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An Industry-Adjusted Index of State Environmental Compliance Costs

Arik Levinson

4.1 Introduction

This paper describes a new industry-adjusted index of state environmental compliance costs that can be used to compare regulations both across states in a given year and within states over time.[1] It compares that index to others used in the environmental economics literature and uses the index to answer several often-raised questions about the pattern of environmental regulations in the United States and how that pattern has changed over time. Finally, the paper describes an application of the index, as used to assess the effect of environmental regulatory stringency on foreign direct investment to U.S. states.

There are three key motivations for creating this index. First, the Environmental Protection Agency (EPA) has worried publicly that some states are laggards in enforcing federal standards.[2] The index described here documents the variation across states in their environmental compliance costs. Second, since 1980 responsibility for monitoring and enforcement of environmental regulations has been devolving from the federal government to state and local regulators. In theory, this could cause states to become less or more similar in their standard stringency as they are freed to set their

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1. Interested readers can find a Stata file containing the index at http://www.georgetown.edu/faculty/am16/index2.htm.

2. See, e.g., the articles by J. H. Cushman, Jr., "States Neglecting Pollution Rules, White House Says," *New York Times,* 15 December 1996, p. 1.1; and "E.P.A. and States Found to be Lax on Pollution Law," *New York Times,* 7 June 1998.

own levels of stringency and to compete with their neighbors to attract industry or clean their environments. This index provides data on the degree of convergence in state standard stringency over time. Third, analysts studying the effects of environmental regulations on local and national economies have been hampered by the difficulty of accurately measuring and comparing the stringency of those regulations (Jaffe et al. 1995). In particular, studies of the effect of regulations on local economies rely almost exclusively on cross-sectional data,[3] subjective indexes of state standards or cost-based measures that do not control for industrial composition.

Existing measures of environmental regulatory stringency take two forms. First, there are the environmental groups' rankings of states. These are subjective and typically only measure perceptions of states' efforts at one time, so intertemporal comparisons are not possible. Most analysts have therefore relied on the Census Bureau's Pollution Abatement Costs and Expenditures (PACE) survey data to construct measures of statewide compliance costs per unit of output. These measures, however, fail to control for states' industrial compositions. Consequently, states with a lot of polluting industry have relatively high environmental compliance costs, regardless of their regulations.

To address these concerns, section 4.2 describes the new industry-adjusted index and reports findings about relative stringency and how it has changed over time. Section 4.3 describes existing subjective measures of environmental standard stringency and compares them to the industry-adjusted index. Section 4.4 describes an application of the index to assess the effect of environmental stringency on foreign direct investment to U.S. states.

4.2 An Industry-Adjusted Index of State Environmental Compliance Costs

Many researchers have relied on the Census Bureau's PACE survey to construct indexes of state environmental regulatory stringency. The PACE survey collected data from manufacturing establishments about their pollution abatement operating and capital costs from 1977 to 1994, when it was discontinued.[4] Most commonly, studies use these costs divided by some measure of state economic activity, such as total employment or

3. Because most studies examine differences among jurisdictions at one time, they cannot distinguish between the simultaneous effects of regulations on economic growth and that of economic growth on regulations. Notable exceptions include Gray (1997), Greenstone (1998), and Becker and Henderson (1997).

4. Recently, it appears that the EPA and the Census Bureau have agreed on plans to again collect the PACE data. Unfortunately, there will have been a minimum of 5 years during which the data were not collected. The PACE data collected from 1973 to 1976 are incompatible with later surveys in their treatment of small plants. Also, the PACE data were not collected in 1987.

gross state product (GSP).[5] The most significant problem with such measures is that they fail to adjust for industrial composition. States that have pollution-intensive industrial compositions will incur high pollution abatement costs, whether or not they have stringent regulations. Ideally, one would use the pollution abatement costs in the relevant industry as an index of regulatory stringency. While abatement costs by state and industry are published annually by the Census Bureau, so many of the observations are censored to prevent disclosure of confidential information that the data are not comparable year-to-year or state-to-state.[6] Therefore, this paper proposes an alternative index.

