Income and Power Inequality as Determinants of Environmental and Health Outcomes: Some Findings*

Mariano Torras, *Adelphi University*

Objective. The article corrects for two main shortcomings in conventional economic analyses of environmental change. First is the overemphasis placed on income growth, and general disregard for other socioeconomic factors. Second is economists' often oversimplified view of the environment, where distinctions between environmental necessities such as potable water and so-called environmental luxuries are ignored. I test for the effectiveness of power inequality in explaining access to sanitation and safe water as well as their health consequences. *Methods.* I develop a two-stage model seeking first to explain changes in the environmental variables and then population health. I employ ordinary least squares regressions on international cross-sectional data. *Results.* Some dimensions of power inequality outperform per-capita income as possible determinants of population health. Neither power inequality nor income is clearly superior at explaining environmental quality. *Conclusion.* The study casts further doubt on the importance of per-capita income in explaining environmental and health outcomes.

Income per capita is one of the principal conjectured determinants of environmental outcomes. Conventional wisdom has it that richer individuals or countries "demand" superior environmental quality because their more pressing needs are already met. The environment is, in other words, a luxury good. The environmental Kunzets curve hypothesis (see, e.g., Grossman and Krueger, 1993; Selden and Song, 1994) is among the more well-known expressions of the argument, and the ecological modernization thesis (e.g., Christoff, 1996; Mol, 1995; Simonis, 1989) reasons along similar lines. What these and related hypotheses ignore is the fact that environmentally degrading economic activities generate winners as well as losers. Unless the "winners" happened to invariably be the poorer members of society, we must call into question the idea that income increases necessarily lead to an amelioration of environmental problems.

*Direct correspondence to Mariano Torras, Assistant Professor of Economics, Adelphi University, 1 South Ave., Garden City, NY 11530⟨torrasm@panther.adelphi.edu⟩. I will share all data and coding information with those wishing to replicate the study. For comments on earlier versions of the article, I thank Michael Ash, James Boyce, Carol Heim, Neha Khanna, four anonymous reviewers, and participants in the History and Development Workshop of the Economics Department at the University of Massachusetts, Amherst. All errors are mine.

SOCIAL SCIENCE QUARTERLY, Supplement to Volume 86

Boyce (1994) argues that social decisions governing environmental degradation almost invariably favor more powerful over less powerful individuals and that, consequently, wider inequalities of power within society tend to result in greater environmental degradation. There is already abundant evidence supporting his first claim in the literature on environmental justice or environmental discrimination (e.g., Bullard, 2000; Davidson and Anderton, 2000; Ringquist, 1998). The second hypothesis has to date received less attention.

This article examines Boyce's presumed link between power inequality and environmental quality and also tests for the stronger assertion that power inequality explains environmental quality better than income per capita. I focus exclusively on so-called environmental necessities, or environmental aspects to a greater degree associated with population health conditions (such as, e.g., potable water), recognizing the often-overlooked distinction between these and the so-called environmental luxuries such as pristine wilderness areas.[1] I develop a model that considers the effectiveness of power inequality in explaining both environmental quality and population health outcomes.

I test the hypothesis that greater power inequality produces inferior environmental and health outcomes using an international cross-sectional data set. Absent any known quantitative measure of power inequality, I employ a number of socioeconomic variables as proxies. My analysis provides preliminary support for Boyce's original hypothesis, and in a few cases for the more forceful argument that power inequality is more important than income in explaining population health outcomes. My findings suggest that the role of income in explaining population health, as well as certain environmental outcomes associated with it, may be overstated.

Background

Most research on causes of environmental damage or pollution emphasizes the environmental outcomes themselves instead of their health consequences. The range of variables considered in such studies is broad, extending from deforestation and wetlands removal (e.g., Ehrhardt-Martinez, 1998; Norton, 1998; Stavins, 1990) to safe water or sanitation access (e.g., Shafik, 1994; Strauss and Thomas, 1998), to atmospheric or riverine pollutants such as lead, sulfur dioxide, or heavy metals (e.g., Grossman and Krueger, 1995; Pargal and Wheeler, 1996). Although socioeconomic variables such as the degrees of inequality or democracy have been studied as possible determinants of environmental damage or pollution (e.g., Copeland and Taylor, 1994; Midlarsky, 1998), income per capita has been the chief explanatory variable in most studies found in the economics literature.

[1]Beckerman (1992) and Martinez-Alier (1995) are among the minority of economists that emphasize the distinction.

The environmental Kuznets curve (EKC) hypothesis is perhaps the most well-known articulation of the income-environment link. It depicts a relationship between per-capita income and the environment that follows an inverted U, where environmental conditions worsen with income increases early in a country's development, after which, beyond a certain turning point, environmental quality improves as income continues to increase. The potential policy implications of the hypothesis have generated enormous attention to the EKC in the literature (see, e.g., Grossman and Krueger, 1993, 1995; Selden and Song, 1994). Yet while the quadratic functional form might have some intuitive appeal, the case for it seems overstated considering that it probably relates to only a small subset of environmental variables. Ekins (1997) and Shafik (1994), among others, have found that a number of environmental variables vary monotonically with income, some improving (e.g., access to safe water or sanitation), others worsening (e.g., carbon dioxide emissions, municipal waste per capita).

In related studies, Londregan and Poole (1996) find that higher income levels make it more likely that a country will have a democratic political system, while Neumayer (2002) finds democratization correlated with a number of variables associated with a country's commitment to redressing environmental problems. Taken together, the two studies suggest a positive income-environment link, consistent only with the descending phase of the EKC. Homer-Dixon (1995) and Simon (1981), among others, write of the supply of "ingenuity" that countries can deploy to help them overcome environmental problems associated with resource scarcity and, insofar as richer countries possess more of it, also imply that wealth is conducive to environmental quality. Homer-Dixon nevertheless strikes a pessimistic note, foreseeing a "bifurcated world" in which some countries continue to supply the ingenuity necessary to countervail scarcity while others will be increasingly unable to.

