Chapter 3

Income and the Race to the Top

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IN MARCH 2001, Matt Ridley, zoologist, editor, and author of *The Origins of Virtue* (1996), delivered the Prince Phillip Lecture to the Royal Society of Arts in London, an address he titled "Technology and the Environment: The Case for Optimism" (Ridley 2002). Noting that he was convinced that things environmental were getting better, Ridley explained how, in an earlier time, he had been a deep-ecology environmentalist. Like many others, at the time, he believed that the duo of modern technology and unbridled capitalism was the chief source of harm to the environment. As the cause of the problem, these combined forces could never be the solution to modern environmental decay.

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Ridley's position on the cause of environmental decay and the prospects for improvement changed fundamentally when he encountered the work of Aaron Wildavsky (1988) and Julian Simon (1981). These two American scholars, more so than any others, were unrelenting in their marshalling of facts and logic demonstrating that the world was getting safer, not riskier, cleaner, not dirtier; that mankind's future would be brighter, not more dismal; and that uncoordinated market forces, not government, would provide the stimulus for delivering a cleaner and richer world. Ridley became convinced that when property rights are enforced under a rule of law, the market works to improve environmental quality.

More recently, the Danish statistician Bjørn Lomborg provided another volume of good cheer for the yet-to-be-persuaded environmental pessimists. Having also encountered Julian Simon's work, Lomborg explains how he, a committed pessimistic environmentalist, changed his position after completing a massive examination of data.[1] His altered position is captured in the title of his book, *The Skeptical Environmentalist: Measuring the Real State of the World* (2001). Lomborg indicates that he deliberately chose a title to serve as counterpoint to the best-selling *State of the World*, a widely read annual publication of the Worldwatch Institute. As he takes the reader through reams of charts and data, Lomborg debunks a number of pessimistic assertions found in the Worldwatch publication. Where Ridley's conversion was based primarily on theory and logic, Lomborg's transformation was based on cold hard facts.

Lomborg and Ridley join a growing list of author-scientists who report good news about the modern search for improved environmental quality. Instead of somehow being caught in a never-ending race to the bottom where, in the name of keeping and attracting industry, each community accepts more pollution than its neighbor, people of the industrialized and developing worlds alike are engaging in what might be called a race to the top. But it is a peculiar race, one in which—barring takeover by despots, natural disasters, and destruction that can

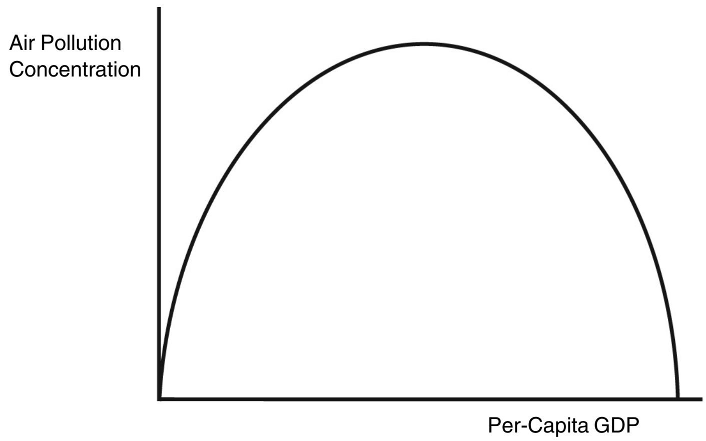

Figure 3.1 Environmental Kuznets Curve

be unleashed by holy and unholy wars—all contestants win. There are no obvious losers. The race has to do with building a better life with the same amount of resource utilization, or even less. When structured around property rights and the rule of law, it is a positive-sum game involving natural resource management and environmental improvement in which all participants taken together are made better off.

All this sounds too good to be true. How can it be? How can risks be reduced, environmental quality improved, endangered species given more protection, forests be better managed, and income increased so that all are made better off? When it is clear that many dimensions of environmental quality are improving, explaining how this has happened is indeed the challenge.

This chapter is about the evidence that incomes can increase and environmental quality can improve simultaneously. It is about environmental Kuznets curves (EKCs), those statistical artifacts that map relationships between a community's income and some specific measure of environmental quality, such as concentrations of sulfur dioxide at particular locations. A general-form EKC is shown in Figure 3.1. For illustrative purposes, the EKC shows a relationship between per-capita gross domestic product (GDP) and concentrations of a specific air pollutant.

An in-depth discussion of the general shape and what we know about EKCs comes later, but for now the point needs to be made that there is a human story that lies behind any observed EKC. It is this: Rising incomes enable human communities to build advanced property rights institutions that limit environmental decay and reward environmental improvement. The race to the top, which is that part of an EKC that shows environmental improvement accompanying income increases, is about escaping the commons and building fences. More will be said later about the first part of the curve where the environment deteriorates with rising income.

