CHAPTER 17

EXTERNALITIES: THE FREE MARKET–INTERVENTIONIST BATTLE CONTINUES

Economic development brings great increases in the standard of living of all the inhabitants of our no longer primitive society. Unfortunately, it also brings a major problem—pollution. As our model society becomes more productive, its factories begin to pollute the air and water. At first, the pollution is tolerable and no one pays any attention to it. But after a number of years, it begins to have adverse effects on people's health and lifestyles. On bad days, pollutants in the air cause some people to have difficulty breathing and make almost everyone's eyes itch and burn. "No swimming" signs have been posted along the river because the water is so badly polluted. As a result of these events, some members of our model society have begun demanding that government leaders do something about the pollution problem. Others argue against government intervention, claiming that the economy can solve the pollution problem by itself if given the chance to do so. Thus, free-market advocates and interventionists are resuming the ideological battle that racked our model society in Chapter 15.

In this chapter, we will investigate the economic causes of such problems as pollution and the challenges they present to a free-market economy. We will then examine some solutions, both interventionist and noninterventionist, and evaluate the effectiveness of these solutions.

17.1 THE EXTERNALITY PROBLEM DESCRIBED

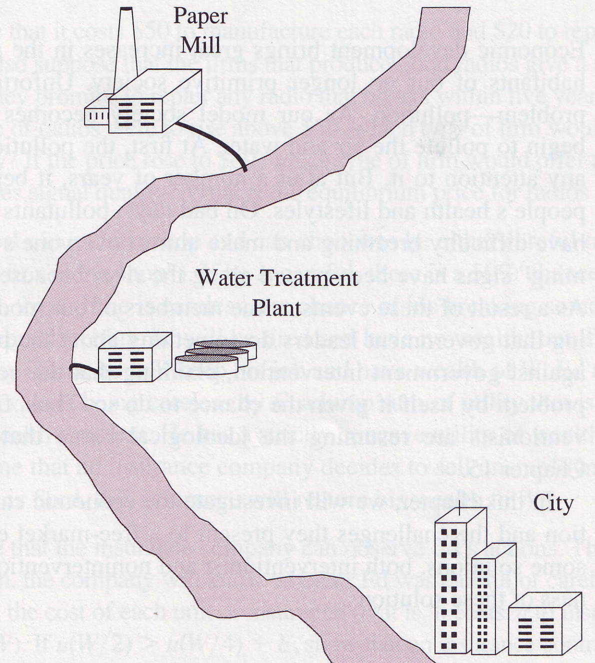
To understand the economic causes of social problems like pollution, we will make use of the society envisioned by Edward Dolan in his book *TANSTAAFL: Economic*

Strategy for the Environmental Crisis.[1] This society produces only two products: clean water and paper. As Figure 17.1 shows, this society is situated on the banks of a river, with the paper mill upstream from the water treatment plant. Below the water treatment plant is the city where all the people live.

This society has a problem because the paper mill dumps its wastes into the river, and such wastes make it more expensive for the water treatment plant to produce clean water for the inhabitants of the city. In other words, the paper mill imposes a cost on the water treatment plant. Because this cost has no direct effect on the paper mill, it is *external* to the paper mill. In general, we will use the term **externality** to describe any cost or benefit generated by one agent in its production or consumption activities but affecting another agent in the economy. The paper mill does not take the external cost created by its wastes into account when making its production decisions. As we will see shortly, this myopia causes the market to fail to determine an efficient outcome for society.

FIGURE 17.1 Dolan's water-paper society.

The paper mill imposes an external cost on the water treatment plant by dumping its wastes into the river. These wastes increase the treatment plant's cost of cleaning the water.



[1]Edward Dolan, *TANSTAAFL: Economic Strategy for the Environmental Crisis* (New York: Holt, Rinehart & Winston, 1969), pp. 24–27. *TANSTAAFL* stands for "there ain't no such thing as a free lunch."

To make the situation more concrete, let us say that the paper mill is producing 10 tons of paper. Its marginal cost (the cost of the capital and labor required to produce an additional pound of paper) is $0.005 per pound. Note that this is the mill's **private marginal cost.** It does not include the external cost that the wastes from the mill impose on the water treatment plant. Assuming that paper production is a competitive industry, we know that the price of paper will be forced down to its marginal cost, so paper will sell for $0.005 per pound in this economy.

