3. The Cost Effectiveness and Environmental Effects of Incentive Systems

3.1 Introduction

This chapter reviews several of the attributes of incentive-based strategies for managing the environment. From the perspective of economics, pollution is an output that occurs outside of normal market transactions. Termed an "externality," it has little or no cost to the source but may impose significant costs on other economic actors. How best to get sources to control their pollution is an issue that has been studied closely by economists and policy analysts.

One means of control is to rely on private negotiations between those who bear the costs of pollution and the sources of pollution. If several conditions are satisfied, such negotiations can lead to an optimal level of pollution control in which the full costs of pollution are taken into account in the decision process of the source.[14] One condition is that the sources and victims do not engage in strategic behavior. Another condition is that individuals who are harmed by pollution and sources can negotiate without any transaction costs (such as personal time or the need for third-party involvement). The final condition is that sources and victims are fully informed as to risks and harms that may occur. Although the assumption of no strategic behavior may be reasonable in many cases, costless transactions may never be a realistic assumption. The more parties who are harmed and the more geographically dispersed these parties are, the higher the transaction costs are likely to be. Likewise, it is unrealistic to assume that victims of pollution are as fully informed about risks as are the sources.

The existence of environmental legislation reflects the fact that negotiations between victims and sources of pollution cannot be relied upon as a means of control for most pollution problems. EPA's governing legislation uses various approaches to set environmental goals. Under some of the laws, the goal is to adequately protect public health and the environment without explicitly considering costs. In other cases, the governing statutes instruct EPA to take costs into account in protecting public health and the environment or to set goals that balance cost, health and environmental considerations.

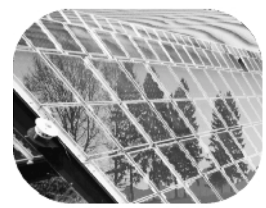
The governing environmental statutes have varying opportunities and limitations with respect to the mechanisms that are available for achieving environmental goals. In the traditional regulatory approach, EPA often specifies requirements for different types of sources (factories, vehicles, fuels, etc). The regulations may impose limitations on the amount of discharge, the technology used to control pollution, the inputs that may be used, or characteristics of the outputs that are produced.

Market-based or incentive approaches, by contrast, provide rewards for reducing pollution (and, conversely, assign penalties for releasing pollution). The rewards may or may not be financial. In contrast to the traditional regulatory approach, an incentive-based regulatory strategy gives sources great flexibility in selecting both the type and

Pollution Charges, Fees, Taxes

Deposit-Refund Systems

Trading Programs



Subsidies for Pollution Control

Liability Approaches

Information Disclosure

Voluntary Programs

magnitude of their response and gives them incentives to develop new and cheaper strategies and technologies to control pollution.

Depending upon the characteristics of the sources of pollution and the damages (see Table 3-1), some tools of environmental management are likely to be more cost-effective than are others. Cost-effective tools achieve environmental goals for the least cost. Other criteria such as fairness, political acceptability, stimulus for innovation and technological improvement, and enforceability also could be used in place of, or in conjunction with, cost effectiveness.

Table 3-1. Considerations for Selecting Regulatory Instruments

CHARACTERISTICS OF THE SOURCES OF POLLUTION

- Are the costs of control known with certainty? If not, how great is the uncertainty?
- Is the technology of pollution control static, or is it likely to change over time?
- Can the quantity of pollution from each source be measured (or approximated) easily?
- How many sources are there for each pollutant?
- Are incremental control costs similar for different sources, or is there considerable variation?

CHARACTERISTICS OF THE DAMAGE CAUSED BY POLLUTION

- Does a unit of pollution from each source have the same impact on health and the environment, regardless of where it is released?
- Are the impacts on health and the environment known with certainty? If not, how great is the uncertainty?
- What are the major sources of uncertainty? What is known regarding the effect of pollution on environmental quality, exposures, physical effects, or the economic valuation of effects?
- How many parties are experiencing damage from pollution?
- Is it critical to control pollution within narrow limits to achieve environmental goals, or is the damage caused by pollution such that there is a continuum of effects from less serious to more serious, with no obvious unacceptable level and no obvious safe level of pollution?

The following sections describe alternative means for managing the environment and the circumstances under which one mechanism is likely to perform better than another tool.

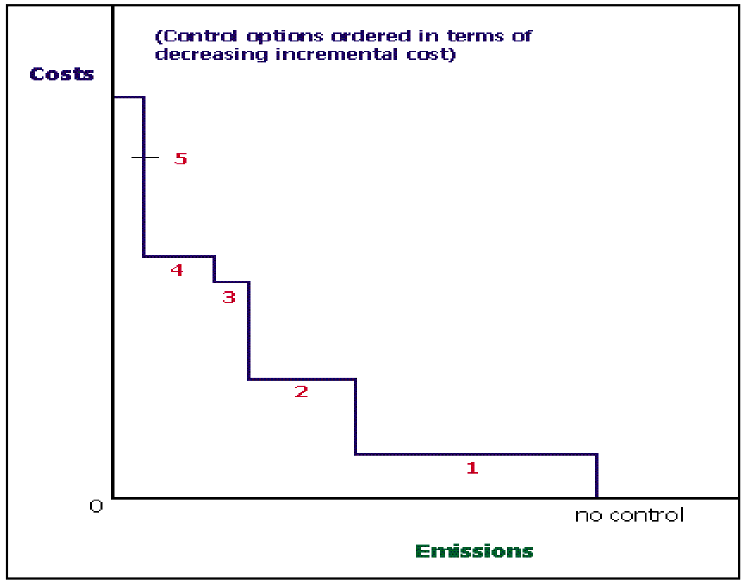
3.2 Traditional Regulatory Approaches

Traditional regulatory approaches normally operate through one of three means: source-specific emission limits, output specifications, or technology requirements. A brief description of each alternative illustrates both the strengths and weaknesses of traditional forms of regulation.

The first alternative applies emission (or effluent) limits to specific sources as a means of achieving health standards or environment-based ambient standards. The total amount of pollutants that are released could be limited by setting emissions standards for individual sources, such that total emissions just equaled the sum of the individual contributions from each source. Other pollution allocation formulas that do not treat new sources more harshly than existing sources could also be used. One such formula, for example, determines a set weight of pollution that can be released per unit of output.

Unless the authority responsible for controlling pollution is able to identify which sources have the lowest incremental costs for controlling pollution and insist that those sources implement their pollution controls first, this source-specific approach to emissions will not be cost-effective. As Figure 3-1 depicts, each source will usually have a number of options for controlling emissions. The least cost option (#1 in the figure) will control some emissions. Other successively more expensive measures may be implemented until all emissions are controlled.

