Outside and Inside Cubatao: Brazil's Serra do Mar in the 1980s

**Source:** *Carlos Renato Fernandes and Eco Parana; Corbis*

## Chapter Five

# National Economic Policies: Pollution's Hidden Half

Southeast of São Paulo, Brazil's continental plateau crests in the Serra do Mar before dropping off sharply to the sea. Along the crest stand remnants of Brazil's fabled Atlantic Forest, one of the world's most diverse and threatened ecosystems. As the highway from São Paulo winds down the coastal scarp to Santos, the region's major seaport, it encounters a small, quiet river. Upstream and surrounded on three sides by mountains lies the industrial city of Cubatao. In the 1980s it was known as the "Valley of Death."

In the go-go days of Brazil's state-led development, the valley's location made it irresistible to industrial planners. Near the port of Santos, it was a perfect place for industries like steel, petroleum, fertilizer, and chemicals to turn imported heavy raw materials into finished products before shipping them to São Paulo via the long climb uphill. The river provided a source of water as well as a convenient place to dump wastes.

Led by huge state corporations like COSIPA (steel) and PETROBRAS (oil), the Cubatao valley mushroomed into an industrial complex so large that it accounted for 3 percent of Brazil's GDP by 1985. Employment boomed for immigrants from Brazil's poor regions, and the future looked bright—except for two unfortunate lapses by nature. The small, quiet-flowing river was no match for the torrent of industrial wastewater, and the valley was a natural trap for air pollution. Undeterred by local regulators, state-owned mills and their private counterparts spewed a thousand tons of pollutants into the air every day. In the early 1980s the city recorded the highest infant mortality rate in Brazil, and over one-third of the residents suffered from pneumonia, tuberculosis, emphysema, and other respiratory sicknesses. By 1984, the Cubatao River was basically dead from organic pollution. Downstream from Cubatao, tons of heavy metals accumulated in bottom sediments and washed into the sea near Santos. Above the valley, fallout from air pollution began killing the Atlantic Forest and denuding the mountainsides.

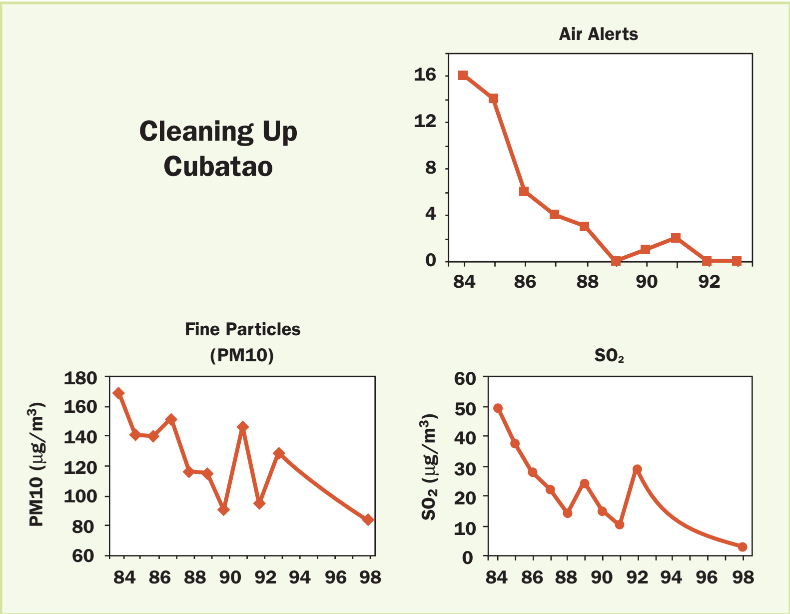
Finally, in January 1985 the crisis became a catastrophe, as 15 inches of rain poured onto the bare hillsides in 48 hours. Hundreds of mudslides cascaded into the valley, and one broke a large ammonia pipeline in Vila Parisi, releasing gas that injured many residents and forced a mass evacuation. Official denial ended as the governor of São Paulo State declared an emergency and mandated forceful action by CETESB, the state's pollution control agency.[1]

Fifteen years later much has changed in the Cubatao Valley. It is still no paradise, but environmental conditions are typical of medium-sized industrial cities in Brazil. The Atlantic Forest is growing back, sunny days are a reality again, children are healthier, and fish are returning to the Cubatao River, although their tissues are still laced with toxic metals. CETESB deserves great credit for this restoration. Supported by an aroused populace, its actions have made air pollution emergencies rare and cut damaging emissions considerably (Figure 5.1).[2]

Only one obstacle prevented even faster cleanup—the resistance of the state-owned factories that spearheaded the valley's development. By 1994, state enterprises contributed 42 percent of total suspended particulates (TSP) before end-of-pipe control but 77 percent of the actual emissions after control (Figure 5.2). The case of sulfur dioxide ($SO_2$) was similar. State-owned factories were simply doing far less to abate pollution than private mills. Even this substandard performance had required years of targeted inspections by CETESB, embarrassing public disclosures, and shutdown threats. Managers of the state-owned plants stubbornly resisted, complaining about financial losses and invoking political support at the state and national levels.

