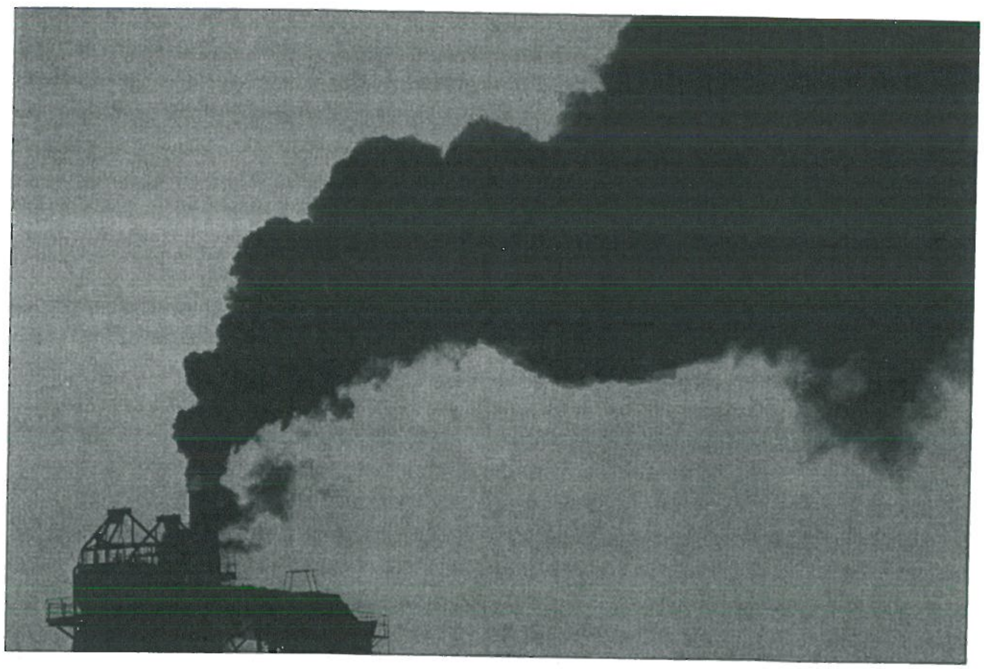
Chapter Two

Externalities and the Environment



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This chapter concentrates on an extremely important *negative* externality—environmental pollution. Economic analysis has led virtually all economists to make a controversial recommendation: charge polluters a price (either by levying a pollution tax or by requiring polluters to buy a permit for each unit of pollutant they emit) in order to discourage pollution. By contrast, many noneconomists recommend other approaches to reducing pollution. Some would require (mandate) each polluter to cut back a particular amount or switch to a particular low-polluting technology or manufacture a low-polluting product. Others would subsidize low-polluting technologies or products. This chapter explains why economists prefer charging polluters a price.

To Minimize Cost, Levy the Same Tax on All Firms Emitting Pollutant X

This section demonstrates a point that is of the utmost importance for public policy:

> *To minimize the cost of achieving a given reduction in pollutant X, the same tax per emission should be levied on all firms emitting pollutant X.*

To show this important point, we work with a diagram, Figure 2.5, that has emissions (pollution), instead of the quantity of the polluting good (such as gasoline), on the horizontal axis. In this diagram, the marginal damage (MD) is the amount of damage per emission (per unit of pollution). We simplify our example and diagram by assuming that the marginal damage stays constant as the quantity of emissions increases so that the MD curve is a horizontal line; the marginal damage is $40 per unit of pollutant X at all levels of emissions. The main conclusions of this section would still remain valid if MD varied with the quantity of pollution.

