Colombia's Rio Negro

Source: *David Shaman*

Chapter Two

Regulating Pollution in the Real World

Rising in the Andean highlands, the rivers of Colombia's Antioquia region tumble wild and clean as they begin their descent to the Caribbean. The headwaters pass through upland ecosystems whose variety makes Colombia a world treasure of biodiversity. As the highlands give way to broad valleys, the rivers of Antioquia flow more slowly past human settlements. Their sparkle fades as wastes pour in from farms, factories, and towns along their banks. Before the waters reach the sea, their life-sustaining oxygen is depleted and their beds are laced with toxic metals. Sustainers of richly varied life in the highlands, they become purveyors of death in their encounters with human society in the lowlands.

Economic development has not been kind to Colombia's rivers. Regulations have stipulated limits on discharges for decades, and Colombians have supported corrective action, but polluters have flouted these regulations for just as long. Yet in the early 1990s community support for cleaner rivers finally crystallized into demands for reform. The result is one of the world's most innovative programs for controlling pollution. Its governing maxim is simple: All polluters—towns, factories, and farms—must pay for each unit of organic pollution they discharge into the waterways of the Antioquia district.

The result? Reported organic discharges have dropped by 18 percent during the program's first year. The most striking change has occurred along the Rio Negro, where factories have accounted for over 40 percent of organic pollution: These factories have reduced their organic discharges by 52 percent.

Colombia's recent experience reflects a movement toward regulatory reform throughout the developing world. Decades of attempts to control pollution through traditional regulations, which make discharges above designated limits illegal, have often yielded disappointing results. Under traditional regulation, pollution above the legal limit is punishable by fines, plant shutdowns, or, in extreme cases, imprisonment of offending managers. But such an approach requires strong enforcement mechanisms: Regulators have to monitor and analyze pollution from each plant, determine whether it has violated the rules, and institute legal proceedings in cases where violation is clear. These steps are not cheap, and many developing countries have not been able to implement them. What's more, such a system requires every commercial enterprise to toe the same regulatory line regardless of cost.

In an effort to break out of this one-size-fits-all approach, many countries are opting for more flexible and efficient regulation that nevertheless provides strong incentives for polluters to change their ways. Some countries have chosen strategies for traditional regulation that take benefits and costs into account. Some are using pollution charges like those in Colombia—often combined with other strategies—to achieve impressive results. Still others, discussed in Chapter 3, are using public disclosure programs that pressure polluters to clean up their act.

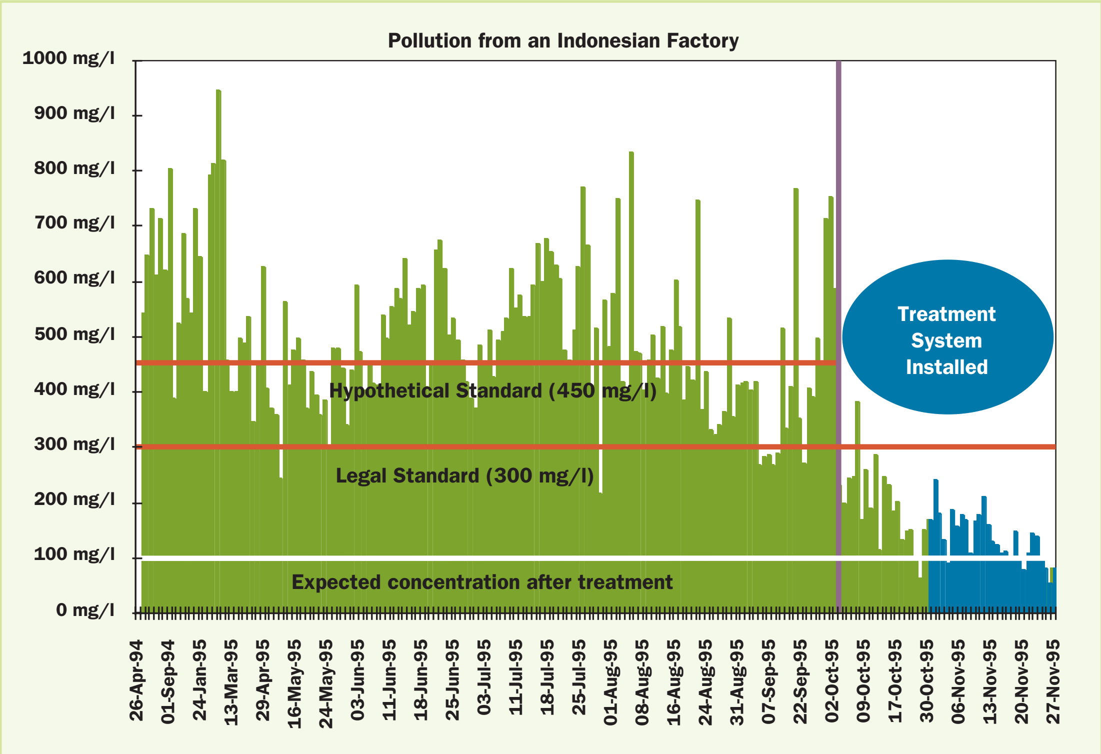
2.1 The Role of Economic Incentives

We begin with an obvious but important proposition: Plant managers respond mainly to economic incentives. Although public spirit moves a notable minority to control pollution, most managers are bound by pressures from markets and shareholders. They will reduce discharges only if they expect the additional cost to be less than the penalties that continued pollution will impose on them. Such penalties can include not only fines and plant closures but also pollution charges, credit refusals from bankers worried about liability, reduced sales to consumers who care about the environment, and even social ostracism within communities outraged about pollution.

However, a manager's situation is uncertain because a plant's emissions vary daily, local regulators may be spread too thin to enforce penalties, and reactions from markets and communities are unpredictable. Managers must find the right balance between the possibility of heavy penalties from too much pollution and the certainty of high costs from too much abatement. Understanding this balancing act is the key to more effective regulation.

Figure 2.1 shows why this is not a simple problem. The figure portrays information on the concentration of organic pollution in emissions from a large Indonesian factory during 1994 and 1995. At the beginning of a public disclosure program in June 1995, Indonesian regulators privately notified the plant's managers that they had received a poor rating because their average daily pollution exceeded Indonesia's legal standard of 300 milligrams per liter for that industry sector. Faced with the threat of public disclosure, the managers quickly installed equipment designed to reduce concentration to around 100 milligrams per liter. By late November, the plant had

Figure 2.1 Normal Variations in Emissions



Source: BAPEDAL

moved down the learning curve sufficiently to bring its typical emissions into the 100 milligrams per liter range.

Yet Figure 2.1 shows that even before the treatment equipment was installed, effluent concentrations occasionally dipped below the legal standard. Suppose the standard had been 450 milligrams per liter—would the plant have been in compliance? The answer would have been no if regulators had insisted that all daily observations fall below the standard. Yet if regulators had averaged emissions over time, they might have judged the plant compliant.

Faced with such variation, regulators and plant managers alike find themselves in a complex game.[1] Inspectors need enough information to establish a characteristic pollution level. They would like the cooperation of plant management, since managers can easily delay or complicate the regulatory process. For their part, managers have no interest in antagonizing inspectors; because once a plant has become suspect, regulators will demand time-consuming and costly investigations and reports. However, managers will also tend to rationalize strings of bad observations as anomalies, and in some cases they will undoubtedly be justified. The result is that uncertainty reigns, and regulation involves continual negotiation.

