CHAPTER 2.1

Ranking National Environmental Regulation and Performance: A Leading Indicator of Future Competitiveness?

DANIEL C. ESTY, Yale University

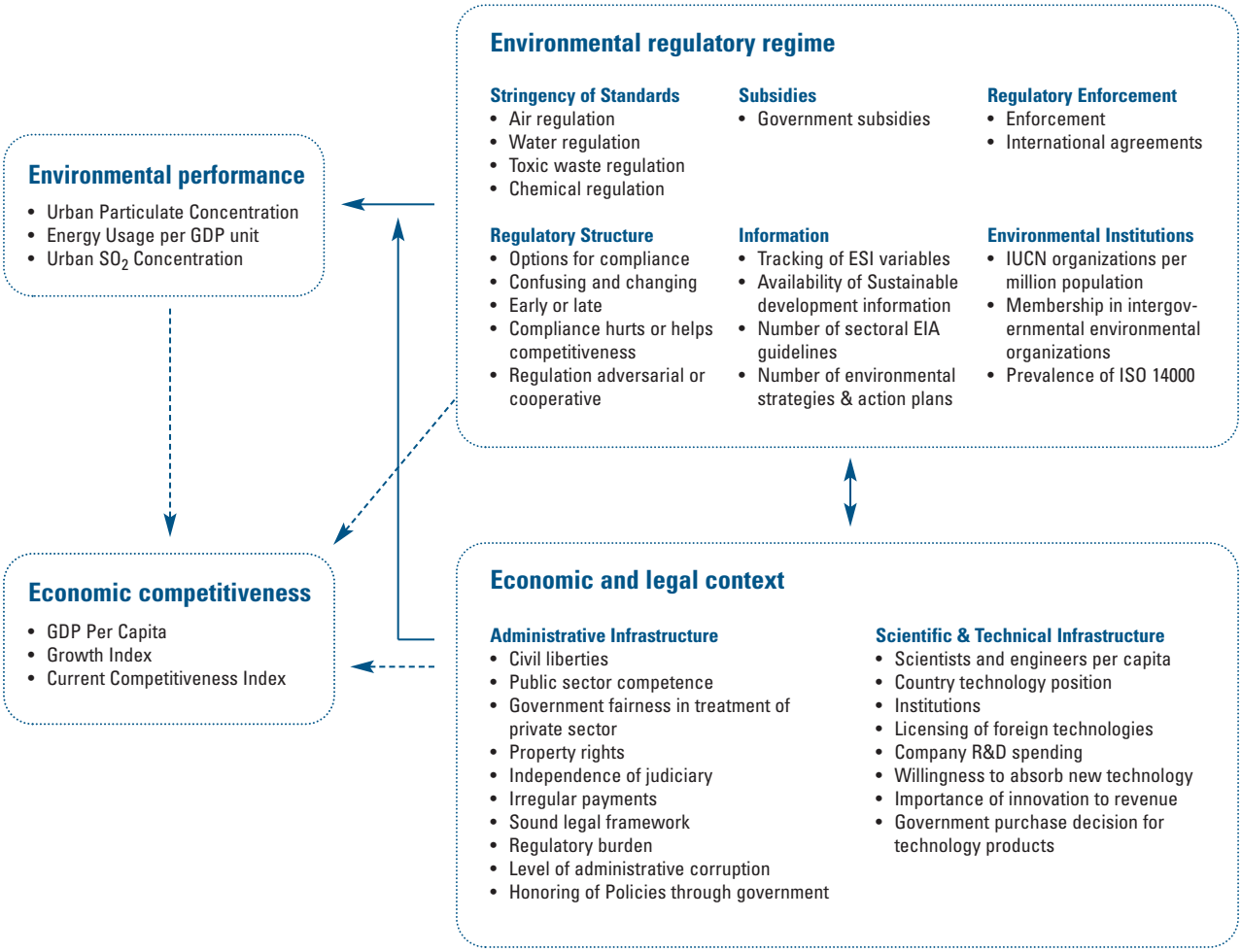
MICHAEL E. PORTER, Harvard Business School and Director, Institute for Strategy and Competitiveness

Environmental performance, encompassing the control of pollution and stewardship of natural resources, is of growing concern in both advanced and developing economies. Environmental quality plays a major role in quality of life, with a direct impact on the health and safety of a nation's citizens as well as its attractiveness as a place to live. It is becoming increasingly clear, however, that environmental performance has a further, more indirect, effect on living standards through its impact on a nation's capacity to sustain economic growth. The ability to grow requires resources and places strains on the environment that can drive up costs, especially in the longer run. But a growing body of research suggests that economic competitiveness and environmental performance are compatible, if not mutually reinforcing. Low pollution and efficient energy use are a sign of the highly productive use of resources. Policies that stimulate improvements in environmental quality, then, may actually foster improvements in competitiveness that underpin a rising standard of living in the long run.

Despite growing concern for the environment across almost all countries, and protestors from Seattle to Genoa demanding more emphasis on pollution control and natural resource management, environmental policymaking remains more an art than a science. Statistical analyses of the determinants of environmental performance across nations have been rare—indeed, almost nonexistent. Research in the environmental realm has traditionally relied heavily on anecdotal evidence and case studies. There are precious little systematic data on which to base environmental judgments at both the public policy and corporate levels. This may explain why the environmental field remains mired in deep controversies over the best path forward, with debate often dominated by emotional claims and heated rhetoric. We believe that more sophisticated use of environmental indicators and statistical tools to develop objective ways to gauge progress offer a constructive way out of the current stasis.

This chapter builds on our previous effort to investigate statistically the causes of environmental performance and to use the findings to rank countries in terms of environmental outcomes and environmental policies.[i] In particular, we seek to explain differences in national environmental outcomes—as measured by levels of air pollution (particulates and SO_2) and energy use—based on national policy choices in environmental regulation as well as in broader economic, political, and legal structures. We also explore empirically the question of whether strong environmental performance must come at the expense of competitiveness and economic development, as traditional

Figure 1: Determinants of environmental performance



economic theory has suggested (Jaffee et al 1995). More broadly, we also aim to put environmental decision-making on a firmer analytic footing and to encourage further efforts to generate better data and improve statistical methods.

Although hampered by imperfect data, a lack of time-series data that would permit more definitive tests of causality, and the need to utilize relatively crude methods, we find substantial evidence that environmental performance varies systematically with both the quality of a country's environmental regulatory regime and its broader economic and legal context. We utilize our model to create a framework for measuring the quality of national environmental regulation and to rank countries on both the quality of regulation and on environmental performance (see Table 8). We find a significant correlation between income and environmental performance, suggesting that alleviating poverty should be seen as a priority for environmental policymakers. However, dramatic differences in environmental performance occur among countries at similar economic levels. This finding implies that environmental improvement is not merely a function of economic development but benefits from conscious policy choices. Our analysis suggests that a country's broader economic, legal, and other institutional underpinnings are also important in determining environmental performance. On the tradeoff between green and competitive, we find no evidence that improving environmental quality compromises economic progress. In fact, strong environmental performance appears to be positively correlated with competitiveness.

Modeling environmental performance and its causes

We employ three measures of environmental performance (environmental "output") that are available with broad country coverage: the level of urban particulates, urban SO_2 concentrations, and energy usage per unit of GDP.[ii] These measures constitute the dependent variables for the analysis.

Building on theoretical work in the economic, legal, regulatory, and environmental domains, we then assemble data on policy variables that potentially determine environmental outcomes.[iii] The framework for the analysis is shown in Figure 1. Environmental performance is hypothesized to result from two broad sets of independent variables. One set, which we term the *environmental regulatory regime*, is comprised of measures of various aspects of a country's environmental regulatory system including standards, implementation and enforcement mechanisms, and associated institutions. These variables capture regulatory elements that directly affect pollution control and natural resource management.

The second set of independent variables, which we term *economic and legal context*, are indicators of a country's more general administrative, scientific, and technical institutions and capabilities. These include measures of the extent of the rule of law, protection of property rights, and technological strength. The hypothesis is that a nation's environmental regulatory regime will be more effective in producing the desired outcomes if the economic and legal context is sound. Hence context indirectly (but perhaps importantly) determines environmental performance.

The dotted arrows in Figure 1 represent the final stage of the analysis, in which we examine the connection between environmental performance and economic success. We explore, in particular, the relationship between our environmental quality measures and GDP per capita, as well as the relationship between an index measuring the overall environmental regulatory regime (the environmental regulatory regime index (ERRI)) and GDP per capita. We also examine the relationship between the ERRI and the Current Competitiveness Index reported in Chapter 1.2. These relationships shed light on the longstanding debate over the extent of the tradeoff between environmental progress and economic success—a question of particular interest in the developing world.

Environmental Outcomes

Environmental output data are notoriously spotty, unreliable, and uneven, as are data on the characteristics of national regulatory regimes. Hence, establishing a sufficient database for a broad empirical analysis is no small undertaking. The performance measures used in this study are drawn from data assembled for the World Economic Forum's Environmental Sustainability Index (ESI) Project.[iv]

Three measures of environmental performance emerge as reliable enough and available in a large enough number of countries to utilize in our analysis. The first is urban particulate concentration, derived from World Bank and World Health Organization (WHO) data sources. This measure provides the mean total suspended particulate concentrations in the air (airborne dust) normalized by a country's urban population. A higher concentration indicates more pollution and thus worse air quality.

The second performance measure is mean SO_2 concentration normalized by urban population. This measure is also drawn from World Bank and WHO data. Again, higher figures represent worse air pollution.

The third environmental performance measure gauges energy efficiency. Using US Department of Energy data, we measure total energy consumption per unit of a country's GDP. Higher figures represent more energy consumed per unit of economic output and thus greater energy inefficiency. In comparing this measure across countries, we need to account for the fact that Russia and the countries of the former Soviet bloc operated for decades under an energy regime with prices set well below market prices. This history has left a legacy of energy inefficiency in these countries that is only slowly being corrected. We therefore include a dummy variable in our model to control for this history, which proves to be highly significant statistically.

Table 1 provides absolute rankings by country for each of the three environmental performance measures. Urban particulate data are available for just 42 of the 75 countries covered by the *Global Competitiveness Report 2001–2002* (GCR). The United States and the United Kingdom track particulates, but on a more refined basis than the rest of the world; thus their particulate rankings are not comparable, so they are therefore excluded from the urban particulate analysis.[v] Sweden and Norway are at the top of the particulate ranking, with China and Honduras at the bottom.

Table 1: Absolute environmental performance by country

Urban Particulate Concentration*
(Per City Population)

Rank	Country	Annual Mean
1	Sweden	9.0
2	Norway	10.3
3	France	14.2
4	Iceland	24.0
5	New Zealand	27.3
6	Switzerland	30.7
7	Canada	31.3
8	Netherlands	40.0
9	Australia	43.2
10	Germany	43.3
11	Japan	43.6
12	Austria	45.7
13	Finland	49.9
14	Argentina	50.0
15	Portugal	50.4
16	Venezuela	53.0
17	Czech Republic	58.4
18	Denmark	61.0
19	Hungary	63.7
20	Slovak Republic	64.5
21	Spain	72.7
22	Romania	82.0
23	Korea	83.8
24	Italy	86.9
25	Malaysia	91.6
26	Latvia	100.0
27	Russia	100.0
28	Brazil	106.2
29	Lithuania	114.3
30	Colombia	120.0
31	Ecuador	125.7
32	Greece	178.0
33	Bulgaria	199.2
34	Philippines	200.0
35	Thailand	223.0
36	Costa Rica	244.5
37	Indonesia	271.0
38	Guatemala	272.3
39	India	277.5
40	Mexico	279.0
41	China	310.8
42	Honduras	320.0

* Not all data were available for all countries.