Now, let us say that the water treatment plant's marginal cost is $0.50 per 1,000 gallons when the paper mill is idle and therefore generating no waste. (This is the cost of the capital and labor needed to treat the unpolluted river water to make it suitable for drinking.) However, when the paper mill is operating, the water treatment plant has an additional cost of $0.05 per 1,000 gallons for each ton of paper produced. Because the paper mill is currently producing 10 tons of paper, the cost of treating the river water has increased by $0.50 per 1,000 gallons—10 tons · $0.05 per ton = $0.50. Adding this marginal externality cost of $0.50 per 1,000 gallons to the water treatment plant's marginal cost for capital and labor inputs of $0.50 per 1,000 gallons raises its total marginal cost to $1 per 1,000 gallons. Assuming that water treatment is a competitive industry, the price of water will be $1 per 1,000 gallons, or $0.001 per gallon. At this price, let us assume that 1 million gallons are demanded, so society spends $1,000 on water.

17.2 THE EFFECTS OF AN EXTERNALITY ON OUTPUT

Given the externality created by the paper mill's wastes, can we expect our model society to produce Pareto-optimal amounts of clean water and paper? (Recall from Chapters 4 and 15 that a Pareto-optimal outcome requires that there be no other amounts of clean water and paper that, if produced, would make someone in society better off without making anyone worse off.) Intuitively, we might expect the answer to be no. The paper mill is imposing an additional cost on the water treatment plant, but there is no mechanism to make the mill accountable for this cost, so it seems unlikely that the outcome for society will be Pareto-optimal. Indeed, it is not. To understand why this is so, we must analyze the problem.

Another Look at the Conditions for a Pareto-Optimal Outcome

In Chapter 15, we saw that there are three conditions that must be met by a perfectly competitive economy for the outcome it determines to be Pareto-optimal. In our water-paper economy, the first condition is that the marginal rate of substitution of paper for water must be the same for each individual in the society. That is, $MRS^1_{w \text{ for } p} = MRS^2_{w \text{ for } p} = \cdots = MRS^i_{w \text{ for } p}$, where $MRS^i_{w \text{ for } p}$ is the marginal rate of substitution for person i. For each person, the marginal rate of substitution is equal to the ratio of the marginal utility of paper to the marginal utility of water, which is in turn equal to the ratio of the price of paper to the price of water. That is, $MRS_{w \text{ for } p} = MU_p/MU_w = P_p/P_w$. In our model society, the price of paper is \$0.005 per pound and the price of water is \$0.001 per gallon, so $P_p/P_w = \$0.005/\$0.001 = \frac{5}{1}$. If we assume that each consumer is maximizing his or her utility, then all consumers will set their marginal rates of substitution so that they are equal to the same price ratio, $\frac{5}{1}$. Thus, our first condition is met.

The second condition has to do with production inputs. It requires that the marginal rate of technical substitution of the paper mill be equal to that of the water treatment plant. We need not concern ourselves with this condition at the present time.

It is in fulfilling the third condition that our model society runs into trouble. This final condition states that the marginal rate of substitution of water for paper must equal the marginal rate of transformation of water for paper. That is, $MRS_{w \text{ for } p} = MRT_{w \text{ for } p}$. The marginal rate of transformation is supposed to be equal to the ratio of the marginal cost of producing paper to the marginal cost of producing clean water. That is, $MRT_{w \text{ for } p} = MC_p/MC_w$. From our earlier discussion, we know that the marginal cost of producing paper is \$0.005 per pound and that the marginal cost of producing clean water is \$0.001 per gallon. The ratio of these costs is \$0.005/\$0.001 $= \frac{5}{1}$. Thus, at first glance, it would appear that $MRS = MRT = \frac{5}{1}$ and so our third condition is met. In reality, however, it is not met.

A marginal rate of transformation of $\frac{5}{1}$ implies that we must give up 5 gallons of water in order to obtain 1 more pound of paper. Unfortunately, this is not actually the case. To see why, let us take \$1 away from the production of clean water. *When the mill is producing 10 tons of paper,* the marginal cost of water production is \$0.001 per gallon. The water treatment plant will therefore be producing 1,000 fewer gallons of water, or 999,000 gallons instead of 1 million gallons. Our model society will then be spending only \$999 on water purchases.

Now let us give the \$1 to the paper mill. Because its marginal cost is \$0.005 per pound of paper, this change allows the mill to produce 200 more pounds of paper. Note that it still looks like our marginal rate of transformation is $\frac{5}{1}$ because we appear to have given up 1,000 gallons of water in order to obtain 200 pounds of paper. But the story is not over yet.

When the paper mill produces the extra 200 pounds of paper, it will be producing 10.1 tons of paper instead of 10 tons. Recall that for each ton of paper it produces, the mill imposes a cost of \$0.05 per 1,000 gallons on the water treatment plant. The mill's additional output of 0.1 tons will therefore increase the marginal cost of the water treatment plant by another \$0.005 per 1,000 gallons. The marginal cost, and hence the price, of water will be \$1.005 per 1,000 gallons, not \$1. Thus, with the \$999 that society has available to spend on water, it can purchase only about 994,000 gallons rather than 999,000 gallons.

