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Confronting the Environmental Kuznets Curve

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The environmental Kuznets curve posits an inverted-U relationship between pollution and economic development. Kuznets's name was apparently attached to the curve by Grossman and Krueger (1993), who noted its resemblance to Kuznets's inverted-U relationship between income inequality and development. In the first stage of industrialization, pollution in the environmental Kuznets curve world grows rapidly because people are more interested in jobs and income than clean air and water, communities are too poor to pay for abatement, and environmental regulation is correspondingly weak. The balance shifts as income rises. Leading industrial sectors become cleaner, people value the environment more highly, and regulatory institutions become more effective. Along the curve, pollution levels off in the middle-income range and then falls toward pre-industrial levels in wealthy societies.

The environmental Kuznets curve model has elicited conflicting reactions from researchers and policymakers. Applied econometricians have generally accepted the basic tenets of the model and focused on measuring its parameters. Their regressions, typically fitted to cross-sectional observations across countries or regions, suggest that air and water pollution increase with development until per capita income reaches a range of $5000 to $8000. When income rises beyond that level, pollution starts to decline, as shown in the "conventional EKC" line in Figure 1. In developing countries, some policymakers have interpreted such results as conveying a message about priorities: Grow first, then clean up.

Numerous critics have challenged the conventional environmental Kuznets curve, both as a representation of what actually happens in the development process and as a policy prescription. Some pessimistic critics argue that cross-sectional evidence for the environmental Kuznets curve is nothing more than a

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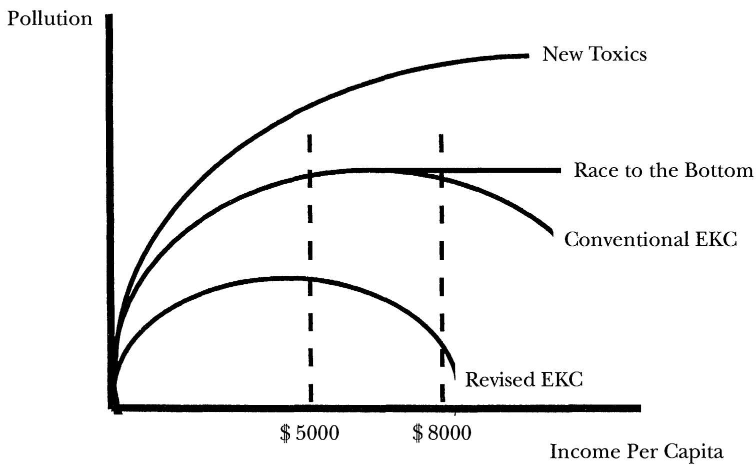
Figure 1
Environmental Kuznets Curve: Different Scenarios



snapshot of a dynamic process. Over time, they claim, the curve will rise to a horizontal line at maximum existing pollution levels, as globalization promotes a "race to the bottom" in environmental standards, as shown in Figure 1. Other pessimists hold that, even if certain pollutants are reduced as income increases, industrial society continuously creates new, unregulated and potentially toxic pollutants. In their view, the overall environmental risks from these new pollutants may continue to grow even if some sources of pollution are reduced, as shown by the "new toxics" line in Figure 1. Although both pessimistic schools make plausible claims, neither has bolstered them with much empirical research.

In contrast, recent empirical work has fostered an optimistic critique of the conventional environmental Kuznets curve. The new results suggest that the level of the curve is actually dropping and shifting to the left, as growth generates less pollution in the early stages of industrialization and pollution begins falling at lower income levels, as shown by the "revised EKC" in Figure 1.

The stakes in the environmental Kuznets curve debate are high. Per capita GDP in 1998 (in purchasing power parity dollars) was $1440 in the nations of sub-Saharan Africa, $2060 in India, $2407 in Indonesia, and $3051 in China (World Bank, 2000). Since these societies are nowhere near the income range associated with maximum pollution on the conventional environmental Kuznets curve, a literal interpretation of the curve would imply substantial increases in pollution during the next few decades. Moreover, empirical research suggests that pollution costs are already quite high in these countries. For example, recent World Bank estimates of mortality and morbidity from urban air pollution in India and China suggest annual losses in the range of 2–3 percent of GDP (Bolt, Hamilton, Pandey and Wheeler, 2001).

The stakes are not trivial for industrial societies, either. Those who believe in the "race to the bottom" model repeatedly advocate trade and investment restrictions that will eliminate the putative cost advantage of "pollution havens" in the developing world. If their assessment of the situation is correct, then industrial society faces two unpalatable options: Protect environmental gains by moving back toward autarky, but reducing global income in the process, or accept much higher global pollution under unrestrained globalization. Moreover, industrialized countries surely must consider the daunting possibility that they are not actually making progress against pollution as their incomes rise, but instead are reducing only a few measured and well-known pollutants while facing new and potentially greater environmental concerns.

In this paper, we review the arguments and the evidence on the position, shape and mutability of the environmental Kuznets curve. We ultimately side with the optimists—but with some reservations.

Theory and Measurement of the Relationship between Economic Development and Environmental Quality

Numerous theoretical and empirical papers have considered the broad relationship between economic development and environmental quality. The focus of the theoretical papers has mainly been to derive transition paths for pollution, abatement effort and development under alternative assumptions about social welfare functions, pollution damage, the cost of abatement, and the productivity of capital. This theoretical work has shown that an environmental Kuznets curve can result if a few plausible conditions are satisfied as income increases in a society: specifically, the marginal utility of consumption is constant or falling; the disutility of pollution is rising; the marginal damage of pollution is rising; and the marginal cost of abating pollution is rising. Most theoretical models implicitly assume the existence of public agencies that regulate pollution with full information about the benefits and costs of pollution control. In addition, they assume that the pollution externality is local, not cross-border. In the latter case, there would be little local incentive to internalize the externality.