Inequality is the principal focus of other research, such as that of Martinez-Alier (1995), who notes that income distribution may affect environmental outcomes from both the demand and the supply side. On the demand side, he distinguishes between environmental "amenities" (e.g., pristine wilderness areas) and environmental "necessities" (e.g., potable water), arguing that since income elasticity is higher for the former, an income redistribution would influence the demand for each of these categories of environmental goods.[2] His analysis suggests that population health conditions would improve if inequality were reduced, ceteris paribus, since more necessities and

[2]This is technically a false dichotomy since, as many have noted (e.g., Costanza et al., 1997; Torras, 2003), our growing understanding of ecological benefits and services suggests many previously unknown health links. Nevertheless, it would be intellectually dishonest to ignore differences in the *extent* of the health association among different environmental variables. I suspect that few would question the idea, for example, that clean drinking water in a remote village in some lesser-developed (or developing) country should be more important to the villagers than keeping a nearby wilderness area in a pristine state.

less amenities would be demanded. Beckerman (1992) also distinguishes between the two categories—placing great relative importance on environmental "necessities"—although he does not emphasize inequality.

Since supply of environmental goods is determined by the cost of providing them, income redistribution will also alter their supply. As Martinez-Alier (1993:113) puts it, "the poor sell cheap"—that is, the fact that environmental goods are not traded in any market makes the poor undervalue them relative to other commodities more than do rich people. Heerink, Mulatu, and Bulte (2001) and Magnani (2000) place the Gini coefficient of inequality on the right-hand side (RHS) of their EKC estimates, finding some evidence that higher inequality worsens environmental quality. Torras and Boyce (1998) test not only the Gini index, but also literacy and a political rights and civil liberties index, since their main focus is *power* inequality. They find that these proxies for power inequality have more explanatory power than the Gini index and that including all three variables on the RHS in most cases mutes the effect of per-capita income on environmental quality.

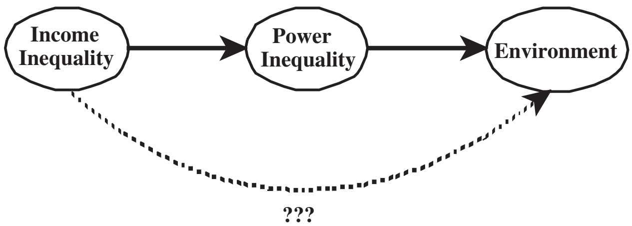
The hypothesized direct relationship between power inequality and environmental degradation dates back to Boyce (1994). The relationship between the two variables is, according to him, likely to depend on whether individuals enjoying greater relative power are on the whole net gainers or net losers from environmentally degrading economic activities. Although few if any *prefer* degraded environments, the fact that economic decisions frequently sully the natural environment to some degree implies the existence of net gainers—else the activities would not occur. Boyce's emphasis on power inequality serves to remind us of an inescapable fact so often overlooked in standard economics approaches: some individuals have significantly greater influence on social or environmental outcomes than others.[3]

Richer individuals are much more likely to be net beneficiaries of environmentally degrading economic activity since they gain proportionately more than the poor from the fact that they consume more and own more assets. They would only be net losers if their share of the resulting environmental externality were skewed even more unequally against them—an unrealistic scenario (see, e.g., Khan, 1997; Martinez-Alier, 1995; Torras, 2001). Richer individuals tend to be more powerful as well, since greater access to wealth grants one greater political influence. It is in this way that the impact of income inequality on environmental quality might be limited to the indirect effect it contributes by determining the degree of power inequality (Figure 1). If the richer segment of the population is both a net gainer from environmental degradation and has more power,

[3]The role of power in Boyce's theory is similar to the role that Becker (1983) accords to "influence" in determining fiscal policy.

FIGURE 1

Inequality as a Determinant of Environmental Quality



greater power inequality should, ceteris paribus, lead to a lower quality natural environment.[4]

If we assume, as is not unreasonable, that power inequality diminishes as a country becomes richer, Boyce's hypothesis is consistent with the ecological modernization thesis. Reduced inequality, for example, leads to greater communication, negotiation, and consultation between environmental groups and "economic agents and state representatives" (Mol, 1995:58), presumably producing superior environmental outcomes. Yet such a sequence of events is not axiomatic. For example, in a recent paper, York, Rosa, and Dietz (2003) present evidence contradicting the ecological modernization thesis, finding that basic material conditions (population size, geography) better explain environmental outcomes.[5]

What are the implications for population health? Although there seems to be a fairly transparent link between environmental quality and population health outcomes, it is likely to be stronger for some environmental variables than for others. Deforestation and atmospheric carbon dioxide concentration, for example, do not suggest obvious health outcomes, while aquatic heavy metal concentration or percentage of households with access to

[4]I do not mean to imply that the wealthy do not care about the environment, or even that they care less about it than the poor. The contrary belief is fairly widespread—since the environment is often believed to be a luxury good, the rich are often regarded as being more conservationist than the poor, and the observation is often used to justify the environmental Kuznets curve hypothesis or the general belief that a reliable remedy for environmental problems is increasing the average income level of a population. Yet the view is simplistic for at least two reasons. First, the environment is not a pure public good in the sense that the rich have greater mobility than the poor and are more easily able to locate away from areas of greater pollution concentration. Second, even though the rich may care more about the environment in an absolute sense, other arguments in their utility functions may dampen the *relative* importance that they place on the environment.

[5]Their study is rather narrow, however, in that the principal environmental measure considered was the ecological footprint, which is a comprehensive index of general environmental impact, based on land area equivalents of estimated resource flows (see, e.g., Wackernagel et al., 1999). It is not clear what would be the health consequences of a larger ecological footprint.

sanitation do.[6] For the latter examples it is reasonable to expect that a poorer performance on the environmental variable will cause inferior health outcomes. It is indeed what Beghin et al. (2002), Gangadharan and Valenzuela (2001), and Gardner (1973), among others, have found.

Yet population health most likely has other determinants. Although some have studied the relationship between income and population health, findings here have largely been mixed. Pritchett and Summers (1996), for example, argue that more income or wealth is conducive to better health, and Carey and Judge (2001) find evidence of a "virtuous cycle" whereby more income and better health mutually reinforce each other (since, the authors presume, better health leads to productivity increases). Rivera and Currais (1999) also find support for the reverse causality between health and income. In contrast, the work of Easterlin (1995, 1999) and Shiffman (2000) suggests that there is at best a very weak causal link between income and health improvements despite the high correlation between the two variables. Finally, Gangadharan and Valenzuela (2001) find that, at least among poorer countries, health gains attributable to income increases are often significantly offset by concomitantly worsening environmental conditions.

