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FISCAL DECENTRALIZATION AND LAND POLICIES

Edited by Gregory K. Ingram and Yu-Hung Hong

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A Cross-Country Comparison of Decentralization and Environmental Protection

Hilary Sigman

The division of responsibility for environmental policy between national governments and lower-level governments has changed over time. Historically, environmental policy was largely conducted through provision of local services, such as waste disposal and water supply. In the United States, movement toward centralization began in the 1960s and early 1970s. President Richard M. Nixon created the U.S. Environmental Protection Agency in 1970 to manage burgeoning federal environmental policy.

For a variety of reasons, however, recent trends in the United States have been toward decentralization. First, U.S. environmental policies have always been a hybrid of centralized standard setting and decentralized enforcement; as activity has progressed from establishing standards toward enforcing them, states (and sometimes counties) make a greater share of decisions. Second, many states now wish to surpass federal standards; for example, some states are developing cleanup programs for sites not covered by the federal Superfund program or are even addressing global public goods, such as climate. Finally, political support for decentralization seems to have gained strength. Recent United States Supreme Court decisions—for example, limiting federal control over wetlands in cases involving the Clean Water Act—tend to restrict the federal government's role (Wroth 2007).

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In other countries, trends may differ; for example, the European Union has been "harmonizing" environmental laws, effectively reducing decentralization. Thus, it is important to understand the implications of decentralization for environmental outcomes.

An extensive theoretical literature addresses the effects of decentralization on supply of local public goods. This literature concludes that decentralization can improve welfare, but only under certain conditions. Environmental policy fits easily into this framework, with the environment differing from other public goods mostly in that environmental protection is sometimes funded through implicit taxes—costs of compliance with command-and-control regulations—rather than direct fiscal measures.

Several hypotheses in the decentralization debate imply that it affects levels of environmental protection. First, some authors are concerned about the prospect of destructive competition, usually in the form of a "race to the bottom"; such competition would likely result in lower environmental protection when policies are decentralized. Studies support the conclusion that regulatory competition occurs in federal systems, but find it difficult to ascertain whether such competition is destructive (Fredriksson and Millimet 2002; Levinson 2003). Second, with interjurisdictional environmental spillovers, jurisdictions may free ride, giving rise to higher levels of transboundary pollutants with greater decentralization. Previous studies have found evidence of free riding by jurisdictions within the U.S. federal system (Gray and Shadbegian 2004; Helland and Whitford 2003; Sigman 2005). Third, distributive politics within the central government may give rise to more environmental protection than local decision making would (Besley and Coate 2003; Lockwood 2002). Finally, some authors have posited that local governments are either more or less susceptible to environmental or industrial pressure groups (Esty 1996; Revesz 2001).

To test the net effects of these factors, this chapter examines the relationship between decentralization and environmental protection across countries. Four different measures of environmental protection or realized environmental quality are examined: (1) air pollution; (2) treatment to improve water pollution; (3) sanitation access; and (4) land conservation. As measures of decentralization, the equations use, alternately, a standard qualitative measure of federalism and a measure of decentralization of environmental expenditures. Other country characteristics, such as gross domestic product (GDP) and the quality of government, are included. The results do not suggest a strong association between decentralization and environmental protection, which is consistent with the traditional model of decentralization in public goods provision and inconsistent with concerns about a race to the bottom.

Hypotheses

Many normative claims about the effects of decentralization on public goods provision have positive implications for the association between these variables.

Table 8.1
Summary of Hypotheses About Effects of Decentralization

Hypothesis	Effect of Decentralization on Environmental Protection
Uniform central policies (Oates 1972)	?
Destructive competition:	
Race to the bottom	–
Race to the top (NIMBY)	+
Interjurisdictional environmental free riding:	
For regional pollutants	–
For local pollutants	0
Redistribution in central legislature	–
Scale economies in interest-group influence	+/–

At the risk of oversimplification, table 8.1 summarizes the implications of several hypotheses for the effects of decentralization on environmental protection.[1]

A first hypothesis about decentralization is that it allows greater variability in environmental protection according to local costs and benefits, as under Oates's decentralization theorem (1972). The central government may be unable to vary stringency either because it has less information about local conditions than local governments or because it finds variation costly for political reasons. Under these conditions, the implications of decentralization for the level of environmental protection are unclear and depend on the model of government decision making and on the distribution of preferences. For example, if all states have the same costs for environmental protection but voters with greener preferences are concentrated in a few states, these few states will choose less pollution than the remaining states. A national median voter might choose the same average pollution, resulting in no effect of decentralization. A national government elected by the states (along the lines of the U.S. Senate), however, could choose less pollution control because the few green states' preferences are less influential. Because all outcomes seem possible, table 8.1 simply reports uncertainty for this effect.