López (1994) uses a fairly general theoretical model to show that if producers pay the social marginal cost of pollution, then the relationship between emissions and income depends on the properties of technology and preferences. If preferences are homothetic, so that percentage increases in income lead to identical percentage increases in what is consumed, then an increase in output will result in an increase in pollution. But if preferences are nonhomothetic, so that the proportion of household spending on different items changes as income rises, then the response of pollution to growth will depend on the degree of relative risk-aversion and the elasticity of substitution in production between pollution and conventional inputs.

Selden and Song (1995) derive an inverted-U curve for the relationship between optimal pollution and the capital stock, assuming that optimal abatement is zero until a given capital stock is achieved, and that it rises thereafter at an increasing rate. John and Pecchenino (1994), John, Pecchenio, Schimmelpfennig and Schreft (1995), and McConnell (1997) derive similar inverted-U curves by using overlapping generations models. Recent analytical work by López and Mitra (2000) suggests that corruption may also account for part of the observed relationship between development and environmental quality. Their results show that for any level of per capita income, the pollution level corresponding to corrupt behavior is always above the socially optimal level. Further, they show that the turning point of the environmental Kuznets curve takes place at income and pollution levels above those corresponding to the social optimum.

Numerous empirical studies have tested the environmental Kuznets curve model. The typical approach has been to regress cross-country measures of ambient air and water quality on various specifications of income per capita. For their data on pollution, these studies often rely on information from the Global Environmental Monitoring System (GEMS), an effort sponsored by the United Nations that has gathered pollution data from developed and developing countries. The GEMS database includes information on contamination from commonly regulated air and water pollutants. Stern, Auld, Common and Sanyal (1998) have supplemented the GEMS data with a more detailed accounting of airborne sulfur emissions. Although greenhouse gases have not been included in the GEMS database, carbon dioxide emissions estimates for most developed and developing countries are available from the U.S. Oak Ridge National Laboratories (Marland, Boden and Andres, 2001).

Empirical researchers are far from agreement that the environmental Kuznets curve provides a good fit to the available data, even for conventional pollutants. In one of the most comprehensive reviews of the empirical literature, Stern (1998) argues that the evidence for the inverted-U relationship applies only to a subset of environmental measures; for example, air pollutants such as suspended particulates and sulfur dioxide. Since Grossman and Krueger (1993) find that suspended particulates decline monotonically with income, even Stern's subset is open to contest. In related work, Stern, Auld, Common and Sanyal (1998) find that sulfur emissions increase through the existing income range. Results for water pollution are similarly mixed.

Empirical work in this area is proceeding in a number of directions. First, international organizations such as the United Nations Environment Programme and the World Bank are sponsoring collection of more data on environmental quality in developing countries. As more data is collected, new opportunities will open up for studying the relationship between economic development and environmental quality. In the meantime, it is useful to think about how to compensate for incomplete monitoring information. For example, Selden and Song (1994) develop estimates of air emissions based on national fuel-use data and fuel-specific pollution parameters that are roughly adjusted for conditions in countries at varying income levels.

A second issue is that for many pollutants data is scarce everywhere, not just in developing countries. The GEMS effort has focused on a few "criteria" pollutants, so-designated because legal statutes have required regulators to specify their damaging characteristics. Criteria air pollutants, for example, have generally included ozone, carbon monoxide, suspended particulates, sulfur dioxide, lead and nitrogen oxide. A far broader class of emissions, known as toxic pollutants, includes materials that cause death, disease or birth defects in exposed organisms. Among the hundreds of unregulated toxic pollutants that have been subjected to laboratory analysis, the quantities and exposures necessary to produce damaging effects have been shown to vary widely. Literally thousands of potentially toxic materials remain untested and unregulated.

Data gathering in this area has started, as some countries have mandated public reports of toxic emissions by industrial facilities. For example, the United States has a Toxic Release Inventory; Canada has a National Pollutant Release Inventory; the United Kingdom has a Pollutant Inventory; and Australia has a National Pollutant Inventory. Using sectoral estimates of toxic emissions relative to level of output, developed from U.S. data by Hettige, Martin, Singh and Wheeler (1995), researchers have estimated toxic emissions in eastern Europe (Laplante and Smits, 1998) and Latin America (Hettige and Wheeler, 1996; Dasgupta, Laplante and Meisner, 2001). However, the underlying scarcity of data has as yet made it impossible to do more than speculate about the shape of an environmental Kuznets curve for toxics.

A third empirical issue involves thinking about the curvature of the environmental Kuznets curve. In most cases, the implied relationship between income growth and pollution is sensitive to inclusion of higher-order polynomial terms in per capita income whose significance varies widely.

Fourth, it is useful to compare the results of time series studies where the environmental evidence is available. De Bruyn, van den Bergh and Opschoor (1998) estimate time series models individually for Netherlands, Germany, the United Kingdom and the United States and show that economic growth has had a positive effect on emissions of carbon dioxide, nitrogen oxides, and sulfur dioxide. They argue that conventional cross-section estimation techniques have generated spurious estimates of the environmental Kuznets curve because they do not adequately capture the dynamic process involved.