The chapter is organized as follows: The next section is launched by making quick reference to the idea of Aaron Wildavsky that inspired Lomborg and Ridley, the idea that richer is safer. The section then explains how the income–environmental quality relationship was first discovered and applied in a policy controversy and how that first episode of discovery inspired a host of EKC investigations. The results of these investigations are summarized.

But, of course, institutional change lies behind the observed correlation. Humankind is an institution builder. If new institutions are to emerge, older ones must be displaced. A process of creative destruction takes place when resources are conserved.[2] Institutional change and property rights are made part of the EKC discussion in the second section. The last section provides some final thoughts on the EKC relationship.

Richer Is Safer and Cleaner

One part of the inverted U-shaped environmental Kuznets curve emphasizes Aaron Wildavsky's (1988) point, that richer is safer and cleaner. Another part of the EKC, that which maps very low incomes to a measure of environmental quality, implies just the reverse: Richer is riskier and dirtier. But although we can observe what might be called the "race to the bottom" exemplified in the first part of the EKC, we just as readily see the portion that describes "the race to the top." As Wildavsky understood it, those societies that engage in wealth creation at some point become engaged in selective environmental improvement. No, not every dimension of life that someone might term environmental will be improved; reflected in the EKC are only those environmental elements that are seen as being worthy of the cost of protecting and enhancing by the people who make the decision and bear the cost. It should be emphasized that the structure of property rights institutions has a lot to do with who decides and who bears the cost. If property rights ownership is decentralized and private citizens gain and lose on the basis of environmental decisions, then public and private parties who make environmental decisions will be conditioned by private property rights.

Improving the environment is not free; opportunity costs matter to real people. How it happens is a story about growing incomes and environmental use. But it is not just a story about income and the environment. Income increases alone will not bring changes in environmental quality. Rising incomes become the means for making institutional changes that will conserve and, in some cases, rebuild environmental quality. Income-driven institutional change is costly, but not as costly as an unbounded tragedy of the commons.

Early EKC Discoveries

Grossman and Krueger (1991) were the first to model the relationship between environmental quality and economic growth. They analyzed the EKC relationship in the context of the much-debated North American Free Trade Agreement. At the time, many people feared that opening markets with Mexico would invite a race to the bottom—companies would try to find the lowest environmental standards they could get away with. Environmentally intensive factories, it was said, would rush across the border to escape the stricter environmental standards of Canada and the United States.

Without saying so, Grossman and Krueger implicitly tested the Wildavsky hypothesis. They proposed that rising incomes from trade would lead to stricter environmental control. In other words, free trade would improve incomes and protect the environment. To address the hypothesis, they developed a cross-country panel of comparable measures of air pollution in various urban areas and explored the relationship between economic growth and air quality. The data for their statistical experiments came from a joint project of the World Health Organization and the United Nations Environment Programme that began in 1976. The Global Environmental Monitoring System (GEMS) has as its goal the improvement of air-quality monitoring in urban areas worldwide. GEMS monitors air quality in cities around the world on a daily, weekly, or less frequent basis.[3] In all, forty-two countries are represented in Grossman and Krueger's sample for sulfur dioxide, nineteen countries for smoke or dark matter, and twenty-nine for suspended particulates. The participating cities are located in a variety of developing and developed countries and were chosen to roughly represent the world's different geographic conditions. In most of the cities, air quality measurements are taken at two or three different sites, which are classified as center city or suburban and as commercial, industrial, or residential. Multiple sites in the same city are monitored because pollutant concentrations can vary dramatically with local conditions and land use.

Grossman and Krueger held constant the identifiable geographic characteristics of different cities, a common global time trend in the levels of pollution, and the location and type of the pollution measurement device. With these constant, they found that ambient levels of both sulfur dioxide and dark matter (smoke) suspended in the air increase with per-capita GDP at low levels of national income, but decrease with per-capita GDP at higher levels of income. These findings provided statistical evidence for the existence of an EKC relationship for two indicators of environmental quality. The turning point came for sulfur dioxide and smoke when per-capita GDP was in the range of $4,000 to $5,000 in 1985 US$ (or about $6,200 to $8,200 in 2001). Unlike the relationship found for sulfur dioxide and smoke, no turning point was found for the mass of suspended particulate matter in a given volume of air. In this case, the relationship between pollution and GDP was monotonically increasing.[4] Based on revealed behavior, sulfur dioxide and smoke emissions mattered more to the populations in the study than suspended particulate matters. On the basis of health risks, the people in the study areas seem to have gotten it right.

Following closely on the heels of the Grossman and Krueger study, Shafik and Bandopadhyay (1992) estimated the relationship between economic growth and several key indicators of environmental quality reported in the World Bank's cross-country time-series data sets.[5] They found a consistently significant relationship between income and all indicators of environmental quality they examined. As income increases from low levels, quantities of sulfur dioxide, suspended particulate matter, and fecal coliform increase initially, then decrease once the economy reaches a certain level of income. The turning-point incomes in 1985 US$ for these pollutants are $3,700, $3,300 and $1,400 respectively.[6] (In 2001 US$, the turning points would be about $6,100, $5,400, and $2,300).