Destructive regulatory competition would also give rise to differences in pollution levels between decentralized and centralized regimes. Destructive competition models typically assume that each level of government maximizes welfare within its borders. Without market imperfections or redistributive public poli-

1. In this discussion, I assume that decentralization is chosen through forces exogenous to environmental policy, such as historical constitutional choices in the case of federalism. If the level of decentralization is endogenously chosen, it is harder to make predictions about cross-sectional patterns.

cies, welfare-maximizing state governments will make efficient choices for local pollutants (Oates and Schwab 1988; Wilson 1996). Both market failures and redistributive policies are common, however, so destructive competition seems a practical possibility (Kunce and Shogren 2005; Oates 2002). The competition may take the form of a race to the bottom, in which counties lower environmental standards to compete for scarce capital, or a race to the top, in which they raise environmental standards so as to shift to other jurisdictions the costs of polluting activities, such as waste disposal. Empirical evidence supports the view that environmental competition arises within the U.S. federal system (Fredriksson and Millimet 2002; Levinson 2003).

Interjurisdictional environmental spillovers are a third possible source of differences in environmental protection. Failing to consider the welfare of neighbors, subnational governments will provide less environmental protection than the national government for pollutants that cross internal borders. Several studies find empirical evidence that U.S. states free ride on one another (Gray and Shadbegian 2004; Helland and Whitford 2003; Sigman 2005). Thus, as represented in table 8.1, free riding would reduce environmental protection with decentralization for regional problems, but would have no effects for local environmental problems.

The central government decision-making process can yield a fourth set of effects. Besley and Coate (2003) conclude that the central government may provide too high a level of local public goods when regional spillovers arise.[2] The overprovision comes from strategic voting for representatives to the central legislature. Thus, Besley and Coate would predict that environmental protection would fall with decentralization. In contrast to the destructive competition and spillover hypotheses, however, the resulting reduction in environmental protection is welfare improving.

Finally, a few authors have advanced hypotheses about the role of scale economies in interest groups' influence at different levels of government. The argument does not seem to have been formalized, and proponents even disagree about the nature of the economy. Some argue that environmental groups cannot wield influence as effectively at the state level as the federal level (Esty 1996); better-funded industry groups may overcome high fixed costs to maintain an office and informed staff in each state capital and thus be better represented at lower levels. For example, Morriss (2000) argues that the U.S. Clean Air Act's delegation to the states creates complexity that favors regulated industries. Others have argued that the scale economy is a spending threshold that must be met to be heard above the din at the national level. This argument would mean that

2. Lockwood (2002) also finds inefficient provision of local public goods under a variety of rules governing the decisions of the central legislature. He does not report results about the level of public good provision, however, so the implications for the current analysis are unclear.

centralization favors industry, whereas grassroots environmental organizations would have a comparative advantage in state capitals (Revesz 2001).

A few recent studies look at the empirical effects of changes in decentralization. List and Gerking (2000) and Millimet (2003) examine the changes before and after 1980, when they argue that the Reagan administration scaled back the central government's role in U.S. environmental policy. List and Gerking conclude that no change in environmental spending or air pollution (nitrogen oxide and sulfur dioxide emissions) arose after 1980, whereas Millimet argues that a race to the top in spending (but not air pollution) arose by the mid-1980s. Although both papers interpret their results in terms of regulatory competition, the broader set of hypotheses discussed above may also be relevant to interpreting their results.

In a similar vein, Goklany (1999) looks at an earlier reduction in decentralization. Goklany argues that states had aggressive air pollution regulation before federal policy was strengthened in 1970 and thus did not participate in a race to the bottom. Most federal environmental policies are minimum standards, which states' standards may exceed. Some states do set higher standards, for example, extending regulations to hazardous wastes not covered by federal policy. Oates (2002) points out that this behavior is also evidence against a race to the bottom.

In Sigman (2007), I explore the effects of decentralization on water pollution in rivers around the world; that study uses a panel of countries over time and focuses on both a local and a regional pollutant. The evidence suggests an increase in pollution with decentralization only when country fixed effects are included and perhaps only for the regional pollutant, where interjurisdictional free riding may be to blame. In addition, the water pollution data provide observations at multiple sites within a country. Under Oates's decentralization theorem, decentralization would likely be associated with greater spatial variability.[3] The empirical results in Sigman (2007) support the hypothesis that spatial variability in environmental quality is higher in federal countries. The analysis presented here complements that study by addressing a broader set of environmental protection activities and by focusing specifically on environmental expenditure decentralization, a measure that is available only recently and thus not feasible as an explanatory variable for the water pollution panel.

Data

To test the hypotheses in table 8.1 empirically requires data on environmental protection and decentralization across countries, as well as some other country characteristics.

3. For example, Strumpf and Oberholzer-Gee (2002) find empirical evidence that more heterogeneous preferences encourage decentralization of policies for regulation of alcohol in the United States.

ENVIRONMENTAL PROTECTION

The analysis focuses on several measures of environmental protection, broadly defined. The measures concern not only traditional pollution, but also environmental health and land preservation.