Things changed abruptly in late 1993 when the government privatized COSIPA, the state-owned steel company. The Cubatao plant shared in the industry's ensuing rapid modernization. From 1990 to 1996, Brazilian steel mills expanded production from 22.6 to 25.2 million tons while doubling output per worker.[3] Use of materials is

**Figure 5.1 Air Pollution, 1984–1998**



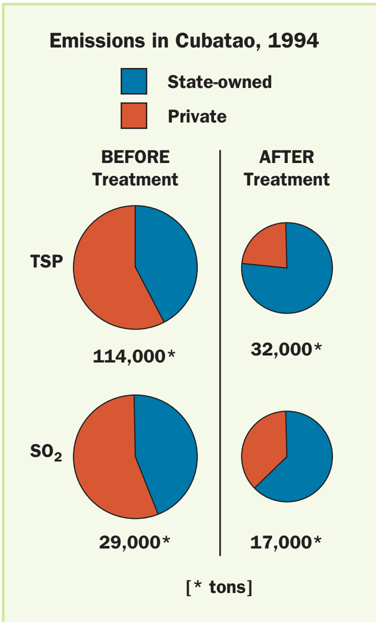

*Source:* CETESB

down, quality is up, and there is widespread interest in the new ISO 14001 quality standard, including its environmental provisions. CETESB also finds it easier to regulate the privatized Cubatao steel mill. Although Brazil's privatization program had no explicit environmental goals, it proved to be a godsend for hard-pressed pollution control agencies like CETESB.

The impact of privatization on Cubatao is not an isolated case: National economic policies affect industrial emissions so strongly that they constitute "pollution's hidden half." Recent research shows that cleaner production generally results from economic reforms—reducing barriers to international trade, privatizing state industries, developing new stock markets, eliminating subsidies for energy and raw materials, and deregulating domestic industries. However, such reform is not a panacea. Few countries reform their economies for environmental reasons, so it would be a peculiar stroke of luck if all such actions had clean impacts. In some cases economic reform can actually increase industry's pollution intensity, and the faster growth sparked by more-open markets magnifies the potential for pollution.

Fortunately, numerous studies have suggested ways to anticipate and offset such side effects while economic reform attacks pol-

**Figure 5.2 Ownership and Pollution**




*Source:* CETESB

lution's "hidden half" on a broad front. Incomes should also rise with economic reform, increasing public support for formal and informal regulation of pollution. However, ensuring lower pollution requires close cooperation between economic reformers and environmentalists, as well as added resources to help regulators monitor pollution in the wake of reform.

## 5.1 How Trade Reform Influences Polluters

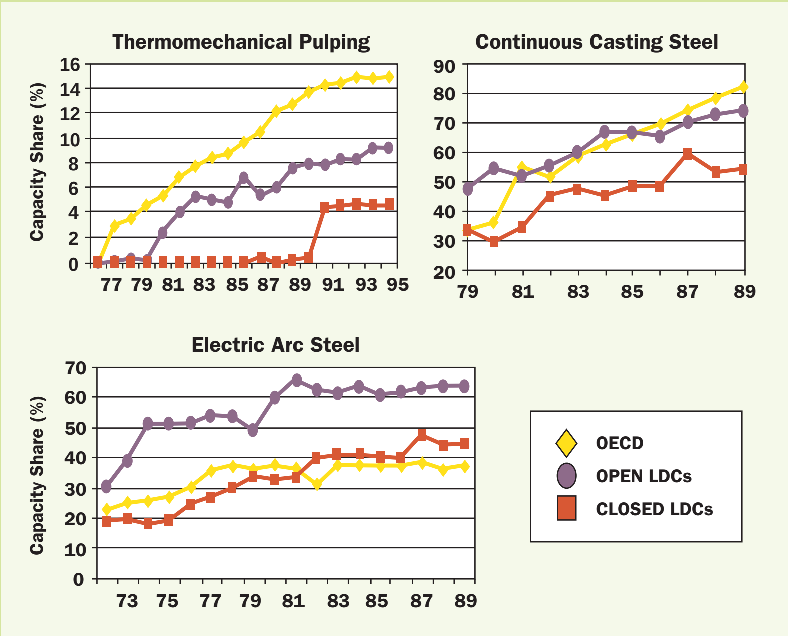
When developing countries become more "open"—cutting tariffs and lowering other barriers to international trade—domestic firms have better access to cleaner manufacturing technologies. Such technologies emerged rapidly in the 1970s because of stricter environmental regulation in the OECD economies.[4] In steel making, for example, continuous casting revolutionized production by eliminating energy-intensive intermediate stages, thereby reducing pollution by about 20 percent. The use of electric arc furnaces in the industry also grew rapidly, partly because the process is far less pollution-intensive. In the paper industry, thermomechanical pulping greatly reduced the need for polluting chemicals.

Although these new technologies were available on world markets soon after they were developed, weak regulation in developing countries provided little incentive for plants to adopt them for environmental reasons. However, the new technologies also operated more efficiently than their predecessors. Lowering trade barriers made them cheaper to acquire, and potentially increased domestic firms' interest in more efficient production by opening the market to international competition.