Urban SO_2 Concentration*
(Per City Population)

Rank	Country	Annual Mean
1	Argentina	1.02
2	Lithuania	2.10
3	New Zealand	3.49
4	Finland	4.38
5	Iceland	5.00
6	Sweden	5.23
7	Latvia	5.36
8	Norway	5.47
9	Denmark	7.00
10	Portugal	9.22
11	Netherlands	10.00
12	Romania	10.00
13	Spain	11.00
14	Thailand	11.00
15	Switzerland	11.34
16	Germany	12.80
17	Canada	12.87
18	Australia	13.17
19	Austria	13.21
20	France	13.89
21	United States	15.43
22	Italy	15.55
23	Ireland	18.89
24	Singapore	20.00
25	Malaysia	20.49
26	Belgium	21.02
27	Ecuador	21.52
28	United Kingdom	21.96
29	South Africa	22.37
30	Slovak Republic	22.66
31	Japan	24.33
32	Czech Republic	27.34
33	India	27.55
34	Chile	29.00
35	Philippines	33.00
36	Venezuela	33.00
37	Greece	34.00
38	Hungary	37.33
39	Costa Rica	38.84
40	Korea	52.41
41	Bulgaria	52.45
42	Poland	54.72
43	Egypt	69.00
44	Mexico	74.00
45	Brazil	75.78
46	China	97.07
47	Russia	97.55

* Not all data were available for all countries.

Energy Usage
(Per Mil. $ GDP)

Rank	Country	Bil. BTU
1	Denmark	4.84
2	Switzerland	5.19
3	Japan	6.55
4	Italy	6.66
5	Ireland	6.85
6	Austria	7.09
7	Germany	7.28
8	France	7.39
9	Finland	8.37
10	United Kingdom	8.59
11	Spain	8.73
12	Honduras	8.97
13	Mauritius	9.11
14	Sweden	9.14
15	Israel	9.96
16	Peru	10.81
17	Netherlands	11.01
18	Slovenia	11.26
19	Australia	11.46
20	Guatemala	11.52
21	Portugal	11.77
22	Belgium	11.83
23	Norway	12.17
24	Argentina	12.22
25	Uruguay	12.86
26	Greece	12.95
27	Bangladesh	13.15
28	United States	13.41
29	Sri Lanka	13.70
30	El Salvador	13.75
31	Brazil	14.01
32	Iceland	14.49
33	New Zealand	15.09
34	Paraguay	15.32
35	Estonia	16.09
36	Costa Rica	16.13
37	Chile	16.63
38	Canada	17.54
39	Mexico	17.72
40	Korea	17.91
41	Bolivia	18.41
42	Dominican Republic	18.68
43	Panama	18.70
44	Thailand	19.29
45	Philippines	19.74
46	Singapore	20.41
47	Zimbabwe	22.34
48	Malaysia	22.88
49	Indonesia	22.96
50	Nigeria	23.66
51	Colombia	23.98
52	Latvia	25.01
53	Ecuador	27.57
54	India	28.13
55	Egypt	31.03
56	Hungary	32.29
57	Jordan	34.52
58	Jamaica	35.58
59	Nicaragua	36.46
60	South Africa	37.92
61	China	39.10
62	Venezuela	44.11
63	Poland	45.05
64	Lithuania	54.92
65	Czech Republic	56.22
66	Romania	58.39
67	Bulgaria	60.71
68	Slovak Republic	63.95
69	Vietnam	64.57
70	Russia	74.19
71	Ukraine	96.53

Figure 2: Relationship between urban particulate concentration and GDP per capita

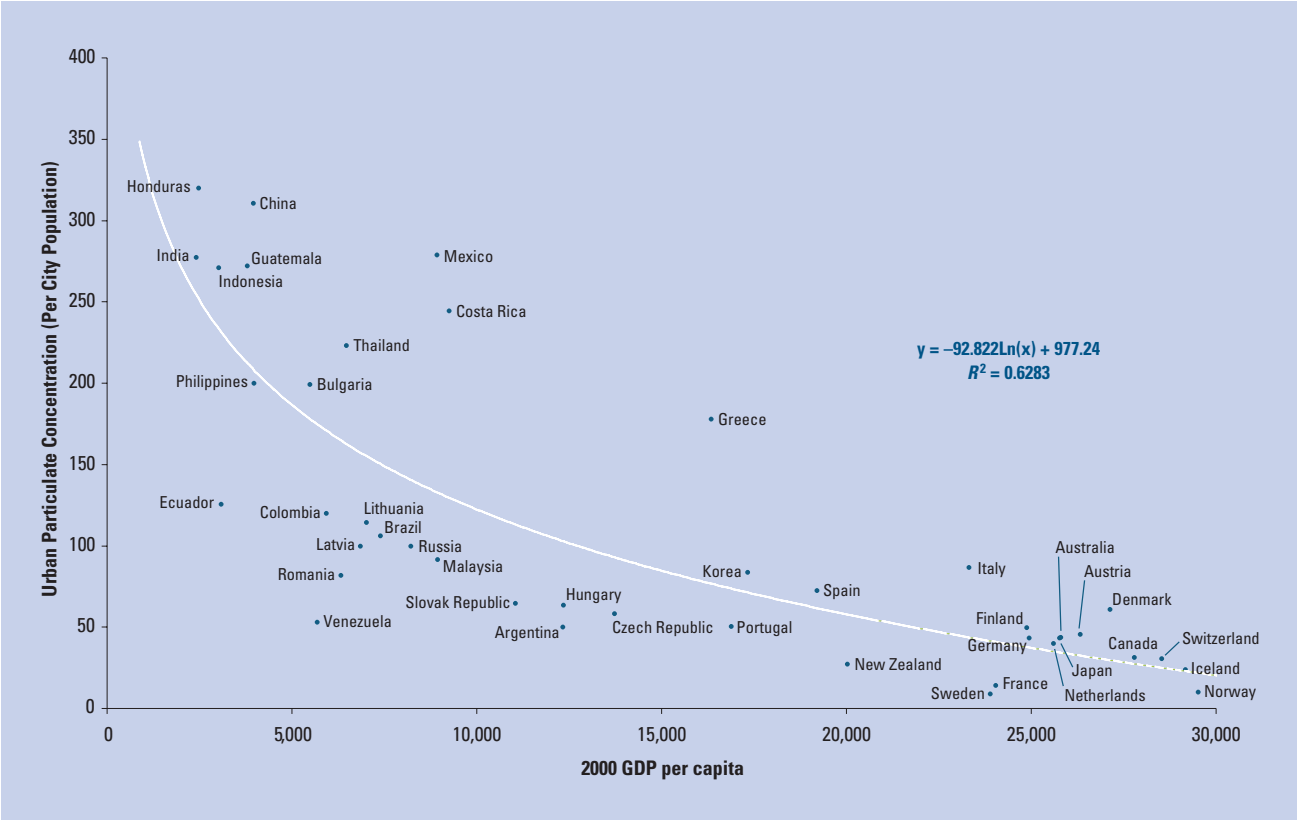


Figure 3: Relationship between urban SO_2 concentration and GDP per capita

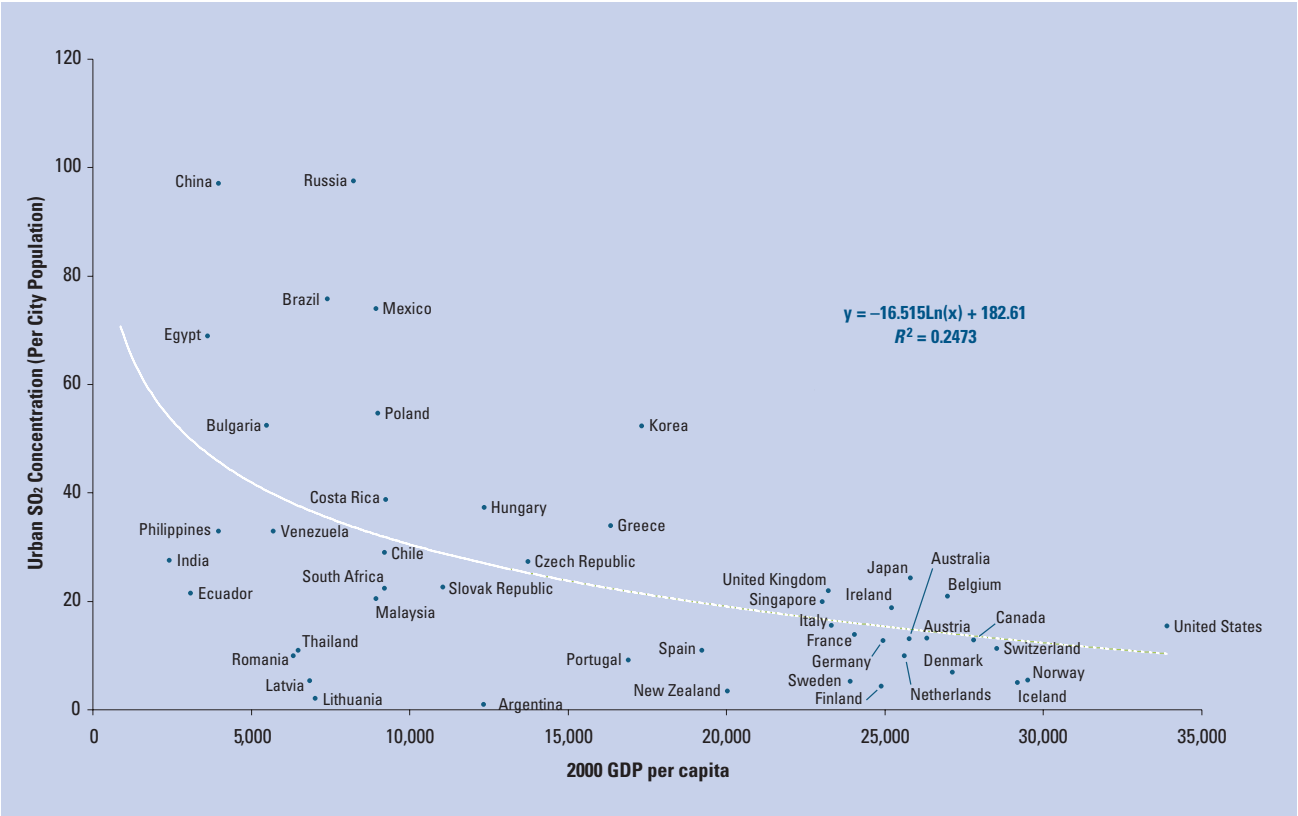


Figure 4: Relationship between energy usage and GDP per capita (log model)