Does Cleaner in Some Places Mean Dirtier Elsewhere?

The early EKC discoveries naturally raised a question about globalization. Does a race to the top in higher-income countries mean that dirty industries are exported, causing an early race to the bottom in developing countries? In a 1992 study, Hettige, Lucas, and Wheeler explored the EKC phenomenon further and indirectly addressed this question. They developed a production toxic intensity index for thirty-seven manufacturing sectors in eighty countries over the period 1960 to 1988.[7] Their goal was to avoid focusing on individual measures of environmental quality, such as air quality, and to instead generalize the environmental impact of manufacturing by determining if manufacturing became more or less "toxic" in relation to income. The index, based on information from the U.S. Environmental Protection Agency and the U.S. Census of Manufacturers, attempted to measure a country's toxicity, or pollution intensity. The researchers could then identify the extent to which polluting production did or did not shift from higher- to lower-income countries when incomes rose faster in one than the other.

The results of the study indicate the existence of an EKC relationship for toxic intensity per unit of GDP. No evidence, however, was found for toxic intensity measured per unit of manufacturing output. When the mix of manufacturing was held constant, Hettige, Lucas, and Wheeler found that manufacturing in low-income countries was not more toxic, nor was manufacturing in high-income countries less toxic. Manufacturing, which is just one part of GDP, did not become cleaner or dirtier as income changed. Instead, manufacturing became smaller relative to services and trade in expanding economies. This suggests that higher income leads to a demand for a cleaner environment regardless of whether the environment has been damaged by a toxic-producing manufacturing sector. The authors conclude that the GDP-based intensity result is due solely to a broad shift away from industry and toward lower-polluting services as development proceeds.

This could mean that dirty production shifts elsewhere. To examine whether this happened, the authors divided the data into subsets for each decade beginning with 1960. They found the estimated pattern for the 1960s to be quite different from that of later decades. For the 1960s, toxic intensity grew most quickly in high-income economies. This pattern was sharply reversed during the 1970s and 1980s, when toxic intensity in manufacturing in less-developed countries grew most quickly. What might explain the shift to these countries?

The authors extended their analysis to investigate the possibility that toxic displacement has been affected by the trade policies of less-developed countries. Their investigation indicates that the toxic intensity of manufacturing output in these countries rises when governments protect their chemical manufacturing sector with tariffs and nontariff trade barriers. They also find that less-developed countries that are outward-oriented and high-growth have slow-growing or even declining toxic intensities of manufacturing, whereas toxic intensity increases more rapidly in inward-oriented economies—those with less trade.

The Hettige, Lucas, and Wheeler findings on trade policy and toxic intensity suggest a revised view of the displacement phenomenon, or "pollution-haven," theory. Rapidly increasing toxic intensity does not seem to characterize all manufacturing in less developed countries in the 1970s, when environmental regulation in industrialized countries became more strict. Rather, toxic intensity in manufacturing has grown much more rapidly in economies that are relatively closed to international trade. Goklany (2001) emphasizes this point, which Grossman and Krueger (1991) also note: Open economies improve their environments. More open economies have had higher growth rates of labor-intensive assembly activities that are also relatively low in toxic intensity. Highly protected economies have had more rapid growth of capital-intensive smokestack sectors. A market-based property-rights theory predicts that when ordinary people have the right to trade and to hold polluters accountable, then open markets can lead to a cleaner outcome. Additional evidence on this point is found in the work of Suri and Chapman (1998). Their findings imply that global diffusion of manufacturing contributes to environmental improvements as incomes rise and development continues.

What About Trees?

An EKC study by Cropper and Griffiths (1994) moved away from pollution to study deforestation. Cropper and Griffiths examined the effect of population pressures on deforestation in sixty-four developing countries. Income and population growth are the factors underlying the rate of deforestation in their study. Since deforestation is primarily a problem of developing countries, the authors restricted their study to non-OECD (Organisation for Economic Co-operation and Development) countries in Africa, Asia, and Latin America roughly located in the tropical belt and with a forest area of more than 1,000,000 hectares. The results were uncertain for Asia owing partly to the small amount of variation in the data, according to the authors. They discovered the inverted U EKC for the Latin America and Africa samples. However, the per-capita income levels in most countries in Latin America and Africa were to the left of (lower than) the respective peaks ($5,420 and $4,760) of their estimated EKCs. The inference could still be drawn that, for countries on these two continents, as income increases the rate of deforestation levels off.