Because society must actually give up almost 6,000 gallons of water, not 1,000, to obtain 200 more pounds of paper, the true marginal rate of transformation of paper for water is $\frac{6{,}000}{200} = \frac{30}{1}$ rather than $\frac{1{,}000}{200} = \frac{5}{1}$. We might call the ratio of $\frac{30}{1}$ the **social marginal rate of transformation** because it takes into account the full marginal cost of producing 1 more pound of paper—the mill's input costs plus the cost it imposes on the water treatment plant.

Once we have determined the true marginal rate of transformation of paper for water *for society,* we can see that the third condition for a Pareto-optimal outcome is not met. Rather than being equal, $MRS_{w \text{ for } p} = \frac{5}{1}$ is much less than $MRT_{w \text{ for } p} = \frac{30}{1}$. In other words, because of the external cost imposed by the paper mill on the water treatment plant, individuals in society are purchasing units of paper with a marginal utility of $0.05 but a *social marginal cost* of $0.30. In short, the competitive market is determining the wrong set of prices. The price of paper is too low; it does not reflect the true social marginal cost of paper production.

An Externality Causes Market Failure

We can now answer our original question about whether our water-paper economy will produce Pareto-optimal amounts of clean water and paper. Obviously, the answer is no. At production levels of 10 tons of paper and 1 million gallons of water, this society's competitive market has failed. It is producing too much paper and not enough water. To prove to ourselves that the amounts of clean water and paper are not Pareto-optimal, all we need to do is find new amounts of water and paper that will make at least one party better off without making any party worse off.

Let us assume that we reduce the production of paper by 200 pounds. Because the price of paper is $0.005 per pound, this is equivalent to asking the paper mill to sacrifice $0.005 per pound · 200 pounds = $1 in revenues. Note, however, that the reduction of paper production by 200 pounds will lower the cost of producing water by $0.005 per 1,000 gallons. This means that the cost of producing clean water will fall from $1 per 1,000 gallons to $0.995. Hence, it will cost only $995 instead of $1,000 to produce 1 million gallons of water—a savings of $5 for the water treatment plant.

In other words, asking the paper mill to cut its production by 200 pounds will decrease the mill's revenues by $1, but it will lower the costs of the water treatment plant by $5. Clearly, then, the cost savings of the water treatment plant will be enough to allow it to produce more water *and* compensate the paper mill for its lost revenues. For instance, if the water treatment plant spends $3.50 of the $5 to produce more clean water, it can still give the paper mill $1.50, which will more than cover the mill's $1 loss in revenues. Thus, it appears that both parties will be better off. The problem is that the impersonal forces of the competitive market will fail to reach this solution.

The realization that externalities can cause the competitive market to determine the wrong set of prices and, hence, cause the market to fail to determine a Pareto-optimal outcome is a matter of grave concern to interventionists and free-market advocates alike. As is usually the case, the agents in our model society call on an economic consulting firm to help them think through the problem.

CONSULTING REPORT 17.1

How Can the Market Failure Caused by an Externality Be Rectified?

Following a thorough search of the economic literature, the consultants suggest that the agents in our model society consider three interventionist solutions to the externality problem. The first is the use of Pigouvian taxes, the second is the use of standards and charges, and the third is the creation of marketable pollution permits. Further, they suggest that the agents take a look at the experiments performed by Charles Plott in evaluating these three forms of intervention.

The consultants do not go so far as to say that intervention is inevitable, however. They suggest that our agents also consider the Coase theorem and the experimental evidence provided by Elizabeth Hoffman and Matthew Spitzer.

17.3 INTERVENTIONIST SOLUTIONS TO THE EXTERNALITY PROBLEM

Pigouvian Taxes

The economist A.C. Pigou argued that, when an externality exists, the government should tax the party causing the externality by an amount equal to the externality.[2] To understand how such **Pigouvian taxes** would work, let us look again at the paper mill in our water-paper society.

Figure 17.2 shows the demand curve for paper faced by the paper mill as well as two marginal cost curves. The lower marginal cost curve, MC, is the mill's private marginal cost curve. It reflects all input costs for producing paper. This marginal cost curve intersects the demand curve at point A, which means that the mill will produce 10 tons of paper. This is the level of production that will result with a competitive market.

Recall, however, that each time the mill produces one more ton of paper, the costs of the water treatment plant increase by $0.05 per 1,000 gallons. In a competitive market, this additional cost is external to the paper mill, so the mill does not take it into account in deciding how much paper to produce. Society, however, must take this cost into account. The higher marginal cost curve, MC', in Figure 17.2 is the social marginal cost curve. It represents the marginal costs faced by society for paper production. It reflects the private input costs of the paper mill *plus* the external costs that the mill imposes on the water treatment plant.