Several criteria helped select environmental protection measures. The measures must be available from a source with a consistent definition for as large a number of countries as possible. The environmental goods should be ones for which government activities may account for a substantial share of the variance; measures dominated by variation in natural conditions, such as water availability, are less appropriate. As a result, several measures are closer to inputs than outputs of the environmental quality production function. The government influences most of the chosen measures by its expenditures, rather than by regulating private behavior. One decentralization measure used in the equations focuses on decentralization in spending specifically; spending-related environmental outcomes may therefore be more likely to show an effect of measured decentralization than other environmental outcomes.

The final restriction is the most limiting. This analysis requires data based on observed environmental protection. A number of cross-country emissions measures are available (WRI 2007). Although temptingly complete in coverage, these emissions data are calculated by applying industry-level pollution intensities to industrial output from national accounts. Because they assume homogeneity in pollution intensities, these measures may miss the effects of enforcement or selective implementation of national standards.

With these restrictions, four environmental measures were chosen. Two measures are inputs to water pollution: access to improved sanitation and the level of treatment provided by public sewage treatment works (the latter is available only for Organisation for Economic Co-operation and Development, or OECD, countries). A third measure is ambient air pollution—specifically, sulfur dioxide (SO_2) in large cities—which measures environmental quality and only implicitly government environmental protection. A final measure is the share of land set aside for parks and conservation purposes.

MEASURES OF DECENTRALIZATION

Measuring environmental decentralization across countries presents a challenge. Given the complexity of environmental policy, it is difficult to conceive of an ideal measure, let alone implement it in practice. The conceptual challenge is that countries use very different regulatory structures, so statutory rules may be a poor guide to true power. For example, in the United States, most environmental standards are established by the federal government, but implementation and enforcement are devolved to the states (Sigman 2003). The flexibility that states gain from power over implementation and enforcement appears to be substantial (Helland 1998). For example, the U.S. General Accounting Office (USGAO 1996) reports that water pollution permits issued by the states under federal technology standards varied by several orders of magnitude in the allowable pollution, although they were written for similar facilities. In addition, only some of the decision making responsible for water pollution may come through environmental regulations; decisions about land use and municipal spending on sewers will also be important, but may not be in the portfolio of an environmental agency or ministry.

This chapter takes two different approaches to measuring decentralization. The first is to use a general characterization of countries as federal and nonfederal.[4] An established political science literature has agreed on a list of federal countries and found that this characterization correlates with other measures of decentralization (Treisman 2002). The federalism characterization has a few advantages relative to other potential decentralization measures. First, it is exhaustive in coverage across countries, allowing the largest possible sample sizes for the regressions. Second, it characterizes the broadest range of government functions. It includes not only explicit environmental policies, but also other functions with environmental implications, such as land use regulations. Unlike fiscal decentralization measures, federalism may reflect decentralization of authority that has little fiscal effect, such as decentralization of regulations that require firms to spend on pollution control.

The second approach is to use decentralization of environmental expenditures. This approach sacrifices the advantages above for a measure of decentralization that is specific to the environment. A long tradition of empirical work uses fiscal or expenditure decentralization, which is defined as the ratio of subnational (state, provincial, and local) government spending to total governmental spending, with intergovernmental transfers netted out. The environmental measure used is the analogous measure of environmental spending only: the ratio of subnational environmental expenditures to total environmental expenditures. Data on expenditures are from the International Monetary Fund's Government Finance Statistics (GFS) (IMF 2007). Beginning in 1998, a few countries report environmental expenditures, allowing the measure to be calculated, but the data are very limited, especially for lower levels of government. To include as many countries as possible, the estimated equations use average environmental expenditure decentralization for any year (from 1998 through 2004) in which GFS contains sufficient data.[5]

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4. The federal countries represented in the data are Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Brazil, Canada, Comoros, Ethiopia, Germany, India, Malaysia, Mexico, Micronesia, Nepal, Nigeria, Pakistan, Russia, St. Kitts and Nevis, Sudan, Switzerland, United Arab Emirates, United States, Venezuela, and Yugoslavia (still in existence in the air pollution data).

5. In place of these country averages, it is possible to use country fixed effects for environmental decentralization from a regression of this variable on year dummies, which would adjust for any global time trends in environmental decentralization. When this approach was taken, the time effects were negligible and the country fixed effects virtually identical to the de-meaned country averages, so country averages are used for simplicity.

Thirty-five countries have at least one year's data on environmental expenditure decentralization. Figure 8.1 presents a map of these data. In the concluding section to this chapter, table 8.6 contains the expenditure decentralization measure for all countries for which it is available, ranked by this measure, and also reports the values of all left-hand-side variables for this subset of countries.