In another 1995 study, Panayotou investigated the EKC relationship for deforestation, sulfur dioxide, oxides of nitrogen, and suspended particulate matter. He used mid- to late-1980s data from forty-one tropical, mostly developing countries for deforestation, and late 1980s data for fifty-five countries (both developed and developing) for emissions of sulfur dioxide and oxides of nitrogen. The findings indicate that the turning-point income for deforestation is earlier than the turning point for emissions. Panayotou argued that environmental degradation overall (combined resource depletion and pollution) is worse at levels of income per capita under $1,000 (in 1985 US$). Between $1,000 and $3,000, both the economy and environmental degradation undergo a dramatic structural change, from rural to urban and from the principal pursuit of agricultural production to industrial production. He noted that a second structural transformation begins to take place as countries surpass a per-capita income of $10,000 and begin to shift from energy-intensive heavy industry into services and information-intensive industries.

Replicating and Updating Earlier Studies

Selden and Song (1994) examined the two air pollutants studied by Grossman and Krueger, along with oxides of nitrogen and carbon monoxide. They used GEMS data across countries and across time to model the relationship between per-capita GDP and the air pollutants.[8] Broadly speaking, their results lend support to the existence of an EKC relationship for all four air pollutants. The EKC turning point (in 1985 US$) for sulfur dioxide was nearly $9,000 and in the vicinity of $10,000 for suspended particulate matter. (In 2001 US$, the figures would be about $14,500 and $16,400.) Both figures are significantly higher than the estimates from Grossman and Krueger.

Seldon and Song attribute the higher turning points in their results to their use of aggregate air-quality data, which include readings from both rural and urban areas, rather than the exclusively urban data used by Grossman and Krueger, who expect urban air quality to improve before aggregate data reveal improvement. The turning point for income Seldon and Song found for oxides of nitrogen was above $10,000, while carbon monoxide peaked when income levels were just above $15,000 (or approximately $16,400 and $24,600 in 2001 US$).

In her approach to EKC modeling, Shafik (1994) expanded the variables considered. She hypothesized that there are four determinants of environmental quality in any country: (1) endowment, such as climate or location; (2) per-capita income, which reflects the structure of production, urbanization, and consumption patterns of private goods, including private environmental goods and services; (3) exogenous factors, such as technology, that are available to all countries, but change over time; and (4) policies that reflect social decisions about the provision of environmental public goods' depending on institutions and the sum of individual benefits relative to the sum of individuals' willingness to pay. Shafik then focused on the availability of clean water, access to urban sanitation, ambient levels of suspended particulate matter, ambient levels of sulfur oxides, changes in forest area between 1961 and

1986, the annual rate of deforestation between 1962 and 1986, dissolved oxygen in rivers, fecal coliforms in rivers, municipal waste per capita, and carbon emissions per capita.[9] Shafik's results were mixed. She found an EKC relationship between per-capita income and sulfur dioxide and suspended particulate concentrations. However, the general EKC shape did not hold for carbon emissions per capita, dissolved oxygen in rivers, or forestation/deforestation. Shafik reasons that human populations worry first about access to safe drinking water. In her view, concerns about air pollution arise much later when income growth tends to be associated with manufacturing and energy production. When the link between environmental benefits and disposal costs are not well established, as when solid waste is disposed of in rapidly flowing rivers and there are no downstream rights holders, the Kuznets curve fails to appear. She also takes into account in her estimates technological change and offers an optimistic assessment of how improvements in technology will lead to even faster environmental repair.

Consolidating the Turning Point Data

By the mid-1990s, investigations of EKC relationships had generated enough consistent findings to give assurance that for many pollutants, richer is cleaner. As more and more environmental data were being gathered systematically, it was now possible for researchers to probe even deeper. Having initiated the EKC enterprise, Grossman and Krueger (1995) went back to the drawing board and conducted a more extensive empirical project. Once again, they modeled the relationship between per-capita income and environmental quality using GEMS data sets. Except this time, although they repeated an analysis of air quality, they focused heavily on water quality.

The GEMS/Water project monitors various dimensions of water quality in river basins, lakes, and groundwater aquifers, but the data on lakes and groundwater are quite limited. Because of this, Grossman and Krueger focused their attention on river basins.[10] Their 1995 study

Table 3.1
EKC Turning Points: Grossman and Krueger Analysis

Pollutant	*EKC Turning Point* (*in 1985 US$*)	(*approx. value in 2001 US$*)
Arsenic	$4,900	$8,000
Biological oxygen demand	7,600	12,500
Cadmium	5,000	8,200
Chemical oxygen demand	7,900	13,000
Dissolved oxygen	2,700	4,400
Fecal coliform	8,000	13,100
Nitrates	2,000	3,300
Lead	10,500	17,200
Smoke	6,200	10,200
Sulfur dioxide	4,100	6,700
Total coliform	3,000	4,900

Source: Grossman and Krueger (1995) and authors' calculations

makes use of all variables that can be considered indicators of water quality, provided that they have anthropogenic constituents (not just "natural" pollutants) and that at least ten countries are represented in the sample. They found an EKC relationship for eleven of the fourteen indicators selected for the analysis. The estimated turning-point incomes (in 1985 US$) are shown in Table 3.1.