The index compares the *actual* pollution abatement costs in each state, unadjusted for industrial composition, to the *predicted* abatement costs in each state, where the predictions are based solely on nationwide abatement expenditures by industry and each state's industrial composition.[7] Let the actual costs per dollar of output be denoted

$$S_{st} = \frac{P_{st}}{Y_{st}}, \tag{1}$$

where P_{st} is pollution abatement costs in state s in year t, and Y_{st} is the manufacturing sector's contribution to the GSP of state s in year t. S_{st} is the type of unadjusted measure of compliance costs commonly used. By failing to adjust for the industrial composition of each state, it probably overstates the compliance costs of states with more pollution-intensive industries and understates the costs in states with relatively clean industries.

To adjust for industrial composition, compare equation (1) to the predicted pollution abatement costs per dollar of GSP in state s:

$$\hat{S}_{st} = \frac{1}{Y_{st}} \sum_{i=20}^{39} \frac{Y_{ist} P_{it}}{Y_{it}}, \tag{2}$$

5. See, e.g., Crandall (1993), Friedman, Gerlowski, and Silberman (1992), or List and Co (2000). Consulting firms specializing in industrial siting decisions have also relied on such simple indexes of environmental regulatory stringency (Alexander Grant & Co. 1985).

6. Several papers have used the confidential plant-level PACE data to construct such indexes (Levinson 1996; Gray 1997). However, those data are unavailable to most researchers, and the purpose here is to construct an easily accessible resource for analysts. Later, I do compare the index created from the confidential data to that compiled from the published data.

7. For two reasons, I use pollution abatement operating expenses (as opposed to capital expenses) in the index. First, operating expenses for pollution abatement equipment are easier for PACE survey respondents to identify separately. Abatement capital expenses may be difficult to disentangle from investments in production process changes that have little to do with pollution abatement. Second, abatement capital expenditures are highest when new investment takes place. So states that have thriving economies and are generating manufacturing investment tend to have high levels of abatement capital expenses, regardless of the stringency of those states' environmental laws. Operating costs are more consistent from year to year.

where industries are indexed from 20 through 39 following the two-digit manufacturing Standard Industrial Classification (SIC) codes,[8] Y_{ist} is the contribution of industry i to the GSP of state s at time t, Y_{it} is the nationwide contribution of industry i to the national GDP, and P_{it} is the nationwide pollution abatement operating costs of industry i. In other words, S_{st} is the weighted average pollution abatement costs (per dollar of GSP), where the weights are the relative shares of each industry in state s at time t.

To construct the industry-adjusted index of relative state stringency, S^*_{st}, I compute the ratio of actual expenditures in equation (1) to the predicted expenditures in equation (2),[9]

$$(3) \qquad S^*_{st} = \frac{S_{st}}{\hat{S}_{st}}.$$

When S^*_{st} is greater than 1, industries in state s at time t spent more on pollution abatement than those same industries in other states. When S^*_{st} is less than 1, industries in state s at time t spent less on pollution abatement. By implication, states with large values of S^*_{st} have relatively more stringent regulations than states with small values of S^*_{st}.[10]

Table 4.1 presents the average values of various environmental indexes. The first column contains the average unadjusted index, S_{st}, from 1977 to 1994 (omitting 1987, when the PACE data were not collected). The second column contains the industry-adjusted index, S^*_{st}.[11] Table 4.2 contains the rankings of these indexes. Several striking facts can be seen from comparing the indexes. First, the ranking of state regulatory stringency according to the industry-adjusted index (S^*) is often quite different from the ranking according to the unadjusted index (S). For example, New Jersey manufacturers spent a relatively large amount on pollution abatement, causing the state to be ranked 20th in terms of the average unadjusted index in column (1) of table 4.2. However, when New Jersey's relatively pollution-intensive industrial composition is accounted for, the state's ranking falls to 34th. In contrast, when Oregon's relatively clean industrial composition is

8. SIC code 23 (apparel) is omitted because it is relatively pollution-free, and as a result no data for that industry are collected by the PACE survey.