Marmot (2001) argues that income inequality explains population longevity better than income levels—with greater inequality resulting in lower life expectancies—and Nganda (1996) argues along similar lines for more general health outcomes, including morbidity incidence. In an empirical study of the U.S. states, Boyce et al. (1999) find evidence that inequality in the distribution of power is an important factor in explaining environmental outcomes, which in turn are found to influence health to a significant degree. The authors of this study construct and test an index of power inequality on data from the 50 states, finding strong evidence that power inequality also plays a direct role in explaining health outcomes.

Model

My analysis is related to that of Boyce et al. (1999), with the major difference that my data set is an international cross-section including the majority of the world's countries. Also, mine is a two- rather than a four-stage model owing to the differences in availability and quality of the international statistics in comparison with available U.S. data. The first stage seeks to explain variations in environmental quality, and the second variations in population health outcomes, with environmental quality among the explanatory variables.

[6]Again, I am not asserting that deforestation and CO_2 emissions play no role in explaining human health. They undoubtedly do, but their effects are far less direct than those of, say, unsafe drinking water. It is no surprise, for example, that most LDCs side with the United States on the Kyoto Protocol controversy (they are in no rush to rein in CO_2 emissions) and that countries such as Brazil have historically been hostile to attempts to persuade it to reduce its deforestation rate (Torras, 2003).

Environmental Quality

As noted earlier, while some ascribe a central role to per-capita income in determining environmental quality, others theorize alternative influences such as income inequality and power inequality. Similarly, I hypothesize environmental quality to conform to the following functional form:

$$EQ = E(Y, G, \pi, \mathbf{X}), \text{ where } E_Y > 0,\ E_G < 0,\ E_B < 0, \qquad (1)$$

EQ represents environmental quality—a higher value signifying better quality—and Y and G stand for per-capita income and the Gini coefficient of inequality. Since power inequality is difficult, if not impossible, to measure directly, the symbol π is a vector of variables that serve as proxies (greater power inequality denoted by higher value of π). Finally, $\mathbf{X}$ is a vector of other environmental-quality determinants or control variables.

I define environmental quality (EQ) as the percentage of a given population with access to safe water (SW) and to sanitation (SNT). I limit my scope to these two because statistics on most other environmental variables are unfortunately only available for a small subset of the world's countries or, even where available for many countries, are of dubious quality.[7] It is convenient that access to safe water and sanitation are intuitively associated with health outcomes, since one would otherwise be unable to test for any relevant link between environmental quality and population health.

I consider five proxies for power inequality in the present study: political rights and civil liberties (P), literacy rate (L), share of population attaining higher education (HE), share of population with internet access (INT), and degree of female representation in government (FG). I assume that a poor country rating for political rights or civil liberties indicates power inequality, with the opposite holding where rights and liberties are more widespread. Since power is to a large degree related to information access, I use literacy rates and densities of higher education and internet use as additional proxies, assuming that higher scores in each case imply that a greater share of the overall population is empowered. Finally, I assume that power distribution is in part influenced by the extent to which females participate in a country's government, since it concerns the power available to one-half of the population.

Concerning the $\mathbf{X}$ vector, I include three variables that intuition would suggest should play a role in explaining environmental outcomes: population density (PD), urbanization (URB), and manufacturing share of output (MNF), also considered by Boyce et al. (1999) and York, Rosa, and Dietz

[7]Perhaps the most extensive compilation of international environmental data is the "Environmental Sustainability Index" project of the Global Leaders of Tomorrow Environment Task Force (2002), World Economic Forum, Annual Meeting. The project collects numerous environmental variables, yet in many cases most observations are extrapolated through a variety of sometimes questionable methods. In other cases, environmental "variables" are mere indexes derived from related variables using factor analysis.

(2003). I test the relationship both with and without the control variables.

$$\begin{aligned}\mathrm{EQ} = {} & \alpha_1 + \beta_{11}\mathrm{Y} + \beta_{12}\mathrm{G} + \beta_{13}\mathrm{L} \\ & + \beta_{14}\mathrm{P} + \beta_{15}\mathrm{HE} + \beta_{16}\mathrm{INT} + \beta_{17}\mathrm{FG} + \mu_1, \quad (1\mathrm{a})\end{aligned}$$

$$\begin{aligned}\mathrm{EQ} = {} & \alpha_2 + \Delta_{21}\mathrm{Y} + \Delta_{22}\mathrm{G} + \Delta_{23}\mathrm{L} + \Delta_{24}\mathrm{P} + \beta_{25}\mathrm{HE} + \beta_{26}\mathrm{INT} \\ & + \beta_{27}\mathrm{FG} + \beta_{21}\mathrm{YPD} + \beta_{22}\mathrm{URB} + \beta_{23}\mathrm{MNF} + \beta_{24}\mathrm{YURB} \\ & + \mu_2. \qquad (1\mathrm{b})\end{aligned}$$

I expect both PD and MNF to be negatively related to EQ, but the case is not as clear for URB. Although urbanization tends to accompany income growth (hence is potentially beneficial to the environment), urbanization *in the absence of growth* could be disastrous for the environment (Angotti, 1996; Brockerhoff and Brennan, 1998; Brown, 1989). I therefore insert an additional control variable (YURB) that accounts for the interaction between income level and urbanization rate.

Population Health

Environmental quality, the dependent variable in the first stage of the model, figures to be a critical factor in explaining population health. It also stands to reason that health outcomes are influenced by the share of GDP that a country's government allocates to promoting public health. Finally, given the conflicting claims in the literature, it also seems warranted to test for the direct impacts of per-capita income, income inequality, and power inequality on health. The reduced form model is as follows.

$$\mathrm{HEALTH} = \mathrm{H}(\mathrm{EQ},\ \mathrm{Y},\ \mathrm{G},\ \pi,\ \mathrm{PH}), \qquad (2)$$

where $H_{EQ} > 0$, $H_Y > 0$, $H_G < 0$, $H_B < 0$, $H_{PH} > 0$. HEALTH represents population health performance (again, a higher value indicating greater success), and PH stands for share of national output spent by the government on public health. Contrary to Boyce et al. (1999), I do not include elements from the earlier **X** vector in the second-stage equation. To the extent that greater values for population density, urbanization rate, and manufacturing sector share of output suggest worsening health conditions (and vice versa), a significant portion of this effect is likely to be manifested through the environmental variables. More important, I do not include them because I have no a priori expectation about what the sign of any of these coefficients might be, independent of the influence of safe water and sanitation.