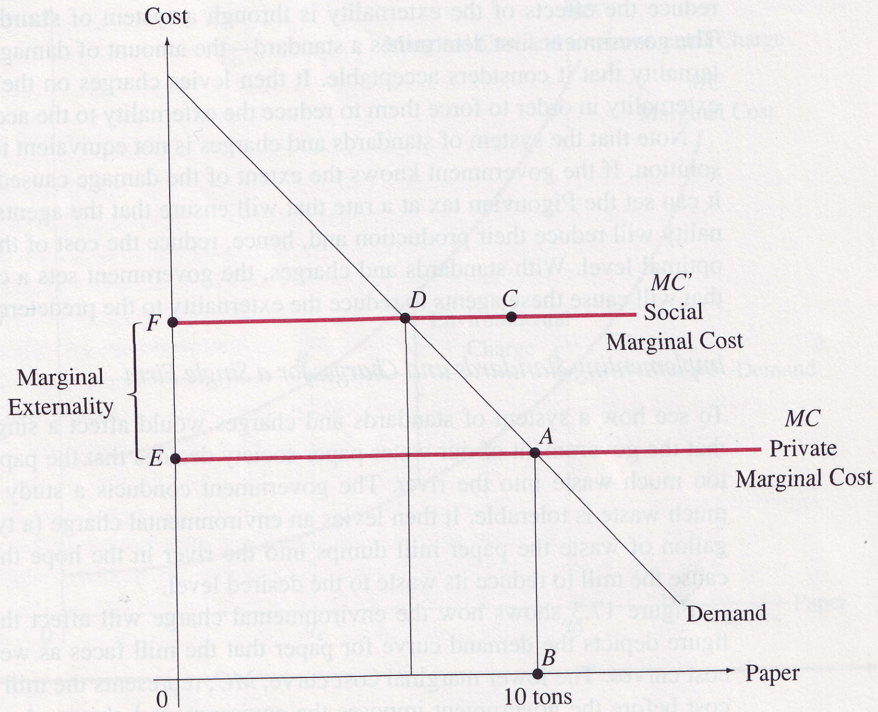
We can now see that the competitive solution at point A of Figure 17.2 is not optimal for society. The social marginal cost of producing the tenth ton (the distance BC) is greater than the social marginal benefit to consumers of receiving that ton (the distance BA). Clearly, production at point D would be socially optimal, but the competitive market will not achieve this solution on its own.

According to Pigou, the solution to the problem is to tax the paper mill by an amount equal to the **marginal externality,** the difference between the private marginal costs of the mill and the social marginal costs for paper production (the distance EF). This tax will force the paper mill to *internalize* the externality and take it into account when deciding how much paper to produce. As a result, the mill will

[2] Arthur Cecil Pigou (1877–1959) was an English economist who held the chair of political economy at Cambridge University from 1908 to 1944. He did extensive work in the area of welfare economics. He provided the basis for the theory of externalities by making a distinction between private and social costs and proposing taxes and subsidies to remedy situations where such costs differ.

FIGURE 17.2 Pigouvian taxes.

The imposition of a tax equal to the marginal externality (distance *EF*) equates the private marginal cost *MC* faced by the paper mill with the social marginal cost *MC′* and thereby induces the mill to produce at the optimal level for society (point *D*).



reduce paper production to the socially optimal level represented by point *D* of Figure 17.2.

The Weakness of the Pigouvian Tax Solution

Although the Pigouvian tax solution to the externality problem may seem ideal in theory, there is a major practical problem in administering it. If the government is to set the externality tax at its optimal level, it must know the exact amount of the externality. This information is very difficult for the government to obtain. In fact, the party affected by the externality may not even know exactly how much it is being damaged. And, even if it does know, it might not report the amount to the government accurately. The affected party has a great incentive to exaggerate the amount of damage it experiences with a view toward reducing this damage as much as possible.

Thus, unless the government can obtain accurate information about the amount of an externality, the Pigouvian tax solution is unlikely to be effective.

Standards and Charges

Another way the government can intervene in a market with an externality in order to reduce the effects of the externality is through a system of **standards and charges.** The government first determines a standard—the amount of damage caused by the externality that it considers acceptable. It then levies charges on the agents causing the externality in order to force them to reduce the externality to the acceptable level.

Note that the system of standards and charges is not equivalent to the Pigouvian tax solution. If the government knows the extent of the damage caused by the externality, it can set the Pigouvian tax at a rate that will ensure that the agents causing the externality will reduce their production and, hence, reduce the cost of the externality to the optimal level. With standards and charges, the government sets a charge that it hopes that will cause these agents to reduce the externality to the predetermined level.

Implementing Standards and Charges for a Single Firm

To see how a system of standards and charges would affect a single firm, let us say that the government of our water-paper society decides that the paper mill is dumping too much waste into the river. The government conducts a study to determine how much waste is tolerable. It then levies an environmental charge (a type of tax) on each gallon of waste the paper mill dumps into the river in the hope that this charge will cause the mill to reduce its waste to the desired level.