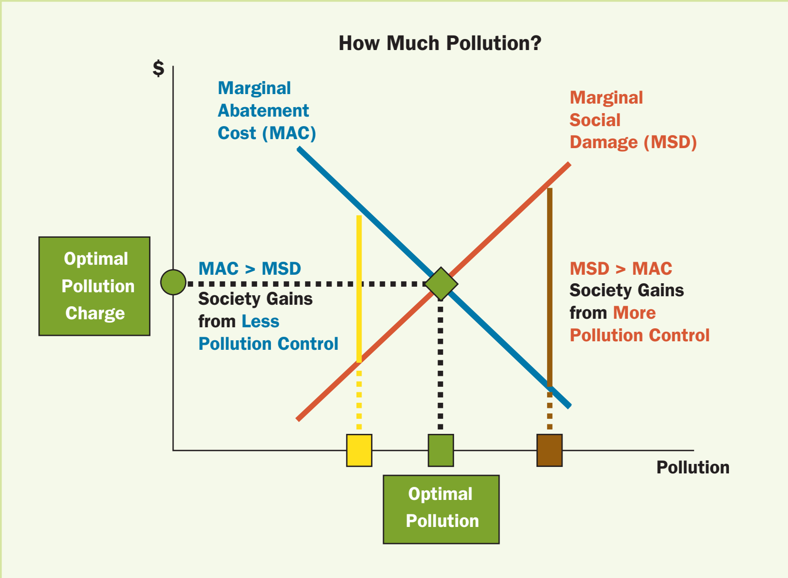
The Regulator's Dilemma

Figure 2.2 illustrates the fundamental dilemma regulators must confront—as well as a way of resolving it. The red line shows that each additional (or marginal) unit of pollution creates more damage than the previous unit—progressively more respiratory disease from air pollution, fewer fish in contaminated water, etc. This is called the marginal social damage (MSD) schedule.

Pollution abatement is subject to the opposite effect—a law of diminishing returns. As the blue line shows, each additional (or marginal) unit of pollution control costs more than the previous unit. This graph is the marginal abatement cost (MAC) schedule. It shows that pollution control can be cheap at low levels of abatement but expensive at high levels.

If regulators target the brown level of pollution, the marginal cost of abatement will be much lower than the marginal social damage. This means that reductions in damage through pollution control will more than compensate for increases in abatement costs. The opposite will be true for the yellow level of pollution, where MAC is much higher than MSD. The optimal choice for regulators is the green level of pollution, where MAC and MSD are equal. At this

Figure 2.2 Abatement Benefits and Costs



point, neither increasing nor decreasing pollution will improve overall social welfare.

MAC vs. MEP: The Manager's Dilemma

Figure 2.3 illustrates the complex decisions factory managers face in weighing the penalties for polluting. The factory's cost is measured on the vertical axis, and pollution per unit of output (or pollution intensity) on the horizontal axis.[2] The two upward-sloping lines show that marginal expected pollution penalties (MEP) increase as pollution intensity rises. That's because even weak regulators are bound to take notice if the plant's pollution intensity exceeds the legal limit by a wide margin. And even if regulators do not enforce legal standards, communities and markets will exact penalties from obvious, heavy polluters. The green and red MEP lines reflect differences in the strength of local regulation and the quality of information on the factory's pollution available to banks, consumers, and local communities.

Confronted with green or red MEP, a cost-minimizing manager needs information about abatement costs before deciding how much to pollute. Figure 2.4 illustrates the cost problem for two different

Figure 2.3 Penalties for Polluting

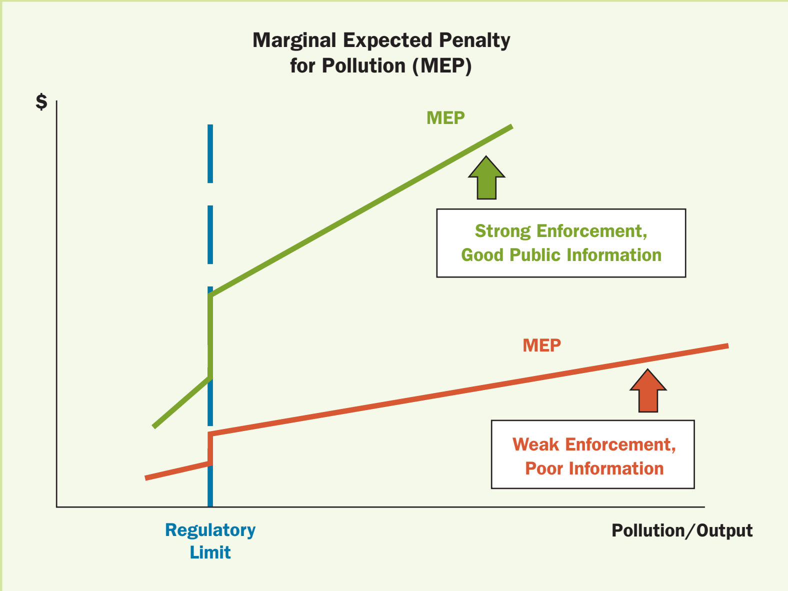
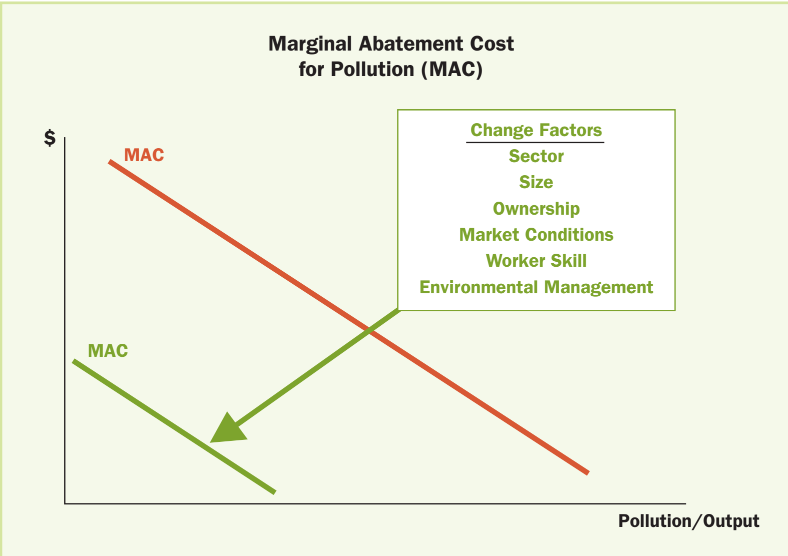


Figure 2.4 Abatement Cost



factories. The red factory incurs much more cost than the green factory, although each incremental unit of abatement costs more for both. Recent research, discussed in later chapters, suggests that the lower MAC of the green plant correlates with factors such as larger size, ownership by a private, multi-plant company, better-educated workers, and better environmental management.