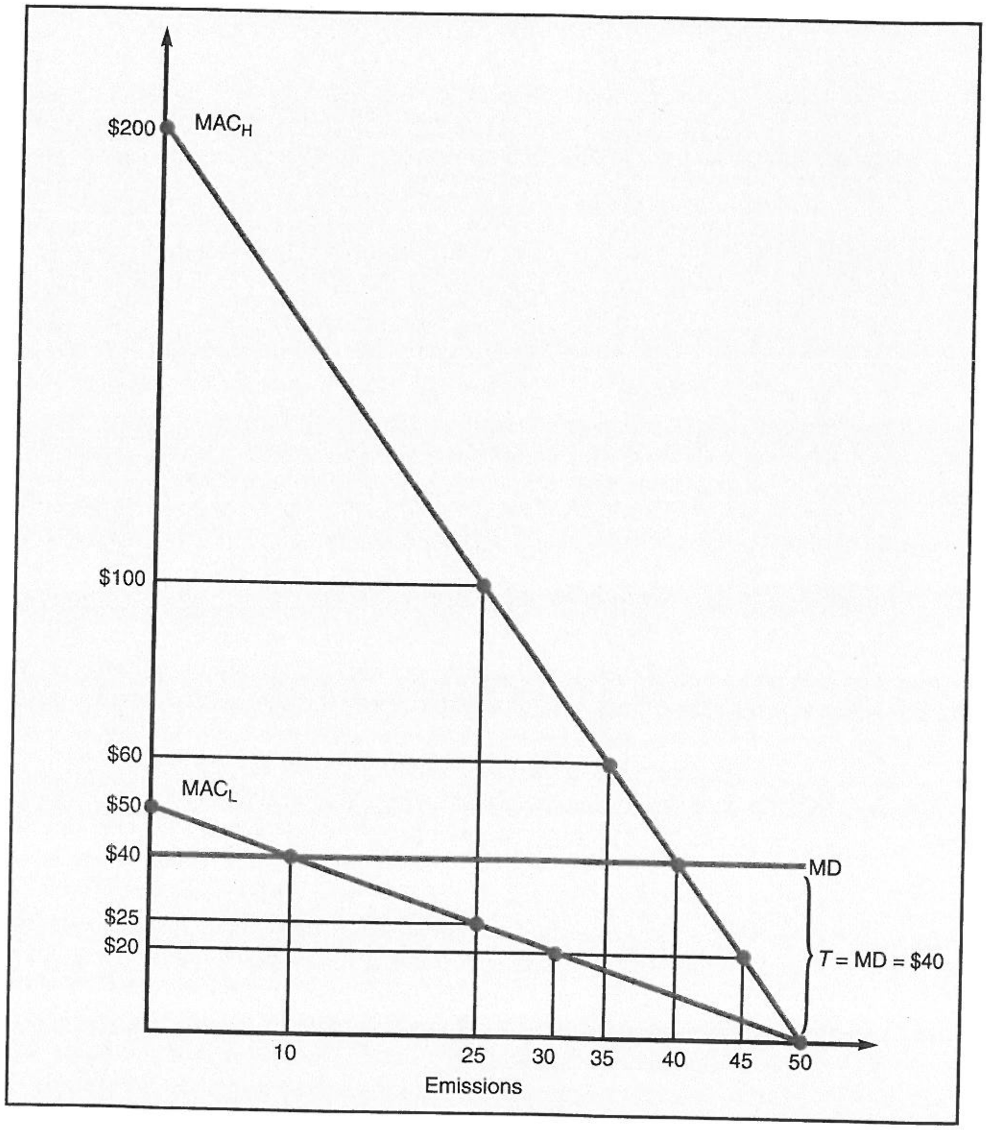
There are two firms emitting this pollutant. Suppose in the absence of any government policy that each firm, coincidentally, emits 50 units. Although the two firms emit the same chemical pollutant, assume that the two firms produce different goods and therefore would incur different costs for abating pollution. Each firm can abate pollution—reduce its emissions starting from 50 units by moving leftward—but at a cost. For example, emissions can be reduced by installing equipment that reduces the pollution that accompanies a given quantity of its output or by switching to a more costly but less polluting production process.

For each firm, starting from an emissions level of 50, each unit abated entails a higher marginal abatement cost (MAC). For example, as shown in Figure 2.5, as firm H (the high abatement cost firm) moves left from 50 emissions, its MAC_H rises sharply; and as firm L (the low abatement cost firm) moves left from 50 emissions, its MAC_L rises slowly.

It is socially optimal for each firm to abate another unit of pollution as long as its MAC is less than the MD ($40). Thus, starting from 50 emissions, firm H should abate 10 and continue to emit 40, while firm L should abate 40 and continue to emit 10.