9. Note that the state's GSP is in both the numerator and the denominator of equation (3). Equation (3) can thus be expressed as $S^*_{st} = P_{st}/\hat{P}_{st}$, where $\hat{P}_{st}$ is the summation term in equation (2).

10. I have also calculated the index described by equations (1), (2), and (3) using the number of production workers in each two-digit SIC code to control for industrial composition, instead of using each industry's share of GSP. The broad conclusions are similar, although the rankings of some states do change. Also, annual employment totals by state and industry are more often censored to prevent disclosure of confidential information.

11. Appendix table 4A.1 presents annual values of the industry-adjusted index (S^*) and its ranking of states. Appendix table 4A.2 presents annual values of the unadjusted index (S) and its rankings.

Table 4.1 Indexes of State Environmental Effort

	Unadjusted Cost (S_S) Average[a] (1)	Adjusted Cost (S_S^*) Average[a] (2)	Conservation Foundation (3)	FREE Index (4)	Green Index (5)	Southern Studies (6)	LCV Average[a] (7)	Levinson (1996) (8)
AL	0.0219	1.19	10	16	8,658	681	24.4	−0.035
AZ	0.0148	1.39	24	27	7,342	567	29.2	−0.232
AR	0.0168	1.17	27	18	8,353	579	43.7	−0.072
CA	0.0121	0.90	46	48	4,931	423	57.4	−0.149
CO	0.0113	1.01	26	24	6,110	377	48.0	−0.384
CT	0.0079	0.67	32	44	5,483	442	74.0	−0.001
DE	0.0344	1.30	29	24	6,821	518	67.8	−0.273
FL	0.0138	1.21	31	41	6,320	461	50.3	0.022
GA	0.0127	0.91	25	26	7,488	544	43.3	−0.194
ID	0.0181	1.66	16	18	6,513	425	17.2	−0.004
IL	0.0132	0.91	28	41	7,052	563	60.3	0.055
IN	0.0196	1.14	36	36	7,939	687	45.9	0.013
IA	0.0106	0.96	29	39	6,541	491	54.5	−0.034
KS	0.0115	0.76	23	29	7,732	625	35.5	−0.330
KY	0.0146	0.99	34	28	7,694	594	32.3	0.065
LA	0.0538	1.51	21	21	8,383	708	25.7	−0.102
ME	0.0237	1.55	32	36	4,892	331	77.1	−0.041
MD	0.0185	1.17	37	34	5,585	413	70.6	0.148
MA	0.0067	0.67	44	41	5,076	389	86.6	−0.109
MI	0.0121	1.01	30	43	6,297	541	67.9	0.084
MN	0.0092	0.66	47	38	5,000	381	64.9	−0.209
MS	0.0213	1.47	15	14	8,299	612	20.1	−0.255
MO	0.0104	0.79	14	31	7,006	530	42.6	−0.195
MT	0.0341	1.49	37	23	6,546	559	49.9	0.110

(*continued*)

Table 4.1 (continued)