Given the data limitations, concerns over appropriate functional forms, and choices between cross-section and time series analysis, structural interpretations of the environmental Kuznets curve have remained largely ad hoc. In view of these uncertainties, few researchers have taken the next step and begun to study the sources of change in the marginal relationship between economic development and pollution.

How the Environmental Kuznets Curve Can Become Lower and Flatter

Research on the environmental Kuznets curve has suggested that its shape is not likely to be fixed. Instead, the relationship between growth in per capita income and environmental quality will be determined by how many parties react to economic growth and its side effects—including citizens, businesses, policymakers, regulators, nongovernmental organizations, and other market participants. A body of recent research has investigated these connections. The theme that emerges from this research is that it is quite plausible for developing societies to have improvements in environmental quality. It also seems likely that because of growing public concern and research knowledge about environmental quality and regulation, countries may be able to experience an environmental Kuznets curve that is lower and flatter than the conventional measures would suggest. That is, they may be able to develop from low levels of per capita income with little or no degradation in environmental quality, and then at some point to experience improvements in both income and environmental quality.

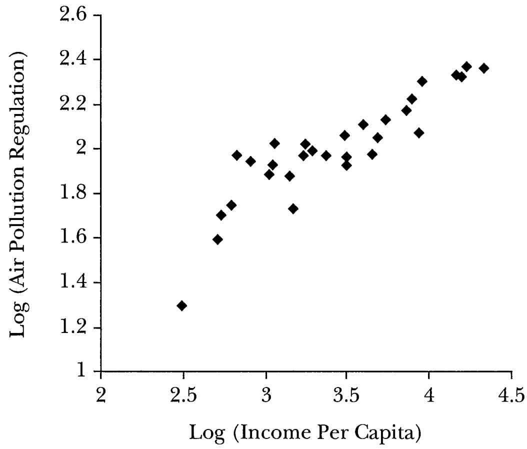
The Primary Role of Environmental Regulation

In principle, observed changes in pollution as per capita income rises could come from several different sources: shifts in the scale and sectoral composition of output, changes in technology within sectors, or the impact of regulation on pollution abatement (Grossman and Krueger, 1993). The absence of appropriate microdata across countries has precluded a systematic empirical approach to this decomposition. However, the available evidence suggests that regulation is the dominant factor in explaining the decline in pollution as countries grow beyond middle-income status.

For instance, Panayotou (1997) estimates a decomposition equation for a sample of 30 developed and developing countries for the period 1982–1994. He incorporates policy considerations into the income-environment relationship while decomposing it into scale, sectoral composition and pollution intensity (or pollution per unit of output) effects. His main finding, at least for ambient sulfur dioxide levels, is that effective policies and institutions can significantly reduce environmental degradation at low income levels and speed up improvements at higher income levels, thereby lowering the environmental Kuznets curve and reducing the environmental cost of growth. However, the estimated equation is not derived from any formal structural equation. In addition, in the absence of actual measures of environmental regulation, Panayotou uses indices of contract enforcement and bureaucratic efficiency as proxies. De Bruyn (1997) decomposes the growth-environment relationship in a sample of OECD and former socialist economies, using a divisia index methodology. Analyzing changes in sulfur dioxide pollution, he finds a significant role for environmental policy, but not for structural change in the economy. In a cross-country study of water pollution abatement, Mani, Hettige and Wheeler (2000) find that while some of the improvement in water quality with increases in per capita income is attributable to sectoral composition and technology effects, the main factor is stricter environmental regulation.

There appear to be three main reasons that richer countries regulate pollution more strictly. First, pollution damage gets higher priority after society has completed basic investments in health and education. Second, higher-income societies have more plentiful technical personnel and budgets for monitoring and enforce-

Figure 2
Air Pollution Regulation and Income Per Capita in 31 Countries



Source: Dasgupta, Mody, Roy and Wheeler (2001).

ment activities. Third, higher income and education empower local communities to enforce higher environmental standards, whatever stance is taken by the national government (Dasgupta and Wheeler, 1997; Pargal and Wheeler, 1996; Dean, 1999). The result of these mutually reinforcing factors, as shown in Figure 2, is a very close relationship between national pollution regulation and income per capita (Dasgupta, Mody, Roy and Wheeler, 2001).

Economic Liberalization

During the past two decades, many countries have liberalized their economies by reducing government subsidies, dismantling price controls, privatizing state enterprises and removing barriers to trade and investment. Easterly (2001) provides strong evidence that measures of financial depth and price distortion have improved significantly for developing countries since 1980. The result has been an adjustment toward economic activities that reflect comparative advantage at undistorted factor and product prices, which in turn can affect the level of pollution in an economy by shifting the sectoral composition.

One result has been growth of labor-intensive assembly activities such as garment production. These activities are seldom pollution-intensive, although there are some notable exceptions such as electronics assembly that employs toxic cleaning solvents and fabric production that generates organic water pollution and toxic pollution from chemical dyes (Hettige, Martin, Singh and Wheeler, 1995). Another likely area of comparative advantage is information services with relatively low skill requirements, such as records maintenance for internationally distributed information-processing services. Such activities are typically not very polluting. More environmentally sensitive areas of comparative advantage include large-scale agriculture and production that exploits local natural resources such as forest products, basic metals and chemicals (Lee and Roland-Holst, 1997). These industries are often heavy polluters, because they produce large volumes of waste residuals and frequently employ toxic chemicals.