Figure 3-1. Control Options for a Source



It is very difficult in practice to identify the least cost strategy for controlling emissions from multiple sources. If all control measures and their costs are known, linear programming or other modeling techniques could be used to find the least cost strategy for every level of emission control for the sources taken as a whole. However, in most cases all potentially available control measures are not known, and, even if they were, pollution control laws typically do not allow an agency to impose strict controls at one source and relatively lenient control burdens on another, even if their control costs are quite different. Generally, similar sources must be treated the same. Furthermore, incremental control costs include more than simply the costs that sources must bear in order to comply with regulations, as noted earlier. It is likely to be difficult to predict in advance how emission limits would affect production technology, energy and other input use, and other cost elements. Economic instruments avoid the problems that a pollution control agency would have in identifying the least cost methods of meeting a pollution control objective by harnessing market forces to identify cost-effective solutions.

The second alternative specifies certain characteristics of outputs that are destined for the product market. Some examples include fuel efficiency requirements for automobiles, product specifications for gasoline, and regulations regarding the ability of products to be recycled and the recycled material content of consumer products. The regulatory strategy of imposing limitations on the polluting characteristics of products is affected by the same issues noted above that make it difficult to regulate emissions in a cost-effective manner. For example, the cost to individual refineries of meeting a sulfur limit in gasoline is likely to vary significantly. It would be more efficient to allow trading among sources to meet pollution reduction obligations than to apply uniform standards to each source.

The third alternative imposes technology requirements that specify the techniques or equipment that sources must use to control pollution. EPA prefers to use performance-based numerical limits rather than technology requirements whenever feasible, and, in fact, the Agency's programs rely heavily on numerical limits. Some standards that are performance-based demand a level of emission control that can be met only with one existing technology. Unless pollution control technologies improve, such performance standards have the same effect as technology standards. (For example, new source performance standards for SO_2 emissions at coal-fired electric power plants require a 90% reduction in these emissions from their uncontrolled state, a degree of control that can be met only by scrubbing.)

Technology standards (or more accurately de facto technology standards) are likely to be less cost-effective than emission or effluent standards, since the latter give sources the freedom to choose the least costly method of compliance. Further, technology standards tend to lock firms into one accepted method of compliance, which discourages technical change and innovation. However, when emissions cannot be measured or concerns exist about the feasibility of enforcing tax or trading systems or both, technology standards provide a practical way to reduce pollution.

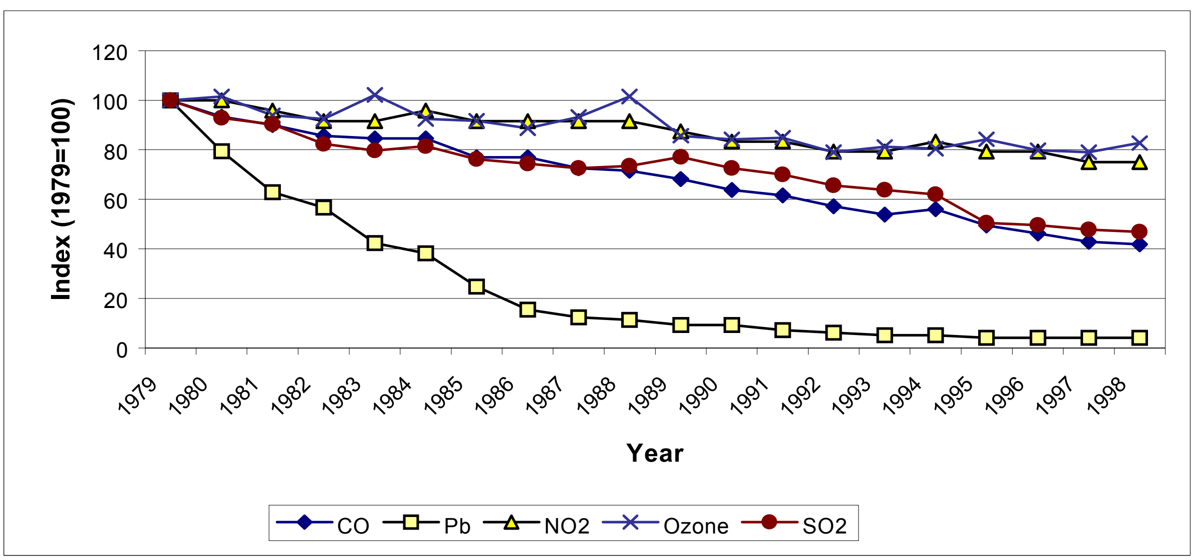
From a dynamic perspective, identifying the strategies that should be implemented to control pollution at the least cost is more problematic. Technology is not static. Over time, the number of possible options increases. Most of the options offer improvements over earlier technologies, in terms of cost, environmental performance or both. A traditional regulatory strategy to identify and mandate least cost controls can lock firms into technologies that become progressively less effective, and thus less attractive, over time.

These issues aside, traditional regulatory policies have achieved much in the United States. For the most part, traditional regulatory policies have resulted in ambient air and water quality that is demonstrably better now than it was 30 years ago when the EPA was established. The most recent *Emissions Trends Report* (EPA, 1998b) reveals that emissions of all criteria pollutants have declined since 1979: In the case of sulfur dioxide and carbon monoxide, emissions have been reduced by more than 50% and lead emissions by more than 95%. (See Figure 3-2.) Water quality is also improving. This achievement is significant given the economic growth and increasing populations that has occurred over the same period of time.

3.3 Incentive-Based Mechanisms

While incentive-based systems have existed in some form for decades as tools of environmental

Figure 3-2. National Long-Term Air Quality Trends, 1979-1998



Source: EPA 1998b

management, the federal government has aggressively sought their implementation for only the past 10 to 15 years. Economic incentives to protect the environment rely on decentralized decision making by economic agents, all acting in their own self interest. In contrast, traditional regulatory approaches to environmental management are based on the regulations established by federal, state, or tribal governments that have been given the authority to make pollution control decisions. Actual compliance is the responsibility of the sources of pollution that are subject to the regulations. However, the flexibility that sources have to choose technology, as well as the extent of pollution control, tends to be quite limited under a traditional regulatory approach. Economic incentive methods generally allow sources to select how much they reduce pollution and the technology that helps them in this endeavor.