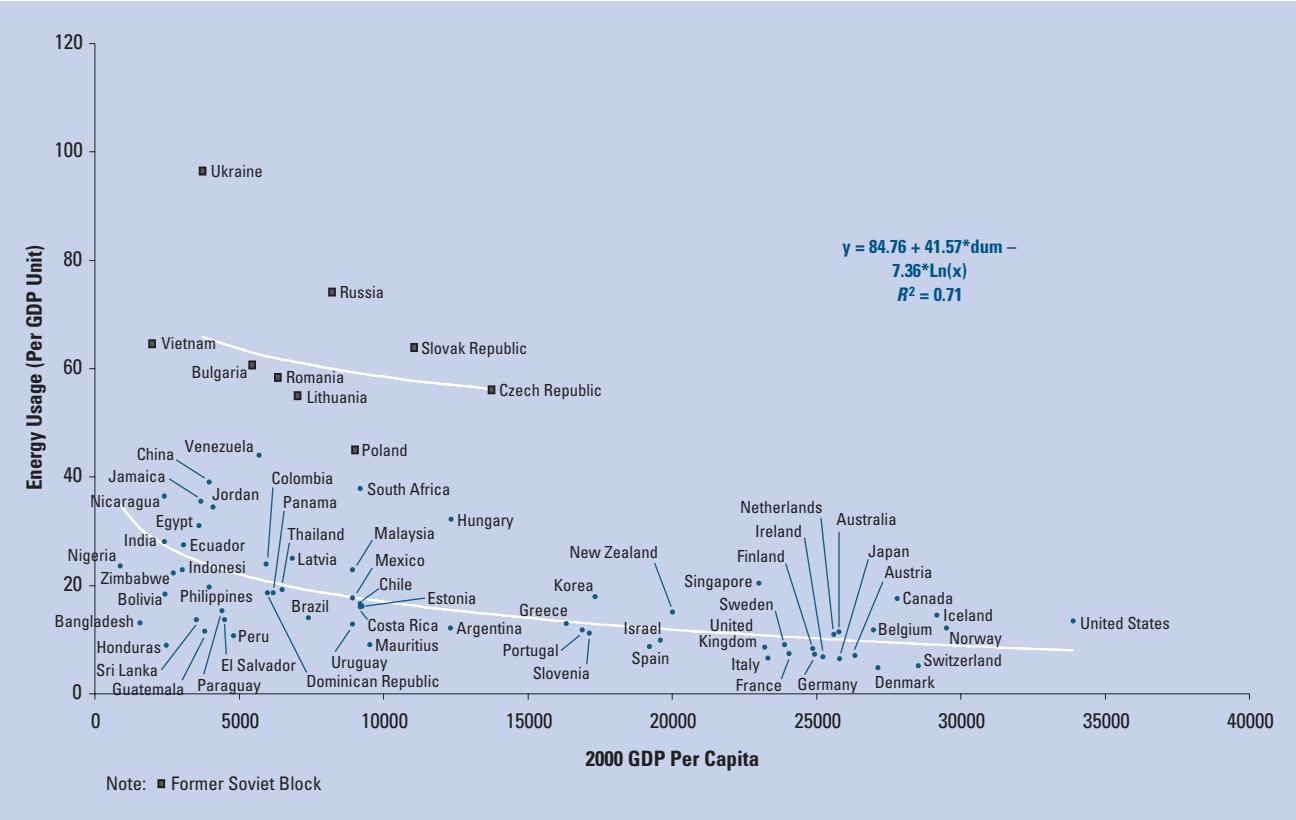


Table 2: Energy usage relative to expected given GDP per capita, listed by income groups

Low-Income Countries (≤ $6,500)

Rank	Country	Residual
1	Honduras	–18.29
2	Bangladesh	–17.48
3	Guatemala	–12.60
4	Peru	–11.57
5	Nigeria	–11.28
6	Sri Lanka	–10.96
7	El Salvador	–9.13
8	Bolivia	–9.04
9	Paraguay	–7.69
10	Zimbabwe	–4.27
11	Philippines	–4.05
12	Romania	–3.53
13	Indonesia	–2.84
14	Bulgaria	–2.26
15	Dominican Republic	–2.09
16	Panama	–1.82
17	Thailand	–0.88
18	India	0.67
19	Ecuador	1.90
20	Colombia	3.17
21	Egypt	6.55
22	Nicaragua	8.98
23	Jordan	10.96
24	Jamaica	11.21
25	China	15.30
26	Venezuela	22.98
27	Ukraine	30.66
28	Vietnam	35.66

Middle-Income Countries ($6,500–$23,000)

Rank	Country	Residual
1	Hungary	–24.70
2	Poland	–14.29
3	Mauritius	–8.22
4	Lithuania	–6.24
5	Brazil	–5.19
6	Uruguay	–4.96
7	Spain	–3.44
8	Argentina	–3.21
9	Israel	–2.06
10	Slovenia	–1.74
11	Estonia	–1.51
12	Costa Rica	–1.42
13	Portugal	–1.34
14	Chile	–0.96
15	Greece	–0.41
16	Mexico	–0.09
17	Czech Republic	0.02
18	New Zealand	3.24
19	Korea	4.98
20	Malaysia	5.08
21	Latvia	5.25
22	Slovak Republic	6.14
23	Singapore	9.58
24	Russia	14.20
25	South Africa	20.33

High-Income Countries (≥ $23,000)

Rank	Country	Residual
1	Denmark	–4.78
2	Italy	–4.08
3	Switzerland	–4.06
4	Japan	–3.44
5	Ireland	–3.31
6	France	–3.12
7	Germany	–2.96
8	Austria	–2.75
9	United Kingdom	–2.18
10	Finland	–1.89
11	Sweden	–1.42
12	Netherlands	0.96
13	Australia	1.46
14	Belgium	2.16
15	Norway	3.17
16	Iceland	5.41
17	United States	5.43
18	Canada	8.10

Table 3: Urban particulate concentration relative to expected given GDP per capita, listed by income groups

Low-Income Countries (≤ $6,500)

Rank	Country	Residual
1	Venezuela	–121.87
2	Ecuador	–106.27
3	Romania	–83.06
4	Colombia	–50.93
5	Philippines	–8.40
6	Bulgaria	20.92
7	India	22.78
8	Indonesia	37.35
9	Guatemala	59.80
10	Thailand	60.26
11	Honduras	67.85
12	China	102.36

Middle-Income Countries ($6,500–$23,000)

Rank	Country	Residual
1	Latvia	–57.59
2	Argentina	–52.99
3	Slovak Republic	–48.69
4	Brazil	–44.20
5	Malaysia	–41.31
6	Lithuania	–41.17
7	Russia	–40.59
8	Hungary	–39.10
9	Czech Republic	–34.57
10	New Zealand	–30.61
11	Portugal	–23.31
12	Spain	10.93
13	Korea	12.41
14	Greece	101.19
15	Costa Rica	114.79
16	Mexico	146.02

High-Income Countries (≥ $23,000)

Rank	Country	Residual
1	Sweden	–32.50
2	France	–26.77
3	Norway	–11.65
4	Iceland	1.05
5	Canada	3.80
6	Netherlands	4.93
7	Switzerland	5.62
8	Germany	5.75
9	Australia	8.73
10	Japan	9.28
11	Finland	12.13
12	Austria	13.20
13	Denmark	31.29
14	Italy	43.13

Table 4: Urban SO_2 concentration relative to expected given GDP per capita, listed by income groups

Low-Income Countries (≤ $6,500)

Rank	Country	Residual
1	Ecuador	–28.49
2	Romania	–28.10
3	Thailand	–26.69
4	India	–26.49
5	Philippines	–12.81
6	Venezuela	–6.84
7	Bulgaria	11.99
8	Egypt	21.64
9	China	51.25

* Not all data were available for all countries.

Middle-Income Countries ($6,500–$23,000)

Rank	Country	Residual
1	Lithuania	–34.29
2	Latvia	–31.41
3	Argentina	–26.04
4	New Zealand	–15.54
5	Portugal	–12.63
6	Malaysia	–11.88
7	South Africa	–9.52
8	Spain	–8.72
9	Slovak Republic	–6.21
10	Chile	–2.89
11	Czech Republic	2.07
12	Singapore	3.26
13	Costa Rica	7.03
14	Hungary	10.30
15	Greece	11.60
16	Poland	22.43
17	Korea	30.98
18	Brazil	40.29
19	Mexico	41.61
20	Russia	63.80

High-Income Countries (≥ $23,000)

Rank	Country	Residual
1	Finland	–11.07
2	Sweden	–10.89
3	Iceland	–7.81
4	Norway	–7.16
5	Denmark	–7.02
6	Netherlands	–4.97
7	Germany	–2.60
8	France	–2.12
9	Switzerland	–1.85
10	Australia	–1.70
11	Austria	–1.31
12	Italy	–0.97
13	Canada	–0.75
14	Ireland	3.67
15	United States	5.09
16	United Kingdom	5.37
17	Belgium	6.91
18	Japan	9.49

The SO_2 rankings cover 47 countries. Argentina and Lithuania rank at the top on this measure. China and Russia face the most severe SO_2 problems.

Energy usage data are available for 72 countries. Denmark and Switzerland rank highest in energy efficiency. Russia and the Ukraine emerge as the most energy inefficient countries.

Figures 2, 3, and 4 plot the relationship between each measure of environmental performance and GDP per capita. One pattern that is immediately discernable across all three measures is that richer countries achieve better results than poorer ones. The improvement of environmental performance as income rises is most pronounced with regard to urban particulates and energy efficiency, and least strong for SO_2 emissions. Among lower-income countries, the variance on all three measures is particularly high relative to more prosperous countries. This suggests that environmental performance can be *substantially improved* in many low-income countries independent of the gains that come with economic development.

The regression relationship between environmental performance and GDP per capita provides an interesting perspective on how each country performs *relative* to its wealth. Countries above the regression line in Figures 2, 3, and 4 exhibit weaker environmental results on the particular performance measure than would be expected given their level of GDP; those countries below the regression line demonstrate better performance. These results are shown in Tables 2, 3, and 4.

With regard to particulate levels, Italy, Greece, Mexico, Costa Rica, China, and Denmark are notable laggards relative to income. Sweden, Norway, Argentina, Latvia, Ecuador, and Venezuela show relatively strong performance. In terms of SO_2 performance, Russia, Brazil, Mexico, Korea, China, Egypt, Japan, and Belgium lag relative to income. The United States is also a weak performer. Iceland, Finland, Sweden, Argentina, Latvia, Lithuania, Thailand, Romania, and Ecuador show relatively strong results.

In energy efficiency, Denmark, Switzerland, Japan, Italy, Hungary, Poland, Honduras, and Bangladesh, among others, appear to be more energy efficient than would be expected given their level of income. The United States, Canada, Singapore, Russia, South Africa, Venezuela, the Ukraine, and Vietnam emerge as relatively poor performers relative to income. As can be seen in Figure 4, the dummy variable for former Soviet bloc countries is highly significant, suggesting that the countries that faced artificially low energy prices suffered a common fate of huge inefficiency.

Taken together, these findings are consistent with established theory that suggests that pollution control improves with economic development (World Commission on Environment and Development 1987). Our data do not, however, reveal an inverted U-shaped environmental "Kuznets curve." A number of other studies have found such a pattern, characterized by rising emissions in the early stages of development and improving environmental performance after middle-income levels have been reached (Grossman and Krueger 1995; Harbaugh et al. 2000). Our results may be explained by the fact that our sample of countries contains relatively few countries in the "early industrialization" stage of development in which emissions and energy usage would be low and rising, especially for the air pollution measures.

The relationship between environmental performance and level of development supports several preliminary but important policy conclusions. First, the evidence that poorer countries uniformly perform less well on all three environmental quality measures supports an emphasis on alleviating poverty as a core policy goal from the perspective of environmental progress.

Second, the wide variations in environmental performance among countries at a similar level of economic development suggest that income or development stage affects, but does not alone determine, environmental outcomes. Some rich countries seem to have learned how to advance environmental quality ahead of their economic progress; others have not. Similarly, some developing countries appear to have achieved far better environmental quality relative to their level of development, while other countries seem to be sacrificing environmental goals in the pursuit of economic growth. We explore whether this approach is effective later in this chapter.

Third, it is notable that environmental performance gains with income emerge most quickly for the most localized problem (particulates), least rapidly with regard to environmental impact (energy usage) that generates the harms (CO_2 emissions from fossil fuel burning) most widely spread over space and time.[vi] Intermediate results occur for the variable (SO_2) that arises on an intermediate spatial and temporal scale. This pattern comports with the theoretical prediction that the geographic and temporal spread of an environmental issue represents critical policy variables. Where harms have a trans-boundary or intertemporal dimension, they constitute "super externalities," which raise special collective action problems and often prove especially difficult to address (Dua and Esty 1997).