The share of environmental expenditure at the subnational level is fairly high, with a median across countries of 66 percent. The values range from 1 percent in Moldova and 3 percent in Uganda to 95 percent in Belgium and 98 percent in China.[6] The correlation between environmental expenditure decentralization and total expenditure decentralization across countries is only 0.2. Environmental decentralization, however, does seem to be greater in federal countries; median environmental decentralization is 83 percent in federal countries, compared with 60 percent in nonfederal countries.

OTHER COUNTRY CHARACTERISTICS

The analyses include a few other country characteristics to distinguish the effect of decentralization from other heterogeneity with which it may be correlated. Given the small number of observations, the equations must include only a parsimonious selection of other variables. To avoid known areas of potential omitted variable bias, the focus is on variables that earlier literature associates with decentralization.

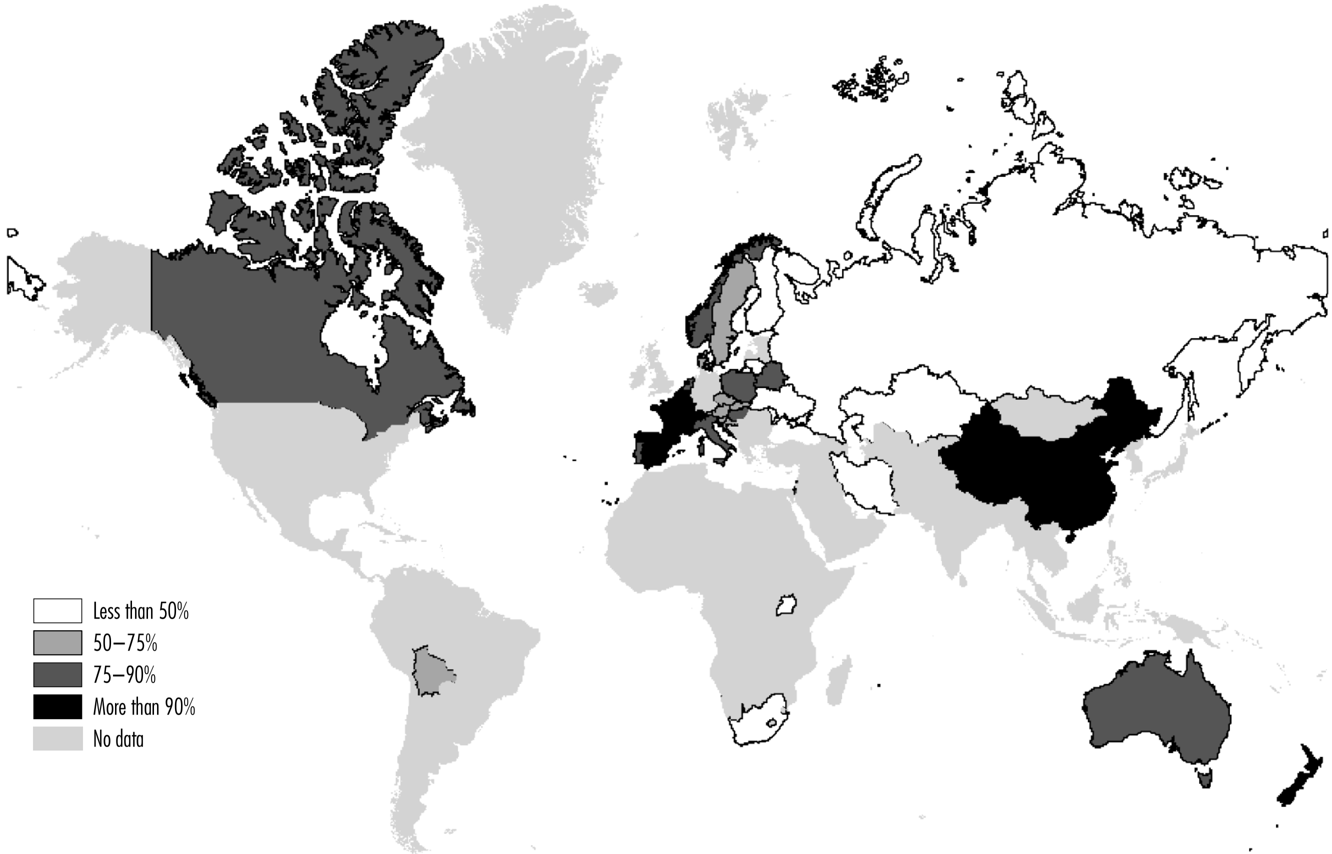
First, income is likely to be a major factor in environmental quality. The Penn World Table (Heston, Summers, and Aten 2006) provides annual per capita income levels standardized for cross-country comparisons. For a few countries, the current data extend only to 2003 and for some equations have been linearly extrapolated to 2004. Some previous studies have found that pollution rises and then falls with income, a pattern sometimes called the "environmental Kuznets curve" (e.g., Grossman and Krueger 1995; Selden and Song 1994). The estimated equations include a cubic in income to adjust flexibly for these effects.