3.3.1 Pollution Charges, Fees, and Taxes

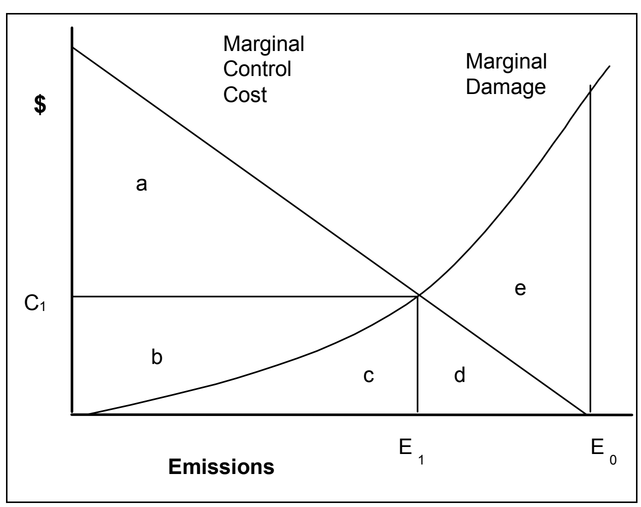
Pollution charges, fees, and taxes are payments required of sources for emitting pollution. (The three terms are used interchangeably here.) Ideally, sources would pay for each unit of pollution they emit. A source that is concerned with minimizing costs and is also faced with such a tax will control those emissions for which control costs are less than the tax and release the remainder. The source will then pay the tax on each of those units of pollution released into the environment.

A simplified analysis of charges, fees, and taxes from an economic perspective is illustrated in Figure 3-3. Prior to regulation, total uncontrolled emissions are equal in magnitude to E_0. Damage to the environment is equal to the area (c+d+e) and the source spends nothing on pollution control. If an emission fee of magnitude C_1 were imposed, cost-minimizing polluters would reduce total emissions to E_1. The total costs of pollution, which is equal to the sum of pollution control costs and environmental damage (c+d), are minimized with the fee at level C_1

Emission fees set at C_1 per unit of emissions cause cost-minimizing polluters to pay for all emissions up to E_1, an amount equal to the area (b+c) in Figure 3-3. Polluters subject to the fee spend an amount equal to area (d) to control emissions beyond E_1 and reduce environmental damage by an amount equal to the area (d+e) relative to uncontrolled emissions.

Emission fees that are high enough to change behavior significantly, like the one shown in this example, would typically result in large revenue transfers to the government. That is, payments the government, equal to area (b+c) in Figure 3-3, tend to be large, especially relative to the environmental damage that is mitigated, area (d). For this reason, polluters usually oppose pollution charges, taxes, and fees that would be high enough to act as an incentive for them to reduce pollution. They would prefer that their environmental expenditures be used to control pollution, not sent to the government.

Figure 3-3. Tax Per Unit of Emissions



From an economic perspective, charges, taxes and fees are basically interchangeable, although from a legislative and legal perspective some differences exist. The House Ways and Means Committee must review proposed taxes, since tax revenues are a part of general federal revenues. Fees and charges, in contrast, are designed to recover some or all of EPA's administrative costs and need only be reviewed by environment committees and subcommittees. Fees and charges are imposed in two ways. First, an environmental statute may specify the activities that are subject to fees and charges. Second, EPA has additional general authority to collect and assess fees and charges under the Independent Offices Appropriations Act (31 U.S.C. §9701). Fees and charges assessed and collected under this Act must be deposited into the General Fund of the Treasury and cannot be retained by EPA.

Legislation authorizing pollution fees, taxes, and charges typically limits their magnitude to what is necessary to recover the costs of administering the program in question or related programs. Worldwide, the vast majority of emission tax, fee, and charge systems collect revenues that amount to only a few percent of pollution control costs.

Two exceptions are noted. The first is the tax on U.S. chlorofluorocarbon (CFC) production. This tax was designed to remove windfall profits that would otherwise accrue to CFC producers from increases in CFC prices due to reductions in the quantities of CFCs allowed in commerce. This tax is discussed in more detail later in this report. The second exception is the Swedish charge on NO_x emissions, which is set at a high level with the objective of changing behavior. Power plants pay the NO_x charge on emissions of NO_x and receive rebates in proportion to their energy output. The result is a mechanism that raises no revenue for the government yet produces significant incentives.[15] Relatively clean facilities receive rebates in excess of payments while relatively dirty facilities pay more in charges than they receive in rebates.

Designing pollution taxes that minimize the total costs of pollution (damage costs plus control costs) is difficult for a variety of reasons, including the lack of data on pollution damages, the inability to precisely measure emissions, and political opposition to large revenue transfers from pollution sources (companies) to the authority imposing the tax (government). The relationship between the quantity of emissions and the cost of the damages caused by those emissions (often called the "pollution damage function") depicted in Figure 3-3 is highly simplified and glosses over a number of difficult measurement issues. In many situations, the function is not well known, so the ability of an agency to set charges to equate marginal control costs with marginal damages is questionable. Moreover, the damage function may differ from one localized area to another depending upon the population at risk, prevailing winds, sunshine, temperature, and other factors. If marginal control costs or marginal damages differ from one region to another, a single charge level may be inappropriate. Charges that differ by region may be required in order to achieve the efficient amount of pollution control. In addition, an emission tax provides the pollution control agency with limited control over the physical quantity of emissions dispersed into the environment because sources have the choice of controlling emissions or releasing emissions and paying the tax. If the magnitude of emissions is very important, as could be the case with toxic emissions that threaten public health, an emission tax may be viewed as an inadequate control over the actual quantity of emissions.

The implementation of emission fees, taxes, and charges also depends on the ability to measure emissions. The precision with which a pollution tax can be levied depends on the precision with which emissions can be measured. Political concerns may also be an issue in implementing emission taxes. Environmentalists sometimes oppose emissions fees because they seem to sanction the release of pollution.

3.3.2 Deposit-Refund Systems

A deposit-refund system operates like a tax on the purchase of a product with a subsidy for returning the used item to a designated collection site. The purpose of the subsidy or refund is to encourage individuals and firms to dispose of these items in an environmentally acceptable manner. The tax or deposit is made on the original purchase and yields sufficient revenue to pay future refunds. Some or all of the unclaimed deposits may be used to subsidize collection facilities. While the magnitudes of the deposit and the refund often are the same, there is no reason that this has to be the case.

Although most deposit-refund systems are created by legislation, deposit-refund systems sometimes are developed by the private sector when the used product has economic value. Thus, private-sector deposit-refund systems for beverage containers were widespread in the early part of the twentieth century before cheaper, non-returnable containers appeared. Mandatory deposit legislation for lead-acid automotive batteries has been enacted in about a dozen states, while the private sector has created deposit systems for lead-acid batteries in the remainder of the states, largely because of the economic value of used batteries. Ten states have enacted beverage container deposit-refund systems. Deposit systems exist for car bodies in four European nations, and for a wide variety of containers throughout most European nations. In a few nations of Europe, deposit systems help assure the recycling of used motor oil.