To determine whether open developing economies absorbed these technologies more rapidly than closed economies, a World Bank research team examined steel and paper production in 50 countries. We found that the open economies led closed economies in adoption of cleaner technologies by wide margins (Figure 5.3), and that the open economies reaped significant environmental benefits. For example, we estimated that more rapid adoption of continuous casting and electric arc technology made steel making in the open economies about 17 percent less pollution-intensive than in the closed economies.[5]

Some economists have also argued that greater openness to trade can encourage cleaner manufacturing because protectionist countries tend to shelter pollution-intensive heavy industries. In the early 1990s, a World Bank team found that pollution intensity was indeed higher in protectionist Latin American economies than in

**Figure 5.3 Trade Policy and Adoption of Clean Technology**




*Source:* Wheeler, Huq, and Martin (1993)

countries with fewer barriers to trade. Another Bank team uncovered the same result in a study encompassing all developing countries.[6] Recent evidence from China suggests that greater openness to trade has reduced the share of dirty sectors (Box 5.3).

However, research at the plant level in Indonesia, India, and Mexico has found that factories with more external trade links do not have lower pollution intensity, nor are they more likely to comply with environmental regulations.[7] Thus, we can conclude that countries that are more open to trade adopt cleaner technologies more quickly, but individual factories that are export oriented have no special advantage. Open economies also seem to harbor fewer pollution-intensive industries.

Of course, growing international trade may stimulate more production, swamping cuts in pollution intensity and raising a country's total pollution. We will address that problem later in the chapter.

## 5.2 How Input Prices Affect Pollution

Eliminating subsidies for energy and raw materials, and breaking up protected monopolies that produce them, change the prices of these goods. Because industry relies heavily on such inputs, changes in their prices also exert significant effects on industrial pollution—sometimes in opposing directions.

Much previous research, for example, suggests that materials-intensive industries also produce a lot of waste. Thus, eliminating subsidies for raw materials—thereby raising their prices—shifts production toward processes that use fewer materials and pollute less. (End-of-pipe pollution control also uses material inputs such as chemicals. Increasing their cost makes end-of-pipe control more expensive and thus less likely to be used. Overall pollution declines, however, because process-level waste reduction more than compensates for the end-of-pipe effect.)[8] On the other hand, breaking up monopoly producers of raw materials should increase competition and reduce prices. Companies should respond by using more materials, thereby increasing pollution intensity.

Cutting energy subsidies has opposing effects at the plant and industry levels. Several research projects have shown that raising energy prices also tends to raise pollution intensity *for individual plants* (Box 5.1).[9] Higher energy prices increase the cost of end-of-pipe treatment, thereby discouraging pollution control. They also induce substitution away from relatively clean, capital- and energy-intensive processes that generate fewer waste residuals. Electric arc furnaces and thermomechanical pulping are examples of such processes.

However, raising energy prices tends to lower pollution intensity *for industry as a whole* because sectors that process heavy raw materials (and generate most of the pollution) are also heavy energy users. As energy becomes more expensive, demand shifts toward products that are less energy (and pollution) intensive. Higher energy prices also reduce energy demand, lowering production from power plants that are often heavy air polluters. The conventional assumption is that these industry-level effects are greater than countervailing plant-level effects, so higher energy prices should reduce overall pollution from industry. However, data scarcity has prevented careful research on this issue in developing countries. Even if the overall impact of higher energy prices is beneficial, some local areas may suffer from greater pollution if local factories become much more emissions intensive. In Ciudad Juárez, the impact of propane price decontrol on brick-kiln emissions provided an excellent case in point.

Figure 5.4 illustrates possible responses to economic reforms at a plant whose managers minimize costs by equating marginal abate-

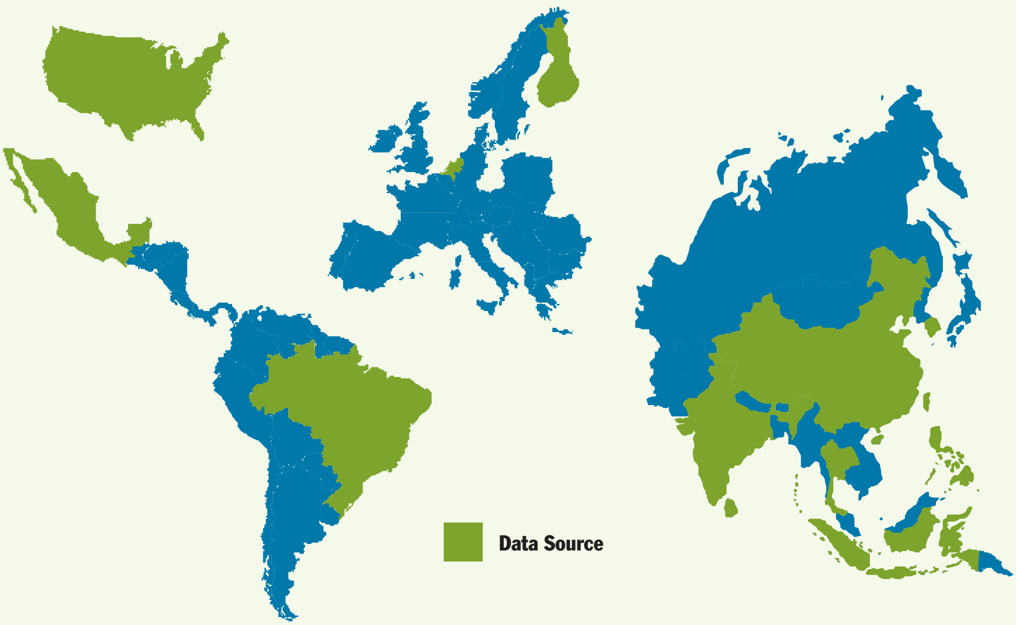
## Box 5.1 Beyond Anecdotes: Building a Database through Collaborative Research