Determinants of environmental performance

Data on the environmental regulatory regime and the broader economic and legal context are drawn from both the ESI project and the *Global Competitiveness Report 2001–2002* annual Survey of business and government leaders.[vii] We categorize the determinants of environmental performance in two broad groups: measures related to a country's environmental regulatory regime, and measures of its economic and legal context. The full list of variables along with their definitions and sources can be found in Appendix A.

For the purposes of analysis, we divide the environmental regulatory regime variables into a number of categories representing different aspects of a country's regulatory approach:

- stringency of environmental pollution standards
- sophistication of regulatory structure
- quality of the environmental information available
- extent of subsidization of natural resources
- strictness of enforcement
- quality of environmental institutions

The stringency of standards category includes measures of the perceived rigor of a nation's air pollution, water pollution, toxic waste, and chemical regulations. This information is drawn from the GCR Survey. We expect a negative relationship between each of the measures of regulatory stringency and our dependent variables, since more rigorous standards should lead to lower levels of urban particulates, lower SO_2 concentrations, and lower energy usage per unit of GDP.

The regulatory structure category measures the degree to which a nation's environmental regulations are flexible, clear, consistent, progressive, structured to help competitiveness, and designed to promote cooperative versus adversarial business-government relations. In each case, we anticipate a negative relationship between variables and our measures of environmental performance because a more refined and sophisticated regulatory structure is expected to produce less pollution and energy usage. In this category, we have introduced two new variables this year drawn from the GCR Survey: (1) a measure of whether regulatory structure helps or hurts competitiveness; and (2) a variable capturing the degree of cooperation versus adversarial behavior characteristic of the regulatory approach.

The information category attempts to measure the degree to which a nation has a sufficient data foundation for policymaking and to support enforcement of environmental regulations. There are no direct measures of the quality of the information underlying each country's environmental regime, and we rely on four proxy variables drawn from the ESI data set: (1) the degree to which a country collects data in the 65 categories tracked by the ESI analysis; (2) the extent of sustainable development information and the existence of plans to support national environmental decision-making (as called for in the Rio Earth Summit's Agenda 21 process); (3) the prevalence of guidelines for sectoral environmental impact assessments; and (4) the breadth of environmental action plans. The last two of these measures are new and reflect the ESI project's ongoing effort to get a better grasp of the quality of environmental information across countries. All of these information indicators are relatively crude, but should provide some basis for gauging whether a nation seeks to make environmental judgments on an analytically rigorous basis. We expect a negative relationship between these information variables and our environmental performance measures.

The subsidies measure is derived from the GCR Survey data on the extent of a country's subsidization of energy and other materials. Where price signals are distorted, we expect to see greater inefficiency and higher levels of pollution. Thus we anticipate a positive relationship between the level of subsidies and particulate levels, SO_2 concentrations, and energy usage.

The strictness of enforcement measures are drawn from the GCR Survey. The first measure gauges how aggressively a nation's environmental regulations are enforced, and the second provides a gauge of the depth of a country's commitment to treaty requirements and other international environmental obligations. We expect a negative relationship between these measures of enforcement rigor and our dependent variables, as those countries that take environmental regulations (whether domestic or international) seriously should experience better pollution control and energy usage.

The final regulatory regime category, institutional quality, seeks to measure the degree to which intergovernmental (international) organizations and nongovernmental entities (environmental groups, community organizations, business associations, and other elements of civil society) reinforce governmental environmental efforts. The mechanisms for such reinforcement are diverse (Esty 1998). In some cases, these entities directly undertake environmental activities and thus substitute for government action. Environmental groups, for instance, may identify harms, highlight issues that demand attention, undertake data gathering and analyses, or throw a spotlight on poor environmental performers who should be pursued. NGOs may also strengthen a society's capacity for pollution control by providing environmental education to the public or technical assistance to polluters. Of course, such entities may also play counterproductive roles as well, especially if they pursue extreme positions and utilize solely adversarial approaches, unnecessarily increasing cost.

Our capacity to measure the degree of institutional quality is limited, and the variables in this category are, of necessity, somewhat crude proxies. We use data from the ESI database (a new variable) on the number of entities (scaled by population) that participate in the World Conservation Union (IUCN), an umbrella organization of environmental NGOs and research centers. We also draw on ESI data that provide a measure of the breadth of a country's engagement with intergovernmental environmental bodies. A third institutional quality variable comes from the GCR Survey and gauges the extent to which a nation's companies utilize the ISO 14000 certification process for environmental management. We expect a negative relationship between these measures and our dependent variables gauging environmental outcomes.

The second broad group of independent variables tracks potentially significant dimensions of a country's economic and legal context. We analyze this broader set of societal variables based on a growing theoretical literature, which suggests that a country's underlying political, legal, and economic structures may contribute as much to environmental protection as the details of its regulatory regime (Esty 1997; Sachs 1998; Esty and Porter 2000).

Under the economic and legal context, there are two categories of variables. First, we analyze what we call *administrative infrastructure*. In this category, we assemble data on civil and political liberties drawn from the ESI and measures (from the GCR Survey) of public sector competence, degree of governmental favoritism, how vigorously private property is protected, the independence of the judiciary, demands for irregular payments as a price for doing business, the extent of the rule of law, burdensome regulations, corruption, and the degree to which new governments honor the obligations of prior administrations. For each of these variables, we would anticipate a negative relationship vis-à-vis our particulates, SO_2, and energy usage measures. The last three datasets represent new information developed in the 2001 GCR Survey.

The second group of variables under legal and economic context addresses various aspects of a country's technical capacity. It is again hard to measure scientific and technological sophistication directly, so we rely upon a series of proxies. These include ESI data on the number of scientists and engineers (scaled by population) in each country and GCR Survey data that provide a gauge of a country's technology position, the strength of its scientific community, the degree to which foreign technology is commonly licensed, intellectual property protection, research and development spending, willingness to absorb new technologies, business commitment to innovation, and governmental commitment to technology development and innovation. We expect each of these measures of technical capacity to be negatively correlated with environmental impacts, as greater technical strength should lead to better environmental performance. The last three variables in this category are new datasets drawn from the 2001 GCR Survey.

As noted above, the independent variables are far from perfect measures of the potential determinants of national environmental outcomes. These variables are, however, the best ones currently available, and represent, in some cases, a significant improvement over prior efforts to model the policy levers and other drivers of environmental performance. Despite their limitations, the data allow us to begin to identify empirically the variables that determine a nation's success in controlling pollution and improving energy efficiency.

Statistical methodology

Our analytic approach unfolds in several stages. First, we use bilateral regressions (Tables 5, 6, and 7) to explore whether there is a statistically significant relationship between each independent variable and energy usage, urban particulate levels, and SO_2 concentrations. Because many of the independent variables are collinear and the degrees of freedom are limited, multiple regression techniques cannot be used to examine the joint influence of all the variables. Instead, as a second stage of analysis, we "roll up" the significant independent variable in each category into a subindex using common factor analysis. Then, we regress these subindexes against the dependent variables.[viii] Appendix B reports the percentage of covariance explained by the first factor and the first factor coefficient for each index variable. Finally, the statistically significant category subindexes are rolled up into an overall environmental regulatory regime index (ERRI) and an overall economic and legal context index (ELCI).

In light of the significant association between per capita GDP and environmental performance, we also analyze performance relative to a peer group of countries defined by income level. We regress ERRI against GDP per capita (graphed in Figure 5) and calculate the residuals (distance above or below the regression line) for each country (Table 9). This provides a way of analyzing how each country performs against expectations established by its income level. We also examine the relationship between the ELCI and ERRI, and the relationship between ELCI and GDP per capita.

Table 5: Bilateral regressions: energy usage

2001 Dependent Variable:
Energy Usage (Per Unit GDP)

	(ß)	R^2	Sig.	df
ENVIRONMENTAL REGULATORY REGIME INDEX	**–5.281**	**0.67**	**0.000**	**68**
Stringency Subindex	–5.632	0.68	0.000	68
Air Regulation	–4.044	0.69	0.000	68
Water Regulation	–3.859	0.68	0.000	68
Toxic Waste Regulation	–3.576	0.67	0.000	68
Chemical Regulation	–3.902	0.68	0.000	68
Overall Regulation	–3.917	0.67	0.000	68
Regulatory Structure Subindex	–4.480	0.64	0.002	68
Options for Compliance	–4.005	0.60	0.102	68
Confusing and Changing	–4.982	0.65	0.001	68
Early or Late	–4.058	0.67	0.000	68
Compliance Hurts or Helps Competitiveness	–6.094	0.62	0.016	68
Regulation Adversarial or Cooperative	–6.355	0.63	0.007	68
Information Subindex	–2.507	0.61	0.081	68
ESI–Variables %–available	–0.271	0.62	0.020	68
Sustainable Development Info	–1.009	0.58	0.764	41
Number of Sectoral EIA Guidelines	0.041	0.59	0.923	68
Number of Environmental Strategies & Action Plans	–0.197	0.59	0.815	68
Subsidies Subindex	0.43	0.33	0.00	39
Government Subsidies	7.065	0.66	0.000	68
Regulatory Enforcement Subindex	–4.466	0.65	0.001	68
Enforcement	–3.890	0.65	0.001	68
International Agreements	–3.976	0.64	0.002	68
Environmental Institutions Subindex	–4.740	0.65	0.001	68
IUCN	–1.392	0.60	0.300	68
Memberships	–0.699	0.65	0.001	67
Prevalence of ISO 14000	–3.994	0.63	0.011	68
ECONOMIC AND LEGAL CONTEXT INDEX	**–4.836**	**0.65**	**0.001**	**68**
Administrative Infrastructure Quality Index	–5.647	0.68	0.000	68
Civil Liberties	–5.190	0.75	0.000	68
Public Sector Competence	–2.383	0.59	0.333	68
Gov't Favor Private Sector Firms	–4.200	0.64	0.003	68
Property Rights	–4.756	0.71	0.000	68
Independent Judiciary	–3.426	0.66	0.000	68
Irregular Payments	–4.973	0.68	0.000	68
Legal Framework	–3.880	0.66	0.000	68
Regulatory Burden	–5.144	0.63	0.006	68
Level of Administrative Corruption	–5.695	0.69	0.000	68
Honoring of Policies through Gov. Transition	–4.558	0.65	0.001	68
Scientific and Research Infrastructure Index	–3.788	0.63	0.008	68
Scientists and Engineers	–0.003	0.64	0.004	64
Technology Position	–3.636	0.66	0.000	68
Institutions	–3.341	0.62	0.018	68
Licensing of Foreign Technology	–3.692	0.61	0.055	68
Company R & D Spending	–4.207	0.64	0.002	68
Willingness to Absorb New Technology	–3.803	0.62	0.033	68
Importance of Innovation to Revenue	–6.158	0.62	0.020	68
Gov't Purchase Decisions for Tech. Products	–2.962	0.60	0.160	68

*Refer to Appendix A for definitions of variables.