Figure 2.5 combines the red MAC with the green MEP to show how a manager can choose to react to penalties and abatement costs. At the brown level of pollution intensity, MEP is much higher than MAC, so the manager can lower costs by reducing pollution. At the green level of pollution intensity, MAC is much higher than MEP, so the manager can lower costs by reducing pollution control activity. The manager's cost-minimizing choice is the yellow level of pollution intensity, where MAC and MEP are equal. At this level, neither increasing nor decreasing pollution will lower a plant's overall costs.

Why Compliance Varies So Widely

Our model of cost-minimizing pollution shows why plants in developing countries vary widely in complying with regulation, even where it is weak. In Figure 2.6, the pairs of MAC and MEP schedules intersect at four points, colored green, blue, yellow, and red. The red (or "outlaw") case occurs when a plant with high MAC faces a weak

Figure 2.5 Plant-Level Pollution

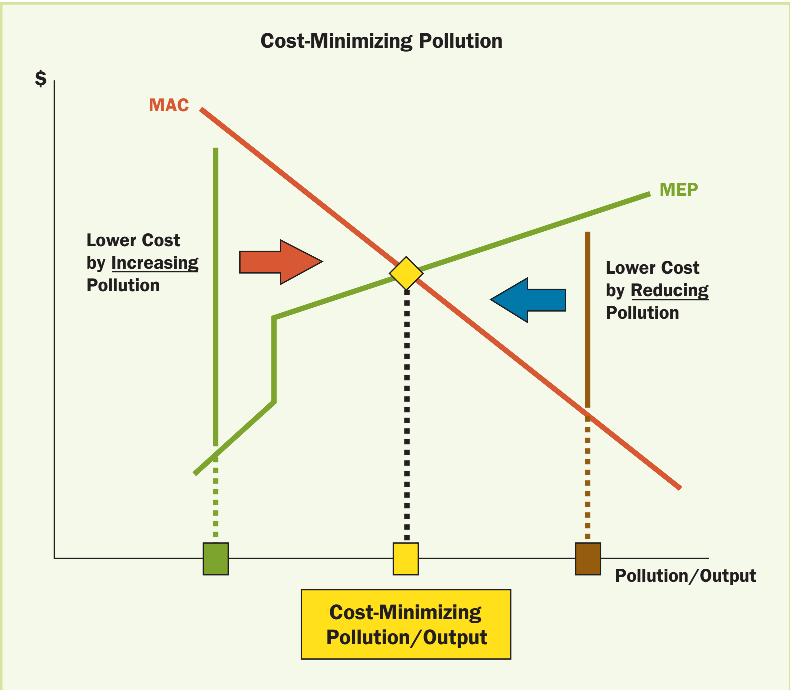
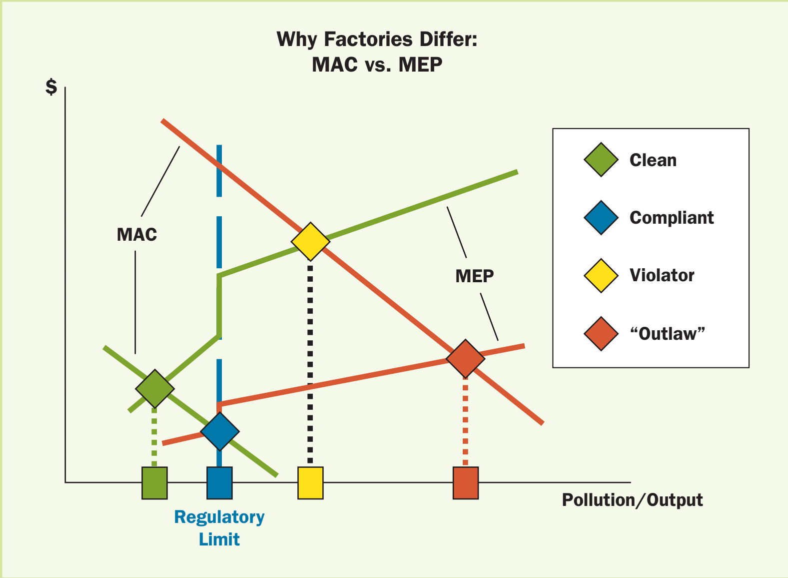


Figure 2.6 Cost-Minimizing Pollution Choices



regulatory and information environment in which MEP is low. Such a plant will pollute heavily.

Strengthening regulation and public information will shift the MEP schedule from red to green and motivate the plant manager to lower overall costs by reducing pollution intensity to the yellow level. At this level, the plant still exceeds the legally permissible (blue) limit but by much less than in the red case.

In contrast, even weak regulation can induce compliance if changes in a plant lower its MAC. In Figure 2.6, the legal (blue) pollution limit occurs at the point where green MAC equals red MEP.

Recent research shows that plant managers sometimes reduce pollution below the blue point required by law, given other pressures from communities and markets (Chapter 3). In Figure 2.6, this occurs where green MEP equals green MAC.

Chapter 1 has shown that more pollution control can yield a large social payoff in many developing-country cities. This entails shifting the industry mix from plants that are predominantly red and yellow to those that are predominantly blue and green. As Figure 2.6 shows, this can be achieved by changing MEP, MAC, or both from red to green status. Policies that promote these changes work because they rely on plant managers' natural incentive to minimize their pollution-related costs.

2.2 Pollution Charges: The Right Solution?

Pollution charges, such as those imposed by Colombia, level the economic playing field by confronting all managers with the same price for each unit of pollution. Under such a system, managers are free to adjust their operations until they have minimized pollution-related costs—charges plus the cost of abatement. This system minimizes overall abatement costs while providing the right incentives for managers to clean up. Yet at first glance a charge system looks unnecessarily complicated. Why not just require all factories to cut back pollution by the same uniform percentage until overall pollution falls to the desired level? That system can also work, but it will heavily penalize factories with high marginal abatement costs.

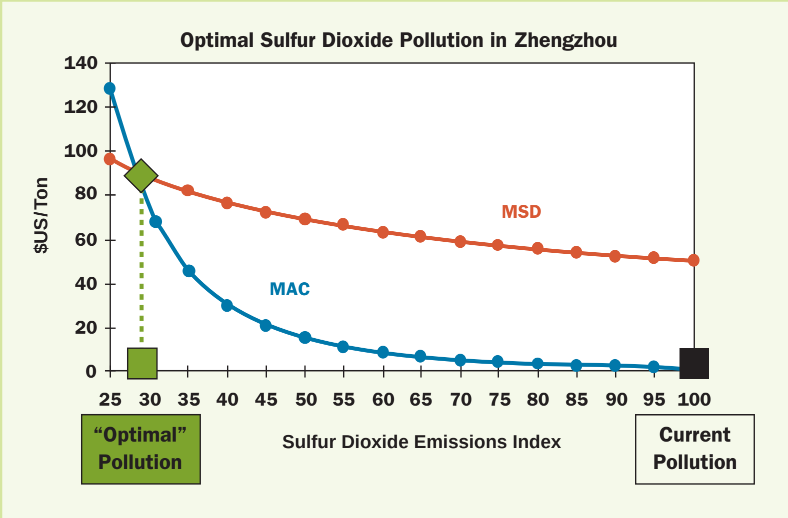
The challenge is to set pollution charges that promote the right level of cleanup from society's perspective. A recent study for Zhengzhou, the capital of Henan province in central China, shows how regulators can do so if they have good information. With a 1993 population of 1.8 million and an average industrial wage of 3,350 yuan per year, Zhengzhou is typical of China's large cities. Its industry pours approximately 45,000 tons of sulfur dioxide (SO_2) into the atmosphere every year, contributing to an ambient SO_2 concentration of 90 micrograms per cubic meter. At this level, over 400 Zhengzhou residents die annually from SO_2-related pollution, and thousands suffer from serious respiratory illness.