Information scarcity makes research on industry-and-environment issues difficult in developing countries. National and regional environmental agencies are potentially good sources of information, but their data on industrial emissions and compliance are generally not in the public domain. The World Bank has therefore developed a collaborative program with several environmental agencies to address the need for better information. For the partner agencies, the program provides information on international experience with pollution control, and technical assistance on designing new regulatory programs and evaluating program results. For the World Bank research team, the partner agencies have provided access to information on plant-level pollution and regulation. The Bank team has developed collegial relationships with regulatory agencies in several OECD countries as well.

The fruits of collaboration are well illustrated by a cross-country study of industrial water pollution intensity cited in this chapter (Hettige, Mani, and Wheeler, 1998). For that study, the World Bank team acquired information from 12 countries (Figure B5.1):

**Brazil:** CETESB, the environmental agency for São Paulo State, provided information on organic water pollution from its 1,250-plant database.

**Figure B5.1 Data for Comparative Research**



### Box 5.1 *(Continued)*

**China:** The State Environmental Protection Agency (SEPA) supplied information on water pollution from its comprehensive database on major sources of industrial pollution. Our estimates are based on SEPA's 1993 data for 269 factories scattered throughout China.

**Finland:** The Industrial Waste Water Office of the National Board of Waters and the Environment provided data on water emissions in 1992 from 193 large water-polluting factories.

**India:** The Tamil Nadu Pollution Control Board, which monitors air and water pollution for all the manufacturing units in the state, provided plant-level data for 1993–94.

**Indonesia:** BAPEDAL, Indonesia's National Pollution Control Agency in the Ministry of Environment, provided data on plant-level emissions.

**Korea:** The National Pollution Control Agency provided 1991 data on water emissions from 13,504 facilities.

**Mexico:** The State Water Monitoring Authority provided 1994 data on water emissions from 7,500 facilities in the Monterrey Metropolitan Area.

**The Netherlands:** The Ministry of Housing, Spatial Planning, and the Environment provided 1990 data on water pollution from its Emissions Inventory System, which encompasses 700 regularly monitored facilities.

**Philippines:** The Philippine Department of Environment and Natural Resources (DENR) and the Laguna Lake Development Authority provided data on emissions from factories in the Manila area.

**Taiwan (China):** The Water Quality Protection Division of the Taiwan Environment Protection Agency provided data on emissions from 1,800 plants.

**Thailand:** Seatec International, a private environmental consulting firm in Bangkok, provided plant-level data on water emissions from 450 facilities in two industrial estates in Rangsit and Suksawat in 1992.

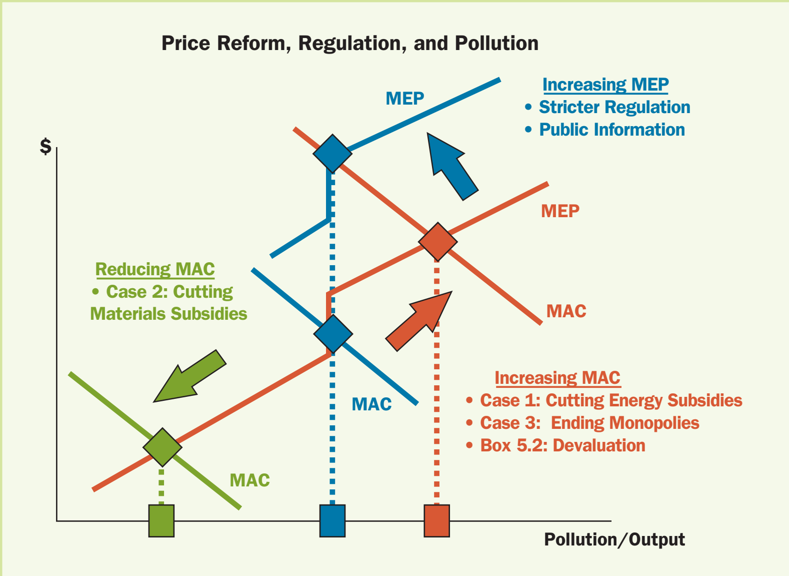
**Sri Lanka:** The World Bank's Metropolitan Environment Improvement Program and the Sri Lankan Board of Investment supplied data on pollution and employment as part of their study of wastewater treatment options for the Ekala/Ja-ela Industrial Estate. Ekala/Ja-ela, one of two major estates in Sri Lanka, includes 143 industrial establishments with 21,000 employees.

**USA:** Regional databases provided information on industrial water discharges, collected by the U.S. Environmental Protection Agency.