I test the relationship for three distinct health measures: mean percentage of lifetime spent disabled (DISPCT), child mortality rate (CHMOR), and an index of health achievement estimated by the World Health Organization (IHACH). The disability ratio is based on estimates of the "disability-adjusted" life expectancy (DALE) for each country, and is simply the difference between (conventional) life expectancy and DALE divided by life expectancy. I prefer using DISPCT instead of the DALE itself because, since the latter is highly correlated with conventional life expectancy, using it as a health indicator would be biased in favor of richer countries (they always exhibit higher life expectancies). More important, doing so conflates health and longevity, the precise mistake that Kirigia (1996), and the WHO (2000), among others, caution against. Contrariwise, using the "disability gap" (difference between unadjusted life expectancy and DALE) as a proxy would be biased *against* richer countries, since their citizens are likely to experience more disabled years on average for the simple reason that they live more years overall. My use of DISPCT therefore avoids both traps.

In testing the determinants of health outcomes, I first consider the effect of environmental quality in isolation, and then I add the share of output spent on public health. Next I add income and the Gini index to the regression line, and finally the power inequality proxies. The equations that I estimate are:

$$\text{HEALTH} = \kappa_1 + \varphi_{11}\text{SW} + \varphi_{12}\text{SNT} + \xi_1, \quad (2a)$$

$$\text{HEALTH} = \kappa_2 + \varphi_{21}\text{SW} + \varphi_{22}\text{SNT} + \gamma_{21}\text{PH} + \xi_2, \quad (2b)$$

$$\text{HEALTH} = \kappa_3 + \varphi_{31}\text{SW} + \varphi_{32}\text{SNT} + \gamma_{31}\text{PH} + \lambda_{31}\text{Y} + \lambda_{32}\text{G} + \xi_3, \quad (2c)$$

$$\text{HEALTH} = \kappa_4 + \varphi_{41}\text{SW} + \varphi_{42}\text{SNT} + \gamma_{41}\text{PH} + \lambda_{41}\text{Y} + \lambda_{42}\text{G} + \psi_{41}\text{L} + \psi_{42}\text{P} + \psi_{43}\text{HE} + \psi_{44}\text{INT} + \psi_{45}\text{FG} + \xi_4. \quad (2d)$$

Importantly, I expect the signs for all the partial derivatives to be reversed for CHMOR and DISPCT, since better health performance is indicated by *lower* values for each of these.

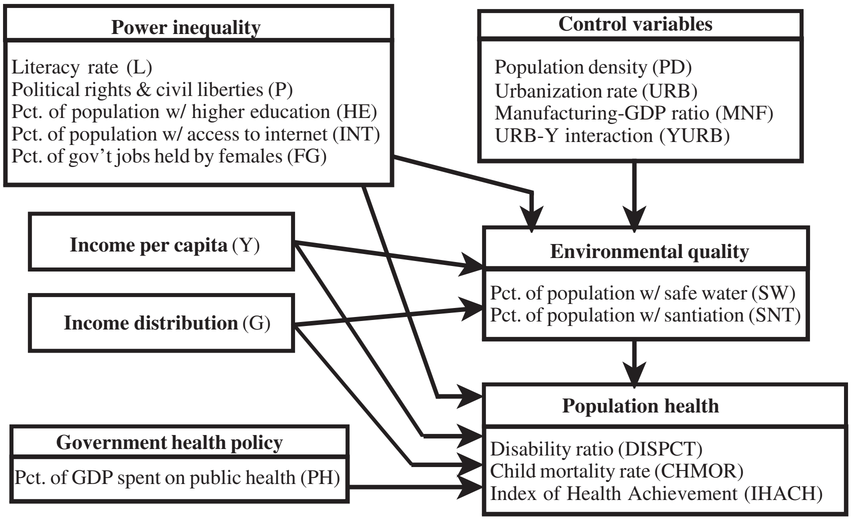
Figure 2 summarizes the model. Unlike Boyce et al. (1999), I study the effects of per-capita income and income inequality not only on environmental quality but also on health outcomes. Doing so enables us to assess whether these variables remain significant determinants after accounting for power inequality. I hypothesize that greater inequality in power distribution leads, ceteris paribus, to inferior performance in population health, but also that power inequality explains health outcomes better than per-capita income and income inequality.

Data

The data set that I employ contains economic, environmental, and health statistics for 180 countries (see Appendix Table A for the country list). Statistics for access to safe water and sanitation are expressed in percentage of

FIGURE 2

The Model



national population with access and are taken from the World Bank (2003), UNDP (2000), and WRI (2001). Per-capita income (in PPP-adjusted U.S. dollars) and Gini coefficients are also obtained from the World Bank (2003), as are literacy rates.[8] There are separate ordinal scales for political rights and for civil liberties, each ranging from 1 (most free) to 7 (least free). I use 14 minus the sum of the two measures for each country, making the new variable range from 0 to 12. Data are from Freedom House (2000). Access to higher education is defined as individuals per 10,000 in the population with a college degree or the equivalent; internet use is also per 10,000. The "government" in the female-government-representation variable refers to a country's parliament or some equivalent for nonparliamentary governments, and the variable expresses the percentage of government officials that are women. Statistics for these variables are from Prescott-Allen (2001).

The numbers for population density (inhabitants per square kilometer), urbanization (percentage of population residing in urban areas), and manufacturing share of value added are also obtained from the World Bank (2003). The figures for the disability ratio are based on recent DALE es-

[8]The Gini coefficient is the only variable in the study for which I used estimated values in the case of missing observations since *N* was equal to only 112. The estimates were calculated from coefficients obtained from regressing Gini on per-capita income and dummy variables for geographical region.

TABLE 1

Determinants of Environmental Quality (Equation (1a))

	Safe Water	Sanitation
Intercept	40.12***	19.20
	(4.24)	(1.60)
Per-capita income (Y)	1.30E-3***	1.49E-3***
	(4.48)	(4.03)
Gini coefficient (G)	−11.61	−13.39
	(−0.68)	(−0.62)
Political/civil rights (P)	−4.56E-3	−0.19
	(−0.01)	(−0.40)
Literacy rate (L)	0.31***	0.45***
	(4.06)	(4.65)
Higher education (HE)	2.87E-2*	4.61E-2**
	(1.96)	(2.49)
Internet (INT)	−4.47E-3	−4.70E-3
	(−1.36)	(−1.13)
Female participation in government (FG)	−0.15	−0.25
	(−0.90)	(−1.16)
Adjusted R^2	0.47	0.49
N	180	180

***Significant at the 1% level of confidence; **significant at the 5% level of confidence; *significant at the 10% level of confidence (*t* ratios are in parentheses).

timates published by the WHO (2000). "Conventional" life expectancy (also needed to calculate the disability ratio) is from the World Bank (2003), since the WHO only publishes these numbers split according to gender. The index of health achievement is taken from the WHO (2000), and data for child mortality, represented as child deaths per 1,000 in the population, are from Prescott-Allen (2001). Finally, the statistics for government public-health expenditure as a percentage of GDP are also from the WHO (2000).

