affect the actual crawfish catch, the efficient catch, and the social cost of common access? (Hint: Use the marginal social cost and private cost curves given in the example.)

The relevant information is now the following:

$$\text{Demand: } C = 0.50 - 0.0064F$$

$$MSC: C = -5.645 + 0.6509F.$$

$$\text{MPC: } C = -0.357 + 0.0573F$$

With an increase in demand, the demand curve for crawfish shifts upward, intersecting the price axis at \$0.50. The private cost curve has a positive slope, so additional effort must be made to increase the catch. Since the social cost curve has a positive slope, the socially efficient catch also increases. We may determine the socially efficient catch by setting demand equal to *MSC*:

$$0.50 - 0.0064F = -5.645 + 0.6509F, \text{ or } F^* = 9.35.$$

To determine the price that consumers are willing to pay for this quantity, substitute F^* into the demand equation and solve for C :

$$C = 0.50 - 0.0064(9.35), \text{ or } C = \$0.44.$$

To find the actual crawfish catch, set demand equal to the private marginal cost:

$$0.50 - 0.0064F = -0.357 + 0.0573F, \text{ or } F^{**} = 13.45.$$

To determine the price that consumers are willing to pay for this quantity, substitute F^{**} into the demand equation and solve for C :

$$C = 0.50 - 0.0064(13.45), \text{ or } C = \$0.41.$$

Notice that the marginal social cost of producing 13.45 units is

$$MSC = -5.645 + 0.6509(13.45) = \$3.11.$$

With the increase in demand, the social cost of common access is the area of a triangle with a base of 4.1 million pounds ($13.45 - 9.35$) and a height of \$2.70 ($\$3.11 - 0.41$), or \$5,535,000. This is \$3,139,000 more than the social cost of common access with the original demand (which was calculated to be \$2,396,000 in Example 18.7).