At this point in EKC research, it is clear that human communities assign a higher priority to improving certain dimensions of water quality than to improving air quality. The evidence is that the income turning points for levels of dissolved oxygen and total coliform in water are lower than for sulfur dioxide, smoke, and suspended particulates in the air. Most likely, the behavior reflects the fact that harms from contaminated water occur much more swiftly and therefore are more clearly visible than those associated with air pollution.

A final piece to be considered in the review of consolidated estimates is that of Cole, Rayner, and Bates (1997). They examined the relationship between per-capita income and a wide range of environmental indicators using cross-country panel data sets. The environmental indicators used in this analysis are: carbon dioxide, carbonated fluorocarbons (CFCs) and halons, methane, nitrogen dioxide, sulfur dioxide, suspended particulates, carbon monoxide, nitrates, municipal waste, energy consumption, and traffic volumes. Data for the years 1970 through 1992 cover ten OECD countries for nitrogen dioxide, eleven for sulfur dioxide, seven for suspended particulate matter and carbon monoxide, nine for nitrogen dioxide and sulfur dioxide from transport, seven for suspended particulate matter from transport, and twenty-four for traffic volumes. Data for concentration of nitrates covers the years 1975 through 1990 for thirty rivers in fifteen OECD countries. Carbon dioxide data are for seven regions between the years 1960 and 1991.

Data on global emissions and total energy use are for twenty-two OECD countries between 1980 and 1992. CFCs and halons data include 1986 data for thirty-eight countries and 1990 data for thirty-nine countries. Late-1980s data were used for methane emissions in eighty-eight countries and for municipal waste in thirteen OECD countries. Energy use from transport covered twenty-four OECD countries from 1970 to 1990. In addition, emissions of nitrogen dioxide, sulfur dioxide, and suspended particulates from the transport sector are considered separately. The range of meaningful turning points estimated by Cole, Rayner, and Bates (in 1985 US$) are shown in Table 3.2.

Introducing Property Rights and the Rule of Law

In 1997, a new approach to the EKC relationship was adopted—an attempt to incorporate explicit policy considerations. Panayotou (1997) studied the EKC relationship for sulfur dioxide both to gain a better understanding of the income-environment relationship and as a basis for conscious policy intervention. Panayotou found that faster economic growth and higher population density do moderately increase the envi-

Table 3.2
Consolidated Turning Points: Cole, Rayner, and Bates Estimates

	EKC Turning Point	
Pollutant	*(in 1985 US$)*	*(approx. value in 2001 US$)*
Carbon dioxide	22,500–34,700	37,000–57,000
Carbon monoxide	9,900–10,100	16,300–16,600
Nitrates	15,600–25,000	25,600–41,000
Nitrogen oxide industrial	14,700–15,100	24,100–24,800
Nitrogen oxide transport	15,100–17,600	24,800–28,900
Sulfur dioxide	5,700– 6,900	9,400–11,300
Sulfur dioxide transport	9,400– 9,800	15,400–16,100
Suspended particulates nontransport	7,300– 8,100	12,000–13,000
Suspended particulates transport	15,000–18,000	24,600–29,600

Source: Cole, Rayner, and Bates (1997) and authors' calculations

ronmental price of economic growth, but better policies can offset these effects and make economic growth more environmentally friendly and sustainable. The sample used in the study includes thirty developed and developing countries for the period 1982 through 1994. The country median of annual sulfur dioxide concentrations was the average of all daily observations obtained from the GEMS air-quality monitoring project.

Proxies for the quality of institutions are used as variables in the study. Panayatou experimented with a set of five indicators of the quality of institutions in general: respect or enforcement of contracts, efficiency of the bureaucracy, the efficacy of the rule of law, the extent of government corruption, and the risk of appropriation, all obtained from Knack and Keefer (1995). Because all these variables were highly correlated, the author chose to use just one of the indicators, the respect or enforcement of contracts. Panayatou's main finding is that the quality of a country's policies and institutions can significantly reduce environmental degradation at low income levels and speed up improvements at higher income levels. Policies such as more secure property rights under a rule of law and better enforcement of contracts and effective environmental regulations can help flatten the EKC and reduce the environmental price of higher economic growth. The results showing a strong relationship between property rights enforcement and environmental quality are consistent with findings by Seth W. Norton (see Chapter 5 of this book).

Following in the footsteps of Panayotou, Qin (1998) included property rights considerations when he estimated EKCs for two common measures of environmental quality, sulfur dioxide emissions and levels of dissolved oxygen in rivers. Along with the two traditionally shaped EKCs, Qin also derived a monotonically increasing EKC for carbon emissions.[11] The proxy variables Qin used for the quality of institutions is the index of property rights obtained from Business Environmental Risk Intelligence (BERI) data. These data are provided by the Center for Institutional Reform and the Informal Sector (IRIS) at the University of Maryland and Knack and Keefer (1995), and range continuously from 0 to 4, with a higher score for greater enforceability of laws governing property rights. Contract enforceability measures the relative degree to which contractual agreements are honored and complications presented by language and mentality differences are mitigated.