*Source:* Hettige, Mani, and Wheeler (1998)

ment costs (MAC) and marginal expected penalties (MEP). The plant's pre-reform pollution intensity is blue (where blue MAC = red MEP). In case 1, when energy prices rise, the cost of abating pollution increases to red, and so does pollution intensity (to the point where red MAC = red MEP). In case 2, with declining subsidies, the plant uses fewer raw materials, waste residuals decline, and the cost of abating pollution falls to green, as does pollution intensity (to the

**Figure 5.4 Price Reform and Pollution Intensity**




point where green MAC = red MEP). In case 3, the plant's raw materials supplier has lost monopoly power and lowered prices, so the plant uses more materials (generating more waste residuals), MAC increases, and so does pollution intensity.

The value of a country's currency can also affect the prices of chemicals, equipment, and spare parts used for controlling pollution, because developing countries often import such inputs. By making them more expensive, devaluing a country's currency—a common feature of economic reform—should raise pollution intensity by reducing pollution control. The study summarized in Box 5.2 suggests that Indonesia's recent devaluation had this effect.

For clarity, Figure 5.4 assumes that MAC increases by the same amount for reduced energy subsidies, elimination of monopoly power, and devaluation. The plant will return to blue pollution intensity only if MEP is increased from red to blue by stricter formal or informal regulation.

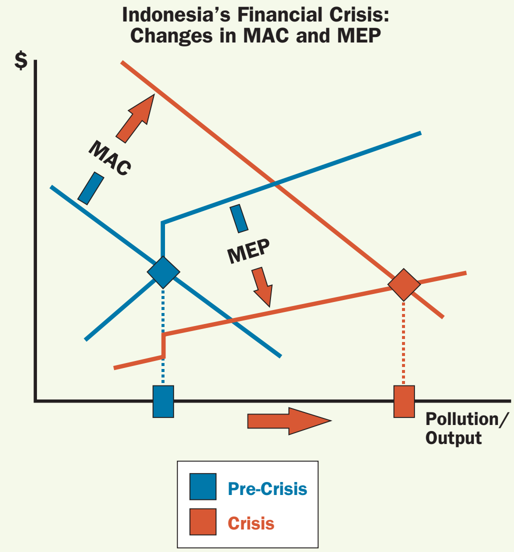
## 5.3 The Impact of Plant Ownership on Pollution

Economic reforms often change a country's pattern of factory ownership, which in turn affects pollution. The most obvious case is

## Box 5.2 Industrial Pollution in Indonesia's Financial Crisis

A recent study analyzed the impact of Indonesia's financial crisis on industrial production and emissions in a large sample of factories (Afsah, 1998). The study confirms that industrial output declined significantly during the crisis—by 18 percent—but also finds that the intensity of factories' organic water pollution rose by 15 percent. The study identifies two main reasons for increased pollution intensity: rapid devaluation of the country's currency, which made imported inputs for curbing pollution much more expensive (raising MAC); and drastic cuts in regulators' budgets (lowering MEP). As plant managers responded to the new conditions, pollution intensity jumped from blue to red (Figure B5.2). However, the country's total emissions of organic water pollutants remained roughly constant, because declining production volume offset the rise in pollution intensity.

**Figure B5.2 Financial Crisis and Pollution**




privatization, which transfers state-owned plants to private hands, but trade reform can also decrease the role of family-owned and single-plant firms in the economy while increasing the role of large enterprises (particularly multinationals). State-owned plants worldwide have compiled an unenviable record of wasteful resource use and financial distress, which in turn means higher abatement costs, less investment in pollution control, and higher pollution intensity. Several recent studies have confirmed these effects. A study in Indonesia finds that public enterprises are considerably more pollution intensive than private factories.[10] Analyses in China reveal that state enterprises have higher pollution intensity and lower regulatory compliance than other firms.[11] And a four-country survey of pulp mills in Thailand, Bangladesh, India, and Indonesia shows that state-owned plants make far less effort to abate pollution than their private counterparts.[12]

Although the public enterprises in Indonesia's PROPER program were more compliant than private firms when the program began, after 18 months the record of the two types of enterprises did not differ significantly. We view this as a reflection of the fact—also experienced by CETESB in Cubatao—that state-owned enterprises are less susceptible to outside pressure, so public information exerts less influence on their behavior. If this reasoning is correct, then state-owned enterprises will probably lag behind other firms participating in PROPER in the coming years. Overall, we believe the evidence clearly shows that privatizing state-owned enterprises reduces pollution.

## The Uncertain Effect of Family Ownership

In Asia and Latin America, family enterprises have traditionally dominated many industry sectors. In Brazil, for example, two-thirds of the 33 largest private business groups are family controlled, and such groups also dominate in Mexico, Argentina, Colombia, and Chile.[13] Family-controlled firms flourished during the protectionist era because state enforcement of business contracts was uncertain, the absence of international competition reduced pressure to hire professional managers, and limited domestic markets curtailed firms' need for large outside sources of capital. With more open markets and vigorous international trade, the advantages of family-owned business structures have begun to wane.