Table 6: Bilateral regressions: urban particulates

2001 Dependent Variable:
Urban Particulates (Per City Pop)

	(ß)	R^2	Sig.	df
ENVIRONMENTAL REGULATORY REGIME INDEX	**–58.19**	**0.44**	**0.000**	**40**
Stringency Subindex	–67.58	0.52	0.000	40
Air Regulation	–46.86	0.52	0.000	40
Water Regulation	–46.44	0.53	0.000	40
Toxic Waste Regulation	–45.10	0.52	0.000	40
Chemical Regulation	–46.24	0.51	0.000	40
Overall Regulation	–47.54	0.51	0.000	40
Regulatory Structure Subindex	–52.54	0.35	0.000	40
Options for Compliance	–89.06	0.33	0.000	40
Confusing and Changing	–60.31	0.42	0.000	40
Early or Late	–45.23	0.47	0.000	40
Compliance Hurts or Helps Competitiveness	–61.14	0.17	0.007	40
Regulation Adversarial or Cooperative	–46.15	0.12	0.028	40
Information Subindex	–56.07	0.22	0.002	40
ESI–Variables %–available	–3.86	0.15	0.011	40
Sustainable Development Info	–58.76	0.18	0.028	25
Number of Sectoral EIA Guidelines	–0.99	0.00	0.825	40
Number of Environmental Strategies & Action Plans	4.94	0.01	0.525	40
Subsidies Subindex				
Government Subsidies	65.95	0.31	0.000	40
Regulatory Enforcement Subindex	–58.31	0.43	0.000	40
Enforcement	–52.79	0.45	0.000	40
International Agreements	–49.93	0.38	0.000	40
Environmental Institutions Subindex	–47.86	0.29	0.000	40
IUCN	–16.40	0.05	0.150	40
Memberships	–6.40	0.22	0.002	39
Prevalence of ISO 14000	–47.01	0.25	0.001	40
ECONOMIC AND LEGAL CONTEXT INDEX	**–58.94**	**0.40**	**0.000**	**40**
Administrative Infrastructure Quality Index	–57.48	0.39	0.000	40
Civil Liberties	–42.67	0.37	0.000	40
Public Sector Competence	–42.49	0.07	0.095	40
Gov't Favor Private Sector Firms	–53.99	0.36	0.000	40
Property Rights	–45.62	0.48	0.000	40
Independent Judiciary	–32.47	0.30	0.000	40
Irregular Payments	–59.91	0.46	0.000	40
Legal Framework	–40.45	0.35	0.000	40
Regulatory Burden	–47.93	0.15	0.013	40
Level of Administrative Corruption	–54.64	0.38	0.000	40
Honoring of Policies through Gov. Transition	–43.16	0.24	0.001	40
Scientific and Research Infrastructure Index	–58.15	0.38	0.000	40
Scientists and Engineers	–0.04	0.42	0.000	39
Technology Position	–42.94	0.40	0.000	40
Institutions	–57.57	0.36	0.000	40
Licensing of Foreign Technology	–56.20	0.15	0.010	40
Company R & D Spending	–49.65	0.32	0.000	40
Willingness to Absorb New Technology	–75.25	0.41	0.000	40
Importance of Innovation to Revenue	–63.51	0.15	0.012	40
Gov't Purchase Decisions for Tech. Products	–68.82	0.26	0.001	40

*Refer to Appendix A for definitions of variables.

Table 7: Bilateral regressions: urban SO_2 concentration

	2001 Dependent Variable: Urban SO_2 (Per City Pop)			
	(ß)	R^2	Sig.	df
ENVIRONMENTAL REGULATORY REGIME INDEX	**–11.351**	**0.21**	**0.001**	**45**
Stringency Subindex	–13.857	0.28	0.000	45
Air Regulation	–9.407	0.27	0.000	45
Water Regulation	–9.592	0.28	0.000	45
Toxic Waste Regulation	–9.283	0.27	0.000	45
Chemical Regulation	–9.538	0.27	0.000	45
Overall Regulation	–9.839	0.27	0.000	45
Regulatory Structure Subindex	–9.686	0.16	0.005	45
Options for Compliance	–9.312	0.05	0.130	45
Confusing and Changing	–11.905	0.20	0.002	45
Early or Late	–10.105	0.28	0.000	45
Compliance Hurts or Helps Competitiveness	–11.584	0.09	0.038	45
Regulation Adversarial or Cooperative	–11.128	0.11	0.022	45
Information Subindex	–10.206	0.10	0.029	45
ESI–Variables %–available	0.207	0.00	0.662	45
Sustainable Development Info	–21.624	0.25	0.004	29
Number of Sectoral EIA Guidelines	–0.708	0.01	0.464	45
Number of Environmental Strategies & Action Plans	0.722	0.00	0.732	45
Subsidies Subindex				
Government Subsidies	12.301	0.15	0.008	45
Regulatory Enforcement Subindex	–10.989	0.18	0.003	45
Enforcement	–8.960	0.17	0.004	45
International Agreements	–10.221	0.19	0.003	45
Environmental Institutions Subindex	–6.921	0.08	0.053	45
IUCN	–6.270	0.10	0.030	45
Memberships	–0.684	0.04	0.194	44
Prevalence of ISO 14000	–8.027	0.10	0.034	45
ECONOMIC AND LEGAL CONTEXT INDEX	**–11.738**	**0.19**	**0.002**	**45**
Administrative Infrastructure Quality Index	–12.815	0.23	0.001	45
Civil Liberties	–12.206	0.47	0.000	45
Public Sector Competence	–3.364	0.01	0.553	45
Gov't Favor Private Sector Firms	–10.056	0.15	0.008	45
Property Rights	–9.644	0.27	0.000	45
Independent Judiciary	–7.166	0.18	0.003	45
Irregular Payments	–12.413	0.26	0.000	45
Legal Framework	–9.343	0.23	0.001	45
Regulatory Burden	–9.259	0.10	0.032	45
Level of Administrative Corruption	–12.877	0.27	0.000	45
Honoring of Policies through Gov. Transition	–8.685	0.11	0.021	45
Scientific and Research Infrastructure Index	–10.010	0.14	0.009	45
Scientists and Engineers	–0.006	0.09	0.038	45
Technology Position	–7.931	0.18	0.003	45
Institutions	–8.883	0.11	0.025	45
Licensing of Foreign Technology	–11.980	0.08	0.049	45
Company R & D Spending	–7.802	0.12	0.020	45
Willingness to Absorb New Technology	–15.067	0.20	0.002	45
Importance of Innovation to Revenue	–15.770	0.13	0.011	45
Gov't Purchase Decisions for Tech. Products	–9.316	0.06	0.109	45

*Refer to Appendix A for definitions of variables.

Figure 5: Relationship between the environmental regulatory regime index and GDP per capita

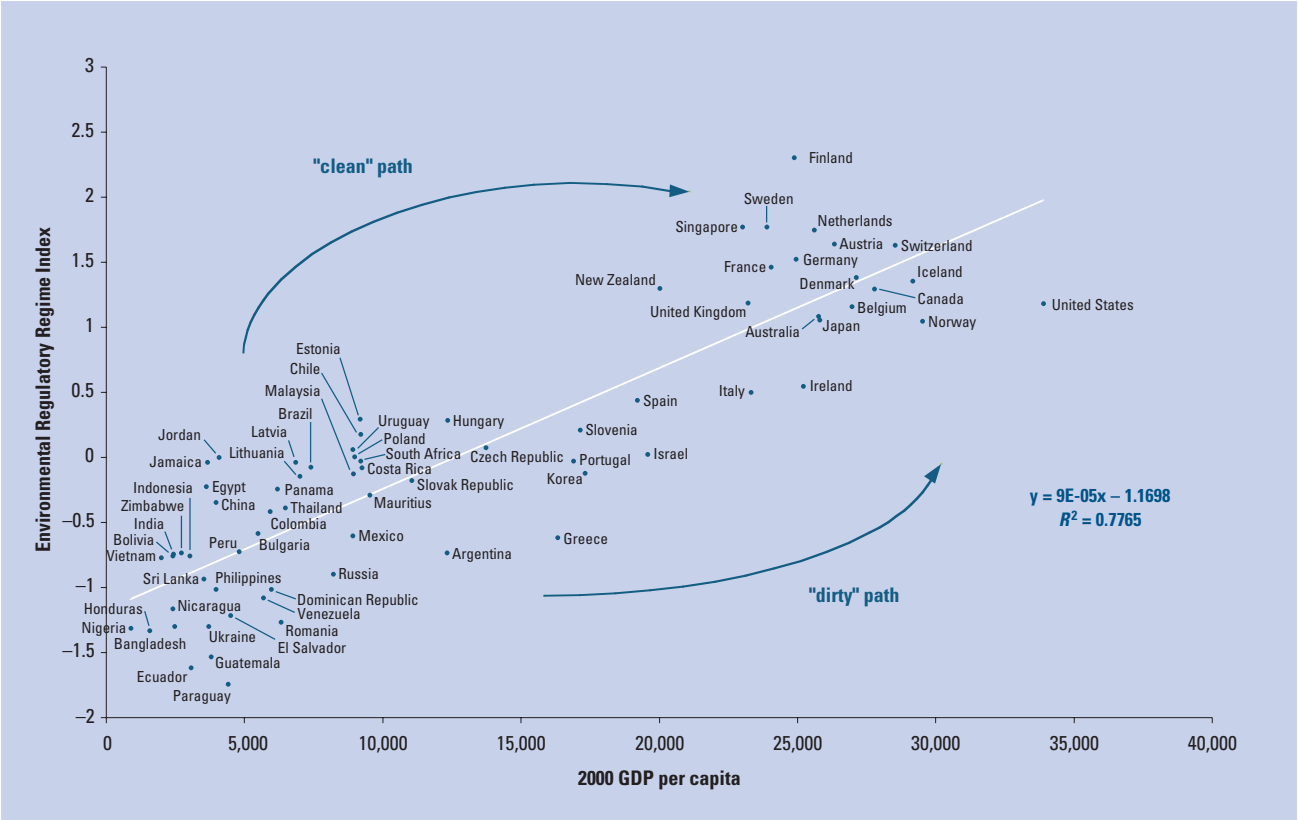
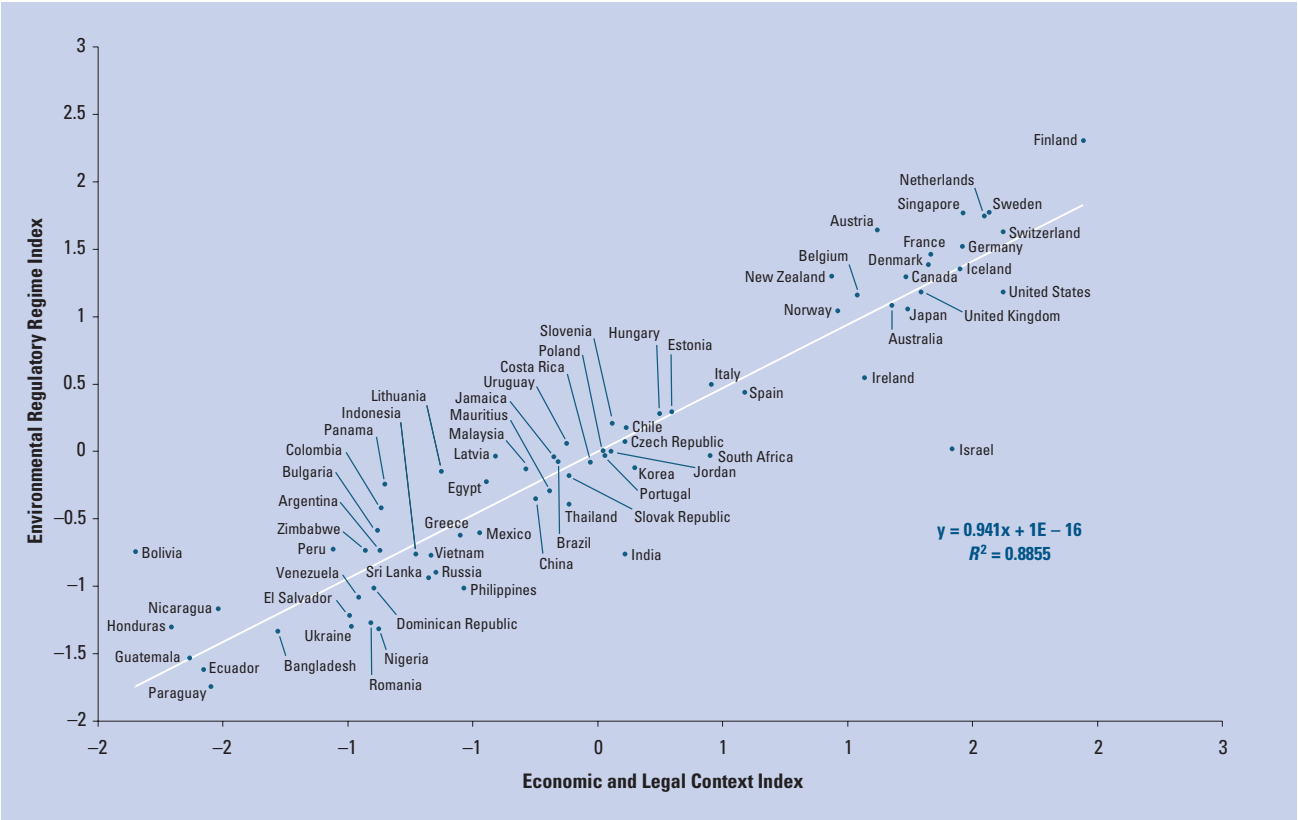


Figure 6: Relationship between the environmental regulatory regime index and economic and legal context index



Results for individual measures and indexes

The bilateral regression results are shown in Tables 5, 6, and 7. The energy efficiency regressions are shown in Table 5. A large number of the independent variables show a statistically significant relationship with energy usage, with the expected negative sign and a reasonable degree of explained variance. All of the elements of the regulatory stringency category show particular significance, as do the enforcement variables. Most of the regulatory structure measures also prove to be highly significant. These categories of variables account for the highest amount of explained variance. The subsidies variable is highly significant and has the expected positive sign. This result suggests, consistent with economic theory, that mispriced resources will be inefficiently used, and that subsidies represent a major policy error.