Qin found the turning-point income for sulfur dioxide to be $7,798 in 1985 purchasing-power-parity-adjusted dollars (about $12,800 in 2001 US$.) The property-rights variable was significant and corresponded to a flatter EKC as the index rose. The estimated turning-point income for dissolved oxygen in rivers was $3,249 per-capita GDP in 1985 purchasing-power-parity-adjusted dollars (about $5,300 in 2001 US$). The results for the property-rights variable were similar to that of sulfur dioxide, again saying that property-rights enforcement matters.

Using the annual percentage change in forest area between the years 1972 and 1991 as an indicator of environmental quality, Bhattarai (2000) analyzed the EKC relationship for tropical deforestation across sixty-six countries in Latin America, Asia, and Africa. The study quantifies the relationship between deforestation and income, controlling for political and governing institutions, macroeconomic policy, and demographic factors. The results from his empirical analysis suggest that underlying political and civil liberties and governing institutional factors (that is, the rule of law, quality of the bureaucracy, level of corruption in government, enforcement of property rights) are relatively more important in explaining the process of tropical deforestation in the recent past than other frequently cited factors in the literature—for example, population growth and shifting cultivation. The study suggests that improvements in political institutions and governance and establishment of the rule of law significantly reduce deforestation. In a related way, macroeconomic policies that lead to increased indebtedness and higher black-market premiums on foreign exchange (measures of trade and exchange-rate policies) will increase the process of deforestation.

Goklany (1999) also was interested in the forces underlying changes in pollution, but he took a more direct policy-analysis approach rather than engaging in statistical analysis for the purpose of estimating an EKC. He examined long-term air quality and emissions data for each of the original five traditional "criteria" air pollutants or their precursors in the United States—sulfur dioxide; particulate matter; carbon monoxide; nitrogen oxides; and ozone or one of its precursors, volatile organic compounds and, to a lesser extent, lead. His data covered the period before and after major environmental laws shifted control of air pollution to the federal government.

Specifically, Goklany examined three separate sets of indicators for each air pollutant. The first set consists of national emissions estimates, which are available from 1900 onward for sulfur dioxide, nitrogen oxides, and volatile organic compounds; the second set from 1940 for particulate matter and carbon monoxide; and the third from 1970 for lead. The second set of indicators is composed of outdoor air-quality measurements. These include ambient concentrations in the outdoor air, which are usually better indicators for the environmental, health, social, and economic impacts of air pollution than are total emissions.

Based upon available data, Goklany developed qualitative trends in national air quality for the various pollutants. These were established from 1957 forward for particulate matter, from the 1960s for sulfur dioxide and carbon monoxide, and from the 1970s for ozone/volatile organic compounds and nitrogen oxides.

The final set of indicators consisted of estimates from 1940 to 1990 of residential combustion emissions per occupied household. Those estimates served as crude proxies for indoor air pollutants, which should serve as a better indicator of the public health impact of various air pollutants than outdoor air quality.

Goklany's findings indicate that before society reaches an environmental transition for a specific pollutant—that is, during the early phases of economic and technological development—"the race to the top of the quality of life" may superficially resemble a "race to the bottom"—or a race to relax environmental standards. But once a society gets past the transition, the race to the top of the quality of life begins to look more like a race to the top of environmental quality.

This could, in fact, create a not-in-my-backyard (NIMBY) situation. Goklany suggests that the apparent race to the bottom and the NIMBY effect are two aspects of the same effort to improve the quality of life. During the apparent race to the bottom, people are improving their lives in ways not clearly "environmental"; during the NIMBY phase, they are improving their lives by keeping out polluters because they are unwilling to pay the costs of controlling the pollution. The former occurs before the turning point, whereas the latter occurs after.

Goklany also examined whether the data support the contention that prior to the national control effected by the Clean Air Act Amendments of 1970, there had been little progress in improving air quality and that states had been engaged in a race to the bottom. His findings do not support those claims, which were used to justify the 1970 federalization.

Final Thoughts

Property rights matter, but there is no single EKC that fits all pollutants for all places and times. There are families of relationships and, in many cases, the inverted U–shaped EKC best approximates the link between environmental change and income growth. The indicators for which the EKC relationship seems most plausible are local air pollutants, such as oxides of nitrogen, sulfur dioxide, and particulate matter.

By way of contrast, there is mixed or little evidence to test the EKC hypothesis for water pollution or for gases, such as carbon dioxide. Robert E. McCormick (see Chapter 6 of this book) provides some initial data that carbon emissions follow the EKC pattern, albeit at much higher income levels. The EKC evidence for water pollution is mixed. There is evidence of an inverted U–shaped curve for biological oxygen demand, chemical oxygen demand, nitrates, and some heavy metals (arsenic and cadmium). In most cases, the income threshold for improving water quality is much lower than that for improving air pollution.