Elimination of government subsidies often has an environmentally beneficial effect in this context. The heaviest polluters often receive subsidies, because they operate in sectors such as steel and petrochemicals where state intervention has been common. Privatization and reduction of subsidies tend to reduce the scale of such activities, while expanding production in the assembly and service sectors that emit fewer pollutants (Dasgupta, Wang and Wheeler, 1997; Lucas, Hettige and Wheeler, 1992; Jha, Markandya and Vossenaar, 1999; Birdsall and Wheeler, 1993). Elimination of energy subsidies increases energy efficiency, shifts industry away from energy-intensive sectors, and reduces demand for pollution-intensive power (Vukina, Beghin and Solakoglu, 1999; World Bank, 1999). However, higher energy prices also induce shifts from capital- and energy-intensive production techniques to labor- and materials-intensive techniques, which are often more pollution-intensive in other ways (Mani, Hettige and Wheeler, 2000).

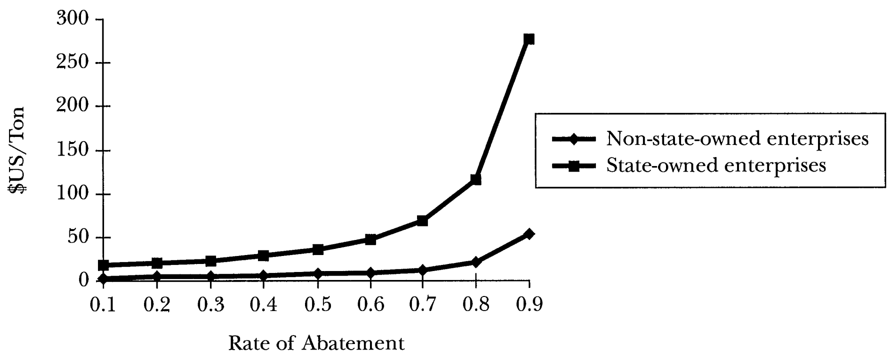
Economic liberalization also has a common effect, at least in pollution-intensive sectors, of enlarging the market share of larger plants that operate at more efficient scale (Wheeler, 2000; Hettige, Dasgupta and Wheeler, 2000). This change often involves a shift toward publicly held firms at the expense of family firms. The improvement in efficiency means less pollution per unit of production, although larger plants may also concentrate pollution in a certain locality (Lucas, Dasgupta and Wheeler, 2001). In China, state-owned enterprises have much higher costs for reducing air pollution because they are operated less efficiently. Figure 3 displays recent econometric estimates of control costs for sulfur dioxide air pollution in large Chinese factories (Dasgupta, Wang and Wheeler, 1997).[1]

The level of polluting emissions also reflects managers' technology decisions. In the OECD countries, innovations have generated significantly cleaner technologies that are available at incremental cost to producers in developing countries. Even in weakly regulated economies, many firms have adopted these cleaner technologies because they are more profitable. Increased openness to trade also tends to lower the price of cleaner imported technologies, while increasing the competitive pressure to adopt them if they are also more efficient (Reppelin-Hill, 1999; Huq, Martin and Wheeler, 1993; Martin and Wheeler, 1992). Thus, firms in relatively open developing economies adopt cleaner technologies more quickly (Birdsall and Wheeler, 1993; Huq, Martin and Wheeler, 1993).

While liberalization can certainly improve environmental conditions, it is no panacea. The evidence suggests that in a rapidly growing economy, the effect of lower pollution per unit of output as a result of greater efficiency is generally

[1] Xu, Gau, Dockery and Chen (1994) have shown that atmospheric sulfur dioxide concentrations are highly correlated with damage from respiratory disease in China. Sulfur dioxide and other oxides of sulfur combine with oxygen to form sulfates and with water vapor to form aerosols of sulfurous and sulfuric acid. Much of the health damage from sulfur dioxide seems to come from fine particulates in the form of sulfates.

Figure 3
Sulfur Dioxide Marginal Abatement Costs: Large Chinese Factories



Source: World Bank (1999).

overwhelmed by the rise in overall pollution as a result of rising output (Beghin, Roland-Holst and van der Mensbrugghe, 1997; Dessus and Bussolo, 1998; Lee and Roland-Holst, 1997). Thus, total pollution will grow unless environmental regulation is strengthened (Mani, Hettige and Wheeler, 2000).

Pervasive Informal Regulation

Low-income communities frequently penalize dangerous polluters, even when formal regulation is weak or absent. Abundant evidence from Asia and Latin America shows that neighboring communities can strongly influence factories' environmental performance (Pargal and Wheeler, 1996; Hettige, Huq, Pargal and Wheeler, 1996; Huq and Wheeler, 1992; Hartman, Huq and Wheeler, 1997). Where formal regulators are present, communities use the political process to influence the strictness of enforcement. Where regulators are absent or ineffective, nongovernmental organizations and community groups—including religious institutions, social organizations, citizens' movements, and politicians—pursue informal regulation. Although these pressures vary from region to region, the pattern everywhere is similar: Factories negotiate directly with local actors in response to threats of social, political or physical sanctions if they fail to compensate the community or to reduce emissions.

The response of factories can take many forms. Cribb (1990) cites the case of a cement factory in Jakarta that—without admitting liability for the dust it generates—"compensates local people with an ex gratia payment of Rp. 5000 and a tin of evaporated milk every month." Agarwal, Chopra and Sharma (1982) describe a situation where, confronted by community complaints, a paper mill in India installed pollution abatement equipment—and to compensate residents for remaining damage, the mill also constructed a Hindu temple. If all else fails, community action can also trigger physical removal of the problem. In Rio de Janeiro, a neighborhood association protest against a polluting tannery led managers to relocate it to the city's outskirts (Stotz, 1991). Mark Clifford (1990) has reported in the *Far Eastern Economic Review* that community action prevented the opening of a chemical complex in Korea until appropriate pollution control equipment was installed. Indeed, communities sometimes resort to extreme measures. Cribb (1990) has recounted an Indonesian incident "reported from Banjaran near Jakarta in 1980 when local farmers burned a government-owned chemical factory that had been polluting their irrigation channels."