Figure 17.3 shows how the environmental charge will affect the paper mill. This figure depicts the demand curve for paper that the mill faces as well as two marginal cost curves. The lower marginal cost curve, *MC*, represents the mill's private marginal cost before the government imposes the environmental charge. As long as the mill is on curve *MC*, it will set its output at point *A*, where its marginal cost equals the market price. At this point, the mill's output is q_0.

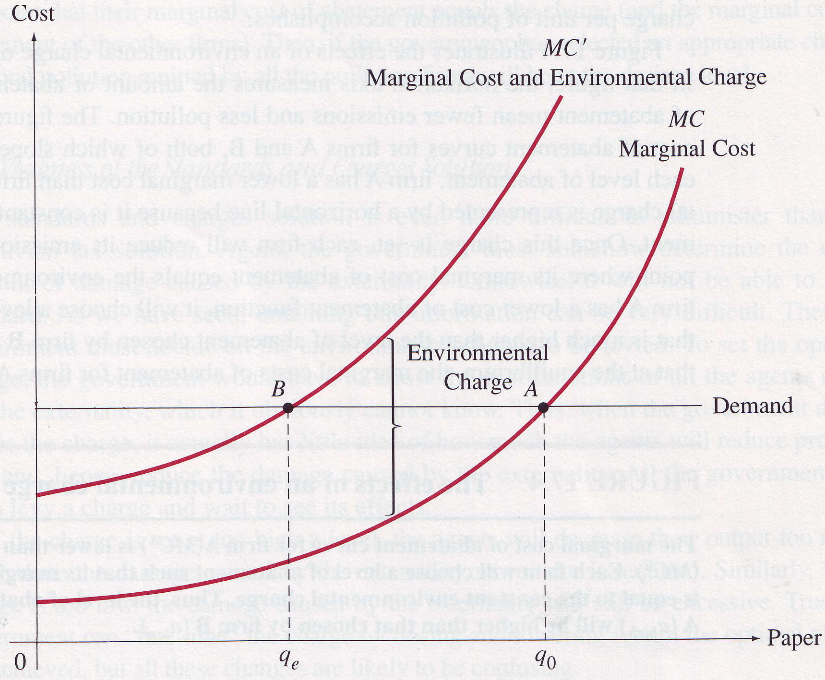
When the government imposes the environmental charge on the paper mill, the mill's marginal cost function increases by an amount equal to the charge. Its marginal cost curve therefore shifts upward to *MC′*. On curve *MC′*, the mill's marginal cost equals the market price at point *B* and the mill reduces its output to q_e. Ideally, at this lower output, the mill will have decreased the amount of waste it dumps into the river to the standard established by the government—the level the government feels is tolerable.

Implementing Standards and Charges for Two or More Firms

Suppose there are several agents that are creating an externality. How should the government apply the system of standards and charges to reduce the effects of the externality in this case? To answer such a question, let us begin by assuming that there are two paper mills in our water-paper society. Each day, mill A is dumping 70 gallons of waste into the river and mill B is dumping 30 gallons of waste. The government decides that this pollution should be cut in half. What should it do? An obvious possibility is to require across-the-board cuts of 50% in the waste that the two mills dump. Although this would reduce

FIGURE 17.3 The effect of an environmental charge on a single firm.

The imposition of an environmental charge equal to the distance between the marginal cost curves *MC* and *MC′* induces the firm to cut back its output from q_0 to q_e.



pollution by the desired amount and would be simple to administer, it is not the least-cost way to achieve the desired reduction and, hence, is not the most efficient solution.

The reason across-the-board cuts are not efficient is that different firms have different abilities to reduce pollution. For instance, let us say that firm A has a new plant that includes a modern pollution abatement system, whereas firm B has an old plant with an obsolete pollution abatement system. Firm A's marginal cost of abatement function will be lower than firm B's, so firm A will be able to reduce pollution more efficiently than firm B.