A tax T of $40 per emission—a tax T equal to the marginal damage (MD) per emission—would induce each firm to abate the socially optimal quantity. The manager of each firm would recognize that it is profitable to abate a unit as long as its MAC is less than the tax it would otherwise have to pay to emit the unit. So starting at 50 emissions, each firm would find it profitable to reduce emissions as long as its MAC is less than the tax of $40. Thus, firm H would keep abating pollution until its emissions have

FIGURE 2.5
The Optimal Cutback of Pollution
A tax equal to marginal damage will induce each firm to cut back until its MAC equals MD.



been cut to 40, while firm L would keep abating until its emissions have been cut to 10. Here's the key point:

> *If the government sets the tax* T *equal to the marginal damage MD, what the firms then do for profit will unintentionally be what is best for society.*

To appreciate this achievement of the tax, suppose instead that the government required each firm to abate 25 units; equivalently, the government permitted each to emit 25 units. At first glance, the government requirement might appear reasonable—each firm would be required to abate the same quantity, 25, and each firm would be permitted to emit the same quantity, 25.

However, the result of this government requirement would not be socially optimal. From Figure 2.5 you can see that abating the 25th unit costs firm H $100 (its MAC is

\$100), while the MD is only \$40—so the requirement forces firm H to abate more than is socially optimal. Conversely, abating the 25th unit costs firm L \$25; since the MD is \$40, it would be socially optimal for L to abate still further.

When each firm complies with the government requirement to abate 25 and emit 25, their MACs differ: MAC_H is \$100, while MAC_L is only \$25. Whenever MACs differ, it is possible to reduce the total cost of abatement while achieving the same total abatement: Just let the high MAC firm H abate less and the low MAC firm L abate more. In the diagram, starting from 25, letting firm H abate 1 unit less (emit 1 unit more) avoids a cost of \$100, while having firm L abate 1 unit more (emit 1 unit less) incurs a cost of only \$25—for a net cost saving of \$75 (\$100 − \$25), while keeping total abatement the same and total emissions at 50. Starting from 25, when H abates 15 units less (and emits 15 units more, or 40) and L abates 15 units more (and emits 15 units less, or 10), the two MACs become equal (\$40), and no further total cost reduction is possible. This is sometimes called the **equimarginal principle**:

The total cost incurred to achieve a pollution target has been minimized only if each polluter reduces pollution until its marginal abatement cost is the same as every other polluter.

The reason is simple. If two polluters have unequal MACs, then total cost can be reduced while keeping total pollution the same by having the low MAC firm abate more (and emit less) while having the high MAC firm abate less (and emit more). A policy conclusion follows immediately:

To induce polluters to equalize their MACs, charge all polluters the same tax per emission of pollutant X.

As long as the same tax per emission is levied on all firms, their MACs will end up equal, because each firm will find it profitable to abate until its MAC equals the tax it faces. Thus, the emissions tax—provided it is the same for all firms emitting the pollutant—will result in equal MACs across firms and will therefore achieve a given total abatement at minimum possible total cost.

The message of economists to policy-makers is this: Resist arguments for varying the tax per emission among polluters of chemical X. An extreme variation is a zero tax—in other words, exempting certain polluters from the tax. Firms emitting the same pollutant differ along many dimensions, and firm managers, owners, and workers will present arguments to the government about why their firm's tax should be low or even zero (an exemption). But if the tax is varied across firms, then MACs will end up unequal, and the reduction in pollution will not be achieved at minimum possible cost.

A Carbon Tax or Tradable Permits to Reduce Global Warming

According to most scientists, gaseous carbon emissions (such as carbon dioxide) from the burning of carbon fuels are contributing to global warming. If so, it would be worth reducing carbon emissions if the cost of reduction is less than the future harm from global warming. Economists agree that rather than use command and control technology regulations, a price should be put on carbon emissions to give potential emitters an incentive to cut back. The price can be implemented either through a carbon tax or carbon permits. Because carbon emissions anywhere in the world contribute to global warming, ideally potential emitters in all countries should be faced with the same carbon emissions price so that a given reduction in global warming can be achieved at minimum cost to the world economy.

There are two policy decisions that must be made. First, which should be used: a carbon tax or carbon permits (cap and trade)? Second, how can low-income countries like China and India be induced to participate in cutting carbon emissions? Earlier in this chapter we discussed the pros and cons of a tax versus permits; the application to carbon is examined in the box titled "A Carbon Tax versus a Carbon Cap and Trade Program." The second decision—the participation of low-income countries—is discussed in the remainder of this section where we consider how to induce the participation of low-income countries under either a carbon tax treaty or a carbon permits (cap and trade) treaty.