Administrative costs are an important consideration when determining whether to create deposit systems. Ackerman et al. (1995) estimate that administrative costs average about 2.3 cents per container—more than $300 per ton for steel containers and $1,300 per ton for aluminum cans—in states with traditional legislation on beverage container deposit systems. A full accounting of the desirability of deposit-refund systems would compare administrative costs and the costs imposed on consumers with the benefits of reduced disposal costs, energy savings, reduced litter, and other environmental benefits. Deposit-refund systems appear best suited for products whose disposal is difficult to monitor and potentially harmful to the environment. When the used product has economic value, the private sector may initiate the program.

3.3.3 Marketable Permit Systems

Two main forms of trading systems are observed: emission (or effluent) reduction credits (ERCs), and tradable allowances for future pollution. ERCs are earned by sources when they release less pollution than is authorized in their environmental permits. With either form of trading system, sources with high marginal control costs will try to buy credits or allowances from sources with low marginal control costs. Trading ERCs or allowances in such a situation is mutually beneficial.

For trading systems to function well, several requirements must be satisfied. First, there should be several potential participants (i.e., sellers and buyers of allowances or ERCs) so that a functioning market can develop. Exactly how small a universe of potential participants is sufficient for a functioning market is difficult to say, but simulation experiments suggest that 8 to 10 participants is a reasonable estimate.[16] Second, if sources are dispersed geographically, trading ratios other than one-to-one might have to be imposed to assure no degradation in environmental quality in particular locations.

Third, pollution control agencies must have the ability to monitor emissions (or measure a surrogate) reasonably well. The commodity to be traded needs to have constant or near-constant impacts across the geographic area where trading is allowed. Fourth, the commodity to be traded must be quantifiable. The process of establishing emission baselines so that credits or allowances can be quantified is likely to require good historic data on emissions, input use, processes, etc.

Trading systems tend to be more popular with pollution sources than pollution charges because in many cases sources do not have to pay for emissions that are below permitted amounts. In fact, the right to emit pollutants up to permitted amounts and not pay for those emissions may have a considerable value once a trading system is created.

The literature that is cited later in this chapter predicts large, potential savings from trading systems. Available evidence on actual achievements, however, points to relatively modest savings from many of the programs. In searching for the reasons why such a wide gap exists between the potential savings and the actual savings, Stavins (2000) identifies transaction costs as the primary culprit. For example, the need to ensure that the credits claimed under the trading system represent real emissions reductions is one source of transaction costs.

With high transaction costs, the prices that sellers receive for pollution rights is depressed and the prices that buyers must pay for these rights remains high, which makes transactions less attractive for both buyers and sellers. With transaction costs acting as a barrier to trading, sources find it difficult to identify potential trading partners and to conclude trades. Transaction costs were especially high for some of the early emissions and effluent trading programs. Only a tiny fraction of the potentially beneficial trades actually took place.[17] Transaction costs were lower for programs such as lead credit trading and resulted in a far higher proportion of available credits actually being traded.

Price versus Quantity Instruments

The economics literature makes an important distinction between price and quantity instruments when a regulatory authority is uncertain regarding control costs and damage functions (Weitzman, 1974). Quantity instruments, such as cap and trade systems, provide the pollution control authority strict control over the quantity of emissions. Price instruments, such as pollution taxes and fees, provide strict limits on how much a firm must spend to control pollution but do not limit the release of emissions.

With uncertainty, the regulatory authority would not be able to predict costs well if it implements a quantity-based pollution control mechanism, or the environmental consequences if it implements a price-based approach. Which type of uncertainty is likely to be more serious? If important environmental threshold effects exist, a quantity approach would be preferred. But few pollutants have that characteristic; most exhibit relatively stable dose-response relationships. Because of difficulties in forecasting control technologies, it may be more important to limit the maximum amount that sources incur to control pollution. Thus, uncertainty may offer a reason to prefer price to quantity instruments for many types of pollution.

Transaction costs also feature prominently in the choice between making trades between sources within a firm (internal trades) and between firms (external trades). For all of the trading programs that have been studied, firms exhibit a strong preference for internal trading when it is feasible, often even when larger cost savings can be achieved by external trading.[18]

3.3.4 Subsidies for Reducing Pollution or Improving the Environment

Subsidies are the mirror image of emission taxes. Rather than taxing emissions to encourage firms to reduce their emissions, the subsidy approach offers cash payments to firms for reducing emissions. Polluters who release emissions forgo the cash payment. Under a subsidy system, polluters have an incentive to control all units of pollution whose marginal control cost is less than the subsidy. Subsidy systems for pollution control are especially popular in two sectors: farming and municipal government.

Economists point out a major drawback of subsidy systems. Existing firms, farmers, and other entities that receive pollution control subsidies would have an incentive to reduce their pollution. However, the subsidies could attract new firms to enter the industry. In some extreme cases, pollution control subsidies could have the perverse effect of increasing total pollution.

Both federal and state governments have numerous subsidies already written into the tax code, a number of which are perceived as having harmful environmental consequences. Reducing environmentally harmful subsidies is another mechanism for improving the environment.

3.3.5 Liability for Harm Caused by Pollution

Another approach for resolving environmental issues is to make polluters liable for the damage their pollution causes. The purpose is twofold: First, to get polluters to make more careful decisions about the release of pollution; and second, to compensate victims of pollution. Liability rules control pollution through the decentralized decisions of polluters to act in their own best interest.

If polluters are liable (and must pay) for the damage they cause, they will control pollution to the point where the marginal pollution damage equals the marginal costs of control. At this point, their total payments for controlling pollution and compensating victims are minimized.

Liability can take two forms: civil law and common law. Civil liability is expressly written into law. Many environmental statutes worldwide have liability provisions. In the United States, the most important statutes are the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which holds responsible parties liable for cleanup costs, and the Oil Pollution Act (OPA), which holds responsible parties liable for damage to natural resources caused by releases of hazardous substances and petroleum. Liability under CERCLA applies to historic as well as contemporary releases of pollutants. The form of liability is strict, joint, and several, meaning that a single contributor can be held responsible for all of the damage, even though many contributors caused the damage. Furthermore, liability is retroactive. Therefore, an individual or company can be held liable for actions that were perfectly legal at the time they occurred.

In an attempt to improve the incentive effects for cleaning up hazardous waste sites, EPA and the states have developed numerous so-called "Brownfields" initiatives, which are described in this report. The initiatives provide limited relief from strict and retroactive liability in exchange for promises to clean hazardous waste sites and turn them into productive assets. EPA recognized the need to address some of the concerns raised in the past regarding the fairness of enforcement in Superfund. As a result, EPA has taken significant steps to reduce litigation, to promote faster settlements, and to emphasize fairness in the application of Superfund's liability scheme. By streamlining the process by which claims are resolved at Superfund sites, EPA is accelerating the cleanups themselves and increasing the pace at which contaminated properties can be moved back into viable economic use, which is the critical first step in expediting many brownfields development projects.