Descriptive statistics for all the variables used in the analysis are in Appendix Table B.

Econometric Results

I use ordinary least squares (OLS) to estimate all equations.[9] Results for environmental quality are in Tables 1 and 2. Not surprisingly, the effect of per-capita income is positive and statistically significant for both safe water and sanitation. The same is true for literacy, although not for income

[9]I test for heteroskedasticity in all regressions using the White (1980) test. It reveals that heteroskedasticity is excessive in only four of 16 cases, and with only a 10 percent degree of confidence in three of these (1 percent in the other). Therefore, while I urge caution in interpretation of the *t* statistics, it is in most cases unlikely that they are greatly overstated.

TABLE 2

Determinants of Environmental Quality (Equation (1b))

	Safe Water	Sanitation
Intercept	35.88***	26.45**
	(3.49)	(1.98)
Per-capita income (Y)	1.10E-3***	1.37E-3***
	(2.75)	(2.64)
Gini coefficient (G)	– 20.86	– 26.07
	(– 1.21)	(– 1.17)
Political/civil rights (P)	0.23	– 0.11
	(0.63)	(– 0.22)
Literacy rate (L)	0.20**	0.38***
	(2.45)	(3.57)
Higher education (HE)	1.48E-2	3.58E-2*
	(0.98)	(1.83)
Internet (INT)	– 3.91E-3	– 5.64E-3
	(– 1.15)	(– 1.23)
Female participation in government (FG)	– 0.10	– 0.19
	(– 0.61)	(– 0.85)
Population density (PD)	2.44E-3	2.19E-3
	(0.87)	(0.60)
Urbanization rate (URB)	0.30***	0.24*
	(3.11)	(1.88)
Urbanization/per-capita income interaction (YURB)	– 3.24E-6	– 1.47E-6
	(– 0.55)	(– 0.19)
Manufacturing as % of output (MNF)	9.09E-2	– 0.26
	(0.64)	(– 1.39)
Adjusted R^2	0.50	0.50
N	180	180

***Significant at the 1% level of confidence; **significant at the 5% level of confidence; *significant at the 10% level of confidence (*t* ratios are in parentheses).

inequality or political and civil rights.[10] Higher education also has a positive and statistically significant effect, although at a lower degree of confidence—10 percent for safe water and 5 percent for sanitation. Its effect is reduced when we add the control variables (becomes insignificant when safe water is on LHS). Neither internet use nor female participation in government proved statistically significant.

Adding the control variables does not alter the results to a significant degree. Adjusted R^2 in each case increases only marginally, mostly due to the effect of the urbanization variable, which for both estimates also has a

[10]This is not surprising, given the high degree of multicollinearity among the independent variables. A bivariate correlation test reveals statistically significant correlations for *all* possible pair combinations. Regression coefficient *t* ratios are therefore likely to be understated throughout, and statistical significance may in some cases (e.g., possibly the immediately preceding) be suppressed.

TABLE 3

Determinants of Population Health (Equation (2a))

	Disability Ratio	Child Mortality	Index of Health Achievement
Intercept	21.83***	221.78***	43.62***
	(28.65)	(18.76)	(22.64)
Safe water (SW)	−8.95E-2***	−1.61***	0.30***
	(−5.66)	(−6.56)	(7.39)
Sanitation (SNT)	−3.99E-2***	−0.67***	0.14***
	(−3.26)	(−3.52)	(4.47)
Adjusted R^2	0.48	0.55	0.62
N	180	180	180

positive and statistically significant effect. The interaction term proves insignificant in both cases, as do population density and manufacturing share of output. Otherwise, the coefficients for literacy and higher education are more robust when sanitation is the left-hand-side variable—that is, they both remain statistically significant. The difference might be explained by the fact that provision of sanitation is more visible than availability of safe water. Since the latter can vary according to degree, and the precise definition of a "safe" threshold is never very clear, problems in this area have the potential to go unnoticed for some time, even if the population is educated and politically active. Finally, urbanization becomes only weakly significant in explaining sanitation once the control variables are added. This is somewhat peculiar given that one would expect sanitation provision to increase almost by dint of the fact that a country is more urbanized. Other factors, however, appear to partially countervail this effect.

Table 3 presents the results of testing Equation (2a) on the three distinct health measures. As we can see, the effect of both environmental variables is strongly statistically significant in explaining health outcomes. The result holds independent of which health measure we consider. Most important, the signs are consistently as expected—negative for disability ratio and child mortality, and positive for index of health achievement. Looking at Equation (2b), we find that the share of a country's GDP allocated to public-health expenditures also is statistically significant at the 1 percent confidence level (Table 4). Again, the result is independent of the health measure chosen, and the sign is also as expected in each case. Adding the variable to the equation does not significantly alter the results found in Equation (2a), although it adds the greatest boost to R^2 when the dependent variable is index of health achievement.

Access to safe water appears to be a robust determinant of health outcomes since it remains strongly significant for all three health variables even when we add per-capita income and the Gini index to the regression line

TABLE 4

Determinants of Population Health (Equation (2b))

	Disability Ratio	Child Mortality	Index of Health Achievement
Intercept	22.25***	227.85***	41.78***
	(29.94)	(19.66)	(24.32)
Safe water (SW)	−8.23E-2***	−1.51***	0.26***
	(−5.36)	(−6.28)	(7.43)
Sanitation (SNT)	−2.78E-2**	−0.49**	8.50E-2***
	(−2.27)	(−2.57)	(3.00)
Public health (PH)	−0.52***	−7.58***	2.30***
	(−3.78)	(−3.52)	(7.20)
Adjusted R^2	0.52	0.57	0.71
N	180	180	180

***Significant at the 1% level of confidence; **significant at the 5% level of confidence; *significant at the 10% level of confidence (*t* ratios are in parentheses).