A Carbon Tax Treaty

Consider how a carbon tax treaty would address this problem.

For administrative feasibility, carbon would be taxed *upstream* at the point it enters the economy through a few thousand fuel producers rather than *downstream* when it is actually emitted (in gaseous form) by millions of drivers and homeowners and by thousands of factories and electric utility plants. Thus coal would be taxed when mined, and oil and natural gas when pumped or refined or imported. Each would be taxed according to its carbon content. The fuel producers and importers subject to the carbon tax would then pass the tax on in higher prices so that all fuel users in the economy would face these higher prices. According to a Congressional Budget Office (CBO) study, a carbon tax of $100 per ton, which would raise the price of gasoline about $0.30

Case Study A Carbon Tax versus a Carbon Cap and Trade Program

At a conference in Washington, D.C., in October 2007 hosted by the Hamilton Project of the Brookings Institution, two economists presented papers advocating two different carbon price policies for reducing carbon emissions in the United States. Professor Robert Stavins of Harvard's Kennedy School of Government advocated a carbon cap and trade program, and Professor Gilbert Metcalf of Tufts University, a carbon tax.*

Before discussing their differences, it is important to emphasize that they both agree about the following points: (1) either carbon price policy would be much better than command and control technology regulations; (2) a carbon price policy should raise revenue so that other taxes can be reduced (Stavins therefore proposes that initially half, and eventually all, the permits be auctioned by the government rather than given free to firms); (3) to simplify practical administration, the carbon price should be imposed *upstream* when carbon enters the U.S. economy from a few thousand coal mines, oil refineries, natural gas pipelines, and importers, rather than *downstream* when it is emitted by millions of firms, drivers, and dwellers; and (4) the government should pay the going carbon price to any downstream carbon emitter who captures and sequesters carbon gas instead of releasing it to the atmosphere.

Stavins makes these arguments for preferring cap and trade to a tax. First, any new tax meets stiff political resistance. Second, if some permits are given out free, recipients may politically support rather than oppose the program. Third, some upstream carbon firms may successfully lobby for partial or full exemption from a tax. Fourth, cap and trade is more certain to hit the pollution reduction target than a tax—this fact appeals to environmentalists. Fifth, the European Union countries are adopting cap and trade so harmonization will be easier if the United States does too.

Metcalf makes these arguments for preferring a tax to cap-and-trade. First, historically cap and trade programs have given permits out for free and not collected revenue that can be used to reduce other taxes. Second, there will be wasteful political lobbying by firms for free permits. Third, the administration of a tax is time-tested, whereas administering cap and trade is a new challenge. Fourth, in the short run it is more important to avoid excessive abatement cost than excessive emissions because there is plenty of time to adjust emissions before global temperature is affected. Fifth, cap and trade has the volatility of stock market prices which can disrupt planning.

*The papers are available at the Hamilton Project Web site, http://www.brookings.edu/projects/hamiltonproject.aspx.

a gallon, would reduce carbon emissions in the United States about 15%. The prices of all goods that use a lot of carbon fuel in their production would rise relative to the price of goods and services produced with little carbon fuel, providing an incentive to reduce the use of carbon fuels. Carbon tax revenue would be recycled by cutting other taxes and sending households cash transfers.

To minimize the cost of reducing global warming, all countries should implement the same carbon tax. This important point can be seen by reinterpreting Figure 2.5 as applying to two firms L and H in two countries. With no tax, L and H each emit 50. If each country imposes a \$40 carbon tax, then L would cut back 40 and emit 10, while H would cut back 10 and emit 40, so total emissions would be cut from 100 to 50. The MAC of the last unit cut back by L would equal the MAC of the last unit cut back by H (each MAC would equal \$40, the tax) so the total cost of cutback is minimized.

How much more would it cost if H alone cut back 50 instead of H cutting back 10 and L cutting back 40? If H cuts back 50, the last unit cut back has an MAC of \$200, so the *average* MAC would be $\frac{1}{2} \times \$200 = \$100$. Thus, the total cost of H cutting back 50 would equal $50 \times \$100 = \$5{,}000$. By contrast, if H cuts back 10 and L cuts back 40, the last unit each cuts back would have an MAC of \$40, so the *average* MAC for both H and L would be \$20. Thus, the total cost of cutting back 50 would equal $50 \times \$20 = \$1{,}000$. In this example, the total cost if H alone cuts back 50 would be 5 times (\$5,000 vs. \$1,000) the total cost if the cutback of 50 is shared optimally between H and L.