The information and institutions measures perform less strongly. In the information category, one variable (percentage of ESI variables available) emerges as significant while the other three measures do not. In the institutional category, IUCN membership fails to show significance while the other two measures of institutional capacity are significant.

Among the economic and legal context variables, all but one (public sector competence) emerge as highly significant with the expected negative sign. The new variables measuring corruption and whether new governments honor the commitments of prior administrations prove to be statistically significant. In the scientific and technical capacity category, all of the variables except one (government commitment to technology development and innovation) show a reasonable degree of significance and the expected negative sign.

To build the subindexes and indexes, we employ only the statistically significant variables. All of the subindexes are highly significant in explaining energy usage, have the expected negative sign, and account for substantial explained variance. The ERRI and ELCI register similarly high levels of significance with the expected negative signs and a substantial degree of explained variance.

Although preliminary, the latter results provide some empirical support for the hypothesis that a nation's underlying economic and legal structure may be as important to environmental success as the specific details of its environmental regulatory regime. This conclusion argues for more attention to "fundamentals"—such as eliminating corruption and building functioning market economies—and to "governance"—such as strengthening the rule of law and developing mechanisms to protect property rights—in setting development priorities and in targeting development assistance. Interestingly, this is the direction that the recent policies of the United Nations Development Programme are taking.

The ERRI and the ELCI prove to be highly correlated and show similar levels of significance and explained variance. Hence it appears that environmental regulation and overall economic and legal context generally improve in parallel. We explored the joint influence of ERRI and ELCI on environmental performance. In practice, the high correlation between the two indexes (as shown in Figure 7) means that their effects on energy usage could not be distinguished statistically.

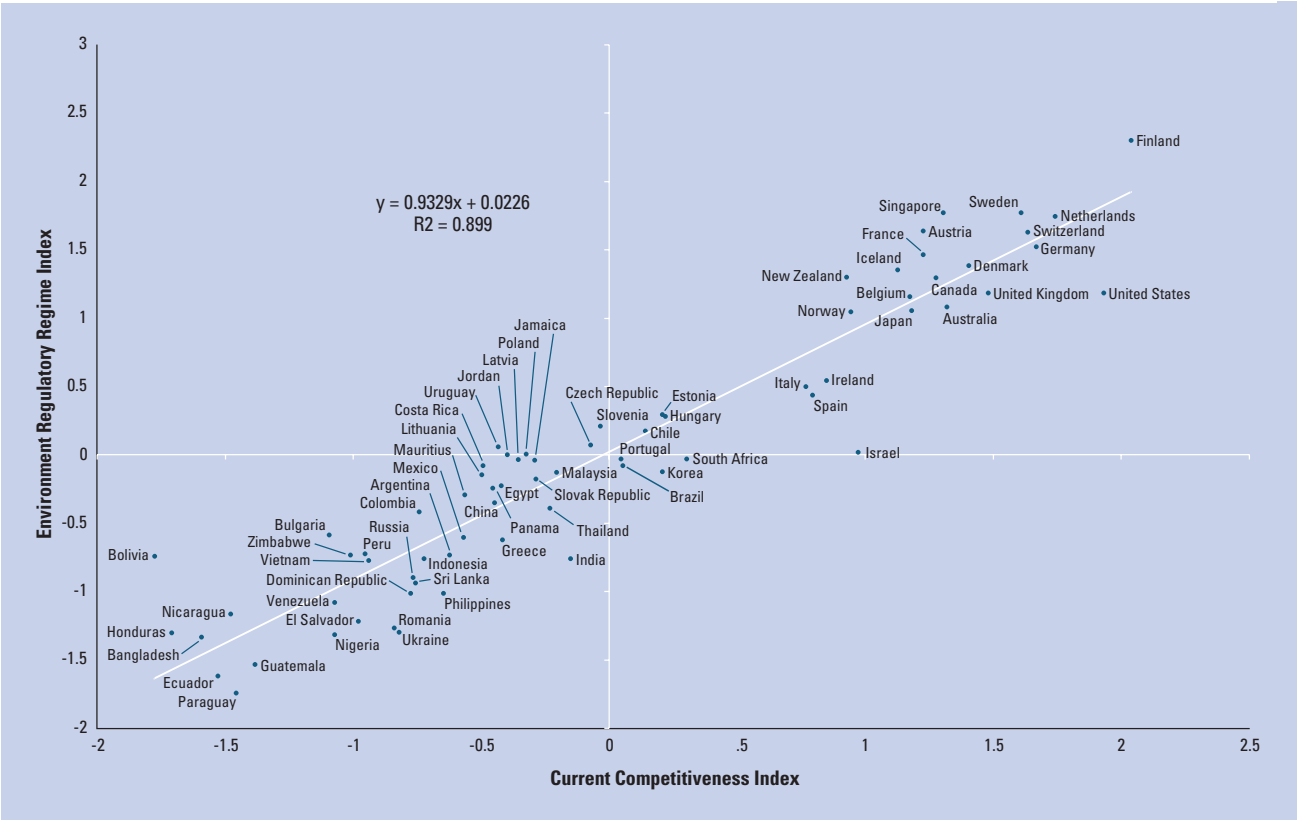
Table 6 presents the second set of bilateral regressions for urban (air) particulate concentrations. Again, the vast majority of variables are significant with the expected sign and account for a reasonable degree of explained variance. All of the measures of regulatory stringency and structure are highly significant, with the stringency variables accounting for the greatest level of explained variance. The subsidies measure is highly significant, has the anticipated positive sign, and accounts for a reasonable degree of explained variance.

In the information category, two variables emerge as significant with the expected negative sign, but do not account for as high a degree of explained variance. In the institutional reinforcement category, the number of IUCN memberships is again not significant, while the other two variables (participation in intergovernmental environmental bodies and corporate participation in environmental management systems) emerge as highly significant.

The regulatory stringency, regulatory structure, information enforcement, and institutional subindexes all emerge as highly significant with the expected negative sign, as does the cumulative ERRI. Across all of these subindexes, however, the degree of explained variance is somewhat lower in the urban particulate regressions than in the energy usage ones. Two of the subindexes—information foundations and institutional reinforcement—perform notably less well than the others. This may reflect the fact that these variables are imperfect proxies or that information and institutions play more mixed roles.

All of the variables in the economic and social context regression emerge as significant in the urban particulates regulations. All have the expected negative sign, with many accounting for a substantial degree of explained variance. The administrative infrastructure and technical capacity subindexes both show very high levels of significance, the expected negative sign, and a high degree of explained variance. The ELCI similarly emerges as highly significant. It accounts for almost as much explained variance as the ERRI. However, both the ERRI and the ELCI explain a somewhat smaller proportion of variations in urban particulate concentrations than energy usage. Again, the independent effects of ERRI and ELCI could not be distinguished statistically.

Figure 7: Relationship between the environmental regulatory regime index and current competitiveness



The SO_2 regression results are presented in Table 7. Most of the independent variables are once again significant with the expected negative sign. The degree of explained variance is, however, generally much lower for SO_2 than for either energy usage or particulate concentrations. This finding may reflect the fact that the benefits of SO_2 control (reduced acid rain) accrue downwind—frequently beyond the territorial boundaries of the jurisdiction undertaking regulatory action. Thus, from a cost-benefit perspective, the regulating entity has less to gain than it has in the control of particulates or with investments in energy efficiency, both of which provide more localized benefits.

The subsidies measure again shows a high level of significance and the expected positive sign, but accounts for a lower amount of variance than with the other measures of pollution. In the information category, three of the four measures are not statistically significant. Again, the looser fit may suggest that even a well-informed government that is serious about environmental protection has less of an incentive to address SO_2, given its geographic dispersion, than other more localized issues.

All of the environmental regulatory regime subindexes are significant and have the expected negative sign in the SO_2 regressions. Only the regulatory stringency subindex accounts, however, for a reasonable degree of explained variance. ERRI once again proves to be highly significant, although the degree of explained variance is not high. As a general matter, the regression fit for SO_2 appears weaker than for particulates or energy usage, perhaps reflecting the more limited regulatory payoffs noted above.

Among the variables in the economic and legal context grouping, all but one (public sector competence) emerge with high statistical significance and the expected negative sign in the SO_2 regressions. Some of the measures account for a reasonable degree of explained variance (eg, civil liberties, property rights, and irregular payments). In general, the administrative infrastructure variables show greater significance and higher degrees of explained variance than the technical capacity measures. The administrative infrastructure subindex is highly significant with a reasonable degree of explained variance. The technical capacity subindex shows a high degree of significance but does not account for an especially large amount of explained variance. The overall ELCI is significant and explains a reasonable amount of the variance in SO_2 concentrations.

Ranking environmental regulatory quality

The bilateral, subindex, and index regressions establish a statistically significant relationship between the various policy measures and environmental performance. The next stage in the analysis is to use ERRI to explore the differences across countries in environmental regulatory quality.

Table 8 presents a ranking of countries ranked by absolute ERRI scores. This index (combining the always significant regulatory stringency, structure, subsidies, and enforcement subindexes) represents a summary performance measure of the quality of the environmental regulatory system in a country. Among the top-ranked countries are Finland, Sweden, and Singapore. Countries at the bottom include Guatemala, Ecuador, and Paraguay.

Given the significant relationship between level of development and environmental performance, we would expect a similar relationship with environmental regulatory quality. What is most interesting in Table 8, then, is not so much the fact that Finland outranks Paraguay on the stringency of environmental regulation, but the reasons why countries with similar incomes perform so differently. For instance, why does Costa Rica (36th place) do better than Panama (42nd place) and Peru (50th place)? Similarly, why do Spain (21st) and Portugal (31st) so dramatically outperform Greece (49th)? Likewise, Chile (25th) distinctly outperforms Argentina (51st), and Poland (29th) comes in way ahead of Russia (57th). The last two pairings reveal a general pattern suggesting that more aggressively market-oriented economies (Chile and Poland) may outperform those (Argentina and Russia) where a more interventionist economic tradition persists.