At current emissions (100 on the horizontal axis), Figure 2.7 suggests that the benefit from abating an additional ton of SO_2—that is, reducing the marginal social damage—is \$50, while the cost of abating it is \$1.70. This illustrative case uses \$8,000 as an extremely conservative estimate of the social benefit from saving a life through air pollution control. Figures in excess of \$1,000,000 could be employed, as we note in Chapter 1. However, even a rock-bottom value of \$8,000 implies that about 70 percent of today's emissions should be eliminated to achieve the social optimum.

The charge that will induce this reduction is about \$90 per ton, at the intersection of MAC and MSD.[3] This is the optimum charge for Zhengzhou, since a lower charge would leave socially profitable abatement opportunities unexploited, and a higher charge would impose an abatement cost higher than the social gain from further cuts in pollution.

This analysis suggests that the air pollution charge should be increased more than fiftyfold in Zhengzhou and, by implication, the rest

Figure 2.7 Optimal Pollution



of urban China. As we saw in Chapter 1, the current pollution charge makes sense only if China's policymakers value the life of an average urban resident at less than $300. For the loss of a human life, this figure seems ludicrously low compared with the pain, suffering, and elimination of a lifetime's contribution to China's economic output.

A pollution charge not only cuts emissions but generates public revenue as well. If Zhengzhou's environmental regulators increased the SO_2 levy to $90 per ton, the city's annual revenue from air pollution charges would be approximately $1.1 million. For China as a whole, revenue from an SO_2 charge of $90 per ton would be about $250 million—even then, only a small fraction of the charge's value as a lifesaving policy tool.

Pollution Charges in Practice

Why does pollution control in China and elsewhere fall short of the social optimum, as in the Zhengzhou case? Good studies of emissions and the damage they cause are still limited to a few air pollutants—principally particulates and sulfur dioxide—in a few cities. Guesstimates must be employed for water pollution and hazardous waste.

As with traditional regulations, effective monitoring, and enforcement of pollution charges can also be costly and time consuming. Claims from industry representatives about the excessive cost of regulation may be well received by high-level policymakers who are not informed about the benefits of controlling pollution. And arguments against charging for illegal pollution are also common on the grounds that criminal acts should be punished, not merely subjected to fees.

Thus, although the "golden rule" MAC = MSD provides a good framework for determining environmental goals and pollution charges, in the real world the actual levels are determined through the political process. Concrete information about lives lost, fisheries destroyed, and other damage can play some role, but it will never be the sole determining factor. Policymakers have to seek consensus on environmental goals and then use the available regulatory instruments to pursue them.

In the 1970s, economists William Baumol and Wallace Oates wrote a classic book showing how pollution charges could be adapted to these political realities.[4] They recommended a four-step approach: 1. Determine environmental quality goals; 2. Estimate the pollution reduction required by these goals; 3. Estimate the marginal cost of abatement at the desired level of pollution; 4. Set the pollution charge equal to the estimated marginal cost. If the estimate is right, pollution should fall to the desired level. If it is wrong, the charge can be raised if there is too little abatement and reduced if there is too much.

Baumol and Oates have joined other public-finance economists in arguing that all revenues from such a system should be rebated to the central treasury, where they can be allocated to the highest-priority spending categories. These categories might be environmental, but they might also include health care, education, transportation, and other public-sector responsibilities.

Has any developing country—or, for that matter, any industrial country—actually instituted an ideal charge system? The answer is no, but some countries have come close. Box 2.1 describes a long-established pollution charge system in the Netherlands, which has applied this economic instrument more successfully than most other OECD countries. Several developing countries have also used charges to regulate pollution. Their experiences illustrate the problems and potential of this economic instrument as a regulatory tool for newly industrializing countries.

(1) Colombia

Colombia experienced a lamentable lack of success with traditional regulation, and contamination of its air and water long went practically unchecked. In a strong attempt to break with the past,

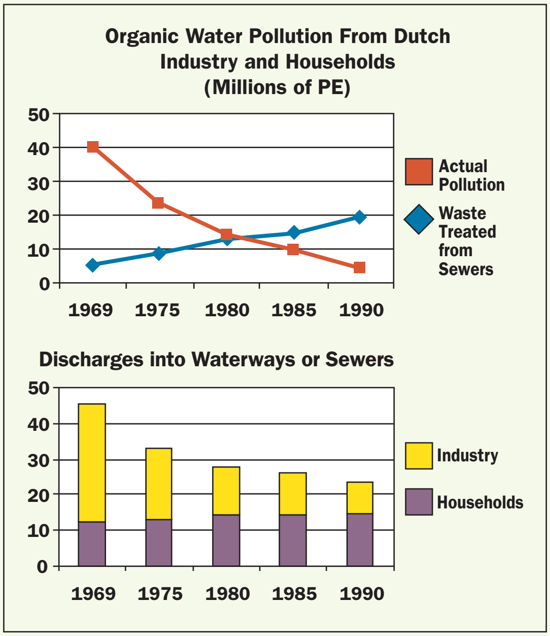
Box 2.1 Dutch Pollution Charges: An "Accidental" Success Story

Among the OECD countries, the Netherlands has had the most extensive and successful experience with charges for water pollution.[5] By 1969, organic water pollution had mounted to the point where many Dutch waterways were biologically dead. Together industry and households were dumping 40 million population-equivalents, or PE—the average organic pollution caused by one person in a normal household—into Dutch sewers and waterways every year. Heavy-metals emissions from industry had also increased to dangerous levels.

The Dutch responded with the Pollution of Surface Waters Act (PSWA) in 1970, which prohibited unlicensed discharges into surface waters and imposed charges on polluting emissions. Industry had to pay for emissions of heavy metals, and all sectors of society were assessed for estimated organic discharges: urban households, 3 PE; farm households, 6 PE; small enterprises, 3 PE; medium enterprises, PE estimated from engineering models; and large enterprises, directly measured PE. Authorities granted rebates to small and medium enterprises if they could prove that their actual emissions were lower than official estimates.

The Dutch system began as a command-and-control exercise, in which pollution charges were simply intended to finance construction of waste treatment facilities mandated by the PSWA. However, pollution-reduction efforts required construction of high-cost facilities in some areas, and charges escalated as construction costs mounted. At some point, many Dutch factory managers found themselves confronted with charges equal to marginal abatement costs at very high levels of cleanup. A careful statistical analysis by Bressers (1988) has shown that these high charges were much more important than the permitting process in promoting reductions in emissions. By 1990, the system had halved both heavy-metals emissions and total organic discharges into waterways and sewers, and waste treatment facilities had expanded sufficiently to reduce organic pollution of waterways to about 6 million PE. Industry displayed the strongest response to pollution charges from 1969 to 1990, reducing its annual organic emissions from 33.0 to 8.8 million PE (Jansen, 1991).