Thus, to minimize total cost, all countries should levy the same carbon tax and share in the cutback until each country's MAC equals the tax. Any treaty that exempts any countries from levying the tax raises the cost of achieving a given reduction in global warming.

However, low-income countries make two points. First, they note that high-income countries have emitted most of the carbon over the past two centuries and are responsible for most of the buildup thus far. Second, they say they have a right to grow their economies to improve the standard of living of their people.

Is there any way to address these objections of low-income countries while heeding economists' point that all firms in all countries must face the same price to minimize the total cost of reducing world emissions? The answer is yes. It can be done if high-income countries are willing to compensate low-income countries, through revenue transfers, for agreeing to implement the carbon tax.

Consider one way this can be done. Each country would decide whether to participate in an international carbon tax treaty. Under the treaty, the country would agree to levy the specified carbon tax—for example, \$40 per ton—on all domestic emitters (the magnitude of the tax would be set by treaty participants). Each country would keep its own tax revenue and either return the revenue to its own population by cutting other taxes or use it to finance its own government programs. Then under a formula based on country per capita income (also set by treaty participants), participating countries with high per capita incomes would contribute revenue that would then be distributed to participating countries with low per capita incomes. For example, the United States would be one of the countries contributing revenue, and China would be one of the countries receiving revenue.

In our H and L example, consider a treaty where each government H and L would agree to levy a tax of \$40 on its own polluters. Even if country L has no benefit from the reduction in global warming, L should agree to levy this tax on its own polluters *if* country H pays country L at least \$800. Why? Because the cost to country L of cutting back 40 is \$800 (the MAC of the 40th unit cut back is \$40, so the average MAC is \$20, so $\$20 \times 40 = \$800$).

Should country H be willing to pay country L \$800? It depends on how much benefit country H expects to receive from the reduction in global warming. In response to the \$40 tax, H would cut back 10 (from 50 to 40), so the cost of cutback to H's economy is \$200 (because the MAC of the 10th unit cut back is \$40, so the average MAC is \$20, so $\$20 \times 10 = \$200$). Thus, the cost of cutback plus the payment to country L equals \$1,000 ($\$200 + \$800$). As long as country H believes its benefit from reducing global warming exceeds \$1,000, it should be willing to pay L \$800 to participate in the treaty.

If country L believes it would get some benefit from a reduction in global warming, then L should be willing to join the treaty for a payment from H that is less than \$800. For example, if L believes its benefit would be \$200, it should be willing to join the treaty if H pays it \$600 because its total benefit ($\$200 + \$600$) would cover its cost of cutback (\$800).

One thing is for certain:

It is better for H to cost-reimburse L in order to get L to help with the cutback rather than for H to do all the cutting back by itself.

Why? Because the first unit that L cuts back has a near-zero MAC. It would therefore be better for H to get L to start cutting back at L's initially low MAC, and to reimburse L an amount equal to L's low MAC, than for H to keep cutting back by itself at an ever-rising MAC.

It would be better for country H to pay country L $800 to join the treaty (so that L cuts back 40 and H cuts back 10) rather than for H to cut back 50 by itself. The cost to H of cutting back 50 would be $5,000 (from Figure 2.5, the MAC of the 50th unit H cuts back would be $200, so the average MAC is $100, so $\$100 \times 50 = \$5{,}000$), whereas if L joins the treaty, the cost to H is only $1,000 ($200 for its own cutback of 10 plus its payment of $800 to L).

Of course, country H wants to pay country L the minimum amount needed to get L to join the treaty, while L wants to get as much as it can from H. So there will be tough negotiations over the redistribution formula.