Polluters respond to federal and state pollution liability statutes by taking precautionary actions that reduce the severity and frequency of spills. Alberini and Austin found this effect with respect to the imposition of strict liability laws by states.[19] The petroleum industry created the

Marine Spill Response Corporation, an emergency spill response effort, following the Exxon Valdez spill and the 1990 Oil Pollution Act.[20]

Common law, such as nuisance, trespass, and negligence, can be used to address harm to individuals and to private property that is caused by pollution. The effectiveness of these approaches in dealing with pollution is an open question. In selected applications, liability can be a strong deterrent, but a number of considerations limit the effectiveness of this approach as a general solution to pollution-related problems. One factor that restricts its widespread use is the time limit for filing claims, otherwise known as the "statute of limitations." In most jurisdictions, a case must be filed within two or three years of discovering a harm. In a few jurisdictions, a case must be filed within a two- or three-year period of when the harm occurred. This distinction is very important for individuals who develop cancer and other diseases of long latency possibly as a result of exposure to toxic substances, since observable effects may arise many years or even decades following the exposure.

A second limiting factor is the burden of proof required by law. The burden of proof required for a judgment against the defendant is usually the standard of “more likely than not,” which usually is interpreted as having a probability greater than 50%. Epidemiological studies may suggest that exposure to a particular toxic substance is but one of many factors that could have caused a disease. Satisfying the more-likely-than-not standard can be difficult. Even if a substance is implicated, it may be difficult to determine which polluter is responsible for the harm. For example, doctors may determine that an auto mechanic’s lung cancer likely was caused by inhaling dust from brake linings, but assigning responsibility to a particular manufacturer may be impossible. A few jurisdictions allow the assignment of proportional responsibility for both the harm-causing substance and for the determination of who is responsible.

A final limiting factor for liability systems are the transaction costs of pursuing a claim. These costs include the legal costs of obtaining evidence, reaching agreement among plaintiffs on how to pursue a case, presenting the case, and following up if the case is appealed. Liability works best when there is one party on each side of the case and an easily demonstrated harm. When the harm is large in magnitude, liability systems may perform reasonably well when transaction costs are small in proportion to the amounts awarded and if there are few defendants and clear causation, even if the number of plaintiffs is large.

3.3.6 Information Disclosure

By information disclosure programs, this report refers to mandatory disclosure requirements, such as those associated with California’s Proposition 65 and the Emergency Planning and Community Right-to-Know Act (EPCRA), which also is referred to as Title III of the Superfund Amendments and Reauthorization Act of 1986. At the time these statutes were enacted, there was little evidence as to how companies would respond to information disclosure rules, other than that they strenuously objected to such requirements.

A number of retrospective studies found that EPCRA requirements gave a strong incentive for firms to identify and act upon opportunities for reducing accidental and routine releases of hazardous substances.[21] Information reporting requirements caused firms to behave as if all emissions were costly. Emissions that could be controlled relatively cheaply were reduced.

3.3.7 Voluntary Pollution Reduction Programs

At both the state and federal level, an enormous number of voluntary programs attempt to motivate firms and individuals to reduce pollution, promote conservation, and increase recycling. There are many reasons why voluntary programs are increasing in popularity. First, although the statutory authorities for creating programs and regulating sources through traditional regulatory mechanisms may be fully implemented, many less serious pollution and resource conservation problems remain. Second, voluntary programs are perceived to have low costs because firms and individuals undertake the measures on a purely voluntary basis. Unlike traditional regulatory measures, voluntary programs do not carry the threat of enforcement actions and penalties for noncompliance. Third, voluntary programs are sometimes used to experiment with new approaches to pollution control, approaches that may be adopted by law or regulation at a later date.

What incentive do firms and individuals have to participate in voluntary programs? In some cases, the reward is limited to the satisfaction of doing a good deed. Many recycling programs would be characterized as such. Participants in some voluntary programs receive free technical assistance regarding pollution control options. The permit approval process may be accelerated for firms that participate in some voluntary programs. Finally, many voluntary programs publicly acknowledge the participants that have successfully met program criteria. Being publicly recognized as an environmentally responsible firm could bring benefits such as increased product sales, improved access to talented workers, and a lower cost of capital to the firm.

3.4 Relative Cost Effectiveness

Economic analysis indicates that incentive mechanisms can often increase the cost effectiveness of pollution control relative to traditional regulatory approaches. Several reasons exist for this conclusion. First, some incentive-based mechanisms explicitly allow the trading of pollution allowances or pollution reduction credits. By trading credits or allowances, sources with high incremental costs of pollution control can have their obligations satisfied by sources with low incremental costs of pollution control. Other incentive-based mechanisms levy a charge or tax on each unit of pollution. Under such an approach sources would control pollution only to the point at which the incremental cost of control equaled the charge or tax. In an ideal world that did not have transaction costs and competitive markets, both permit/credit trading and pollution fee, charge and tax approaches should result in the same marginal cost of controlling pollution at each source. In such an idealized world of economic incentives, control costs should be lower than (or, at most, the same as) the costs associated with a traditional regulatory approach.

Being cost-effective, though, does not necessarily guarantee that the net benefits of pollution control are higher when an incentive-based approach is used. For example, the location of individual sources can matter. One source may be located upwind of a large population center while another is downwind. Equating marginal control costs per ton or equating the trading of allowances or pollution reduction credits among sources may well not maximize net benefits to society. Imagine the consequences if allowance trading resulted in greater emissions at a source upwind of a population center and lower emissions at a downwind source.

A number of other incentive-based mechanisms, such as information reporting requirements, liability rules, and voluntary programs, rely on implicit charges for pollution. The cost effectiveness of such mechanisms is more difficult to predict because sources are reducing pollution for reasons that have only an indirect financial consequence. In some cases, a financial link to incentive-based approaches is very tenuous. The motive for participating in voluntary programs is largely one of improving corporate image to customers, to employees, and to regulators, although management's concern for the environment certainly could be a factor. With corporate image as the principal goal, the benefit to a firm of reducing emissions is difficult to express in financial terms. Perhaps the best that could be done is to examine what firms actually spend to participate in such programs to determine their willingness to pay for pollution reduction. One might find that firms respond in a systematic fashion to the various indirect incentives. Across a sample of firms, liability, for example, might generate a higher willingness to pay for a unit of pollution reduction than an information-reporting requirement, which in turn might exceed the willingness to pay for strictly voluntary activities.