	Unadjusted Cost (S_S) Average[a] (1)	Adjusted Cost (S_S^*) Average[a] (2)	Conservation Foundation (3)	FREE Index (4)	Green Index (5)	Southern Studies (6)	LCV Average[a] (7)	Levinson (1996) (8)
NE	0.0088	0.83	22	31	7,001	520	40.9	−0.196
NV	0.0072	0.63	22	23	6,670	434	38.1	−0.239
NH	0.0072	0.75	21	32	5,803	310	58.6	−0.276
NJ	0.0158	0.82	45	47	5,790	464	78.6	0.117
NM	0.0306	1.64	18	23	6,998	533	30.0	−0.500
NY	0.0087	0.77	37	43	5,419	424	64.4	0.000
NC	0.0088	0.82	25	42	6,772	578	34.2	−0.144
ND	0.0105	0.77	22	16	6,833	458	43.8	−0.566
OH	0.0139	0.82	30	36	7,411	586	61.5	0.056
OK	0.0103	0.58	19	29	7,644	588	27.5	−0.396
OR	0.0139	1.22	42	35	4,583	395	53.9	0.122
PA	0.0169	0.91	28	32	6,905	511	55.1	0.022
RI	0.0075	0.72	26	30	5,105	397	79.8	−0.245
SC	0.0160	0.99	25	31	7,407	611	41.4	−0.184
SD	0.0056	0.68	30	23	6,965	396	51.1	−0.020
TN	0.0165	1.10	23	29	8,151	698	43.2	−0.078
TX	0.0311	1.39	22	26	8,197	703	28.3	−0.151
UT	0.0164	0.93	23	16	7,122	556	17.5	−0.494
VT	0.0065	0.66	32	28	4,921	282	83.8	−0.111
VA	0.0118	0.96	28	33	7,055	521	33.8	−0.097
WA	0.0196	1.37	39	29	5,473	430	56.3	−0.182
WV	0.0433	1.58	23	15	8,117	652	54.4	−0.115
WI	0.0110	0.89	37	49	5,478	379	69.8	−0.186
WY	0.0259	0.72	23	16	7,445	601	16.8	−0.412

[a] For 1977–94; averages omit 1987, when the PACE survey was not collected.

Table 4.2 **Rankings of State Environmental Effort**

	Unadjusted Cost (S_S) Average[a] (1)	Adjusted Cost (S_S^*) Average[a] (2)	Conservation Foundation (3)	FREE Index (4)	Green Index (5)	Southern Studies (6)	LCV Average[a] (7)	Levinson (1996) (8)
AL	9	14	48	44.5	48	44	44	19
AZ	21	9	31	31	33	33	40	38
AR	16	15	25	41.5	46	35	28	21
CA	29	29	2	2	4	12	16	29
CO	32	20	26.5	34.5	15	4	25	44
CT	42	44	14	4	11	17	6	15
DE	3	11	20.5	34.5	23	23	10	2
FL	25	13	16	9	17	19	23	11.5
GA	27	28	29	32.5	37	29	29	34
ID	14	1	45	41.5	18	14	47	16
IL	26	26	23	9	30	32	14	10
IN	12	17	11	14	41	45	26	13
IA	34	24	20.5	11	19	21	19	18
KS	31	38	34	26.5	40	42	35	43
KY	22	22	12	29.5	39	38	38	8
LA	1	5	41.5	40	47	48	43	24
ME	8	4	14	14	2	3	5	20
MD	13	16	8.5	17	12	11	7	3
MA	46	43	4	9	6	7	1	25
MI	28	19	18	5.5	16	28	9	7
MN	38	46	1	12	5	6	11	37
MS	10	7	46	48	45	41	45	41
MO	36	35	47	22	29	26	31	35
MT	4	6	8.5	37.5	20	31	24	6

(continued)

Table 4.2 (continued)