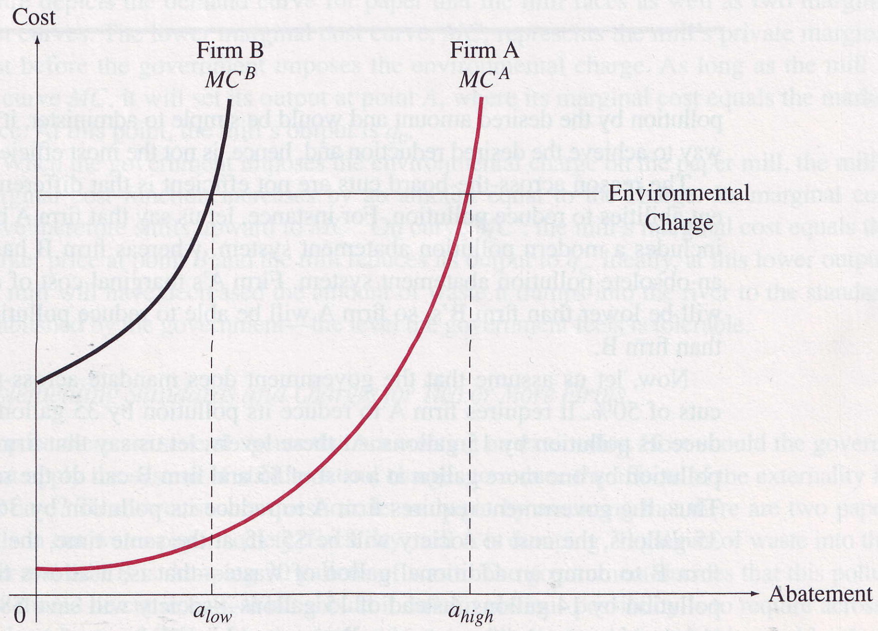
Now, let us assume that the government does mandate across-the-board pollution cuts of 50%. It requires firm A to reduce its pollution by 35 gallons and firm B to reduce its pollution by 15 gallons. At these levels, let us say that firm A can decrease its pollution by one more gallon at a cost of $5 and firm B can do the same at a cost of $8. Thus, the government requires firm A to reduce its pollution by 36 gallons instead of 35 gallons, the cost to society will be $5. If, at the same time, the government allows firm B to dump an additional gallon of waste—that is, it allows firm B to reduce its pollution by 14 gallons instead of 15 gallons—society will save $8. At these new levels, the same total reduction in pollution is achieved, but society realizes a net savings of \$3. Obviously, then, the across-the-board cut is not the least-cost way to achieve the desired reduction in pollution.

The efficient way to achieve any given set of pollution standards is to have the firms with a lower cost of abatement reduce their emission of pollutants by more than the firms with a higher cost of abatement. This is exactly what an environmental charge per unit of pollution accomplishes.

Figure 17.4 illustrates the effects of an environmental charge on our two paper mills. In that figure, the horizontal axis measures the amount of abatement; larger quantities of abatement mean fewer emissions and less pollution. The figure depicts the marginal cost of abatement curves for firms A and B, both of which slope upward. Note that at each level of abatement, firm A has a lower marginal cost than firm B. The environmental charge is represented by a horizontal line because it is constant at all levels of abatement. Once this charge is set, each firm will reduce its emission of pollutants to the point where its marginal cost of abatement equals the environmental charge. Because firm A has a lower cost of abatement function, it will choose a level of abatement (a_{high}) that is much higher than the level of abatement chosen by firm B (a_{low}). Note, however, that at the equilibrium, the marginal costs of abatement for firms A and B are equal.

FIGURE 17.4 The effects of an environmental charge on two firms.

The marginal cost of abatement curve for firm A(MC^A) is lower than that for firm B (MC^B). Each firm will choose a level of abatement such that its marginal cost of abatement is equal to the constant environmental charge. Thus, the level of abatement chosen by firm A (a_{high}) will be higher than that chosen by firm B (a_{low}).



In summary, government intervention through a system of standards and charges works as follows when there are a number of firms polluting the environment. The government sets a standard—an acceptable level of pollution. That is, it determines just how much pollution it feels is tolerable. The government then levies an environmental charge per unit of pollution. In response, the polluting firms reduce their emission of pollutants to the point that their marginal cost of abatement equals the charge (and the marginal cost of abatement of the other firms). Then, if the government has selected an appropriate charge, the total pollution emitted by all the polluting firms will be at the desired level.

The Weakness of the Standards and Charges Solution

The standards and charges solution is even more difficult to administer than the Pigouvian tax solution. Again, the government must somehow determine the exact amount of damage caused by the externality. Otherwise, it will not be able to set a standard. As we have seen, obtaining this information can be very difficult. Then the government must decide on the environmental charge to be levied. To set the optimal charge, the government would have to know the cost functions of all the agents causing the externality, which it obviously cannot know. Thus, when the government determines the charge, it actually has little idea of how much the agents will reduce production and, hence, reduce the damage caused by the externality. All the government can do is levy a charge and wait to see its effects.

If the charge is set at too high a level, the agents will decrease their output too much and reduce the damage caused by the externality more than is required. Similarly, if the charge is too low, the damage caused by the externality will still be excessive. True, the government can "fine-tune" the charge by raising and lowering it until the optimal effects are achieved, but all these changes are likely to be confusing.