An emerging literature has examined the impacts of existing taxes on the cost effectiveness of different approaches to environmental management (the so-called "tax-interaction" effect). If true, the tax interaction effect would raise the social cost of all environmental programs that control pollution. It appears that economic instruments fare better under these calculations than do traditional regulatory approaches. Goulder et al. (1998) used a general equilibrium model to demonstrate that preexisting taxes would make pollution control about 35% more costly than what was calculated with conventional methods. Relative to conventional calculations of cost, the general equilibrium method shows all forms of regulation as being more costly, however economic instruments maintain their cost advantages. Another observation is that the relative performance of economic instruments can be enhanced through careful design. For example, auctioning marketable permits can result in important efficiency gains relative to simply giving these permits to existing sources (so called "grandfathering").

Parry and Bento (1999) extended the results calculated by Goulder et al. with a simple numerical model that evaluated the effects of tax-favored consumption (e.g., employer- provided health insurance and the mortgage interest deduction). In this model, some economic instruments perform much better than traditional regulatory alternatives. In particular, the welfare gain from using revenue-neutral environmental taxes or the auctioning of emission permits can be greater than previously thought. Under certain conditions, the welfare costs of an environmental tax can be negative.

In a reexamination of the Goulder tax-interaction effect, Jaeger (2000) finds evidence of a double-dividend effect but not the alleged tax-interaction effect.[22] With the double-dividend effect, not only is pollution controlled with a tax or trading program, but revenues are also raised for other worthwhile programs.

Several studies that compare the theoretical cost effectiveness of incentive mechanisms to traditional regulatory approaches to managing the environment are summarized in Table 3-2 (air pollution); Table 3-3 (water pollution); Table 3-4 (solid waste); and Table 3-5 (other pollution-related issues). Many of these studies did not specify the precise nature of the market-based mechanism that would be used. Rather, the assumption was made that either pollution taxes or marketable permits would yield the least cost outcome that was identified through linear programming. One observes in every case that the ratio of costs comparing the traditional regulatory approach with the market-based approach exceeds 1, and sometimes it far exceeds 1.

Table 3-2. Potential Savings from Using Economic Incentives to Control Air Pollution

Pollutant Controlled	Study Year, Source	Geographic Area	Traditional Regulatory Approach	Ratio of Costs: Traditional Approach vs. Incentive Approach
Hydrocarbons	Maloney & Yandle (1984) T	DuPont facilities in United States	Uniform percent reduction	4.15
Nitrogen dioxide	Seskin et al. (1983) T	Chicago	Proposed Reasonably Available Control Technology (RACT) regulations	14.4
Nitrogen dioxide	Krupnick (1986) O	Baltimore	Proposed RACT regulations	5.9
Total Suspended Particulates (TSP)	Atkinson & Lewis (1974) T	St. Louis	State Implementation Plan (SIP) regulation	6.0
Particulates (TSP)	McGartland (1984) T	Baltimore	SIP regulations	4.18
Particulates (TSP)	Spofford (1984) T	Lower Delaware Valley	Uniform percent reduction	22.0
Particulates (TSP)	Oates et al. (1989) O	Baltimore	Equal proportional treatment	4.0 at 90 ug/m3
Reactive organic gases and NO_2	SCAQMD (1992) O	Southern California	Best Available Control Technology	1.5 in 1994 1.3 in 1997
Sulfur dioxide	Roach et al. (1981) T	Four Corners Area	SIP regulation	4.25
Sulfur dioxide	Atkinson (1983) A	Cleveland		
Sulfur dioxide	Spofford (1984) T	Lower Delaware Valley	Uniform percent reduction	1.78
Sulfur dioxide	ICF Resources (1989) O	United States	Uniform emission limit	5.0
Sulfates	Hahn and Noll (1982) T	Los Angeles	California emission standards	1.07
Six air pollutants	Kohn (1978) A	St. Louis		
Benzene	Nichols et al. (1983) A	United States		
Chlorofluorocarbons	Palmer et al. (1980); Shapiro and Warhit (1983) T	United States	Proposed emission standards	1.96
All regulated air pollutants	Bates et al. (1994) O	Poland	European Community and German standards	1.1 to 1.2
Sulfur dioxide	Haklos (1994) O	Europe	Uniform percent reduction	1.42
Ozone	Hahn (1995) O	United States	Vehicle mandate in CA and Northeastern United States	1.3 (NE only) 2.0 (CA + NE)
NO_x	Krupnick at al. (2000) O	Eastern United States	EPA SIP call provisions	1.83 (utilities) 2.0 (all sources)[23]

Note: T refers to original citation in Tietenberg (1990), A to original citation in Anderson et al. (1990), and O to original publication of paper.

Table 3-3. Potential Savings from Using Economic Incentives to Control Water Pollution

Substance Controlled	Source Year, Source	Geographic Area	Traditional Regulatory Approach	Ratio of Costs: Traditional Approach vs. Incentive Approach
Biochemical Oxygen Demand (BOD)	Johnson (1967) T	Delaware Estuary	Equal proportional treatment	3.13 at 2 mg/l 1.62 at 3 mg/l 1.43 at 4 mg/l
BOD	O'Neil (1980) T	Lower Fox River, WI	Equal proportional treatment	2.29 at 2 mg/l 1.71 at 4 mg/l 1.45 at 6.2 mg/l
BOD	Eheart et al. (1983) T	Willamette River, OR	Equal proportional treatment	1.12 at 4.8 mg/l 1.19 at 7.5 mg/l
BOD	Eheart, et al. (1983) T	Delaware Estuary	Equal proportional treatment	3.00 at 3 mg/l 2.92 at 3.6 mg/l
BOD	Eheart et al. (1983) T	Upper Hudson River, NY	Equal proportional treatment	1.54 at 5.1 mg/l 1.62 at 5.9 mg/l
BOD	Eheart et al. (1983) T	Mohawk River, NY	Equal proportional treatment	1.22 at 6.8 mg/l
Heavy metals	Opaluch & Kashmanian (1985) O	Rhode Island jewelry industry	Technology-based standards	1.8
Selenium	EDF (1994) O	Central Valley, CA	Best management practices	1.2
Nitrogen	Moore (2000) O	Long Island Sound	Equal treatment	1.46 at 3.5 mg/l
Nitrogen	Shabman and Stephenson (1998) O	Long Island Sound	Equal treatment	1.56 at 3.5 mg/l
Phosphorus	Faeth (2000) O	Minnesota River Valley	Equal treatment	2.7 at 1ppm/l
Phosphorus	Faeth (2000) O	Rock River, WI	Equal treatment	1.74 at 1 mg/l
Phosphorus	Faeth (2000) O	Saginaw Bay, MI	Equal treatment	5.9 at 1 mg/l

Note: T refers to original citation in Tietenberg (1990), A to original citation in Anderson, et al. (1990), and O to original publication of paper.