	Unadjusted Cost (S_S) Average[a] (1)	Adjusted Cost (S_S^*) Average[a] (2)	Conservation Foundation (3)	FREE Index (4)	Green Index (5)	Southern Studies (6)	LCV Average[a] (7)	Levinson (1996) (8)
NE	40	31	38.5	22	28	24	33	36
NV	44	47	38.5	37.5	21	16	34	39
NH	45	39	41.5	19.5	14	2	15	42
NJ	20	34	3	3	13	20	4	5
NM	6	2	44	37.5	27	27	39	47
NY	41	36	8.5	5.5	8	13	12	14
NC	39	33	29	7	22	34	36	28
ND	35	37	38.5	44.5	24	18	27	48
OH	23	32	18	14	35	36	13	9
OK	37	48	43	26.5	38	37	42	45
OR	24	12	5	16	1	8	21	4
PA	15	27	23	19.5	25	22	18	11.5
RI	43	41	26.5	24	7	10	3	40
SC	19	21	29	22	34	40	32	32
SD	48	42	18	37.5	26	9	22	17
TN	17	18	34	26.5	43	46	30	22
TX	5	8	38.5	32.5	44	47	41	30
UT	18	25	34	44.5	32	30	46	46
VT	47	45	14	29.5	3	1	2	26
VA	30	23	23	18	31	25	37	23
WA	11	10	6	26	9	15	17	31
WV	2	3	34	47	42	43	20	27
WI	33	30	8.5	1	10	5	8	33
WY	7	40	34	44.5	36	39	48	1

Note: Equal observations receive the average rank.

[a] For 1977–94; averages omit 1987, when the PACE survey was not collected.

accounted for, that state's ranking improves from 24th to 12th. Similar reordering takes place for other states, supporting the conclusion that using abatement costs without adjusting for industrial composition yields a misleading picture of states' relative regulatory compliance costs.

A second fact that emerges from the industry-adjusted index is that while most state rankings are relatively stable, a few change significantly over time. Appendix tables 4A.1 and 4A.2 present the annual figures. From 1977 to 1991, Florida dropped from the 4th most costly state to the 25th most costly. By contrast, during the same time period Illinois rose from the 32nd most costly state to the 23rd.

Third, each of these statements should be tempered by the observation that there is considerable noise in the data, both in the adjusted and unadjusted indexes especially for the smaller states. For example, it is hard to imagine that Rhode Island leapt from the 42nd most costly state in 1986 to 4th in 1988. Most likely, some of the year-to-year variation in the indexes results from sampling error in the PACE survey or from the small size of some states.

Despite the noisiness of the data for small states, some consistent patterns emerge. To study trends in the data, I regressed S^* on year dummies and a time trend and plotted the residuals. As an example, figure 4.1 plots