To control for income differences and hence the level of economic development, Table 9 ranks countries by their residuals from the regression of ERRI and GDP per capita (plotted in Figure 5). This relative ranking represents a measure of environmental regulatory quality relative to expectations established by income level. Among the low-income countries, Jordan and Jamaica come out on top, while Ecuador and Paraguay trail. Among middle-income countries, Singapore, Estonia, and New Zealand rank high. Israel, Argentina, and Greece lag. Among the wealthiest nations, Finland, Sweden, and the Netherlands lead, while Italy, Norway, and Ireland rank low. The United States occupies the bottom rung of the high-income group ladder.

Table 8: Enviornmental regulatory regime index by country, absolute ranking

Environmental Regulatory Regime Index

Rank	Country	Score	Rank	Country	Score
1	Finland	2.303	37	Korea	–0.121
2	Sweden	1.772	38	Malaysia	–0.127
3	Singapore	1.771	39	Lithuania	–0.146
4	Netherlands	1.747	40	Slovak Republic	–0.177
5	Austria	1.641	41	Egypt	–0.224
6	Switzerland	1.631	42	Panama	–0.242
7	Germany	1.522	43	Mauritius	–0.290
8	France	1.464	44	China	–0.348
9	Denmark	1.384	45	Thailand	–0.389
10	Iceland	1.354	46	Colombia	–0.416
11	New Zealand	1.299	47	Bulgaria	–0.584
12	Canada	1.297	48	Mexico	–0.602
13	United Kingdom	1.185	49	Greece	–0.619
14	United States	1.184	50	Peru	–0.722
15	Belgium	1.159	51	Argentina	–0.732
16	Australia	1.083	52	Zimbabwe	–0.732
17	Japan	1.057	53	Bolivia	–0.743
18	Norway	1.045	54	Indonesia	–0.758
19	Ireland	0.546	55	India	–0.759
20	Italy	0.498	56	Vietnam	–0.770
21	Spain	0.437	57	Russia	–0.895
22	Estonia	0.296	58	Sri Lanka	–0.936
23	Hungary	0.283	59	Philippines	–1.014
24	Slovenia	0.209	60	Dominican Republic	–1.014
25	Chile	0.177	61	Venezuela	–1.079
26	Czech Republic	0.073	62	Nicaragua	–1.164
27	Uruguay	0.059	63	El Salvador	–1.215
28	Israel	0.021	64	Romania	–1.268
29	Poland	0.005	65	Ukraine	–1.297
30	Jordan	0.002	66	Honduras	–1.300
31	Portugal	–0.028	67	Nigeria	–1.314
32	South Africa	–0.029	68	Bangladesh	–1.331
33	Latvia	–0.036	69	Guatemala	–1.532
34	Jamaica	–0.037	70	Ecuador	–1.616
35	Brazil	–0.077	71	Paraguay	–1.743
36	Costa Rica	–0.078			

As noted earlier, ERRI and ELCI are highly correlated, as shown in Figure 6. Nevertheless, it is evident that some countries have an economic and legal context that outpaces their environmental regulatory quality, while others have advanced environmental regulation faster than context. In Israel, India, Ireland, the United States, South Africa, the Philippines, and Nigeria, environmental regulation lags overall context, while in Finland, Austria, New Zealand, Panama, and Bolivia, environmental regulatory quality is ahead of improvements in the broader economic and legal context. The divergence between ERRI and ELCI, however, was not statistically associated with differences in environmental outcomes. This may be due to the high correlation of ERRI and ELCI in the sample.

Table 9: Environmental regulatory regime index relative to expected results given GDP per capital, listed by income groups

Low-Income Countries (≤ $6,500)

Rank	Country	Residual
1	Jordan	0.794
2	Jamaica	0.793
3	Egypt	0.612
4	China	0.455
5	Panama	0.355
6	Vietnam	0.216
7	Colombia	0.204
8	Bolivia	0.204
9	India	0.188
10	Zimbabwe	0.187
11	Thailand	0.180
12	Indonesia	0.132
13	Bulgaria	0.078
14	Peru	0.002
15	Sri Lanka	–0.092
16	Philippines	–0.211
17	Nicaragua	–0.217
18	Nigeria	–0.225
19	Bangladesh	–0.307
20	Honduras	–0.359
21	Dominican Republic	–0.397
22	Venezuela	–0.436
23	El Salvador	–0.461
24	Ukraine	–0.470
25	Romania	–0.684
26	Guatemala	–0.714
27	Ecuador	–0.730
28	Paraguay	–0.981

Middle-Income Countries ($6,500–$23,000)

Rank	Country	Residual
1	Singapore	0.806
2	Estonia	0.614
3	New Zealand	0.612
4	Latvia	0.499
5	Chile	0.494
6	Brazil	0.407
7	Uruguay	0.402
8	Lithuania	0.374
9	Poland	0.343
10	Hungary	0.308
11	South Africa	0.288
12	Costa Rica	0.235
13	Malaysia	0.214
14	Mauritius	–0.003
15	Czech Republic	–0.031
16	Slovak Republic	–0.032
17	Spain	–0.175
18	Slovenia	–0.211
19	Mexico	–0.259
20	Portugal	–0.426
21	Russia	–0.487
22	Korea	–0.558
23	Israel	–0.626
24	Argentina	–0.705
25	Greece	–0.964

High-Income Countries (≥ $23,000)

Rank	Country	Residual
1	Finland	1.165
2	Sweden	0.725
3	Netherlands	0.541
4	France	0.404
5	Germany	0.377
6	Austria	0.368
7	United Kingdom	0.202
8	Switzerland	0.154
9	Denmark	0.037
10	Canada	–0.112
11	Australia	–0.138
12	Japan	–0.168
13	Belgium	–0.173
14	Iceland	–0.184
15	Italy	–0.495
16	Norway	–0.523
17	Ireland	–0.623
18	United States	–0.792

Table 10: Environmental regulatory stringency and economic growth

	Model 1 Dependent Variable: Annual Percentage Growth Rate of GDP per Capita, 1995–2000			Model 2 Dependent Variable: Annual Percentage Growth Rate of GDP per Capita, 1995–2000		
Variable	Parameter Estimate	t Value	Prob > |t|	Parameter Estimate	t Value	Prob > |t|
Intercept	1.577	3.62	0.001	–2.352	–1.91	0.060
GDP per Capita, 1995 (thousand, ppp)	0.056	1.77	0.082	0.092	2.78	0.007
General Government Spending, 2000				–0.043	1.62	0.111
Gross Fixed Investment (as % of GDP)				0.226	5.17	<0.0001
Environment Regulatory Regime Index Relative to Expected Given GDP per Capita	0.830	1.51	0.135	0.795	1.66	0.102

The relationship between environmental performance and competitiveness

Finally, we turn to the question of whether environmental regulatory stringency detracts from or contributes to economic progress. Figure 7 shows that the quality of a nation's environmental regulatory regime is strongly and positively correlated with its competitiveness as measured by the Current Competitiveness Index, or CCI (see Chapter 1.2). Many of the nations with top-tier competitiveness rankings also have strong environmental performance scores. Finland, for example, ranks at the top of the ERRI and at the top of the CCI. The United States stands out as an exception, with a high competitiveness rank and a relatively low environmental regulation score. Figure 5 tells a similar story about how high levels of per capita income and economic development correlate with high environmental regulatory quality.

The correlations revealed in Figures 5 and 7 do not, of course, prove causation. But the finding that a strong environmental regulatory regime is not inconsistent with top-tier economic performance is itself interesting. Indeed, the fact that the top environmental performers do not appear to have suffered economically strongly supports the "soft" version of the "Porter hypothesis," which argues that environmental progress can be achieved without sacrificing competitiveness (Porter 1990 and Porter and van der Linde 1995). Testing the "hard" version of this hypothesis—that countries with forward-leaning environmental policies and programs will actually enhance their competitiveness—requires time-series data that are not yet available.

Figure 5 highlights the development policy choice that every nation faces. Countries would like to move from the lower left corner of the chart (which represents low levels of environmental performance and low national income) to the upper right quadrant (which represents high levels of environmental performance and high income). The question is what path to take. Or, to put it differently, must the environment be sacrificed to achieve economic progress? Those countries above the regression line can be seen as having chosen a "clean" development trajectory in which environmental regulatory quality advances ahead of economic advancement. Those below the line have chosen a relatively "dirty" path to growth, with relatively lax environmental regulation in the hope of growing faster.

In addressing this choice, we are able to provide a crude test using the available data. We regress a number of control variables on GDP per capita growth between 1995 and 2000, including the initial level of GDP per capita, gross fixed capita formation as a percent of GDP, and government spending as a percent of GDP. We then introduce a variable, which measures the residual from the regression of ERRI on GDP per capita (Table 10). Countries with positive residuals have ERRI scores that are higher than would be expected given their income, and vice versa. The residual has a positive sign with significance at virtually the 90 percent level. Countries that pursue a stringent regulatory regime appear to achieve more rapid growth. Although tentative, this result suggests the possible superiority of the "clean" model. However, more years of data and better controls will be necessary to validate this finding.

Conclusion

The results presented here must be seen as preliminary. The data available suffer from many limitations, narrowing the feasible statistical approaches. Precise causal linkages remain unproven. Indeed, a central conclusion of our research is that better environmental data are required at the global, national, local, and corporate levels if a more systematic approach to environmental improvement is to be implemented. As the world community looks toward the Sustainable Development Summit in Johannesburg in 2002, a worldwide commitment to improved environmental data should be adopted as a priority initiative.

With these caveats, however, the relationships that do emerge as statistically significant are striking. The analysis provides considerable empirical evidence that cross-country differences in environmental performance are associated with the quality of the environmental regulatory regime in place. We find that the rigor and structure of environmental regulations have particular impact, as does emphasis on enforcement. The damaging effect of subsidies is also clear. Although developing a strong and sophisticated regulatory regime that fully internalizes externalities presents real challenges, ending price-distorting, inefficiency-creating, and pollution-inducing subsidies is within the policy grasp of every nation. Environmental performance appears to improve with certain kinds of information and also to improve to the extent that a nation's environmental regime is reinforced by an environmentally oriented private sector and broad-based relationships with international environmental bodies. Information and institutions have some but less impact on environmental performance, based on our analysis. This finding may, in part, be due to weaknesses in the available data.

Our results also suggest that environmental performance requires improvements in a country's institutional foundations. In practice, a nation's economic and legal context and its environmental regulatory regime go hand in hand. This association demands further exploration. But the preliminary evidence developed here suggests that countries would benefit *environmentally* from an emphasis on developing the rule of law, eliminating corruption, and strengthening their governance structures.

The strong association between income and environmental performance also carries important implications. Among other things, it provides powerful corroboration for a policy emphasis on poverty alleviation and the promotion of economic growth as a key mechanism for improving environmental results.

The empirical evidence developed here suggests that the anti-globalization arguments of the environmental protestors in the streets at every recent major international gathering are off the mark. Limiting trade and the engagement of developing countries with the rest of the world is a recipe for environmental failure, not environmental success. Rather, the more fully a country moves to modernize its economy, institutional structures, and regulatory system, the more quickly its environment performance appears to improve—along with improvements in per capita income.

The country rankings that emerge from our analysis seem largely to square with observed reality. The variations in performance highlight the fact that countries vary widely in their environmental outcomes and policy choices, even after controlling for level of income. There are clearly better and worse ways to approach pollution control and natural resource management. The data provided here offer some important clues as to where the search for "best practices" should begin. Moreover, our findings suggest that the environment need not be sacrificed on the road to economic progress. Quite to the contrary, the countries that have the most aggressive environmental policy regimes also seem to be the most competitive and economically successful. We also find preliminary evidence that a stringent environmental regime relative to income may speed up economic growth rather than detract from it.

This study highlights the fact that the environmental domain need not rely on guesswork. The results here show that a more analytically rigorous approach to policy-making could pay real dividends. More fundamentally, our analysis strongly supports the notion that the uncertainties that plague environmental decision-making can be reduced, and that current levels of policy contention could be reduced as well.