Second, the political structure of a country may be associated with both federalism and environmental quality. Earlier research has suggested that more responsive governments choose lower pollution than do autocratic regimes (Barrett and Graddy 2000; Congleton 1992). Because more repressive governments may also tend to be more centralized, it is important to consider political freedom in these equations. Freedom House (2007) annually evaluates countries' "political rights" on a scale from 1 (most extensive rights) to 7 (fewest rights).

In a similar manner, government corruption may also need to be included in the equations. Studies have found that corruption plays an important role in

6. The highest value is actually New Zealand, which reports negative central environmental expenditures in the only year it has data (2004), implying a decentralization value of more than 100 percent. GFS documentation seems to suggest that negative expenditures reflect asset sales. This value has been set to missing in the equations; the results were not sensitive to including it.

Figure 8.1 Environmental Expenditure Decentralization by Country



Source: Author's calculation based on data from the IMF's Government Finance Statistics.

environmental outcomes (Damania, Fredriksson, and List 2003; Welsch 2004) and that decentralization or federalism is a source of corruption (Fisman and Gatti 2002; Treisman 2000). Thus, a link between decentralization and environmental protection may come through this pathway, unless the equations explicitly account for corruption. The equations use annual measures of corruption (based on surveys) from the International Country Risk Guide (Political Risk Services 2007). The values range from 0 (most corrupt) to 6 (least corrupt); the index has been rescaled from 1 to 7 to allow it to be converted to logarithms.

Finally, the equations include one or two measures of population density. These measures are the population per square kilometer and the share of the population that is urban. The effects of these variables depend on the measures of environmental protection. A dense country may have higher costs for setting aside protected lands, whereas a dense and urban country may have lower per capita costs for sanitation networks.[7] The benefits of land conservation and pollution control may also be greater in a denser country because more people can enjoy these public goods.

Empirical Analysis

Estimated equations have the form

$$(1) \qquad \ln(EP_i) = f(D_i, GDP_i, POLRT_i, CORRUPT_i, DENSITY_i) + \varepsilon_i,$$

where EP_i is the environmental protection measure, D_i is the measure of decentralization, GDP_i is GDP per capita, $POLRT_i$ is the index of lack of political rights, $CORRUPT_i$ is the index of lack of corruption, and $DENSITY_i$ is the country population density and urbanization. The equations use a log-log functional form, except for the GDP variables which are in a cubic to follow earlier literature.

One potential concern in the interpretation of the results is the possibility of colinearity between the decentralization variables of interest and other country characteristics. Such colinearity could make it hard to identify the effect of decentralization. In practice, the correlation coefficients between decentralization and the other variables are all below 0.5.[8]

7. The equations were also estimated with population density separated into the log of the country's population and the log of the country's area to allow a more flexible relationship. The coefficients of interest were unaffected by replacing these two variables with population density, so the reported equations use this simpler specification.

8. The correlation coefficients between the log of environmental expenditure decentralization and the variables used in the equations are 0.46 with GDP, –0.41 with the log of lack of political rights, and 0.40 with the log of lack of corruption. Much higher correlations prevail among these other country characteristics.

ACCESS TO IMPROVED SANITATION

The variable access to improved sanitation is the share of households that have access to improved sanitation in 2004 from a World Health Organization/UNICEF survey.[9] It includes not only connection to public sewers and septic systems, but also some forms of pit latrines that are considered relatively sanitary. The shares of population with improved sanitation range from 9 percent (in Eritrea and Chad) to 100 percent in the most developed countries. Countries with 100 percent access account for about 20 percent of all countries and half the countries with environmental decentralization data. For this reason, the equations are estimated using a top-censored Tobit model.

The results are presented in table 8.2. The estimates provide some evidence of a relationship between decentralization and sanitation access. The point estimate on federal countries is negative, but not statistically significant. In the much smaller sample with data available for both sanitation access and environmental expenditure decentralization, the coefficient on the latter is negative and statistically significant at 5 percent. Because they suggest lower environmental protection with greater decentralization, these coefficients would be consistent with the bulk of the hypotheses concerning decentralization, such as the race to the bottom.[10] Interjurisdictional environmental spillovers probably do not account for the negative effect because sanitation is fairly local in its benefits.

Not surprisingly, the other coefficients in this equation suggest that GDP per capita has a statistically significant effect on sanitation access. The coefficients on the GDP terms are jointly statistically significant at 1 percent. The predicted values increase in GDP over the entire range of the GDP distribution, although at lower rates with higher GDP.[11]

The two measures of the quality of government, political rights and control of corruption, do not enter with statistically significant coefficients. Population density and urban share of population both have statistically significant positive coefficients in column (1). These variables probably represent lower cost per household for sewer systems.

PUBLIC WASTEWATER TREATMENT LEVELS

The next measure focuses on the quality of the treatment provided in countries with high sanitation access. Three levels—primary, secondary, and tertiary—are

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9. These data and the protected lands data are from the World Resource Institute's Earth-Trends database (WRI 2007).