The acceptance of the EKC hypothesis for select pollutants has important policy implications. First, the relationship implies a certain inevitability of environmental degradation along a country's development path, especially during the take-off process of industrialization. Second, the EKC hypothesis suggests that as the development process picks up, when a certain level of per-capita income is reached, economic growth helps to undo the damage done in earlier years. If economic growth is good for the environment, policies that stimulate growth (trade liberalization, economic restructuring, and price reform) ought to be good for the environment. However, income growth without institutional reform is not enough. As we have seen, the improvement of the environment with income growth is not automatic, but depends on policies and institutions. GDP growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and makes the resources available for supplying it.

Whether, when, and how environmental quality improvements materialize depends critically on government policies, social institutions, and the completeness and functioning of markets. It is for this reason, among others, that Arrow et al. (1995) emphasize the importance of getting the institutions right in rich and poor countries. Along these lines, Torras and Boyce (1998) argue and show empirically that, all else equal, when ordinary people have political power and civil as well as economic rights, air and water quality improve in richer and poorer countries.

Better policies, such as the removal of distorting subsidies, introduction of more secure property rights over resources, and imposition of pollution taxes, will flatten the underlying EKC and perhaps achieve an earlier turning point. Because market forces will ultimately determine the price of environmental quality, policies that allow market forces to operate are expected to be unambiguously positive. Therefore, the search for meaningful environmental protection is a search for ways to enhance property rights and markets.

Notes

1. Lomborg discusses his encounter with Simon's ideas and the reactions to his book, both positive and negative, in an interview at Competitive Enterprise Institute. See *CEI Update* (2001). Julian Simon's manifesto of optimism spurred Lomborg to prove Simon wrong. Much to Lomborg's surprise, Simon's optimistic assessment was found to be accurate. In short, the data simply would not support the notion that human communities were systematically destroying the natural environment. The good news was more than many committed environmental pessimists could bear. There is now growing evidence that human communities are not involved in some systematic and perpetual race to the bottom where tragedies of the commons are the norms and never the exception. See Goklany (this volume) and Norton (this volume).
2. "Creative destruction" is a term of art first used to describe the essence of capitalism by economist Joseph Schumpeter (1975 [1942]).
3. Daily (or, in some cases, weekly or less frequent) measurements are taken of the concentrations of sulfur dioxide and suspended particulate matter. Data on particulates are collected by different methods, measuring either

the mass of materials in a given volume of air or the concentration of finer, darker matter (“smoke”). The GEMS sample of cities has changed over time. Sulfur dioxide was monitored in forty-seven cities spread over twenty-eight different countries in 1977, fifty-two cities in thirty-two countries in 1982, and twenty-seven cities in fourteen countries in 1988. Measurements of suspended particulates were taken in twenty-seven cities in eleven countries in 1977, thirty-six cities in seventeen countries in 1982, and twenty-six cities in thirteen countries in 1988, while data for dark matter (smoke) are available for eighteen cities in thirteen countries for 1977, thirteen cities in nine countries for 1982, and seven cities in four countries for 1988.

4. Discovering turning points requires a data set that contains per-capita income or GDP that ranges from very low to high levels. Without this range of incomes, one might observe a monotonically rising or falling relationship between pollution concentrations and income rather than a curve. The appropriate range of incomes is not always available for higher-income countries, such as the United States. If an EKC relationship is observed, it will likely be for the rightmost part of the curve, that portion where rising income levels are associated with environmental improvement. This result is found in work by Carson, Jeon, and McCubbin (1997). They used U.S. state-level emissions for seven major air pollutants: greenhouse gases, air toxins, carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic carbon, and particulate matter less than ten microns in diameter. In their initial analysis, the authors examined the 1990 state-level per-capita emissions for greenhouse gases converted to pounds of equivalent carbon dioxide, air toxics, and point-source emissions of carbon monoxide, oxides of nitrogen, sulfur dioxide, volatile organic carbon, and particulate matter. They found that emissions per capita decrease with increasing per-capita income for all seven major classes of air pollutants. In this respect, their results are consistent with those from country studies that find an EKC. Hilton and Levinson (1998) found a more complete EKC in their work on auto lead oxide emissions across the developed world. There is a related EKC identification problem when data are examined for all countries worldwide. The heterogeneity of the sample makes it extraordinarily difficult to account for institutional differences (see Stern and Common 2001).