Such examples are not limited to developing countries, of course. They also play an important role in the work of Coase (1960), who called traditional regulation into question by noting that pollution victims, as well as regulators, can take action if they perceive that the benefits outweigh the costs. Of course, the victims need information about pollution risks to take appropriate action. In most cases, such information can only be gathered by public authorities that have a legal mandate to collect it. We will return to this issue in our discussion of public disclosure as a new regulatory instrument in developing countries.

Pressure from Market Agents

Market agents can also play an important role in creating pressures for environmental protection. Bankers may refuse to extend credit because they are worried about environmental liability; consumers may avoid the products of firms that are known to be heavy polluters.

The evidence suggests that multinational firms are important players in this context. These firms operate under close scrutiny from consumers and environmental organizations in the high-income economies. Investors also appear to play an important role in encouraging clean production. Heavy emissions may signal to investors that a firm's production techniques are inefficient. Investors also weigh potential financial losses from regulatory penalties and liability settlements. The U.S. and Canadian stock markets react significantly to environmental news, generating gains from good news and losses from bad news in the range of 1–2 percent (Muoghalu, Robison and Glascock, 1990; Lanoie and Laplante, 1994; Klassen and McLaughlin, 1996; Hamilton, 1995; Lanoie, Laplante and Roy, 1998). One recent study found that firms whose bad environmental press has the greatest impact on stock prices subsequently reduce emissions the most (Konar and Cohen, 1997). Similar effects of environmental news on stock prices have been identified in Argentina, Chile, Mexico and the Philippines (Dasgupta, Laplante and Mamingi, 2001). In fact, the market responses in these countries are much larger than those reported for U.S. and Canadian firms: Stock price gains average 20 percent in response to good news and losses range from 4–15 percent in the wake of bad news.

Multinationals have responded to such factors. A recent study of 89 U.S.-based manufacturing and mining multinationals with branches in developing countries found that nearly 60 percent adhere to a stringent internal standard that reflects OECD norms, while the others enforce local standards (Dowell, Hart and Yeung, 2000). Controlling for other factors such as physical assets and capital structure, the study found that firms with uniform internal standards had an average market value $10.4 billion higher than their counterparts. Indeed, multinational firms operating in low-income economies are often environmentally friendlier than domestically owned firms. For example, a careful audit of Indonesian factories undertaken in 1995 found that almost 70 percent of domestic plants failed to comply with Indonesian water pollution regulations, while around 80 percent of the multinational plants were fully compliant (Afsah and Vincent, 1997).

Better Methods of Environmental Regulation

Poor countries with weak regulatory institutions can reduce pollution significantly by following a few basic principles. The first is focus. In many areas, relatively few sources are responsible for most of the pollution (Hettige, Martin, Singh and Wheeler, 1995; World Bank, 1999). Therefore, emissions can be significantly reduced by targeting regulatory monitoring and enforcement on those dominant sources.

Notable inroads against pollution have also been made where environmental agencies in developing countries have begun moving away from traditional command-and-control policies toward market-oriented forms of regulation. Pollution charges have proven feasible in developing countries, with successful implementation in China (Wang and Wheeler, 1996), Colombia, Malaysia and Philippines (World Bank, 1999). In Colombia, for example, the recent implementation of water pollution charges in the Rio Negro Basin reduced organic discharges from factories by 52 percent during the program's first year of operation. No participating factory seems to have experienced financial difficulties in the process (World Bank, 1999). A pollution charge program in the Laguna Bay region of Philippines reduced organic pollution by 88 percent during its first two years of operation (World Bank, 1999). Similar conclusions have emerged from studies of regulation and control costs in Malaysia (Jha, Markandya and Vossenaar, 1999; Khalid and Braden, 1993).

Better Information

Until recently, relatively little was known about the economic damage associated with pollution in developing countries. During the past few years, however, economic analyses have repeatedly shown that large cities in developing countries suffer very high costs from pollution, even when damage is evaluated at conservative estimates of local opportunity costs (Dasgupta, Wang and Wheeler, 1997; Von Amsberg, 1997; Calkins, 1994). Such evidence has induced rapid strengthening of pollution control in the large cities of China, Brazil, Mexico and other developing countries.

This improved information combines with pressures from citizens, government, nongovernmental organizations and market agents to create pressures for rapid enactment of stricter environmental regulations. Strong results have also been obtained by programs that provide accessible public information about polluters, pollution damages, local environmental quality and the cost of pollution abatement. Such programs significantly improve the ability of local communities to protect themselves, the ability of national regulators to enforce decent environmental standards, and the ability of market agents to reward clean firms and punish heavy polluters.

International institutions such as the World Bank have begun supporting this idea in collaborative programs with environmental agencies in Indonesia, Philippines, China, India, Thailand, Vietnam, Mexico, Colombia, Brazil and elsewhere.[2] In Indonesia and Philippines, pilot public disclosure programs have reduced emissions from hundreds of large water polluters by 40–50 percent during a two-year period (Afsah and Vincent, 1997; World Bank, 1999). After the success of a pilot public disclosure program in two Chinese cities, the approach is now being extended to an entire province, Jiangsu, with a population of approximately 100 million.