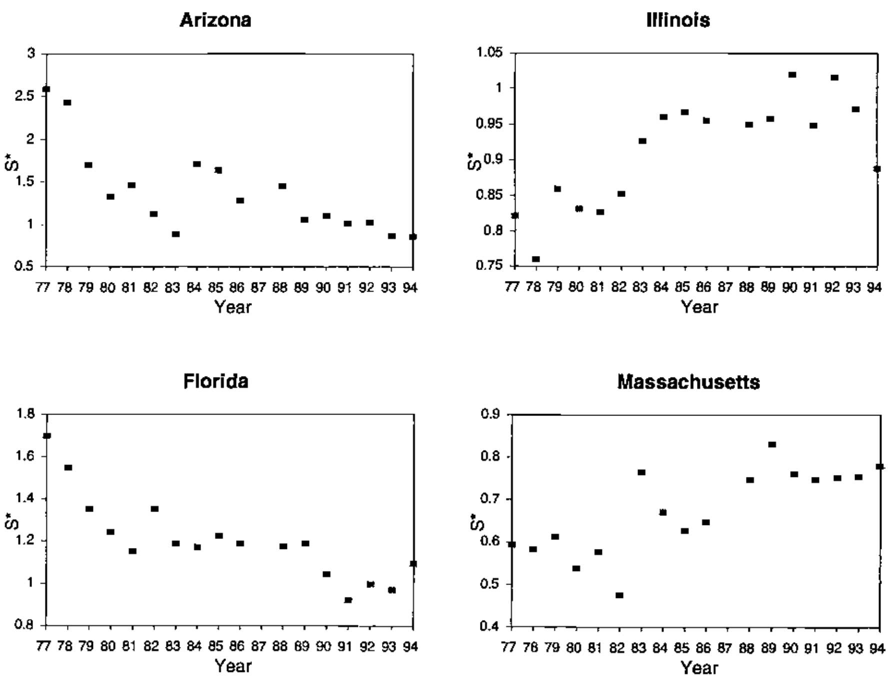

Fig. 4.1 S^* for four states

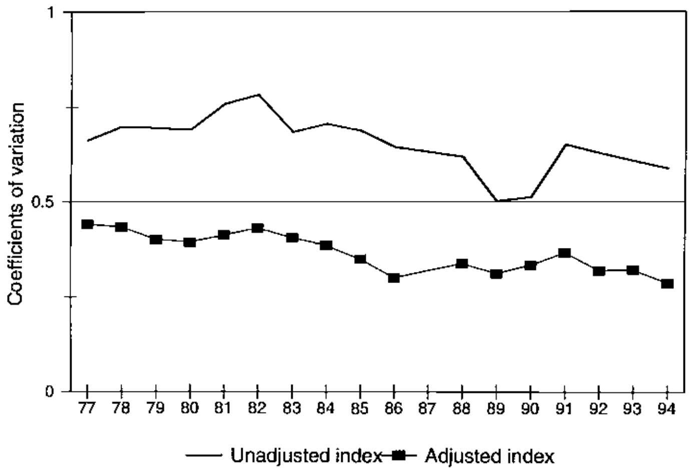

Fig. 4.2 Coefficients of variation: unadjusted and industry-adjusted indexes

S^* for four large states. Compliance costs in Arizona and Florida declined between 1977 and 1994, relative to the changing compliance costs in other states. Note that because S^* is already normalized on an annual basis, the downward trend in S^* does not mean that Arizona and Florida have become less expensive in absolute terms, only less expensive relative to other states. By contrast, over the same period relative compliance costs rose in Illinois and Massachusetts.

Another important fact discernible from this index is that the variation among states in their regulatory stringency is decreasing. It has often been speculated that pressure from federal regulators and national attention is forcing a convergence in state regulatory stringency. This index provides the first simple evidence of that convergence. Figure 4.2 depicts the coefficient of variation in both time series from 1977 to 1994. The coefficient of variation of the industry-adjusted index drops from 0.44 in 1977 to 0.29 in 1994. Meanwhile variation in the unadjusted index falls much less, from 0.66 to 0.59. Taken together, these two time series suggest that while states' industrial compositions have become more dissimilar over time, their regulatory stringency has become more similar.

Appendix table 4A.2 makes clear that despite the convergence of states' stringency, there remains substantial variation among states, even as late as 1994. Expenditures on pollution abatement in 1994 ranged from 0.5 percent of GSP in Nevada, to 6 percent in Louisiana. While much of this difference is accounted for by differences in the two states' industrial compositions, the industry-adjusted index for the most expensive state (Maine) remains 1.7 times the national average, and 4.13 times as large as for the least expensive state (Nevada).

Before comparing this index to others, it is important to note a few caveats. First, this index is not necessarily a measure of regulatory stringency alone. Other state characteristics may well drive up the cost of pollution abatement. For example, if the wages of environmental engineers vary state-to-state, they will affect the relative pollution abatement costs. Furthermore, this index is not intended to be a measure of environmental quality. Many of the nation's most polluted regions also have the strictest regulations.

Second, this industry-adjusted index makes no attempt to control for the relative age of different states' manufacturers. This is important because many state environmental standards are more strict for new sources of pollution than for existing sources. Consequently, states that have relatively new manufacturing bases also have relatively high compliance costs, even after controlling for their industrial compositions. Conversely, states that have relatively old manufacturers will experience lower compliance costs. There is, therefore, potentially a positive correlation between the amount of new investment and this industry-adjusted index of regulatory compliance costs. However, there is also reason to believe that this bias is small. In another paper (Levinson 1996), I regressed pollution abatement expenditures at the plant level on plant characteristics, including an indicator for plants built in the last 5 years. The new plant indicator, although positive, was small and statistically insignificant.