Marketable Pollution Permits

The final method of government intervention to correct the effects of the externality caused by pollution that we will discuss is the creation of **marketable pollution permits.** Each permit allows a firm to pollute the environment by a specified amount. Thus, if a polluting firm wants to produce one unit of a product, it must buy not only the labor and capital it needs to produce that unit but also a permit that will allow it to pollute the environment. Clearly, a firm with a high marginal cost of abatement would be willing to pay a substantial amount to buy such a permit because it would otherwise have to spend a substantial amount to clean up its own pollution. Conversely, a firm with a low marginal cost of abatement would be willing to pay less for the permit because it can always clean up its own wastes at a lower cost.

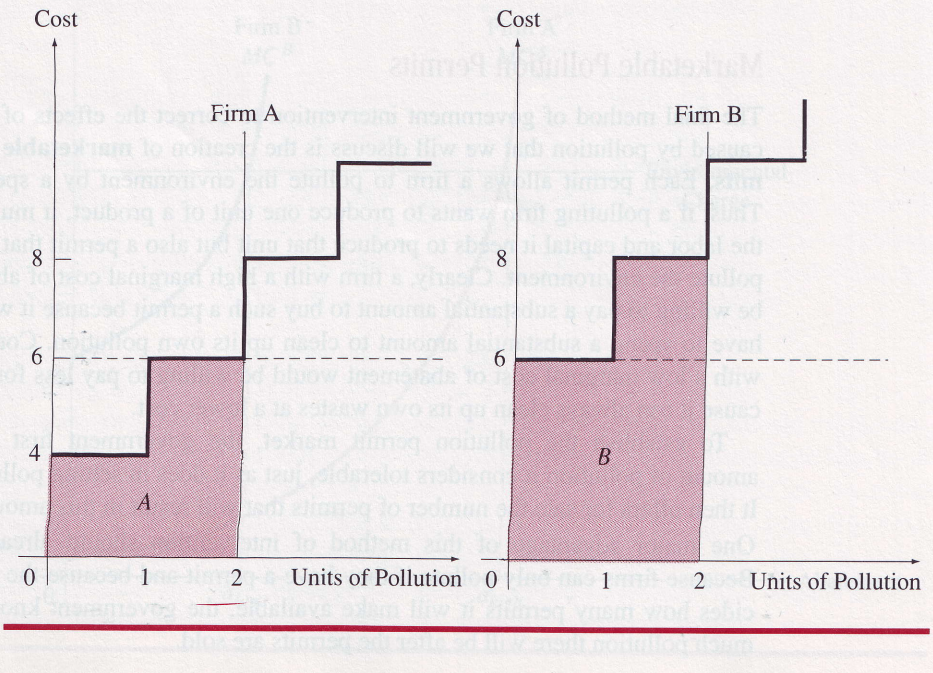
To establish the pollution permit market, the government first determines the amount of pollution it considers tolerable, just as it does in setting pollution standards. It then offers for sale the number of permits that will result in this amount of pollution. One major advantage of this method of intervention should already be obvious. Because firms can only pollute if they have a permit and because the government decides how many permits it will make available, the government knows exactly how much pollution there will be after the permits are sold.

To see how a market in pollution permits would work, let us consider an industry in which there are two polluting firms, firm A and firm B. These firms have the marginal pollution abatement cost functions shown in Figure 17.5. The government determines that pollution should be limited to two units and decides to sell permits allowing only this much pollution. Each firm has a clear choice. It can either buy the permits and continue to pollute as it produces, or it can pay the cost of cleaning up its own pollution. If firm A does not buy the permits, it will have to pay $4 to clean up the first unit of its pollution and $6 to clean up the second unit, a total of $10 in pollution abatement costs. This amount is indicated by area *A* on the left side of Figure 17.5. Firm B, on the other hand, has a higher marginal cost of abatement function. It will therefore have to pay a total of $14 to clean up its own pollution, $6 for the first unit and $8 for the second unit. This amount is indicated by area *B* on the right side of Figure 17.5.

The best solution for society is the one that will reduce total pollution to two units for the least amount of money. If society requires firm B to clean up its own pollution, the total cost to society will be $14. Clearly, then, society is better off if it requires firm A to clean up its own pollution, which will cost only $10, and allows firm B to continue to pollute. Indeed, this is exactly the result that a competitive market in pollution permits will achieve, as we will now see.

FIGURE 17.5 A market for pollution permits.

The cost to clean up two units of pollution is $10 for firm A and $14 for firm B. In a market for permits giving the right to emit two units of pollution, firm A would bid up to $10 and firm B would bid up to $14.