Figure B2.1 The Impact of Dutch Pollution Charges



the country based its new pollution charge system on the Baumol/Oates principles. Analysis of abatement costs concluded that a charge of US$100 per ton would reduce industry's organic emissions to Colombia's waterways by 80 percent. However, the program began by charging only US$28 per ton for organic waste (biochemical oxygen demand, or BOD), as well as $12 per ton for total suspended solids (TSS). These charges were considered high enough to bite, but not so costly as to provoke hostility from industry. The program will expand to include other pollutants based on the environmental and economic results of the first phase.

Seven regions in Colombia with the greatest population, economic activity and pollution are the flagships for implementing the charge system, and most other regions will begin participation during the next few years. Each region starts by setting its own pollution-reduction goals, imposing the national base charges, and tracking total discharges for six months. If the targets are not met, regional authorities can raise charges for the ensuing six months, and this process continues until local targets are met. At that point the charges are frozen, although adjusted to reflect inflation.

The pioneer in instituting this new program has been CORNARE, the pollution control authority in the Oriente Antioqueno region (Figure 2.8). CORNARE's dynamic leaders have forged a good working relationship with local businesses and communities. Before beginning the program, for example, the agency worked closely with several large factories to develop plans for installing cleaner technologies. CORNARE has also collected good information about local water pollution and thus can pinpoint the major sources of discharges into the Rio Negro and other rivers.

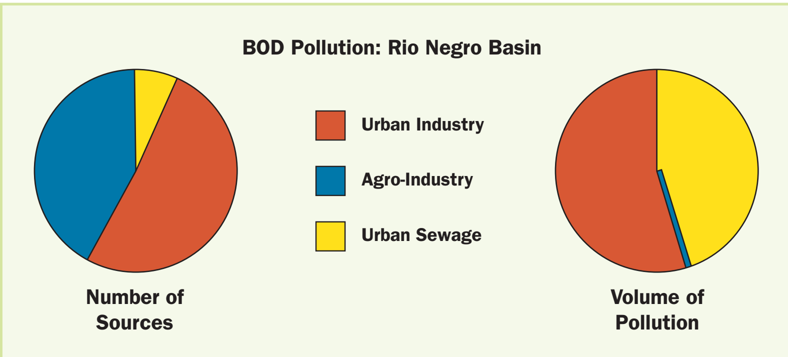
Industry is clearly the kingpin of water pollution in the region, followed by sewage from towns (Figure 2.9). After consulting with factory managers and communities, CORNARE set a reduction target of 50 percent for organic discharges. Although industry leaders protested that such an ambitious target would prove too costly, industry's recorded BOD discharges into the Rio Negro fell by 52 percent in the first six months under the plan, and TSS discharges fell by 16 percent. However, factories' responses varied widely: Of the 55 regulated plants on the Rio Negro, only 7 cut their recorded emissions of BOD, and only 8 cut TSS emissions. Obviously, the responsive plants reduced their pollution much more than average.

Table 2.1 shows that CORNARE's administration of pollution charges has been quite efficient: Assessed charges have been signifi-

Figure 2.8 CORNARE Region

cant, and collection rates have been high. Industries and municipalities have clearly gotten the message. So why have so few responded? One possibility is that the marginal cost of abatement remains above the charge for many factories, or managers may have simply not had enough time to adjust their pollution control practices. Indeed, CORNARE's director has noted that some plants that reduced pollu-

Figure 2.9 BOD Sources in Rio Negro



Source: CORNARE

Table 2.1 Pollution Charge Administration in Rio Negro

Sector	Total Pollution Sources	Sources Charged	Total Charges Assessed (Mill. Pesos)	Total Charge Payments (Mill. Pesos)
Urban Sewage	8	8	57.3	57.3
Urban Industry	55	43	65.6	64.4
Agro-Industry	46	41	.2	.2

Source: CORNARE

tion after the charges began had previously agreed to adopt cleaner technologies. Overall, although it is new, the Colombian experience provides support for the argument that a Baumol/Oates pollution charge system can work well in developing countries.

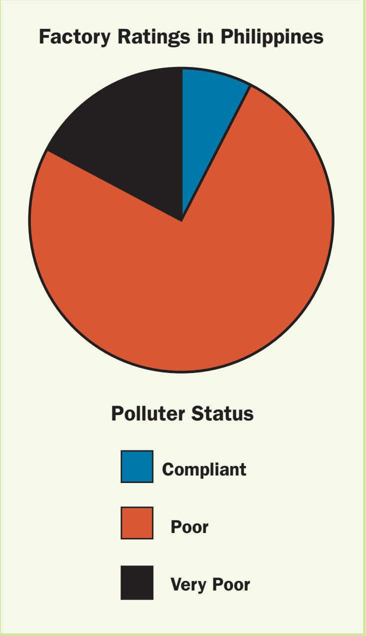
(2) Philippines

With a total surface area of about 90,000 hectares, Laguna Lake in Philippines is the second largest inland body of water in Southeast Asia. Twenty-one rivers flow into the lake, whose drainage region includes Manila and many smaller cities. According to the Laguna Lake Development Authority (LLDA), 1,481 factories occupied about 20 percent of the region's land area in 1994. While a few plants tap the lake's water for industrial cooling, most simply use the lake and its feeder streams as sinks for waste. Industry accounts for about 30 percent of the lake's pollution, while agriculture contributes about 40 percent and domestic sewage about 30 percent.

Philippines has long maintained a traditional regulatory system, and over 60 percent of local factories have adopted at least nominal pollution control. However, polluters had very little incentive to take regulators seriously because the inspection rate was low, legal enforcement was time consuming, and most ensuing fines were minimal. The results are evident in Figure 2.10, which summarizes a rigorous audit of water polluters before recent regulatory reforms. Only 8 percent of polluters were found to be in compliance.

To provide new incentives and restore Laguna Lake, the LLDA instituted an "environmental user fee" (EUF) for industrial pollution. Initial studies identified five industries as the primary sources of organic water pollution: food processing, hog farms, slaughterhouses, beverage firms, and textile makers. The agency first implemented pollution charges—in this case EUFs—in 1997, for a pilot group of 21 plants. The system has two parts: a fixed charge deter-

Figure 2.10 Results of Traditional Regulation



Source: DENR

mined by discharge volume, designed to cover administrative costs for LLDA, and a two-tier assessment for emissions. The latter includes one charge per unit of emissions that meet the legally permissible standard, and a higher unit charge for emissions above the standard. As in the Colombian case, abatement cost analyses provided the basis for setting charges at levels that would induce plant managers to cut pollution significantly.

After two years of implementation, LLDA reports that BOD discharges from the pilot plants have dropped 88 percent. Because pollution charges are remitted to LLDA, its resources for monitoring and enforcement have also increased significantly. In light of this experience, the Philippine Government has announced its intention to implement the EUF system nationwide.

Philippines' experience with pollution charges seems similar to that of Colombia in many respects. Faced with a continuous financial drain rather than sporadic legal action, plant managers have moved quickly to reduce pollution to the point where the marginal cost of abatement is equal to the pollution charge.