10. These coefficients would also be consistent with inefficient central government decision making, such as that proposed by Besley and Coate (2003). This inference, however, implies that some developing countries have excessively good sanitation (conditional on their income). Although such overprovision is a theoretical possibility, it seems more likely that these models do not represent conditions in lower-income countries.

11. For convenience in reporting the coefficients, GDP values in this and subsequent estimated equations are in units of 10,000 constant 2000 U.S. dollars.

Table 8.2
Tobit Estimates: Share of Population with Access to Improved Sanitation, 2004

	Dependent Variable: Log(Pop. share with improved sanitation)	
	(1)	(2)
Federal country	–0.161	
	(0.104)	
Log(Envir. expend. decentralization)		–0.112**
		(0.048)
GDP per capita	.804***	1.684*
	(0.260)	(1.068)
GDP^2	–0.149	–0.985
	(0.163)	(1.004)
GDP^3	0.005	0.225
	(0.033)	(0.403)
Log(Lack of political rights)	–0.014	–0.033
	(0.069)	(0.067)
Log(Lack of corruption)	0.125	–0.032
	(0.109)	(0.202)
Log(Country population density)	0.117***	0.059
	(0.028)	(0.040)
Log(Share of population urban)	0.428***	0.250
	(0.101)	(0.153)
Observations	111	25

* = $p < .10$
** = $p < .05$
*** = $p < .01$

Note: Standard errors are in parentheses. Constant is included but not shown.

used to describe the extent of treatment in public treatment works, each level providing an improvement in the quality of water discharged to the environment. These treatment processes are sequential, so plants with secondary treatment provide primary treatment as well.[12]

OECD provides data on the share of public treatment that is secondary and tertiary. The data are reported at five-year intervals from 1980 through 1995 and

12. Primary treatment involves separating solids from water. Secondary treatment is biological. Tertiary treatment is designed to raise discharged water back to the level in the environment and may include several chemical or physical processes.

in 2002. Coverage is spotty, with many countries appearing for only a year or two, and data are very incomplete in any given year. Most countries with multiple years of data increase the share of treatment in the higher treatment categories. To adjust for time trends without limiting the sample by focusing on a single year, a first-stage equation regresses secondary or tertiary treatment shares on year and country dummies. The coefficient on the country dummy is the measure of EP_i, environmental protection for country *i*. Time-varying right-hand-side variables (except decentralization) are averages for the years the country provides treatment data. The sample size is small because it includes only OECD countries, but most observations have environmental decentralization data, so the number of observations falls only slightly between the two columns.

Table 8.3 presents results from an equation for the share of treatment that is secondary or better. Similar results (on a slightly smaller sample) were estimated for the share of treatment that is tertiary and are not presented. The results do not suggest any effect of either federalism or environmental expenditure decentralization

Table 8.3
Ordinary Least Squares Estimates: Share of Public Wastewater Treatment That Is Secondary or Better

	Dependent Variable: Log(Secondary treatment share)	
	(1)	**(2)**
Federal country	0.216	
	(0.170)	
Log(Envir. expend. decentralization)		–0.415
		(0.247)
GDP per capita	2.383	–2.206
	(2.211)	(1.524)
GDP^2	–1.148	1.358
	(1.167)	(0.892)
GDP^3	0.170	–0.241
	(0.192)	(0.151)
Log(Lack of political rights)	0.122	0.064
	(0.293)	(0.141)
Log(Lack of corruption)	0.654	–0.232
	(0.658)	(0.380)
Log(Country population density)	0.062	0.021
	(0.038)	(0.039)
Observations	23	14
R^2	0.45	0.50

Note: Robust standard errors are in parentheses. Constant is included but not shown.

on this measure of inputs into environmental protection. Indeed, the equations do not produce any statistically significant coefficients (or even joint significance for GDP variables), perhaps because the sample size is simply too small to estimate any effect with much precision.[13]

AIR POLLUTION

The best worldwide monitoring data on conventional air pollutants are the United Nations' Global Environmental Monitoring System (GEMS) Air data set.[14] GEMS/Air reports annual means and sometimes short-period maxima for a few air pollutants, mostly in large cities from 1972 through 2001. Coverage for most pollutants is fairly limited. The focus here is on SO_2, which has about 2,200 city-year observations, about twice as many observations as the next most widely measured pollutant. At least one observation is available for 44 countries.