Our preliminary efforts to use statistical methods to explain environmental successes and failures seem to confirm some aspects of the prevailing wisdom. For example, poverty emerges as a source of serious environmental degradation and thus deserves ongoing policy attention. Subsidies appear not only to skew prices and distort trade; they also lead to inefficient production and unnecessary pollution. But some new priorities also emerge from this research. Notably, there appear to be significant gains to be had by moving environmental laggards toward the best practices of those jurisdictions whose performance is top tier. This argues for much greater strategic emphasis on information development and dissemination. Likewise, the significance of economic and legal context to environmental results argues for a new focus on governance as the foundation for both environmental and economic progress. The results here suggest that there are ways to move beyond the ideological and emotional obstacles that stand in the way of faster environmental progress.

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Notes

[i] This study builds on Daniel C Esty and Michael E Porter, "Measuring National Environmental Performance and Its Determinants," in Michael E Porter, Jeffrey Sachs, et al., *Global Competitiveness Report 2000* (New York: Oxford University Press). As is explained in the pages that follow, the present analysis incorporates new data and a variety of new variables, but utilizes statistical model similar to that of the GCR 2000 study.

[ii] For a further discussion of the data gaps that plague the environmental domain, see World Economic Forum Global Leaders for Tomorrow Environmental Task Force, 2001, *Environmental Sustainability Index 2001* (Geneva: World Economic Forum) (available at www.yale.edu/envirocenter/esi).

[iii] Again, the lack of systematic environmental data gathering in many countries and the limited information available with regard to a number of key issues constrains our model. Filling these data gaps—both in terms of depth and breadth—should be a policy priority. Better data remains a prerequisite for a more analytically rigorous approach to environmental decision making.

[iv] This project, undertaken by the World Economic Forum's Global Leaders for Tomorrow Environmental Task Force, with the support of the Yale University Center for Environmental Law and Policy and the Center for International Earth Science Information Network (CIESIN) at Columbia University, ranks 122 countries on their "environmental sustainability" based on performance in 22 categories building on a dataset of 65 underlying variables. The Environmental Sustainability Index (ESI) report and details on the ESI dataset can be found at www.yale.edu/envirocenter/esi.

[v] Both the United States and the United Kingdom track smaller particulates than the rest of the world. The United States and the United Kingdom emphasis follows the most recent medical evidence, which suggests that it is the smaller particles that penetrate deep into the lungs and present a real health threat.

[vi] Energy usage also has highly localized effects insofar as efficiency directly affects competitiveness and some of the harms (particulates and other local air pollutants) do not spread geographically.

[vii] The 2001 Survey, undertaken jointly by the World Economic Forum and Harvard University's Center for International Development and Institute for Strategy and Competitiveness, builds on questionnaire responses from more than 4,000 business, government, and non-governmental organization (NGO) leaders in 75 countries.

[viii] In developing the category subindexes, we use only those variables that appear appropriately grouped based on Eigen Value analysis, as shown in the factor analysis results given in Appendix B. Thus, in developing the regulatory stringency subindex, we drop the overall regulation measure. The sectoral EIA guidelines measure and the environmental strategies and action plans measure drop out of the information subindex. The measures of civil liberties, public sector competence, irregular payments, and regulatory burden are all dropped from the administrative infrastructure subindex. The scientists/engineers, licensing of foreign technology, and business innovation measures fall out of the technical capacity subindex.

Appendix A: Description of variables

Variable	Definition	Measurement	Source (WEF/ESI)
ENVIRONMENTAL PERFORMANCE			
Energy use	Energy Usage, 1997 (High = More inefficient)	Total energy consumption per unit of country GDP	ESI
Urban SO_2	Urban SO_2 concentration, 1990–96 (High = More particulates)	Average normalized mean of total SO2 per unit of city population	ESI
Urban particulates	Urban particulates concentration, 1990–96 (High = More particulates)	Average normalized mean of total suspended particulates per unit of city population	ESI
ENVIRONMENTAL REGULATORY REGIME			
Stringency of Standards			
Air regulation	Stringency of air regulations (High = More stringent)	Survey data (scale1–7)	WEF
Water regulation	Stringency of water regulations (High = More stringent)	Survey data (scale1–7)	WEF
Toxic waste regulation	Stringency of toxic waste regulations (High = More stringent)	Survey data (scale1–7)	WEF
Chemical regulation	Stringency of manufacturing chemical use regulations (High = More stringent)	Survey data (scale1–7)	WEF
Overall regulation	Stringency of overall environmental regulation (High = More stringent)	Survey data (scale1–7)	WEF
Regulatory Structure			
Flexibility	Options for achieving compliance in environmental regulations (High = Many options)	Survey data (scale1–7)	WEF
Stability	Environmental regulations in your country are confusing and frequently changing (High = Stable)	Survey data (scale1–7)	WEF
Early or late	Environmental regulations are enacted ahead or much later than other countries (High = Ahead)	Survey data (scale1–7)	WEF
Compliance hurts or helps competitiveness	Complying with environmental standards hurts/helps competitiveness (High = Helps)	Survey data (scale1–7)	WEF
Regulation adversarial or cooperative	Environmental gains are achieved through adversarial means or government-business cooperation (High = Cooperative)	Survey data (scale1–7)	WEF
Information			
ESI Variables–%	Percentage of ESI variables in publicly available data sets	% of total ESI variables (n=64)	ESI
Sustainable development info	Availability of sustainable development information at the national level		ESI
Number of sectoral EIA guidelines	Numer of sectoral EIA guidelines		ESI
Number of environmental strategies & action plans	Number of environmental strategies & action plans		ESI
Subsidies			
Government subsidies	Government subsidies in your country encourage inefficient use of energy or materials or there are no subsidies (High = High subsidies)	Survey data (scale1–7)	WEF
Regulatory Enforcement			
Enforcement	Environmental regulations are not enforced or enforced erratically or are enforced consistently and fairly (High = Consistently and fairly)	Survey data (scale1–7)	WEF
International agreements	Compliance with international agreements is a high priority in your country's government (High = Agree)	Survey data (scale1–7)	WEF
Environmental Institutions			
IUCN	Number of IUCN membership organizations, 1998	(per million population)	ESI
Memberships	Number of memberships in environmental intergovernmental organizations, 1998	frequency count	ESI
Prevalence of ISO 14000	How many Companies utilize environmental management system such as ISO 14000 (High = Most)	Survey data (scale1–7)	WEF

(cont'd.)

Appendix A: Description of variables *(cont'd.)*

Variable	Definition	Measurement	Source (WEF/ESI)
ECONOMIC AND LEGAL CONTEXT			
Administrative Infrastructure Quality			
Civil and political liberties	Index ranging from 1 (Low levels of liberties) to 7 (High levels)		ESI
Public sector competence	The competence of personnel in the public sector is higher or lower than in the private sector (High = Higher than private sector)	Survey data (scale1–7)	WEF
Favoritism	Public sector officials tend to favor well-connected private firms and individuals (High = Disagree)	Survey data (scale1–7)	WEF
Property rights	Property rights are unclear and unprotected by law or are clearly delineated and protected by law (High = Clearly delineated and protected)	Survey data (scale1–7)	WEF
Independent judiciary	The judiciary in your country is independent and not subject to interference by the government and/or parties to the dispute (High = True)	Survey data (scale1–7)	WEF
Irregular payments	Irregular payments connected with import-export permits, business licenses, exchange controls, tax assessments, etc. (High = Never occur)	Survey data (scale1–7)	WEF
Trusted legal framework	A trusted legal framework exists in your country for private business to challenge the legality of government actions and/or regulations (High = True)	Survey data (scale1–7)	WEF
Regulatory burden	Administrative regulations in your country are burdensome//not burdensome (High = not)	Survey data (scale1–7)	WEF
Level of administrative corruption	Do other firm' unfair or corrupt activities impose costs on your firm (High = No costs)	Survey data (scale1–7)	WEF
Honoring of policies through Gov't transition	Do new governments honor the contractual commitments and obligations of previous regimes (High = honor)	Survey data (scale1–7)	WEF
Administrative Infrastructure Quality			
Scientists and engineers	Research and development scientists and engineers	(per million population)	ESI
Technology position	Country's position in technology generally lags behind most countries or is a leader (High = Leader)	Survey data (scale1–7)	WEF
Institutions	Scientific research institutions in your country are not internationally reputable (High = World class)	Survey data (scale1–7)	WEF
Licensing foreign technology	Licensing of foreign technology is uncommon or is a common means to acquire new technology (High = Common)	Survey data (scale1–7)	WEF
Intellectual property protection	Intellectual property in your country is or is not adequately protected (High = Well protected)	Survey data (scale1–7)	WEF
Company R & D spending	Companies in your country do or do not spend much on R & D relative to international peers (High = Spend heavily on R & D)	Survey data (scale1–7)	WEF
Willingness to absorb new technology	Companies in your country are not interested//aggressive in absorbing new technology (High = Aggressive)	Survey data (scale1–7)	WEF
Importance of innovation to revenue	In your business, continuous innovation plays a major role in generating revenue not true/true (High = True)	Survey data (scale1–7)	WEF
Gov't purchase decisions for tech. products	Government purchase decisions for technology products are based solely on price / on technology and encourage innovation (High = On technology)	Survey data (scale1–7)	WEF

Appendix B: Factor Analysis Results

	FIRST FACTOR			
	First Eigen Value	Difference from Second EV	Percent of Variance Explained	Score Coefficient
Stringency Subindex	**3.97**	**3.95**	**99.16**	
Air Regulation				0.251
Water Regulation				0.251
Toxic Waste Regulation				0.251
Chemical Regulation				0.251
Overall Regulation				*
Regulatory Structure Subindex	**4.05**	**3.60**	**81.08**	
Options for Compliance				0.216
Confusing and Changing				0.239
Early or Late				0.221
Compliance Hurts or Helps Competitiveness				0.224
Regulation Adversarial or Cooperative				0.210
Information Subindex	**1.15**	**0.29**	**57.31**	
ESI-Variables %-available				0.660
Sustainable Development Info				0.660
Number of Sectoral EIA Guidelines				*
Number of Environmental Strategies & Action Plans			*	
Regulatory Enforcement Subindex	**1.93**	**1.86**	**96.38**	
Enforcement				0.509
International Agreements				0.509
Environmental Institutions Subindex	**1.59**	**1.19**	**79.72**	
IUCN				*
Memberships				0.560
Prevalence of ISO 14000				0.560
Administrative Infrastructure Quality Index	**5.35**	**5.14**	**89.09**	
Civil Liberties				*
Public Sector Competence				*
Gov't Favor Private Sector Firms				0.172
Property Rights				0.178
Independent Judiciary				0.179
Irregular Payments				*
Legal Framework				0.180
Regulatory Burden				*
Level of Administrative Corruption				0.176
Honoring of Policies through Gov. Transition				0.175
Scientific and Research Infrastructure Index	**4.52**	**4.32**	**90.38**	
Scientists and Engineers				*
Technology Position				0.214
Institutions				0.212
Licensing of Foreign Technology				*
Company R & D Spending				0.212
Willingness to Absorb New Technology				0.210
Importance of Innovation to Revenue				*
Gov't Purchase Decisions for Tech. Products				0.203
ROLLUP OF SUBINDICES				
Environmental Regulatory Regime Index	**3.46**	**3.06**	**86.56**	
Stringency Subindex				0.279
Regulatory Structure Subindex				0.274
Government Subsidies				–0.238
Regulatory Enforcement Subindex				0.281
Economic and Legal Context Index	**1.90**	**1.79**	**94.81**	
Administrative Infrastructure Quality Index				0.513
Scientific and Research Infrastructure Index				0.513

Note: * means that variable is not included in the corresponding index