Table 3-4. Potential Savings from Using Economic Incentives to Control Solid Waste

Substance Controlled	Study Year, Source	Geographic Area	Traditional Regulatory Approach	Ratio of Costs: Traditional Approach vs. Incentive Approach
Municipal solid waste	Palmer, et al. (1995)	United States	Uniform percent reduction of 10%	2.0

Of course, these ratios are merely theoretical calculations of potential savings. Actual savings could be much less if sources face high transaction costs with trading regimes, a scenario that severs as the basis for comparison in most of the studies. A recent report to EPA (Anderson, 1999) used these studies and other inputs to calculate the potential savings from the widespread use of economic instruments in environmental management. The estimate is large—on the order of $45 billion a year, or almost one-fourth of current environmental expenditures of $200 billion a year at the federal, state, and local levels.

Table 3-5. Potential Savings from Using Economic Incentives for Other Pollution-Related Issues

Substance Controlled	Study Year, Source	Geographic Area	Traditional Regulatory Approach	Ratio of Costs: Traditional Approach vs. Incentive Approach
Fuel efficiency	Charles River Associates (1991)	United States	Corporate Average Fuel Economy standards	4.5
Agricultural chemicals	Rendleman et al. (1995)	United States	Uniform percent reduction	1.1
Traffic congestion	Hau (1990)	Hong Kong	Car ownership restraint	2.5

Examining the performance of trading systems in particular, one finds that existing applications fail to achieve anywhere near their theoretical potential cost savings.[24] Trades have been fewer and cost savings smaller, according to this analysis, than indicated by economic modeling. A number of explanations have been offered for why the predicted savings are not realized.[25] Regulatory and legal requirements of the actual programs may limit the trading opportunities to a greater extent than portrayed in the models, especially where the incentive programs operate in conjunction with traditional regulatory programs. Various models have not fully reflected all the aspects of real regulatory programs, including the transaction costs, restrictive trading rules, monitoring and reporting requirements, and the administrative burden placed on both emission sources and regulatory agencies.

In addition to the limitations imposed by the regulatory structure, potential participants in trading systems may be reluctant to trade emissions credits or allowances, preferring instead the greater certainty of installing pollution control equipment at their facilities. Moreover, pollution credits have a limited life whereas engineering controls, in principle, last for the life of a facility. In most trading systems, the vast majority of trades that take place occur within firms, not between firms. Furthermore, markets for permits that are available for sale tend to be thin, and it may be difficult to locate potential sellers.[26]

For tax, charge, and fee systems in the United States, the principal limitation to achieving the theoretical gains in cost effectiveness has been the generally low level of charges relative to the levels that would be required to have a significant impact on pollution. Typically, charges are set to recover the administrative costs of a program, not to affect pollution.

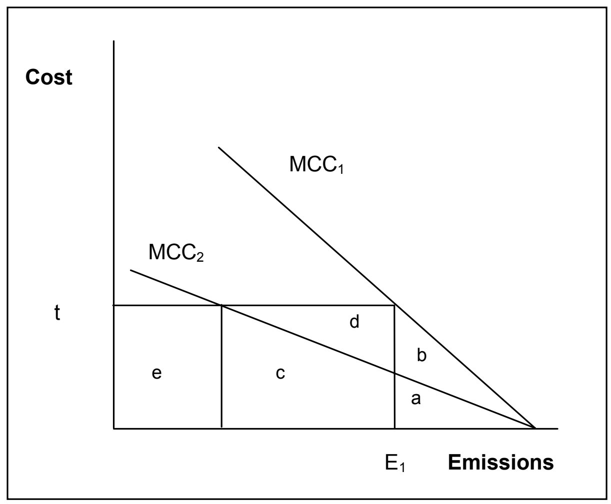
Even if the cost savings of trading systems are less than predicted, the actual savings are still impressive. In the appropriate circumstances, the wider use of incentive programs that are feasible in an actual policy setting will result in substantial cost savings while achieving equivalent environmental goals. In other circumstances, the cost differences between an incentive program and a well-designed traditional regulatory program will be less, although the incentive program will provide a stronger stimulus for innovation and technical change.[27]

3.5 Economic Instruments and Technological Change

Market-based instruments should have significant advantages over traditional regulatory mechanisms in terms of stimulating technical change and innovation in pollution control. The reason is that each and every unit of pollution is costly to the source. In contrast, under a traditional regulatory approach, once a source has satisfied the emission limits, all pollution within those limits has no cost. Why spend valuable resources instituting further controls when there is no offsetting cost savings? In fact, there generally is no incentive for a facility to reduce pollution much below permitted amounts because such an action would invite regulators to reduce the facility's permit limits. In many parts of the nation, pollution control agencies are constantly struggling to find ways of meeting ambient environmental quality goals. Facilities that demonstrate the possibility of making emission reductions below permitted amounts offer an easy target for obtaining some of the necessary emission reductions. These same innovative firms may be the catalysts for developing regulations that require other firms in the same industry to reduce their emissions to the amount shown to be feasible.

Figure 3-4 graphically depicts the difference in incentives produced by an emissions tax and by a traditional regulatory policy. A firm with marginal control costs (MCC) of MCC_1, facing an emission standard set at E_1 will control emissions to that level and incur costs equal to areas (a+b) for controlling all emissions beyond E_1. With an emissions tax set at t, the firm also would control emissions to E_1, but the firm would not only incur control costs of (a+b) but also would have to pay the tax on E_1 of emissions equal to (c+d+e).

Figure 3-4. Comparison of Emission Tax and Emission Limit



The incentive for sources to find improved methods of pollution control are much stronger under the emissions tax, since total pollution control costs are much higher. If the source finds a new, cheaper pollution control technology (represented by the shift in marginal control costs to MCC_2 in Figure 3-4), total abatement costs under the emissions standard approach would fall by an amount equal to area (b). Under the emissions tax approach, total pollution control outlays would equal (a+c+e), a decrease of (b+d).

It should not be surprising that the theoretical and empirical literature concludes that emission taxes provide the greatest stimulus for technical change and innovation, with marketable permits offering a lesser stimulus and traditional regulatory approaches the least. Among traditional regulatory approaches, it is safe to say that performance-based standards should provide a greater incentive to innovate than would pure technology requirements.

Long-run changes in behavior and technology are among the most difficult economic effects to document. For that reason, relatively little is known of the effects that take place as a consequence of different pollution control policies. Yet these effects are thought to be very important.