A Carbon Tradable Permits Treaty

An alternative way to achieve the minimum cost of cutback for the world would be a tradable permits treaty that would establish an international permit market. The treaty would set a world target for total carbon emissions and would then distribute without charge this total amount of permits among participant country governments according to an agreed upon formula. Each country government would sell (or give) a certain quantity of permits to its own firms that emit carbon and sell the rest of its permits in the international permit market. Each firm in any country that signs the treaty would be required to possess as many permits as it emits; it would meet this requirement by buying or selling permits in the international permit market. Each country government would agree to monitor its own carbon polluters to make sure each polluter emits an amount of carbon no greater than the amount of permits it possesses. If the international permit market runs smoothly, carbon polluters in all countries would face the same permit price and adjust their pollution until their own MAC was equal to that price. Hence, the MACs of all polluters would be equal.

How would a tradable permits treaty accomplish the redistribution necessary to induce low-income countries to participate? By using a formula that gives a relatively large number of permits to low-income countries and a relatively small number of permits to high-income countries. Through the international permit market there would then be a transfer of income from high-income countries to low-income countries.

In our example, suppose under the treaty formula the government of country L is given 30 permits and the government of country H is given 20 permits. We showed earlier that no matter how the 50 permits are initially distributed between H and L, the price will end up $40, and firms in L will want to emit 10, while firms in H will want to emit 40. So the government of L will sell (or give) 10 permits to its firms and sell 20 permits to the government of H which will then sell (or give) 40 permits to its firms. Thus, the government of L will sell 20 permits at $40 per permit to the government of H, thereby resulting in a redistribution of $800 from country H to country L.

A Hybrid Carbon Treaty: A Permit System with a Safety Valve

As noted earlier, it would be possible to implement a hybrid: a permit system with a safety valve. The treaty would set an initial pollution target and distribute the corresponding amount of permits to the governments of all participating countries. But if the market price of a permit rises above the ceiling price adopted under the treaty by participant country governments, the treaty would authorize and implement a prompt expansion of the supply of permits that would continue until the market price is brought back down to the ceiling price.

The Political Challenge

Developing, maintaining, and implementing such a treaty—whether it uses a tax or tradable permits—would be politically challenging. Obviously low-income countries would want to maximize revenue transfers while high-income countries would want to minimize transfers. An agreement would have to be reached concerning the voting mechanism among treaty participants that would be used to decide the tax and the formula for transferring income or the total number of permits and the formula for distributing permits to countries. In order to try to win a favorable modification of the formula, some countries might claim they were considering withdrawing from the treaty, so there would always be the risk of country withdrawals. However, it should be recognized that similar problems occur under most international treaties.

Instead of a carbon tax or tradable permits, an international treaty was negotiated in Kyoto, Japan, in 1997 under which each high-income country was assigned a specific numerical emissions target, and low-income countries were exempt. The method of achieving its target was left to each high-income country.

Note the differences between the carbon tax or tradable permits described above and the Kyoto treaty. With the tax or tradable permits, there are no emission targets for individual countries; instead the tax is set with the aim of inducing a target total world emissions, or there is an emissions target for the world that sets the total number of permits to be distributed. With the tax or permits, each carbon emitter in each country has an incentive to reduce its own emissions until its marginal abatement cost (MAC) equals the tax or permit price; because the tax or permit price is the same for all firms in all countries, MACs would end up equal among all emitters, thereby achieving the reduction in world carbon emissions at minimum cost. With Kyoto, MACs will not be equalized, so emission reduction will not be achieved at minimum cost.

Although many high-income countries have ratified the Kyoto treaty, the United States has not, and low-income countries such as China are exempt from the treaty. Thus, the two largest carbon emitters, the United States and China, are not restrained by the treaty.

Summary

Economic analysis has reached several important conclusions. The right tax—a tax equal to the marginal damage to the environment—gets the market to generate the right quantity of a polluting good. Pollution tax revenue should be used to cut other taxes or send households cash transfers. Whenever feasible, the tax should be levied per emission, not per unit of the polluting good. A tax per emission that is the same for all emitters of pollutant X minimizes the cost of abating the pollution. Tradable permits are an alternative way to charge polluters a price in order to discourage pollution. There are pros and cons to tradable permits versus pollution taxes: With tradable permits, the quantity of emissions is certain, but the cost to the economy of abatement is not limited; with a tax, the quantity of emissions is uncertain, but the cost to the economy of abatement is limited. It is better for the government to sell, rather than give, permits to polluters, because then the revenue can be used to cut other taxes; even when permits are given, the price that evolves as permits are traded among polluters tends to minimize the cost of reducing pollution in the short run though not the long run.