The GEMS/Air data provide information at a more disaggregated level than the country, making possible some additional controls. In particular, the data provide the name of the city in which the monitor is located, whether it is in an urban, suburban, or rural setting, and whether the local land use is residential or industrial. The GEMS/Air cities were manually matched by name to urban population.[15]

A two-stage estimation procedure is used to control for these local characteristics and the long time period over which the data are available. The first-stage equation is

$$\text{(2)} \qquad \ln SO2_{ijt} = h(Citypop_{ij}, Landuse_{ijt}, Loctype_{ijt}) + \alpha_t + \alpha_i + \varepsilon_{ijt},$$

where the dependent variable is the annual mean SO_2 levels at monitoring site j in country i in year t. The right-hand-side variables include the city population (and a dummy variable for missing city population, mostly for smaller cities or rural areas) and a vector of dummy variables each for land use and location type. Year effects, α_t, and country effects, α_i, are estimated. The estimated country effect, α_i, is then used as environmental protection from equation (1); specifically, $\alpha_i = \ln(EP_i)$. The results of this first stage are not shown, but they do suggest a strong effect of population and a downward time trend in pollution levels.

Table 8.4 contains the estimates of the second stage in which the country effects are regressed on country characteristics, as in equation (1) above. The second-stage equations are weighted by the number of observations for country

13. The equation is shown without the urbanization variable, which was also not statistically significant. It seems less likely that these values are important in this OECD-only data set than in the other data sets.

14. The data are no longer maintained, but an archived version can be downloaded from USEPA (2002).

15. Population is a one-time snapshot. Disappointingly, GEMS/Air does not provide the geographic coordinates of the stations, which would have made it possible to use Geographic Information System, or GIS, software to construct better local population measures.

Table 8.4
Weighted Least Squares Estimates: Country-Level Determinants of SO_2 Concentrations

	Dependent Variable: Country SO_2 Fixed Effect (1)	(2)
Federal country	0.210	
	(0.190)	
Log(Envir. expend. decentralization)		–0.359
		(0.262)
GDP per capita	0.688	–4.087*
	(1.185)	(1.892)
GDP^2	–0.482	3.278
	(0.987)	(3.39)
GDP^3	0.117	–0.841
	(0.219)	(0.925)
Log(Lack of political rights)	0.561***	–0.474
	(0.194)	(0.963)
Log(Lack of corruption)	0.421	–2.160
	(0.511)	(2.705)
Log(Country population density)	0.200***	0.109
	(0.052)	(0.091)
Observations	44	17
R^2	0.40	0.76

* = $p < .10$
** = $p < .05$
*** = $p < .01$

Note: Robust standard errors are in parentheses. Constant is included but not shown. The dependent variable is α_i from equation (2) in the text and is implicitly in logs. The equations are weighted by the total number of observations for the country.

i in the first stage to reflect differences in the variance of the measurement error of α_i between countries with many monitoring stations for many years and those with few observations.

The results in table 8.4 do not point to a strong effect of decentralization on air pollution levels. The point estimate suggests 20 percent higher air pollution in federal countries, but this estimate is not statistically significant. In addition, the direction of the effect reverses when environmental expenditure decentralization is used. Environmental expenditure decentralization may be a less relevant measure of decentralization in public policies for air quality than for the other measures of environmental quality studied here because air pollution policies typically rely on regulation of private parties rather than on direct expenditures. This difference could explain why these equations are the only ones in which the two measures of decentralization have inconsistent signs.

A few other covariates have the expected effects in table 8.4. An *F*-test (not reported in table 8.4) rejects the hypothesis that all the coefficients on GDP terms jointly equal zero at 10 percent for the equation in column (1). Pollution appears to rise with GDP over most of the range, although the curve has almost flattened out by the 75th percentile. In column (1), countries with poorer political rights (a higher value of the Freedom House index) have higher pollution, consistent with earlier results in the literature. Country population density also increases pollution; this effect is statistically significant only in column (1), but a similar point estimate emerges from column (2).[16] The dependent variable has already been adjusted for the population of the city in which the monitor is located, so the effect of country density may represent longer-range transport of SO_2.

LAND CONSERVATION

The final environmental protection measure is the share of land in the country that is designated as protected by the World Conservation Union. Protected areas include wilderness areas, national parks, and areas managed for habitat protection. The variable does not include areas managed primarily for resource extraction, even if they are subject to sustainable use and in natural states. The data represent 2004 and derive from a United Nations source (WRI 2007). These data are available for the most comprehensive set of countries in this study, with 119 countries present in the federal equation and 33 in the expenditure decentralization equation. Median protected land area is 7 percent of the country (and the mean is 9.5 percent); the range is from 1.4 percent in Moldova and 2.5 percent in the Czech Republic to 28 percent in Switzerland and 29 percent in Mauritius.

In table 8.5, the dummy variable for federalism and the variable for environmental expenditure decentralization both have positive point estimates; the point estimate on the latter is statistically significant. These results would be consistent with higher levels of environmental protection in decentralized countries. This effect is counter to several prominent hypotheses, including the race to the bottom, interjurisdictional environmental spillovers, and some of the models of inefficient central governmental decision making. It might be consistent with an interest-group model in which environmental groups fare comparatively better at the local level (as proposed by Revesz 2001) or with the standard Oates (1972) view with certain population distributions and voting systems.