(3) Malaysia

During the 1960s and 1970s, Malaysia grew rapidly while diversifying exports away from its two traditional products, natural rubber and tin. The country selected palm oil for promotion, and by 1975 private palm oil plantations covered two-thirds as much area as private rubber estates (Figure 2.11). This economic boom, unfortunately, was accompanied by an environmental tragedy. Malaysia's palm oil mills discharged their waste effluent directly into nearby waterways. Since this discharge was laden with organic pollutants, the effect on aquatic life was catastrophic. Freshwater fish could no longer survive in 42 of Malaysia's rivers, marine spawning beds near river mouths were dying, and the stench from decomposing anaerobic waste was so bad that some riverside villages had to relocate.

Faced with this crisis, in 1974 the government passed the Environmental Quality Act and established the Department of the Environment (DOE), which could withhold operating licenses from severe polluters. This gave a strong, credible signal to the Malaysian palm oil producers, who began working on waste-treatment technologies. By mid-1977, the DOE was satisfied that the available technologies would support rapid pollution reduction at feasible cost.

The agency moved swiftly to enact a system that combined traditional regulations with pollution charges. Within four years, palm

Figure 2.11 Malaysian Palm Oil Plantation and Processing Mill

Source: Palm Oil Institute of Malaysia

Source: Malaysian Palm Oil Promotion Council

Source: Malaysian Palm Oil Promotion Council

oil mills were required to reduce BOD in their effluent from 5,000 parts per million (ppm) to 500 parts per million, with the understanding that the fourth-year standard would not be the final one. Operating licenses were issued for a flat M$100 fee, plus a charge of M$10 per ton of organic pollution discharged into water. Because the DOE had no way of valuing actual damages from pollution, it intended this charge to be high enough to provide some abatement incentive without being burdensome.

DOE added a surcharge of M$100 per ton for BOD discharges beyond the allowable limits. The surcharge, intended to have real teeth, was based on mandatory quarterly discharge reports verified by independent laboratories. Mills were required to apply for an operating license every year and include a description of their waste treatment system. DOE could reject license applications if it disapproved of the treatment approach—but it could also waive all fees for mills engaged in serious research and development on cost-effective pollution control.

In a single year, these combined measures produced a remarkable change: The mills' average daily discharges fell from about 220 tons to 125 tons. However, managers' decisions suggested that even the M$100 per ton surcharge was often below the marginal cost of abatement. Of 130 mills, 46 paid excess discharge fees of more than M$10,000, and 7 paid more than M$100,000. Compared with the compliance record in other countries, this was a good result; but full compliance with regulations should have lowered the average daily discharge to 25 tons, and the DOE professed disappointment. Now it faced a choice: It could retain the M$100 per ton surcharge while continuing to tighten the standard, raise the surcharge to induce faster compliance, or abandon the polluter-pays approach for stricter enforcement along traditional lines.

The Malaysian Government chose the third alternative. It abandoned the surcharge, maintaining only the M$10 per ton discharge fee, and specified that the standards would henceforth be mandatory. The agency proved its intent by taking legal action against many noncompliant mills during the ensuing years. And its approach worked. During the second year, the average mill reduced its BOD discharge to 60 tons. In two years, total organic pollution from Malaysia's palm oil mills fell from 15.9 to 2.6 million person-equivalents.[6] This occurred despite an increase in the number of mills from 131 to 147 and an increase in palm oil production from 1.8 to 2.6 million tons. By 1981, a sample survey suggested that 90 percent of the mills had cut BOD concentrations below 500 parts per million (ppm), and that 40 percent were below the sixth-year standard of 100 ppm. By 1991, 75 percent of the mills had dropped below 100 ppm, and organic pollution was less than 1 percent of its level when regulation began, even though palm oil production was at an all-time high.

To our knowledge, no study has attempted to separate the impacts of the fees, the legally imposed standards, and the waivers for R&D on abatement strategies. However, the regulatory package was clearly effective in reducing pollution and improving the quality of Malaysia's rivers. The estimated cost of compliance was also substantial—M$100 million by 1984—and in a highly competitive world market, palm growers bore most of the cost. However, the Malaysian boom absorbed this cost with no apparent problem. Unemployment remained low, and palm oil production remained profitable for most producers. Malaysia might have reached the same goal more cheaply by relying almost exclusively on pollution charges, since they would have allowed plant managers the freedom to minimize pollution-related costs. However, efficient enforcement of emissions standards got the job done in a country where public institutions have traditionally functioned very well.[7]

(4) China

In response to its serious emissions problems, China instituted pollution charges in 1979 (Figure 2.12), and almost all of China's counties and cities have implemented this system. Some 300,000 factories have paid for their emissions and more than 19 billion yuan have been collected. About 80 percent of these funds have been

Figure 2.12 Chinese Industry: Growing Pressure to Improve

Source: Curt Carnemark, World Bank

Source: Corbis

used to finance pollution prevention and control, accounting for about 15 percent of total investment in these activities.

In sheer magnitude, the Chinese charge system may be without peer in the world; it is also one of the few documented long-term applications of charges in a developing country. However, it differs greatly from an idealized charge system. Plants are charged only for pollution in excess of standards, and the charge is levied only on the single air or water pollutant that most seriously violates regulatory standards for each medium. The charges also provide insufficient economic incentives for compliance, since they are often too low to induce abatement to the legally required level.

China's regulators do impose serious penalties, including shutdowns, for plants that persistently violate standards, and have mandated that some large plants install abatement technologies. Charge revenues are earmarked to support regulators' budgets or pollution-control projects in the same region.

Although it has weaknesses, this system has proven highly potent in fighting pollution and cutting pollution intensity. For example, each 1 percent increase in the water pollution levy has led to a 0.8 percent drop in the intensity of organic water pollution from Chinese industry.[8] And each 1 percent rise in the air pollution levy has cut the pollution intensity of suspended particulates from industrial production by about 0.4 percent.[9]

The impact of these reductions during a period of rapid industrial growth has been remarkable. While industrial output has doubled, organic water pollution and air pollution have remained constant, and even declined in some areas. China's industrial pollution problem is far less serious than it would have been without the levies and other regulatory instruments.

China presents a paradox of success. According to estimates for cities like Zhengzhou and Beijing, the air pollution levy should be many times higher in China's major urban areas. But without the levy, pollution-related respiratory diseases would have seriously injured or killed hundreds of thousands more citizens.