Outlays for research and development (R&D) in pollution control are between 2% and 3% of total pollution control expenditures. This percentage is about the same as the average R&D expenditure in all of U.S. manufacturing. Pollution control that is based more heavily on economic instruments would be expected to stimulate greater R&D and, in turn, reduce the costs of improving the environment over the long run.

There is historical evidence that Clean Air Act requirements (some market-based, some not) have helped to provide impetus and market opportunities for technology innovation and performance improvements. Innovative companies have responded by producing breakthroughs such as alternatives to ozone-depleting chemicals and new super-performing catalysts for automobile emissions. There are many examples of technologies that were not commercially available a dozen years ago, but that are now important elements of pollution control programs. These examples include the following:

- Selective Catalytic Reduction (SCR) for NO_x emissions from power plants
- Advanced gas reburning technology for NO_x
- Scrubbers that achieve 95% SO_2 control on utility boilers
- Sophisticated new valve seals and detection equipment to control leaks
- Water-based and powder-based coatings to replace petroleum-based formulations
- Reformulated gasoline
- LEVs (Low-Emitting Vehicles) that are far cleaner than those believed possible in the late 1980s (an additional 95% reduction over the 1975 controls)
- Reformulated lower VOC paints and consumer products
- Safer, cleaner burning wood stoves
- Dry cleaning equipment that recycles perchlorethylene
- CFC-free air conditioners, refrigerators, and solvents

This pattern of technological progress is continuing today. In the regulatory impact statement for the 1997 ozone and PM National Ambient Air Quality Standards (NAAQS), EPA identified a number of emerging technologies—ranging from fuel cells to ozone-destroying catalysts to new coating technologies—that may hold promise for achieving further air pollution reductions. EPA can help foster additional demand for clean technologies by promoting strategies that create a market for the most efficient, best performing technologies.

3.6 Impacts on Environmental Quality

A full understanding of the desirability of incentive programs requires information on the actual environmental benefits that are achieved relative to command and control alternatives. The literature focuses almost exclusively on the cost side of the equation as opposed to the environmental effects because most studies assume that the same environmental goals are being sought in both approaches to environmental management. When comparing incentive-based policies with traditional regulatory approaches, or when comparing one incentive-based policy with another incentive-based policy, there may be impacts on environmental quality that would be of interest to regulators and other parties.

In general, incentive mechanisms based on trading are designed to produce environmental effects that closely approximate what would be achieved through a traditional regulatory approach. Some distinctions exist. For example, a cap-and-trade policy provides control over total emissions, while an open-market trading approach does not limit overall emissions. In an open-market approach, credits are generated at the sources' discretion. Open-market trading could reduce total emissions, however, if trading ratios of greater than 1:1 were applied. Some trading programs described in this report have that feature (e.g., fireplace permit trading), but others do not.

In most cases, emission tax systems have not been designed to produce a specific environmental impact. Rather, the primary goal has been to raise modest revenues. (See, for example, Arnold 1995, chapter 11.) However, in the few examples for which emission fees have been set at a level intended to have environmental impacts, the benefits were greater than forecast (e.g., Swedish NO_x and SO_2 charges, and U.S. chlorofluorocarbon taxes).

Deposit systems appear to have achieved environmental results greater than could be achieved with a traditional regulatory approach. However, the refund must be large enough to induce consumers to bring back the used product. For example, deposits/refunds on automobile bodies (required in some European countries) function well in assuring the proper disposal of car hulks when set at a high enough level. A traditional regulatory approach works less well for car hulks. Thousands of abandoned cars are removed at city expense in New York each year, despite regulations prohibiting that type of disposal.

Variations in environmental effects can be important in evaluating the overall desirability of different approaches. Oates et al. provide an example in a comparison of regulatory approaches for of particulate matter control in the Baltimore, Maryland, region. The traditional regulatory approach of applying uniform emission limits to sources results in control of particulate matter to an extent greater than necessary to meet ambient air quality standards in some parts of the city. In contrast, an incentive-based approach achieves the air quality standard with more uniform ambient concentrations of particulate matter in all parts of the city. The extra reductions of particulate matter in some areas under the traditional regulatory approach yield a benefit that partially offsets the higher costs of the traditional approach.[28]

3.7 Finding the Right Instrument for the Problem

This chapter has described a wide range of instruments from the perspectives of cost effectiveness, distributional consequences, environmental effects, and incentives to develop new technologies to deal with pollution. An ideal tool would maximize the net benefits that accrue to society (all environmental and other benefits, less compliance costs, administrative costs, monitoring and enforcement costs) without creating major imbalances in the distribution of costs or benefits. The evidence accumulated from literally hundreds of applications of economic instruments that is reviewed in the following chapters suggests that the set of instruments that can deal effectively with individual classes of environmental problems is fairly narrow. Table 3-6 identifies the types of incentive-based instruments that have been applied to a variety of environmental problems. The relative effectiveness of the different mechanisms is also characterized. The interested reader is referred to Dower (1995) for other perspectives on selecting the best economic instrument for specific environmental problems.

Table 3-6. Uses of Economic Instruments

Instrument	Examples	Pros & Cons
Pollution Charges & Taxes	Emission charges Effluent charges Solid waste charges Sewage charges	Pros: stimulates new technology; useful when damage per unit of pollution varies little with the quantity of pollution Cons: potentially large distributional effects; uncertain environmental effects; generally requires monitoring data
Input or Output Taxes & Charges	Leaded gasoline tax Carbon tax Fertilizer tax Pesticide tax Virgin material tax Water user charges CFC taxes	Pros: administratively simple; does not require monitoring data; raises revenue; effective when sources are numerous and damage per unit of pollution varies little with the quantity of pollution Cons: often weak link to pollution; uncertain environmental effects
Subsidies	Municipal sewage plants Land use by farmers Industrial pollution	Pros: politically popular Cons: high budgetary cost; may stimulate too much of the activity; uncertain effects
Deposit-Refund Systems	Lead-acid batteries Beverage containers Automobile bodies	Pros: deters littering; stimulates recycling Cons: potentially high transaction costs; product must be reusable or recyclable
Marketable Permits	Emissions Effluents Fisheries access	Pros: provides limits to pollution; effective when damage per unit of pollution varies with the amount of pollution; provides stimulus to technological change Cons: potentially high transaction costs; requires variation in marginal control costs
Reporting Requirements	Proposition 65 SARA Title III	Pros: flexible, low cost Cons: impacts may be hard to predict; applicable only when damage per unit of pollution does not depend on the quantity of pollution
Liability	Natural resource damage assessment Nuisance, trespass	Pros: strong incentive effect Cons: assessment and litigation costs can be high; burden of proof large; few applications
Voluntary Programs	Project XL 33/50 Energy Star	Pros: low cost; flexible; many possible applications; way to test new approaches Cons: uncertain effectiveness

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