16. Urbanization is not included in the second stage because the first stage already adjusts for city size.

Table 8.5
Ordinary Least Squares Estimates: Share of Country Area That Is Protected Land, 2004

	Dependent Variable: Log(Share of land area protected)	
	(1)	(2)
Federal country	0.226	
	(0.275)	
Log(Envir. expend. decentralization)		0.390*
		(0.140)
GDP per capita	–0.546	–1.101
	(0.708)	(1.031)
GDP^2	0.239	0.348
	(0.351)	(0.491)
GDP^3	–0.023	–0.030
	(0.046)	(0.062)
Log(Lack of political rights)	–0.475*	0.112
	(0.234)	(0.158)
Log(Lack of corruption)	0.425	0.785
	(0.377)	(0.535)
Log(Country population density)	0.015	0.111
	(0.071)	(0.102)
Log(Share of population urban)	–0.358	–0.424
	(0.319)	(0.477)
Observations	119	33
R^2	0.16	0.33

* = $p < .10$
** = $p < .05$
*** = $p < .01$

Note: Robust standard errors are in parentheses. Constant is included but not shown.

The GDP coefficients are not jointly statistically significant at conventional levels.[17] Lack of political rights reduces protected areas in the first equation. Somewhat surprisingly, a country's population density does not have a statistically significant effect on protected area. Although this variable would seem to indicate higher costs from protecting land, the point estimates of the coefficient are positive.

17. The point estimates suggest an inverted-U shape: protected land falls with per capita GDP until somewhere above the 75th percentile, when it begins to rise again.

Conclusions

The empirical results present little evidence of a consistent effect of decentralization on environmental protection. Although environmental protection is sometimes lower with greater decentralization, it also appears that it may sometimes be higher, as in the equations for land conservation. The results support earlier research that is skeptical of a dramatic race to the bottom. Although most of the environmental protection measures considered here give rise to regional public goods, the results also do not suggest interjurisdictional environmental free riding, contrary to prior research (including my own) that finds evidence of such free riding. The only evidence of a negative effect of decentralization is on sanitation access, the most local of the goods considered.

In addition to these direct findings, this study underscores the need for better international data on environmental quality. Studying the effects of decentralization (and many other questions of government effectiveness) requires data that reflect the net effects of government policies, including the effects of potentially differential local enforcement of central government rules. Data on local environmental conditions may disclose these effects, whereas calculated emissions data cannot. Unfortunately, few international efforts currently collect data on local conditions; even the GEMS/Air program used here seems to have effectively ended several years ago. Without renewed efforts in this direction, the true effects of environmental policies, whether of central or local governments, may never be fully understood.

Table 8.6
Environmental Expenditure Decentralization and Environmental Protection Measures by Country

Country	Federal	Environmental Expenditure Decentralization	Land Area Protected (%)	Sanitation Access (%)	SO_2 Index	Secondary Treatment Index
Moldova	0	1.0	1.4	68		
Uganda	0	1.6	7.3	43		
Mauritius	0	13.9	29.8	94		
Lithuania	0	23.0	9.2			
Iran	0	25.5	6.4		0.945	
Ukraine	0	40.3	3.3	96		
Russian Federation	1	41.6	5.4	87		
South Africa	0	44.1	5.3	65		
Finland	0	44.2	3.1	100	–0.393	0.272
Kazakhstan	0	48.2	2.9	72		
Denmark	0	51.0	21.8	100	–0.300	0.134
Croatia	0	51.1	6.0	100		
Slovenia	0	54.1	14.4			

Table 8.6
(continued)

Country	Federal	Environmental Expenditure Decentralization	Land Area Protected (%)	Sanitation Access (%)	SO_2 Index	Secondary Treatment Index
Luxembourg	0	55.7	14.4	100		0.080
Czech Republic	0	59.3	2.5	98		0.180
Slovakia	0	60.2	7.3	99		
Bolivia	0	65.0	11.1	46		
Austria	1	65.7	28.0	100	0.972	0.166
Sweden	0	72.7	9.8	100	–0.224	0.276
Belarus	0	75.8	6.3	84		
Portugal	0	77.7	4.4		–0.260	–0.231
Hungary	0	77.8	8.8	95		–0.002
Netherlands	0	79.7	4.9	100	–0.220	0.237
Norway	0	79.8	6.1	100		0.012
Canada	1	81.3	5.3	100	–0.697	0.025
Poland	0	81.6	11.0		0.116	0.075
Italy	0	84.3	7.2		1.154	0.225
Australia	1	85.5	6.7	100	–0.401	
Israel	0	86.9	18.4		–0.880	
Spain	0	92.1	8.0	100	0.218	–0.166
Switzerland	1	93.5	28.7	100	0.539	
France	0	93.8	3.0		0.005	
Belgium	1	95.4	2.7	100	0.598	
China	0	97.9	11.3	44	0.850	

Note: Only countries with environmental and decentralization data are ranked by this measure. The SO_2 index and secondary treatment index are the country fixed effects from the first-stage regressions reported in the text.

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