Like state-owned enterprises, family-owned firms seem likely to be more pollution intensive and less compliant with environmental regulations than publicly traded firms. As we saw in Chapter 3, studies in Mexico and other countries show that the stock market rewards good environmental performance, and a complementary study of Mexican factories shows that plants in publicly traded firms comply with environmental regulations at significantly higher rates than family-owned factories. However, plant-level results from India do not show any compliance differential between family-owned and publicly traded firms. The authors of the India study postulate that better regulatory enforcement in Mexico prompts the Mexican stock market to value environmental performance more highly than the Indian market. However, that interpretation is speculative, and the effect of family ownership on pollution levels remains inconclusive.[14]

## The Impact of Multinationals

Conventional wisdom holds that multinationals are greener than domestically owned businesses in developing countries, because multinationals have high-level technical skills, good information about abatement alternatives, internationally competitive management, and better access to capital. Moreover, as "guests" in the local economy, multinationals may be more susceptible to formal and informal pressure from regulators and communities.

However, systematic evidence from studies of plant-level data in Indonesia, Bangladesh, Thailand, India, and Mexico shows that multinationals are not, in fact, greener than publicly traded domestic firms with similar characteristics.[15] Still, the results of Indonesia's PROPER public-disclosure program imply a caveat. Multinationals and private domestic firms were equally compliant with regulations when the program began. However, after 18 months the former complied at significantly higher rates, suggesting that multinationals adjust more rapidly to public information (Box 3.2). Because the Indonesian study does not fully control for ownership status, we do not know whether this effect stems from the fact that a firm is a multinational or that it is publicly traded. The Mexican results cited in Chapter 3 suggest that public trading is the key.

In any case, by overturning the myth of green multinationals, these studies show that environmental progress is a domestic affair. Foreign investment can be valuable for many reasons, but it is unnecessary for effective pollution control.

## Consolidating Ownership

As countries open their borders to trade and reduce the state's role in the economy, larger, more sophisticated operations that can withstand competition begin absorbing single-plant firms. As we saw in Chapter 4, these changes can boost environmental performance, because larger firms can spread the costs of in-house technical services over more factories. Plant-level analyses in several countries confirm this advantage. A recent study in Mexico also found that multiplant status improves regulatory compliance. (We might expect multiplant firms to attract more attention from regulators, but a recent study in India found that multiplant status has no effect on the rate at which regulators inspect a company.)[16]

Reduced state intervention in the economy generally translates into larger factories in pollution-intensive industries, although this is not inevitable. The Soviet Union constructed huge steel plants with scant regard for the cost of transporting raw materials and steel, and in the post-Soviet era downsizing has reigned as transportation costs have risen. State enterprises in other economies have faced similar problems. However, economic reforms usually increase plant size. Recent work in the Philippines has suggested that larger manufacturing plants are more economically efficient.[17] As Box 5.3 shows, market reform in China has led to a major consolidation of production. In India, many small plants survive only because they are protected by law.

Figure 5.5 draws on four econometric studies to depict the country-wide results of consolidation: Merging two smaller hypothetical plants whose production and pollution levels originally total 100 units would cut overall pollution to about 70 units in Mexico and India and 80 units in China and Indonesia.[18]

However, even though it reduces pollution intensity, consolidation may inflict more overall pollution damage because large plants tend to cluster in populous areas. For example, a recent study in Brazil stratified 3,500 municipalities into 10 groups by income per capita and examined the location of 156,000 factories of various sizes. Figure 5.6 shows that large plants locate in wealthier regions, which also tend to have the largest populations (Box 2.2). Even though the large plants are less pollution intensive, more people die from air pollution because more of them live close to the plants.[19]

Thus, unless regulators tighten pollution control, the net effect of consolidation may be more pollution damage. Fortunately, large plants are also natural targets for regulators with limited monitoring and enforcement capability. Strategies that focus on major polluters, such as CETESB's ABC approach, can lower pollution intensity to compensate for greater population exposure. Even where regulation is weak, local communities can more easily identify large plants and pressure them to reduce pollution.

## 5.4 Accounting for Pollution's Hidden Half

Overall, economic reform reduces pollution intensity by cutting subsidies for raw materials and encouraging international trade, privatization of state enterprises, more publicly traded firms, and larger firms and plants. However, economic reforms do not always reduce pollution: Accelerated output growth may overwhelm cuts in pollution intensity. And devaluing a country's currency, removing energy subsidies, and eliminating monopolies on production of raw materials may actually increase pollution intensity in some cases. Furthermore, consolidation may bring more large plants to urban areas, increasing the impact of pollution on human health.

The bottom line is that environmentalists can welcome most reforms as pollution fighters, but economic reformers should recognize that their efforts can produce perverse environmental impacts.