Cautionary Notes

In light of recent research and policy experience, the most plausible long-run forecast is for rising, not falling, environmental quality in both high- and low-income economies. Indeed, it is likely that the environmental Kuznets curve has begun to flatten downward under the combined impact of economic liberalization, improved information, and more stringent and cost-effective approaches to regulating pollution under developing-country conditions. But although we are sanguine about the prospects for combining economic growth and environmental protection, we remain cautious optimists. At least four plausible concerns have been raised.

Will Countries Need to Suffer Lower Environmental Quality in the Short and Medium Run?

The conventional environmental Kuznets curve implies that vast areas of the world—including much of Asia and Africa—will have to experience rising pollution levels until their per capita incomes rise significantly. However, there is no evidence to support the view that this would be economically advantageous. Several benefit-cost analyses have made a persuasive case for stricter pollution control, even in very low income economies. In China, for example, a recent study has shown that the economic returns to pollution abatement would justify significant tightening of regulation (Dasgupta, Wang and Wheeler, 1997). Studies in Indonesia (Calkins, 1994) and Brazil (Von Amsberg, 1997) have produced similar conclusions.

Countries whose economic policies induce a rapid expansion of income and employment may experience severe environmental damage unless appropriate environmental regulations are enacted and enforced. Economic analysis can be employed to justify environmental regulatory policies that result in a flatter and lower environmental Kuznets curve.

[2] For more information about these programs, see the World Bank's "New Ideas in Pollution Regulation" website at ⟨http://www.worldbank.org/nipr⟩.

Globalization and the Risk of a Race to the Bottom

Perhaps the most commonly heard critique of the environmental Kuznets curve is that even if such a relationship existed in the past, it is unlikely to exist in the future because of the pressures that global competition places on environmental regulations. In the "race to the bottom" scenario, relatively high environmental standards in high-income economies impose high costs on polluters. Shareholders then drive firms to relocate to low-income countries, whose people are so eager for jobs and income that their environmental regulations are weak or nonexistent. Rising capital outflows force governments in high-income countries to begin relaxing environmental standards. As the ensuing race to the bottom accelerates, the environmental Kuznets curve flattens and rises toward the highest existing level of pollution.

In the United States, political opponents of the World Trade Organization (WTO) frequently invoke elements of this model. For example, Congressman David Bonior (1999) offered the following critique: "The WTO, as currently structured, threatens to undo internationally everything we have achieved nationally—every environmental protection, every consumer safeguard, every labor victory." Herman Daly (2000), an economist at the University of Maryland's School of Public Affairs, has recently provided a forceful statement of the race to the bottom model.

Proponents of this model often recommend high environmental standards that would be uniform around the world. For countries that are unwilling or unable to enforce such standards, tariffs or other restrictions and penalties would be imposed on exports of their pollution-intensive products to neutralize their cost advantage as "pollution havens." Proponents of free trade naturally view these prescriptions as anathema, arguing that their main impact would be denial of jobs and income to the world's poorest people.

The race to the bottom model has an air of plausibility. It does appear that polluting activities in high-income economies face higher regulatory costs than their counterparts in developing countries (Jaffe, Peterson, Portney and Stavins, 1995; Mani and Wheeler, 1998). This creates an incentive for at least some highly polluting industries to relocate. But how substantial is this incentive compared to the other location incentives faced by businesses? To what extent have countries actually been reducing their environmental standards to provide such location incentives?

Research in both high- and low-income countries suggests that pollution control does not impose high costs on business firms. Jaffe, Peterson, Portney and Stavins (1995) and others have shown that compliance costs for OECD industries are surprisingly small, despite the use of command-and-control regulations that are economically inefficient. Firms in developing countries frequently have even lower abatement costs, because the labor and materials used for pollution control are less costly than in the OECD economies.

Numerous studies have suggested that, in comparison with other factors considered by businesses, pollution-control costs are not major determinants of relocation (Eskeland and Harrison, 1997; Albrecht, 1998; Levinson, 1997; Van Beers and van den Bergh, 1997; Tobey, 1990, Janicke, Binder and Monch, 1997). More important factors include distance to market and infrastructure quality and cost (Mody and Wheeler, 1992). In a study of Mexican *maquiladora* plants, Grossman and Krueger (1993) found that pollution abatement costs were not a major determinant of imports from Mexico, while their unskilled labor component was of paramount importance. Most OECD-based multinationals maintain nearly uniform environmental standards in their national and international plants. They do so to realize economies in engineering standards for design, equipment purchases and maintenance; to reduce potential liability from regulatory action; and to guard against reputational damage in local and international markets (Dowell, Hart and Yeung, 2000).

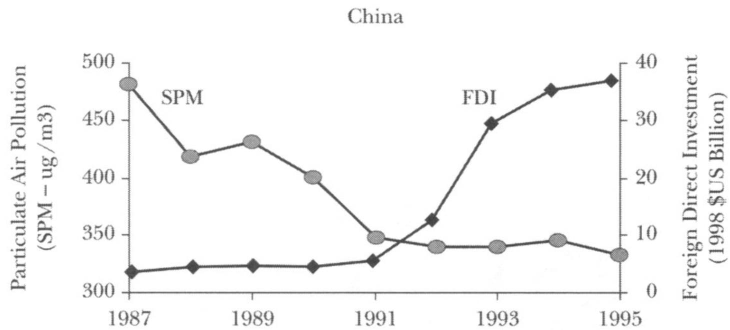
In fairness, the evidence also suggests that pollution havens can emerge in extreme cases (Xing and Kolstad, 1995). During the 1970s, for example, environmental regulation tightened dramatically in the OECD economies with no countervailing change in developing countries. The regulatory cost differential was apparently sufficient to generate a significant surge in production and exports of pollution-intensive products from developing countries. Since then, however, regulatory changes in the developing countries have narrowed the gap and apparently stopped the net migration of polluting industries (Mani and Wheeler, 1998). This pattern of tighter environmental regulations in low-income countries runs counter to the "race to the bottom" scenario.