(Table 5). The influence of sanitation and health expenditure ratio is in most cases reduced, although in no instance is either rendered statistically insignificant. Most surprising, however, is the fact that per-capita income is significant in only one of the estimates—where health is measured by the index of achievement. The coefficient for income inequality is also statis-

TABLE 5

Determinants of Population Health (Equation (2c))

	Disability Ratio	Child Mortality	Index of Health Achievement
Intercept	17.29***	195.66***	54.77***
	(10.51)	(7.45)	(15.94)
Safe water (SW)	−7.29E-2***	−1.39***	0.20***
	(−4.69)	(−5.58)	(6.17)
Sanitation (SNT)	−2.33E-2*	−0.43**	5.44E-2**
	(−1.93)	(−2.25)	(2.15)
Public health (PH)	−0.33**	−5.49**	1.22***
	(−2.19)	(−2.27)	(3.87)
Per-capita income (Y)	−4.23E-5	−9.05E-4	5.34E-4***
	(−1.00)	(−1.33)	(6.01)
Gini coefficient (G)	9.22***	49.51	−17.20***
	(3.04)	(1.02)	(−2.71)
Adjusted R^2	0.55	0.58	0.77
N	180	180	180

***Significant at the 1% level of confidence; **significant at the 5% level of confidence; *significant at the 10% level of confidence (*t* ratios are in parentheses).

TABLE 6

Determinants of Population Health (Equation (2d))

	Disability Ratio	Child Mortality	Index of Health Achievement
Intercept	20.07***	268.00***	48.51***
	(12.97)	(12.18)	(15.57)
Safe water (SW)	– 5.16E-2***	– 0.95***	0.15***
	(– 3.72)	(– 4.83)	(5.38)
Sanitation (SNT)	– 1.85E-3	– 3.50E-2	8.06E-3
	(– 0.17)	(– 0.23)	(0.37)
Public health (PH)	4.25E-2	1.88	0.33
	(0.28)	(0.86)	(1.05)
Per-capita income (Y)	– 9.83E-6	– 9.69E-4	4.88E-4***
	(– 0.20)	(– 1.42)	(5.04)
Gini coefficient (G)	8.32***	38.66	– 16.50***
	(3.11)	(1.01)	(– 3.06)
Political/civil rights (P)	– 2.45E-2	– 0.97	0.25**
	(– 0.41)	(– 1.15)	(2.11)
Literacy rate (L)	– 7.21E-2***	– 1.76***	0.16***
	(– 5.59)	(– 9.60)	(6.29)
Higher education (HE)	– 7.94E-3***	– 4.69E-2	1.43E-2***
	(– 3.40)	(– 1.41)	(3.05)
Internet density (INT)	1.66E-4	9.90E-3	– 9.70E-4
	(0.33)	(1.37)	(– 0.95)
Female/government	3.33E-2	0.24	– 8.18E-2
ratio (FG)	(1.22)	(0.61)	(– 1.49)
Adjusted R^2	0.65	0.74	0.84
N	180	180	180

***Significant at the 1% level of confidence; **significant at the 5% level of confidence; *significant at the 10% level of confidence (*t* ratios are in parentheses).

tically significant for this regression estimate (as indeed are all RHS variables), as well as when we use the disability ratio. As with the other explanatory variables, the signs for income and the Gini index are as expected.

Finally, adding the power-inequality variables changes a great deal (Table 6). Irrespective of health measure used, sanitation and health expenditure are rendered insignificant on inclusion of the power-inequality proxies. In contrast, no changes result in the significance of the coefficients for per-capita income and income inequality. Among the five power-inequality variables, only two are statistically significant: literacy and higher education (the latter in only two of three cases). The signs of their coefficients are also as expected.

The index of health achievement appears to provide the best fit to our model. Aside from the high R^2 coefficient (0.84), more variables are statistically significant. Importantly, however, sanitation and government health expenditures are here also insignificant. Per-capita income and higher education are also strongly statistically significant, and political and civil rights is significant at the 5 percent confidence level. Income inequality is again significant as well, and safe water and literacy remain robust.

Conclusion

Results provide preliminary support for the hypothesis that greater power inequality is adverse to environmental quality and human health. Although not clearly superior to per-capita income as a factor in determining access to safe water and sanitation, two of the power-inequality proxies—literacy and incidence of higher education—outperform per-capita income in explaining health outcomes, while another—political and civil rights—does as well. Even the coefficient for the Gini index (in all likelihood related to power inequality) appears to explain population health better than income, which is statistically significant for only one of three health measures.

The main implication to be drawn is that a relatively equal distribution of power is an important condition not only for improved population health, but for the availability of environmental benefits or services that contribute to favorable health conditions. The power-inequality measure that I derive is based on variables related to political rights and information access. If, through a gradual process of democratization, these become available to more people over time, we might expect power inequality to diminish and ultimately produce results not unlike envisioned by the ecological modernization thesis. Of course, such changes require political will from certain segments of society, and whether it is likely to be forthcoming is a matter not addressed here.

More research in this area is critical, and to this end procurement of more extensive and reliable environmental statistics at the international level is indispensable. Access to safe water and sanitation are among the few such variables for which most countries report, a fact that suited the present study because both are directly related to population health. Yet as noted, there exist a number of other health-related environmental variables, such as local acute atmospheric pollution (not to mention possible nonenvironmental health determinants such as disease, stress levels, or vaccination prevalence), for which international coverage is not nearly as broad. Although progress has no doubt been made over the past few decades in developing measures and obtaining statistics in such areas, it has thus far been insufficient to support a comprehensive study involving the majority of the world's countries.

Another topic deserving of greater attention is the development of a single quantitative indicator of power inequality based on its individual constituents. It is something for which there already is a precedent, as Boyce et al. (1999) employed factor analysis to construct such an indicator for individual U.S. states. Consolidating a variety of related variables into one index would eliminate any multicollinearity that is likely to have suppressed the t ratios of some of the coefficients in this study. Also, such an index would provide a direct quantitative means of comparing individual country performances.

One might hope that the study's focus on population health is at least a step in the direction of mitigating controversy over proper environmental policy. Although different groups might disagree over the importance of environmental quality relative to other human needs, few would argue that health issues do not deserve utmost priority in policy decisions. If my results do not produce greater misgivings over the importance accorded to income growth in explaining environmental and health outcomes, they at least call for further investigation into the role of power inequality.

REFERENCES

Angotti, T. 1996. "Latin American Urbanization and Planning: Inequality and Unsustainability in North and South." *Latin American Perspectives* 23(4):12–34.