## Box 5.3 Economic Reform and Industrial Pollution in China

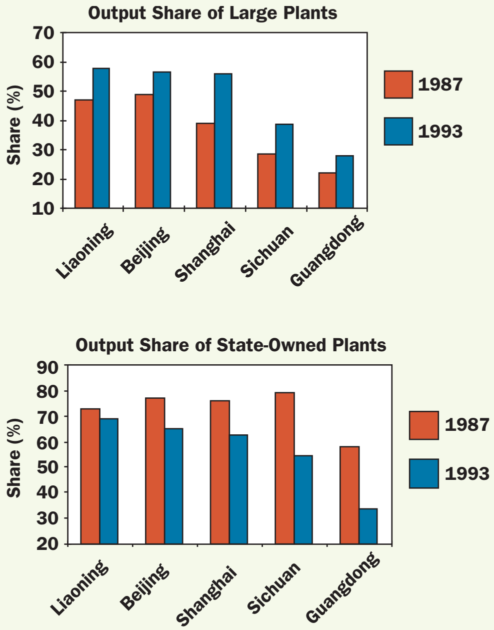
To determine the impact of China's economic reform on industrial pollution, we developed comparative statistics for five provinces in central and eastern China (Figure B5.3a). Four of these provinces (including the Beijing and Shanghai metropolitan regions) are scattered from north to south in China's eastern coastal region. Beijing's industry has a diversity that reflects its status as the nation's political capital. Liaoning is a traditional center of heavy industry, and many of its factories rely on old, highly polluting processes. Shanghai's industrial base is extremely diverse but its sheer scale assures a large potential pollution problem. Guangdong's development has brought rapid growth of light manufacturing. Finally, Sichuan, located in the Red Basin in south-central China, is considerably poorer than the other four provinces, and its industry is highly pollution intensive.

**Figure B5.3a Chinese Provinces**


Five Industrial Regions in Central and Eastern China

China's economic reforms have significantly changed average plant size and ownership patterns in these five provinces. The economy's share of large plants consistently grew from 1987 to 1993, most markedly in Shanghai, while the share of state-owned enterprises (SOEs) declined, particularly in Sichuan and Guangdong (Figure B5.3b).

**Figure B5.3b Plant Size and Ownership**




The econometric results reported in Dasgupta, Wang, and Wheeler (1997) suggest that both larger plants and a smaller role for SOEs should reduce industry's pollution intensity. Figure B5.3c illustrates this result for organic water pollution (chemical oxygen demand (COD)) and air pollution (TSP). At the provincial level, emissions intensities for both types of pollution have declined significantly during the period of economic reform. The greatest absolute declines have occurred in Sichuan

## Box 5.3 *(Continued)*

**Figure B5.3c Pollution Intensities and Reform**

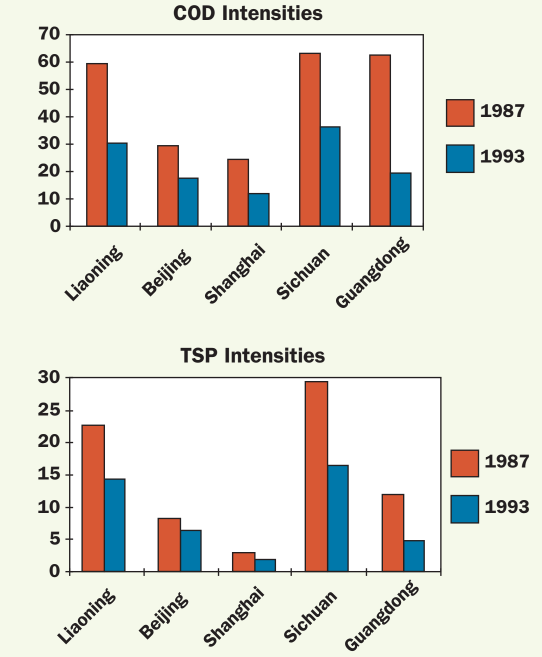
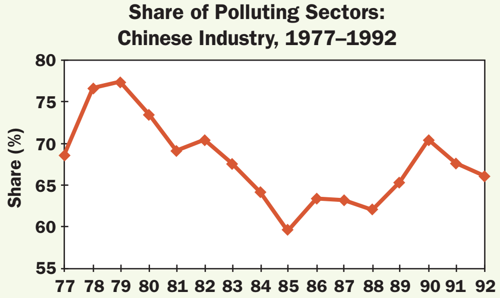



**Figure B5.3d Dirty Sectors in China**



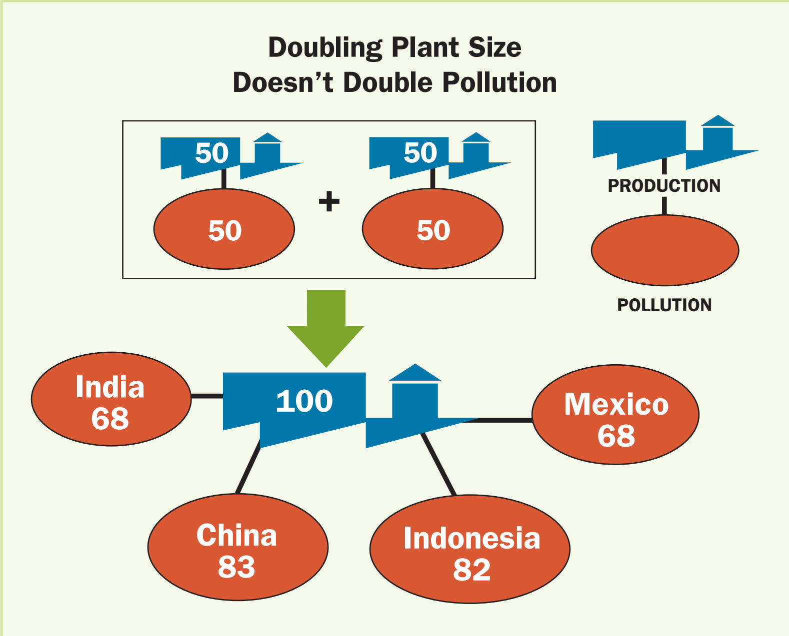

and Guangdong, but all five provinces have seen pollution intensities drop.