Indeed, the scenario in which more heavily polluting industries locate in low-income countries and export back to high-income countries appears to be an incorrect description of actual patterns. In recent times, developing country imports from high-income economies have been more pollution-intensive than their exports to those economies (Mani and Wheeler, 1998; Albrecht, 1998).

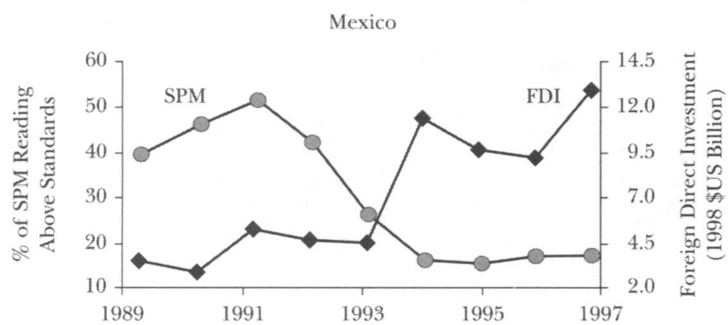
In short, there are many reasons to be dubious about the race to the bottom model. But perhaps the most powerful challenge to the model is a direct assessment of its simple and robust prediction: After decades of increasing capital mobility and economic liberalization, the race to the bottom should already be underway and pollution should be increasing everywhere. It should be rising in poor countries because they are pollution havens, and in high-income economies because they are relaxing standards to remain cost-competitive. Wheeler (2001) has tested these propositions using data on foreign investment and urban air quality in China, Mexico and Brazil. Together, these three countries received 60 percent of the total foreign direct investment for developing countries in 1998. If the race to the bottom model is correct, then air pollution should be rising in all three countries. Moreover, air quality should be deteriorating in U.S. cities, since U.S. industrial imports from all three countries have been expanding for decades.

As Figures 4 and 5 indicate, the converse is true: Instead of racing toward the bottom, major urban areas in China, Brazil, Mexico and the United States have all experienced significant improvements in air quality, as measured by concentrations

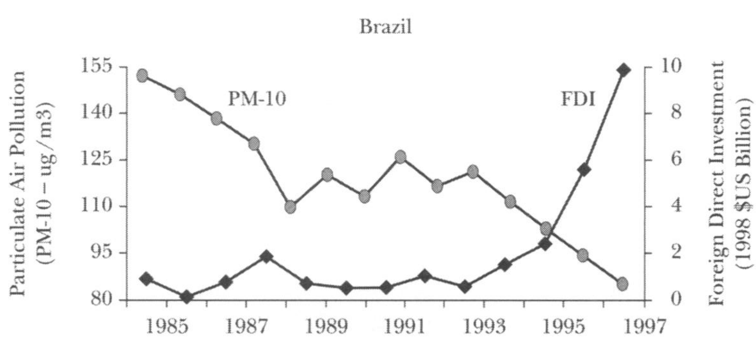
Figure 4
Foreign Investment and Air Pollution in China, Mexico and Brazil



Notes: SPM is suspended particulate matter. FDI is foreign direct investment.



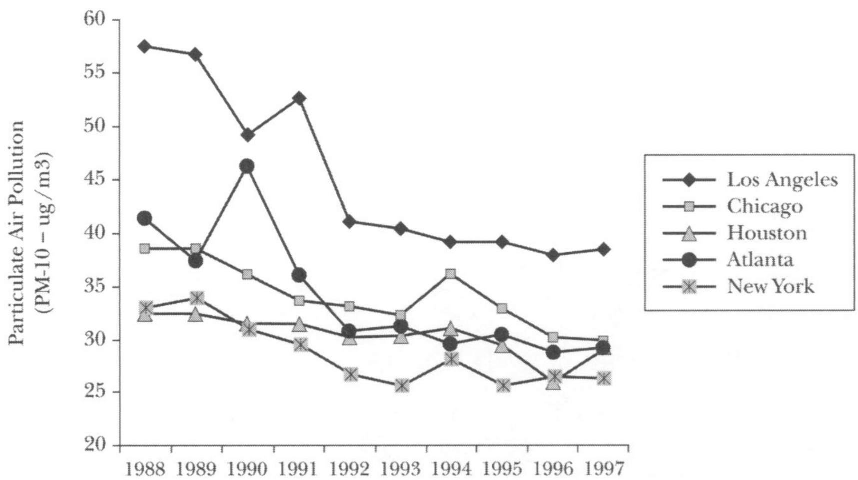
Notes: SPM is suspended particulate matter. FDI is foreign direct investment.



Notes: PM-10 is suspended particulates less than ten microns in diameter. FDI is foreign direct investment.
Source: Wheeler (2001).

of fine particulate matter (PM-10) or suspended particulate matter (SPM). Further research is necessary before any definitive conclusions can be drawn, because similar comparisons are currently unavailable for other pollutants. At present,

Figure 5
Air Pollution in US Metropolitan Areas, 1988–1997



Source: Wheeler (2001).

however, the available evidence strongly suggests that the pessimism of the race to the bottom model is unwarranted.