Becker, G. 1983. "A Theory of Competition Among Pressure Groups for Political Influence." *Quarterly Journal of Economics* 98:371–400.

Beckerman, W. 1992. "Economic Growth and the Environment: Whose Growth? Whose Environment?" *World Development* 20(4):481–96.

Beghin, J., B. Bowland, S. Dessus, D. Roland-Holst, and D. van der Mensbrugghe. 2002. "Trade Integration, Environmental Degradation, and Public Health in Chile: Assessing the Linkages." *Environment and Development Economics* 7:241–67.

Boyce, J. 1994. "Inequality as a Cause of Environmental Degradation." *Ecological Economics* 11:169–78.

Boyce, J., A. Klemer, P. Templet, and C. Willis. 1999. "Power Distribution, the Environment, and Public Health: A State-Level Analysis." *Ecological Economics* 29:127–40.

Brockerhoff, M., and E. Brennan. 1998. "The Poverty of Cities in Developing Regions." *Population and Development Review* 24(1):75–114.

Brown, J. 1989. "Public Reform for Private Gain? The Case of Investments in Sanitary Infrastructure: Germany, 1880–1887." *Urban Studies* 26(1):2–12.

Bullard, R. 2000. *Dumping in Dixie: Race, Class, and Environmental Quality*, 3rd ed. Boulder, CO: Westview Press.

Carey, J., and D. Judge. 2001. "Life Span Extension in Humans is Self-Reinforcing: A General Theory of Longevity." *Population and Development Review* 27(3):411–36.

Christoff, P. 1996. "Ecological Modernization, Ecological Modernities." *Environmental Politics* 5(3):476–500.

Copeland, B., and M. S. Taylor. 1994. "North-South Trade and the Environment." *Quarterly Journal of Economics* 109(3):755–87.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* May 15:253–60.

Davidson, P., and D. Anderton. 2000. "Demographics of Dumping II: A National Environmental Equity Survey and the Distribution of Hazardous Materials Handlers." *Demography* 37(4):461–66.

Easterlin, R. 1995. "Industrial Revolution and Mortality Revolution: Two of a Kind?" *Journal of Evolutionary Economics* 5(4):393–408.

———. 1999. "How Beneficent is the Market? A Look at the Modern History of Mortality." *European Review of Economic History* 3:257–94.

Ehrhardt-Martinez, K. 1998. "Social Determinants of Deforestation in Developing Countries: A Cross-National Study." *Social Forces* 77(2):567–86.

Ekins, P. 1997. "The Kuznets Curve for the Environment and Economic Growth: Examining the Evidence." *Environment and Planning A* 29:805–30.

Freedom House. 2000. *Freedom in the World: Political Rights and Civil Liberties*. New York: Freedom House.

Gangadharan, L., and M. Valenzuela. 2001. "Interrelationships Between Income, Health, and the Environment: Extending the Environmental Kuznets Curve Hypothesis." *Ecological Economics* 36(3):513–31.

Gardner, M. 1973. "Using the Environment to Explain and Predict Mortality." *Journal of the Royal Statistical Society A* 136(3):421–40.

Global Leaders of Tomorrow Environment Task Force. 2002. *Environmental Sustainability Index*. In collaboration with the Yale Center for Environmental Law and Policy, Yale University, and the Center for International Earth Science Information Network, Columbia University. World Economic Forum, Annual Meeting.

Grossman, G., and A. Krueger. 1993. "Environmental Impacts of a North American Free Trade Agreement." In P. Garber, ed., *The U.S.-Mexico Free Trade Agreement*. Cambridge: MIT Press.

———. 1995. "Economic Growth and the Environment." *Quarterly Journal of Economics* 110:353–77.

Heerink, N., A. Mulatu, and E. Bulte. 2001. "Income Inequality and the Environment: Aggregation Bias in Environmental Kuznets Curves." *Ecological Economics* 38(3):359–67.

Homer-Dixon, T. 1995. "The Ingenuity Gap: Can Poor Countries Adapt to Resource Scarcity?" *Population and Development Review* 21(3):587–612.

Khan, H. A. 1997. "Ecology, Inequality, and Poverty: The Case of Bangladesh." *Asian Development Review* 15(2):164–79.

Kirigia, J. 1996. "Health Impacts of Epidemiological Environment Change: Measurement Issues." *Environment and Development Economics* 1(3):359–67.

Londregan, J., and K. Poole. 1996. "Does High Income Promote Democracy?" *World Politics* 49:1–30.

Magnani, E. 2000. "The Environmental Kuznets Curve, Environmental Protection Policy and Income Distribution." *Ecological Economics* 32:431–43.

Marmot, M. 2001. "Income Inequality, Social Environment, and Inequalities in Health." *Journal of Policy Analysis and Management* 20(1):156–59.

Martinez-Alier, J. 1993. "Distributional Obstacles to International Environmental Policy: The Failures at Rio and Prospects After Rio." *Environmental Values* 2:97–124.

———. 1995. "Distributional Issues in Ecological Economics." *Review of Social Economy* 53(4):511–28.

Midlarsky, M. 1998. "Democracy and the Environment: An Empirical Assessment." *Journal of Peace Research* 35(3):341–61.

Mol, A. 1995. *The Refinement of Production: Ecological Modernization Theory and the Chemical Industry*. Utrecht: van Arkel.

Neumayer, E. 2002. "Do Democracies Exhibit Stronger International Environmental Commitment? A Cross-Country Analysis." *Journal of Peace Research* 39(2):139–64.

Nganda, B. 1996. "The Role of Markets in the Worsening Epidemiological Environment." *Environment and Development Economics* 1(3):371–75.

Norton, B. 1998. "Improving Ecological Communication: The Role of Ecologists in Environmental Policy Formation." *Ecological Applications* 8(2):350–64.

Pargal, S., and D. Wheeler. 1996. "Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia." *Journal of Political Economy* 104(6):1314–27.

Prescott-Allen, R. 2001. *The Wellbeing of Nations: A Country-by-Country Index of Quality of Life and the Environment*. Washington/Covelo/London: Island Press.

Pritchett, L., and L. Summers. 1996. "Wealthier is Healthier." *Journal of Human Resources* 31(4):841–68.

Ringquist, E. 1998. "A Question of Justice: Equity in Environmental Litigation, 1974–1991." *Journal of Politics* 60(4):1148–65.

Rivera, B., and L. Currais. 1999. "Economic Growth and Health: Direct Impact or Reverse Causation?" *Applied Economics Letters* 6:761–64.