Concern about possible "pollution havens" in east Asia might focus on China, because the country has weaker environmental regulations and lower prices for heavy raw materials than many of its trading partners. To see whether polluting industries have flourished under these conditions, we analyzed recent trends for the five dirtiest sectors: chemicals, pulp and paper, nonferrous metals, ferrous metals, and nonmetallic minerals (principally cement).* We found that the national output share of these five highly polluting sectors actually declined during the reform period (Figure B5.3d). Thus, for China, opening the economy to more trade has not produced a shift toward dirty industries.

* For identification of polluting sectors, see Mani and Wheeler (1998) and Hettige, Martin, Singh, and Wheeler (1994).

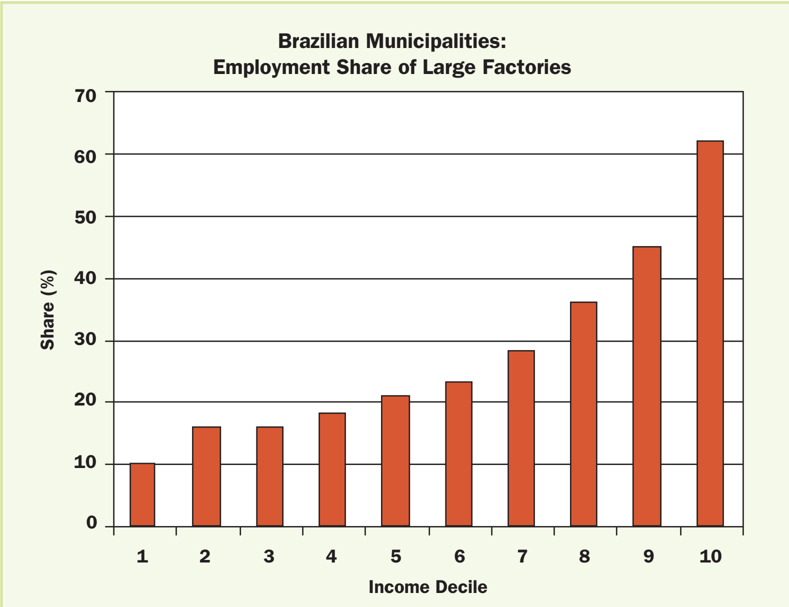
Careful analysis of such effects by both economists and environmentalists—as well as collaboration between them—is essential. Fortunately, as we will show in Chapter 6, sophisticated use of information technology can help regulators focus on the worst polluters and enlist communities in keeping them in line. To sustain such efforts and ensure their success, policymakers will have to devote some of the dividends from economic reform to improving environmental information and regulation.

**Figure 5.5 Plant Size and Pollution**




*Source:* See End Note 16

**Figure 5.6 Plant Size and Regional Development**




*Source:* Dasgupta, Lucas, and Wheeler (1998)

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## End Notes

1. Sources for the Cubatao story include CETESB (1986, 1990, 1994) and several visits to the area by the authors. CETESB stands for Companhia de Technologia de Saneamento Ambiental.

2. For a description of CETESB's ABC targeting strategy, see Chapter 2.

3. See *The Economist* (1997a). COSIPA stands for Companhia Siderúrgica Paulista.

4. Wheeler, Huq, and Martin (1993).

5. See Wheeler, Huq, and Martin (1993). We identified open and closed economies using a measure developed by Dollar (1992).

6. See Birdsall and Wheeler (1993), and Hettige, Lucas, and Wheeler (1992).

7. See Box 3.2, Pargal, Huq, and Mani (1998), and Dasgupta, Hettige, and Wheeler (1997).

8. For econometric evidence on materials prices and plant-level pollution intensity, see Pargal and Wheeler (1996).

9. These research projects included a 12-country study at the World Bank (Box 5.1) and country studies for India and Indonesia. See Hettige, Mani, and Wheeler (1998), Pargal, Huq, and Mani (1997), and Pargal and Wheeler (1996).

10. See Pargal and Wheeler (1996).

11. See Wang and Wheeler (1996) and Dasgupta, Huq, and Wheeler (1997).

12. See Hartman, Huq, and Wheeler (1997).

13. See *The Economist* (1997b).

14. See Dasgupta, Hettige, and Wheeler (1997), and Pargal, Huq, and Mani (1997).

15. References: India and Thailand: Hartman, Huq, and Wheeler (1997); Indonesia: Pargal and Wheeler (1996); Mexico: Dasgupta, Hettige, and Wheeler (1997).

16. References: India: Pargal, Huq, and Mani (1997); China: Wang and Wheeler (1999); Indonesia: Pargal and Wheeler (1996); Mexico: Dasgupta, Hettige, and Wheeler (1997).

17. See Mini and Rodriguez (1998).

18. See End Note 16.

19. See Dasgupta, Lucas, and Wheeler (1998).