China can build on this demonstrated success. For SEPA, the State Environmental Protection Agency, adjustment of the pollution levy is an important task for the next round of policy reform. The record of responsiveness so far suggests that as the levy rises, Chinese industry could reduce pollution far faster than anticipated.[10]

Lessons of Experience

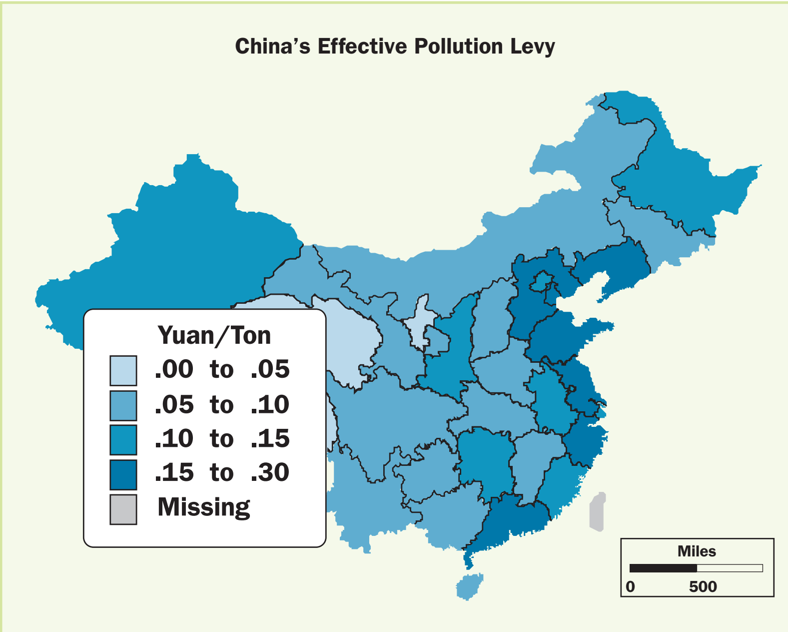
The experiences of China, Philippines, and Colombia suggest that charges can generate a rapid, large, and sustained decline in industrial emissions. Charges appear to be an almost ideal tool because they provide maximum flexibility for both industry and regulators, who can use them to pursue varying levels of environmental quality.

Other significant lessons have also emerged.

(1) Flexible Enforcement

China's experience in using charges to control pollution shows that such charges generally flex with local circumstances. World Bank researchers recently investigated this experience in a collaborative project with SEPA. Using a new database on 29 Chinese provinces and urban regions from 1987 to 1993,[11] they compared actual water pollution charges collected with the amount of wastewater discharged in each region. They found that actual charges per unit of emissions vary widely, although the official rate is supposed to apply uniformly across China (Figure 2.13). This variation is not random: Charges are much higher in urbanized and industrialized provinces of the country, particularly the eastern coastal regions. Two factors explain these variations (Figure 2.14). The first is the price a community places on pollution damage, which varies with the total amount of pollution, the size of the exposed population, and local income per capita. The second is a community's capacity to understand and act on local environmental problems, which is influenced by its level of information, education, and bargaining power.

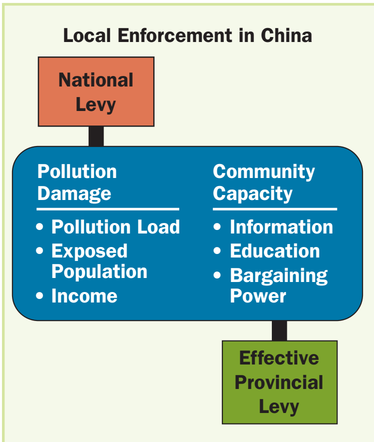
Figure 2.13 Pollution Charges in China



Source: Wang and Wheeler (1996)

Similarly determined variations in enforcement of emissions standards have appeared in other large countries such as Canada and India.[12] Both within and across countries, the available evidence suggests that enforcement varies systematically with local circumstances. Such community-level flexibility in administering national regulations is probably critical to continued support for either charges or standards in countries with highly varied environmental, social, and economic conditions.

Figure 2.14 Why Provincial Levies Differ



(2) Building Support

Political realities indicate that industry has to support any charge system, and this support has proved contingent on four conditions. First, industry has to be convinced that the government is serious about environmental protection. Second, industrialists need credible evidence that pollution control will not bankrupt them. In both Philippines and Colombia, industry support gathered steam after numerous meetings in which regulators and international experts presented credible information about abatement costs. Third, plant managers tend to support charge systems once they understand that these systems give them great flexibility. They can abate or pay, as their conditions warrant.

The fourth condition relates to how the charge revenues are used. Pollution charges are effective regulatory instruments because they reduce pollution through economic incentives. But while this argument appeals to economists, it cuts little ice with factory owners. To them, the charge is simply a tax—a financial sacrifice they have incurred for the common good. With remarkable consistency, they refuse to support charges until they are guaranteed that the revenues will be used to finance public or private waste-treatment projects in their own area. We will return to this issue in Chapter 6.

(3) Technical Foundations

To maintain a credible charge system, regulators must obtain reliable data on plant-level emissions. This requires the ability to audit emissions records, enter and store data, and analyze variations in effluent samples from each plant. Regulators also need good procedures for collecting and accounting for charge funds. These are stiff requirements, and many agencies are not capable of meeting all of them.

Some analysts have argued that information problems can be circumvented through the use of presumptive charges based on engineering estimates of pollution from plants of different kinds. In this system, regulators charge a plant using assumptions about the pollution intensity of its operations. The plant can either pay or reduce the charge by proving that its pollution is lower than the estimate. Presumptive charges have surface appeal because they seem to transfer monitoring costs to polluters, but regulators must still verify that emissions reports are correct, maintain consistent databases, and keep financial accounts. They are also saddled with the need to create and regularly update a large database of engineering parameters. And, of course, they inevitably have to deal with angry (and politically influential) factory owners who feel overcharged from the outset.

In practice, regulators are solving their information and auditing problems by using subcontractors rather than presumptive charges. In Colombia, for example, regulators rely on reports from bonded auditors to analyze emissions. The regulatory agency has also subcontracted fee collection and financial accounting to Colombia's largest commercial bank, which receives a fixed percentage of the revenue flow. This solution has a triple advantage: The bank has the right experience to operate such a system, it knows how to collect debts, and failure to pay these debts can threaten a firm's credit rating.

2.3 Targeting Enforcement

Despite the attractions of pollution charges, most countries still use traditional emissions standards to control air and water pollution. Yet rigid standards can inflict much economic harm if they are enforced without regard to benefits and costs. Fortunately, regulatory agencies can actually turn their inability to regulate all factories to their advantage by flexibly targeting plants for monitoring and enforcement.

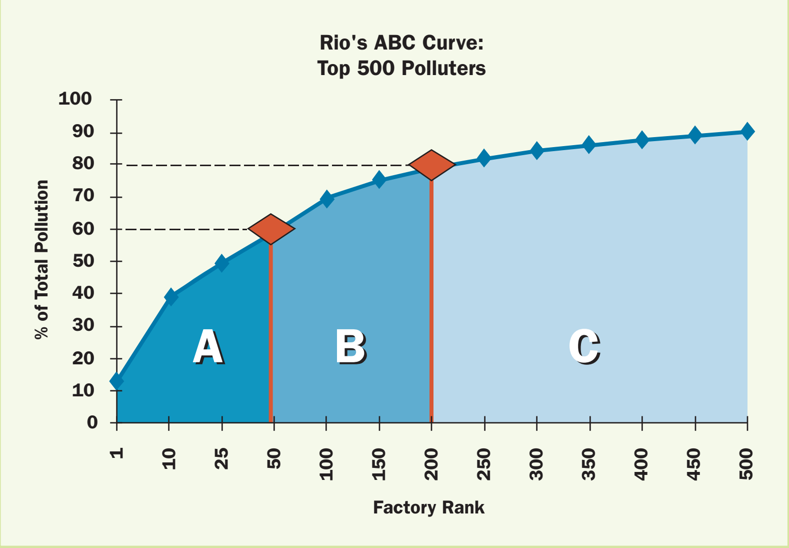
Targeting can crudely approximate the results of a charge system by raising the expected penalties for large pollution sources with low abatement costs. And these plants will often respond more vigorously than other factories because they tend to have more skills to draw on, resources to buy and run complex equipment, and ability to spread their administrative costs over many units of activity.