Let us say that the government holds an auction to sell the two pollution permits, and both firms A and B participate in this auction. Bids are to be offered in increments of $0.10. The bidding will continue until neither firm bids any higher, at which point the permits will be awarded to the firm that has made the highest bid. Firm A will keep bidding until it has bid a total of $10. It will stop bidding at that point because the next bid would be greater than $10, which is what it would cost firm A to clean up its own pollution. Firm B, on the other hand, has a total pollution abatement cost of $14, so it would be willing to bid up to $14 to buy the two permits. However, firm B will not have to bid that high. Because firm A will drop out of the bidding at $10, firm B can win the two permits for a total cost of $10 or slightly more than $10. Thus, the market in pollution permits achieves society's aim of reducing pollution by two units for the least amount of money. Firm B is allowed to pollute because it bought the permits; and firm A, the least-cost abater, must cut its level of pollution.

Although the use of marketable pollution permits must be considered a government intervention, it is a rather minor one. Essentially, it simply creates a new market—a market for pollution permits—where one did not previously exist.

17.4 AN EVALUATION OF THE EXTERNALITY PROBLEM AND THE INTERVENTIONIST SOLUTIONS: THE PLOTT EXPERIMENTS

We have now seen that economic theory predicts that a competitive market will fail to arrive at a Pareto-optimal outcome in the presence of an externality. We have also examined, on a theoretical basis, three interventionist solutions to the externality problem—Pigouvian taxes, standards and charges, and marketable pollution permits. At this point, it seems reasonable to wonder just how well the theories we have studied approximate reality. For a sense of this, let us take a look at a series of experiments conducted by Charles Plott.[3]

Plott's Basic Laboratory Model

Plott set up his experiments by creating a laboratory model of a market with an externality. (Except for the inclusion of the externality, the procedures he used were identical to those used by Vernon Smith in the experiment discussed in Chapter 13.) In Plott's experimental market, the subjects buy and sell units of a fictitious good using the double oral auction mechanism. Each buyer is paid a redemption value for every unit he or she purchases according to a predetermined redemption schedule, and each seller must pay a premium for each unit he or she sells according to a predetermined cost schedule. (These procedures and the auction mechanism are discussed in more detail in Section 13.2. You may want to review this material.) To introduce the externality into the market, Plott stipulated that each transaction completed would impose an

[3]Charles Plott, a Professor of Economics at the California Institute of Technology, is one of the foremost pioneers in the field of experimental economics. The experiments discussed here are reported in Charles Plott, "Externalities and Corrective Policies in Experimental Markets," *Economic Journal*, Vol. 93, 1983, pp. 106–127.

additional cost on all subsequent transactions. This cost increases with the number of units sold.[4]

For example, if we think of each completed transaction as being like a unit of a good that has been produced, then in this market the more transactions that are completed, the more costly it will be to complete each succeeding transaction. This behavior is depicted in Figure 17.6, where the social marginal cost curve shows the cost situation for an individual. Note that after 6 transactions are completed, the difference between the private and social marginal costs is $0.24; while after 43 transactions are completed, the difference between the private and social marginal costs has grown to $0.42. Hence, not only is there an externality, but its magnitude increases as more transactions are completed.

Plott's experimental market is illustrated in Figure 17.6. The redemption and cost schedules Plott used result in the demand curve and the private marginal cost curve *MC* (also the supply curve for this market). The curve *MC′* is the social marginal cost curve, which takes into account the externality. It reflects the private marginal cost of each unit of the fictitious good *plus* the marginal damage done to society with each trade.

Will the Competitive Market Really Fail?

As we know from our discussion in Section 17.2, the Pareto-optimal level of production of the fictitious good for society occurs where the social marginal cost curve *MC′* intersects the demand curve. This point is labeled *A* in Figure 17.6. It indicates an expected output of 13 units and an expected equilibrium price of $2.69. However, economic theory tells us that the market will ignore the externality if left to its own devices. Therefore, the market will reach equilibrium at its competitive outcome. This occurs at point *B*, where the private marginal cost curve *MC* intersects the demand curve. At point *B*, the expected output is 24 units and the expected equilibrium price is $2.44.

In his first experiment, Plott investigated whether the predictions of economic theory were accurate. Would the participants in this experimental market ignore the fact that their actions carry with them an externality that hurts all the agents in the market, including themselves, as the theory predicts? Or would they modify their behavior to take the externality into account?

Plott ran this experiment twice, with two different groups of subjects. The session with each group consisted of five market periods. The results are shown in Figure 17.7. Each graph summarizes the market activity that took place during the five periods of each session. At the top of the graph, we see the mean price determined in each period and the number of units of the good that were sold. During both sessions, the volume sold tended to move toward the competitive output level of 24 units and the price tended to move toward the competitive equilibrium price of $2.44. Based on these results, Plott was able to conclude that the predictions of economic theory were accurate. The market failed. The subjects ignored the externality, and the market came to equilibrium at the competitive level of output rather than at the Pareto-optimal level for society.

[4]Plott's experimental market might be thought of as a model of the market for crack cocaine. In that market, people buy the good and then commit crimes to obtain money to pay for their next purchase. Thus, the more people who buy the good, the more crime there is in society.