Selden, T., and D. Song. 1994. "Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions?" *Journal of Environmental Economics and Management* 27:147–62.

Shafik, N. 1994. "Economic Development and Environmental Quality: An Econometric Analysis." *Oxford Economic Papers* 46:757–73.

Shiffman, J. 2000. "Can Poor Countries Surmount High Maternal Mortality?" *Studies in Family Planning* 31(4):274–89.

Simon, J. 1981. *The Ultimate Resource*. Princeton, NJ: Princeton University Press.

Simonis, U. 1989. "Ecological Modernization of Industrial Society: Three Strategic Elements." *International Social Science Journal* 41(3):347–61.

Stavins, R. 1990. "Unintended Impacts of Public Investments on Private Decisions: The Depletion of Forested Wetlands." *American Economic Review* 80(3):337–52.

Strauss, J., and D. Thomas. 1998. "Health, Nutrition, and Economic Development." *Journal of Economic Literature* 36(2):766–817.

Torras, M. 2001. "Welfare Accounting and the Environment: Reassessing Brazilian Economic Growth, 1965–1993." *Development and Change* 32(2):205–29.

———. 2003. *Welfare, Inequality, and Resource Depletion: A Reassessment of Brazilian Economic Growth, 1965–1998*. Aldershot/Burlington: Ashgate Press.

Torras, M., and J. K. Boyce. 1998. "Income, Inequality, and Pollution: A Reassessment of the Environmental Kuznets Curve." *Ecological Economics* 25(2):147–60.

UNDP. 2000. *Human Development Report*. United Nations Development Programme. New York/Oxford: Oxford University Press.

Wackernagel, M., L. Onisto, P. Bello, A. Linares, I. Falfan, J. Garcia, A. Guerrero, and M. Guerrero. 1999. "National Natural Capital Accounting with the Ecological Footprint Concept." *Ecological Economics* 29:375–90.

White, H. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48:817–38.

WHO. 2000. *World Health Report*. Geneva: World Health Organization.

World Bank. 2003. *World Development Indicators* (CD-Rom version). Washington, DC: World Bank.

WRI. 2001. *World Resources, 2000–2001*. Washington, DC: World Resources Institute.

York, R., E. Rosa, and T. Dietz. 2003. "Footprints on the Earth: The Environmental Consequences of Modernity." *American Sociological Review* 68(2):279–300.

Appendix

Table A: Country List

Afghanistan	Cape Verde	Gambia	Laos	Norway	St Vincent & the Grenadines
Albania	Central African Rep.	Georgia	Latvia	Oman	Sudan
Algeria	Chad	Germany	Lebanon	Pakistan	Suriname
Angola	Chile	Ghana	Lesotho	Panama	Swaziland
Antigua & Barbuda	China	Greece	Liberia	Papua New Guinea	Sweden
Argentina	Colombia	Grenada	Libya	Paraguay	Switzerland
Armenia	Comoros	Guatemala	Lithuania	Peru	Syria
Australia	Congo, DR	Guinea-Bissau	Luxembourg	Philippines	Tajikistan
Austria	Congo, Republic	Guinea	Macedonia	Poland	Tanzania
Azerbaijan	Costa Rica	Guyana	Madagascar	Portugal	Thailand
Bahamas	Cote D'Ivoire	Haiti	Malawi	Qatar	Togo
Bahrain	Croatia	Honduras	Malaysia	Romania	Tonga
Bangladesh	Cuba	Hungary	Maldives	Russia	Trinidad & Tobago
Barbados	Cyprus	Iceland	Mali	Rwanda	Tunisia
Belarus	Czech Republic	India	Malta	Samoa	Turkey
Belgium	Denmark	Indonesia	Mauritania	Sao Tome e Principe	Turkmenistan
Belize	Djibouti	Iran	Mauritius	Saudi Arabia	Uganda
Benin	Dominica	Iraq	Mexico	Senegal	Ukraine
Bhutan	Dominican Republic	Ireland	Moldova	Seychelles	United Arab Emirates
Bolivia	Ecuador	Israel	Mongolia	Sierra Leone	United Kingdom
Bosnia	Egypt	Italy	Morocco	Singapore	United States

continued

Table A: Continued

Botswana	El Salvador	Jamaica	Mozambique	Slovak Republic	Uruguay
Brazil	Equatorial Guinea	Japan	Myanmar	Slovenia	Uzbekistan
Brunei	Eritrea	Jordan	Namibia	Solomon Islands	Vanuatu
Bulgaria	Estonia	Kazakhstan	Nepal	Somalia	Venezuela
Burkina Faso	Ethiopia	Kenya	Netherlands	South Africa	Vietnam
Burundi	Fiji	North Korea	New Zealand	Spain	Yemen
Cambodia	Finland	South Korea	Nicaragua	Sri Lanka	Yugoslavia
Cameroon	France	Kuwait	Niger	St Kitts and Nevis	Zambia
Canada	Gabon	Kyrgyzstan	Nigeria	St Lucia	Zimbabwe

Table B: Descriptive Statistics

Variable	*N*	Mean	*SD*	Minimum	Maximum
Safe water (SW) (% of population with access)	180	70.5	23.61	12	100
Sanitation (SNT) (% of population with access)	180	61.5	31.04	6	100
Per-capita income (Y) ($US)	180	7,022	7,491	458	33,505
Gini coefficient (G) (0–1 scale)	112	0.4	0.098	0.195	0.687
Literacy (L) (%)	180	78.4	21.62	14.7	99.8
Political rights & civil liberties (P) (0–12 scale)	180	6.74	3.93	0	12
Higher education (HE) (per 10,000)	180	163	135	2.6	610.6
Internet (INT) (per 10,000)	180	321	645.2	0	3,953
Females representation in gov't (FG) (%)	180	11.7	8.86	0	42.7
Population density (PD) (per sq km)	180	147	453.4	1.7	5,753
Urbanization rate (URB) (%)	180	54	22.96	6	100
Manufacturing as % of output (MNF) (%)	180	29.8	10.62	7	70
Disability percentage (DISPCT) (% of mean longevity disabled)	180	13.1	4.21	7	25.1
Child mortality (CHMOR) (per 1,000)	180	67.3	69.61	4	316
Index of health achievement (IHACH) (0–100 scale)	180	73	12.48	35.7	93.4
Ratio of health expenditures to GDP (PH) (%)	180	3.21	1.83	0	8.1