Brazilian regulatory agencies have used such a targeting strategy to reduce pollution substantially while economizing on scarce administrative resources. The agencies assign factories to categories A, B, and C according to plant size, and target the largest (A) factories almost exclusively.

How effective is the ABC approach? A good illustration is provided by the case of FEEMA, the pollution control agency of Rio de Janeiro State. FEEMA program analysts have ranked several thousand factories according to their contribution to the overall volume and risks of local air and water pollution (Chapter 6). Figure 2.15 presents the results. Remarkably, the analysis suggests that 60 percent of the state's serious industrial pollution could be controlled by targeting only 50 factories in the A group. Controlling pollution from 150 plants in the B group would eliminate another 20 percent of the total. Targeting the first 300 plants in the C group, which numbers in the thousands, would cut 10 percent more pollution.

Targeting larger plants seems to have impressive potential for reducing pollution, but will it also save lives? Larger factories have taller stacks, so their emissions are more dispersed and less dangerous to nearby residents. But according to a recent study in Brazil (Box 2.2), large plants remain the source of most deaths because the sheer volume of their emissions simply overwhelms the higher per-unit hazard from smaller plants.

Figure 2.15 Polluters in Rio de Janeiro State, Brazil



Source: FEEMA

The Brazilian pattern is not unique: Research in most countries and regions has revealed similarly skewed effects. The ABC approach can substantially reduce pollution by raising the marginal penalties for a few large polluters with relatively low marginal abatement costs. With enough information, regulators can further focus on plants whose abatement costs are exceptionally low, or whose pollution damage is exceptionally high.

2.4 Options for Policy Reform

Our case studies suggest that many roads can lead to reduced pollution. They also highlight flexibility as an important key to effective reform. Pollution charges work well because they provide economic incentives for cleanup while affording maximum flexibility to factory managers. Tradable pollution permit systems can provide similar advantages, although they have not been used as widely. Such systems fix overall pollution limits, and permit polluters to buy and sell rights to pollute within the overall limits. The United States has successfully used tradable permits to control national SO_2 emissions, and Chile has instituted a tradable permit system to control air pollution in Santiago. In the future, more developing countries may adopt tradable permit systems. At present, however, well-documented evidence on their implementation and impact remains scarce.

Box 2.2 Small Is . . . Bad or Beautiful?

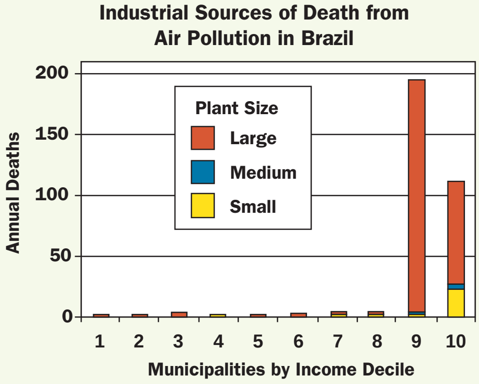
Small enterprises have been controversial in the environmental and development literature. In *Small Is Beautiful,* E.F. Schumacher touted small plants as the agents of choice for sustainable development. Wilfred Beckerman responded with *Small Is Stupid,* which attacked the idea that small factories are environmentally benign. Beckerman argued that small factories are pollution-intensive, costly to regulate, and, in the aggregate, far more environmentally harmful than large enterprises. Recent reports from the World Bank and other international institutions have tended to side with Beckerman, but supporting data have been scarce.

Recently, a team from the Brazilian Census Bureau (IBGE) and the World Bank addressed this issue by estimating pollution-related deaths attributable to small, medium, and large factories in Brazil. The team combined an IBGE database of 156,000 factories with economic and demographic data from 3,500 Brazilian municipalities. To provide another interesting dimension, the team divided the municipalities into 10 groups according to per capita income.

The study estimated the impact of emissions on mortality in four steps:

- A standard World Bank model estimated the impact of emissions from small, medium, and large plants on the atmospheric concentration of particulates in each municipality.
- Ostro's "dose-response" function (Ostro, 1994) converted the estimated concentrations to mortality rates.
- Multiplication of mortality rates by municipality populations yielded expected numbers of deaths attributable to small, medium, and large plants.

Figure B2.2 Plant Size and Mortality in Brazil



- Deaths were added across municipalities to obtain expected deaths by plant size for each income decile.

Figure B2.2 summarizes the results, which clearly show that large plants account for most industry-related air pollution deaths in Brazil. Most of these deaths occur in large urban areas such as São Paulo and Rio de Janeiro, whose municipalities are in the two highest income groups.

The IBGE-World Bank study concluded that some truth lies on both sides of the argument about small plants and pollution. Per unit of output, small plants pollute more and inflict more health damage than large plants. However, large plants dominate the mortality statistics because they produce far greater volumes of output and emissions. Since they also have much lower marginal abatement costs than small plants, they are a natural focus for ABC targeting by regulators with tight budgets.

Source: Dasgupta, Lucas, and Wheeler (1998)

Even under traditional standards-based regulation, ABC-style flexibility in targeting based on benefit-cost analysis can approximate the workings of a pollution charge system. Regional flexibility in enforcing national charges or standards also appears important for maintaining the support of communities with different environmental, social, and economic conditions.

In the next three chapters we will examine other effective roads to pollution control, including public disclosure of polluters' emissions and national economic reforms. Like pollution charges and targeted enforcement, these approaches reduce pollution by changing the calculations of plant managers who are trying to minimize pollution-related costs.

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End Notes

1. For a recent survey of the environmental economics literature on monitoring and enforcement, see Cohen (1998).

2. We use pollution per unit of output to reflect traditional pollution control laws. Environmental regulators do not expect a huge steel mill to produce the same pollution as a corner electroplating shop, but they do expect it to keep its pollution within feasible bounds. So traditional regulations generally focus on discharge intensity—pollution per unit of output or effluent volume—rather than discharge volume.

3. The estimated MSD graph for Zhengzhou slopes downward to the right, while the theoretical graph in Figure 2.2 slopes upward. This difference is caused by the mathematical form of the health impact model that researchers have created for Chinese cities. See Dasgupta, Wang, and Wheeler (1997) for further discussion.

4. The most recent edition is Baumol and Oates (1988).

5. Our thanks to our World Bank colleague Carl Bartone for detailed documentation of the Dutch pollution charge experience.

6. A person-equivalent is the amount of organic pollutant in the waste produced by one person in one year.

7. See Vincent (1993).

8. See Wang and Wheeler (1996).

9. See Wang and Wheeler (1999).

10. See Wang and Wheeler (1996); Dasgupta, Huq, Wheeler, and Zhang (1996).

11. See Wang and Wheeler (1996).

12. For evidence from Canada and India, respectively, see Dion, Lanoie, and Laplante (1998) and Pargal, Mani, and Huq (1997).