5. Most of the variables cited in this paper are included in the environmental data appendix to the *World Development Report 1992* (World Bank 1992). The sample size varied depending on availability of data. Data on lack of safe water were available only for two years, 1975 and 1985 for forty-four

and forty-three countries, respectively, whereas data on lack of urban sanitation were available for 1980 and 1985 for fifty-five and seventy countries, respectively. Annual deforestation reflected the yearly change in the forest area for sixty-six countries between 1962 and 1986. Total deforestation was the change in forest area between the earliest date for which substantial data was available, 1961, and the latest date, 1986. Total deforestation data were available for seventy-seven countries. Data on dissolved oxygen were available for fifty-seven rivers distributed in twenty-seven countries for intermittent years between 1979 and 1988. Data on fecal coliform were available for fifty-two rivers distributed in twenty-five countries for intermittent years between 1979 and 1988. Data on ambient levels of sulfur dioxide were available for forty-seven cities distributed in thirty-one countries for the years 1972 to 1988, and data on ambient levels of suspended particulate matter were available for forty-eight cities in thirty-one countries for 1972 to 1988. Data on municipal solid waste per capita were computed in kilograms, on the basis of available city level information for thirty-nine countries compiled for the year 1985. Data on carbon emissions per capita were available for 118 to 153 countries between 1960 and 1989.

6. Shafik and Bandyopadhyay also explore the impact of political and civil liberties on environmental quality. They use Gastil indexes that measure the level of political and civil liberties in their study. The political rights index measures rights to participate meaningfully in the political process for 108 to 119 countries for 1973 and from 1975 to 1986 on a scale of one to seven where lower numbers indicate greater political rights. A high-ranking country must have a fully operating electoral procedure, usually with a significant opposition vote. It is likely to have had a recent change of government from one party to another, an absence of foreign domination, decentralized political power, and a consensus that allows all segments of the population some power. The index of civil liberties measures the extent to which people are able to express their opinion openly without fear of reprisals and are protected in doing so by an independent judiciary. Though this index reflects rights to organize and demonstrate as well as freedom of religion, education, travel, and other personal rights, more weight is given to the expression of political rights. The results indicate that political and civil liberties have insignificant effects on access to clean water and sanitation. Greater political and civil liberties are associated with increases in the annual rate of deforestation, but total deforestation over the period 1961–1986 was unaffected. River quality (measured by dissolved oxygen) improves with increased political liberties, but other measures are insignificant. In the case of local air pollution, more demo-

cratic countries have higher levels of sulfur dioxides. Particulates and municipal solid wastes were not affected by political or civil liberties. Carbon emissions are ambiguous—with a positive sign in the case of civil liberties and a negative sign for political rights. The results for political and civil liberties therefore indicate no clear pattern.

7. For each country and year, Hettige, Lucas, and Wheeler have used U.N. industrial data to calculate shares of total manufactured output for thirty-seven sectors defined on the international standard industrial classification (ISIC). To obtain country-specific toxic-intensity indexes, they multiplied these shares by U.S. sectoral toxic intensities, estimated as total pounds of toxic release per dollar's worth of output. The sectoral intensities have been calculated from a sample of 15,000 U.S. plants that they obtained by merging data from two sources: the U.S. Environmental Protection Agency's (EPA) 1987 Toxic Release Inventory, which provides plant-level release estimates for 320 toxic substances, and the 1987 Census of Manufacturers, which provides plant-level data on output value. They pool the country-specific toxic-intensity indexes with time-series estimates of income per capita to test two broad hypotheses: (1) industrial pollution intensity follows an inverse U-shaped pattern as development proceeds; and (2) environmental regulation in countries that are part of the Organisation for Economic Cooperation and Development (OECD) has significantly displaced toxic industrial production toward less-regulated LDCs (least-developed countries). The rationale for the latter hypothesis is founded on relative production cost. The former is based on the general notion of three stages of industrial development dominated by (1) agro-processing and light assembly, which are (relatively) low in toxic intensity; (2) heavy industry (for example, metals, chemicals, paper), which has high toxic intensity; and (3) high-technology industry (for example, microelectronics, pharmaceuticals), which is again lower in toxic intensity. This is perceived in part as a natural evolution and in part a response to growing pressure for environmental regulation at higher incomes.

8. The GEMS data used in the paper are obtained from the World Resources Institute. There are twenty-two high-income, six middle-income, and two low-income countries in the sample. Clearly, less-developed countries are underrepresented in the sample.

9. Data and countries covered are the same as in Shafik and Bandyopadhyay (1992).

10. In choosing where to locate its monitoring stations, GEMS/Water has given priority to rivers that are major sources of water supply to municipalities, irrigation, livestock, and selected industries. A number of stations

were included to monitor international rivers and rivers discharging into oceans and seas. Again, the project aimed for representative global coverage. The available water data cover the period 1979–1990. By January 1990 the project had the active participation of 287 river stations in fifty-eight different countries. Each such station reports thirteen basic chemical, physical, and microbiological variables, several globally significant pollutants including various heavy metals and pesticides, and a number of site-specific optional variables.

11. The data for sulfur dioxide emissions were from GEMS, and the sample included data from 1981 to 1986 for fourteen countries. From GEMS/Water stations, three three-year aggregated annual median dissolved-oxygen levels in fifteen countries for 1979–1981, 1982–1985, and 1986–1988 were computed. The data for carbon dioxide were taken from *World Resources 1990–91* and are the cross-country annual carbon dioxide emissions from fossil fuel consumption and cement industries in forty-one countries in 1987.

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