Are Other Pollutants Rising? The Case of Toxic Chemicals

Even if one accepts the evidence that growth in per capita income can be accompanied by reductions in well-known conventional pollutants, there is still a question about whether other less-known pollutants and environmental hazards may be rising with levels of per capita income.

One recent focus has been on emissions of toxic organic chemicals into the air and water. Although some toxic chemicals are monitored in some industrialized countries, they remain largely unregulated almost everywhere. Thornton (2000) argues that conventional regulation has failed to control the proliferation of organic chlorine compounds that are carcinogenic and mutagenic. He recommends banning the whole family of chlorine compounds, which would be economically disruptive, to put it mildly. The international community has begun responding to such thinking for some "persistent" organic pollutants that are among the organochlorines known to be most dangerous, because they accumulate in plant and animal life. In May 2001, 127 countries signed a treaty to ban international production and trade in twelve persistent organic pollutants, including PCBs, dioxins, DDT and other pesticides that have been shown to contribute to birth defects and cancer ("U.N. Treaty on Chemicals," 2001).

Such concerns raise the possibility that economic development will always be accompanied by environmental risks that are either newly discovered or generated by the use of new materials and technologies. If this proves to be the case, the recent treaty banning production and sale of persistent organic pollutants may be a harbinger of broader regulatory changes that will affect both developed and developing countries.

This issue provides a useful reminder that our understanding of environmental problems and remedies must develop over time. It seems unlikely that addressing pollution from organochlorines and other toxics will require measures as radical as those suggested by Thornton (2000). However, it will clearly be inappropriate to declare conventional environmental protection a success if it reduces a limited list of conventional pollutants while ignoring an ever-growing list of toxic pollutants that may pose threats to future generations as well as this one.

Building Regulatory Capability

If per capita income and environmental quality are to increase together, developing countries will require effective regulatory capabilities. These capabilities include not only appropriate legal measures for regulation, but also effective monitoring and enforcement of regulatory compliance. Better environmental governance, broadly understood, involves the enactment of liberalizing economic measures that affect pollution through their impact on an economy's sectoral composition and efficiency. It also includes the capability to develop and disseminate information about environmental quality and pollution sources, even if such information may embarrass certain government officials in the short run. Much of the pessimism about the prospects for environmental quality in developing countries is not about whether a win-win outcome is technically possible for the economy and the environment, but whether these societies have the institutional capabilities necessary for achieving such an outcome.

The evidence on how regulatory capability can be developed is sparse, but the World Bank's indicators of institutional and policy development provide grounds for moderate optimism. It appears that productive public policy is correlated with economic development—but that there is considerable variation in the relationship. Some excellent economic performers have quite poor regulatory capability by international standards. In turn, general policy indicators predict environmental policy performance very well, but some countries with low overall policy ratings have proven capable of focused efforts to protect critical environmental assets. The most pronounced outliers are mostly countries where specific natural resources are important determinants of tourist revenue, such as Maldives, Seychelles, Belize, Ecuador and Bhutan. Apparently, even poorly administered societies can strengthen regulation when environmental damage is clear, costly, and concentrated in a few sites. But these exceptions aside, it seems unlikely that broader environmental regulation will outpace more general institutional reform. A full response to the environmental challenge of globalization will therefore require serious attention to long-run development of public sector administrative and decision-making capacity.

Sustaining effective environmental regulation will also require the design of appropriate financing mechanisms, some of which may depart from theoretically optimal measures under the conditions that prevail in developing countries. For example, Colombia's successful pollution charge program became politically feasible only after regulators, industrialists, and public sewerage authorities agreed to use part of the revenues to support local regulatory agencies and to invest the rest in local environmental projects. Although traditional public finance theory does not support earmarking revenues in this way, rather than balancing costs and benefits of all spending choices, the program's results have clearly compensated for this conceptual flaw. Local financing may also prove to be critical during future recessions, when Colombia's central government may reduce support for national monitoring and enforcement of regulations. However, accepting political reality does not imply uncritical acceptance of any funding scheme. The designers of Colombia's system have stressed the application of clear benefit-cost criteria to local financing of pollution reduction projects.

International Assistance

We believe that the international community can play a valuable role in lowering and flattening the environmental Kuznets curve by financing appropriate training, policy reforms, information gathering and public environmental education. In our view, a steadily accumulating body of research and program experience suggests two keys to rapid progress on this front. The first is support for programs that provide public, easily accessible information about polluters, pollution damages, local environmental quality and the cost of pollution abatement. The second is support for development of stronger regulatory institutions and cost-effective measures to reduce pollution. Sustained support is critical, because institutional development takes time.

We also believe that trade and aid sanctions are inappropriate and ineffective levers for narrowing the regulatory gap between low- and high-income countries. Such sanctions are unjust because they penalize both poor workers and the many firms in developing countries that have excellent environmental performance despite weak regulation (Huq and Wheeler, 1992; Hartman, Huq and Wheeler, 1997; Afsah and Vincent, 1997; World Bank, 1999). In any case, weak regulatory institutions would prevent governments of low-income countries from delivering on promises of OECD-level regulation, even if they were willing to make them. A similar caveat applies to multilateral institutions such as the World Bank, whose operating rules now mandate accounting for environmental risks in economic reform programs. While it is important to avoid serious pollution damage during rapid liberalization, it is also critical to support carefully targeted pollution control programs whose long-run resource requirements are feasible for the recipient countries.

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