Third, this industry-adjusted index of environmental stringency, S^*, controls for states' industrial compositions at the level of two-digit SIC codes. While this surely accounts for a lot of the differences among states, there is equally certain to be heterogeneity among states within two-digit classifications. For example, SIC 26, pulp and paper, includes both pulp mills, which are among the most pollution-intensive manufacturers, and envelope assemblers, which emit very little pollution. To the extent that some states contain relatively more pulp mills and others merely assemble envelopes, if the former experience high abatement costs, that will probably be due to differing industrial compositions rather than more stringent environmental regulations. In other words, the index S^* retains some of the bias due to industrial compositions—in particular, heterogeneity of industrial compositions within any given two-digit SIC code.

4.3 Existing Indexes of State Environmental Regulatory Effort

Attempts to quantify state environmental regulations have taken numerous forms over the years. Many environmental organizations have compiled indexes for this purpose, and these indexes form a standard against which the industry-adjusted index can be compared.

Conservation Foundation Index. In 1983 the Conservation Foundation attempted to measure each state's "effort to provide a quality environment for its citizens" (Duerkson 1983, 218). They compiled an index from 23 components, including environmental and land-use characteristics such as the League of Conservation Voters' assessment of each state's congressional delegation's voting record, the existence of state environmental-impact-statement processes, and the existence of language specifically protecting the environment in state land-use statutes. Conservation Foundation staff assigned weights to each component based on subjective assessments of their importance, and the weighted sum is an index ranging from 0 to 63. Minnesota and California received the best scores, while Missouri and Alabama received the worst.

FREE Index. The Fund for Renewable Energy and the Environment (FREE 1987) published an index of the strength of state environmental programs. The components of the index include state laws regarding air quality, hazardous waste, and groundwater pollution. Wisconsin and California scored the highest, while West Virginia and Mississippi received the lowest marks.

Green Index. Hall and Kerr (1991) compiled the widely cited Green Index of state and environmental health from 256 measures of public policy and environmental quality. Oregon and Maine lie at the top of the ranking, while Louisiana and Alabama are last.

Southern Studies Index. The Institute for Southern Studies (1994) ranked the states based on 20 environmental measures such as air quality, state spending on the environment, pollution and waste generation, and energy efficiency, and then added up the 20 rankings of each state to get a composite index. Vermont and New Hampshire had the best scores, while Texas and Louisiana had the worst.

League of Conservation Voters (LCV). Each year, the LCV assigns each U.S. senator and representative a score from 1 to 100, based on his or her voting record on environmental bills chosen by the LCV. Some researchers have used these scores as a measure of the environmental sentiment in each state (Gray 1997). To compare these scores to the compliance cost index, I averaged each state's House and Senate delegation's environmental voting records. Each record is the average voting record for each member of the state's delegation. Thus, for states with more House members than Senate members, the Senate votes are weighted more heavily (and vice versa).[12]

Table 4.1 reports the values of each environmental index for each state. Table 4.2 presents each index's ranking of states. The rankings of the sub-

12. For further details, see the appendix.

jective indexes conform loosely to anecdotal evidence and to reports in the popular press. Alabama, Mississippi, and Louisiana consistently receive the lowest grades from environmental organizations, while Massachusetts, Wisconsin, Minnesota, and California receive the highest grades. I suspect that few policy analysts, environmental regulators, or industry representatives would be surprised by these rankings, and I therefore refer to these indexes as the "conventional wisdom" regarding states' relative environmental efforts.

In column (8) of table 4.1, I present an index calculated from the confidential plant-level Census of Manufactures, as described in Levinson (1996). Using the raw, establishment-level 1988 PACE data, I regressed the log of gross pollution abatement operating costs on the log of the book value of capital, the log of the number of production workers, the log of value-added, a dummy for new plants, dummies for four-digit SIC codes, and individual state dummies, all from the 1987 Census of Manufactures.[13] The state dummy coefficients are reported in column (8) of table 4.1. A high-point estimate for a state dummy coefficient indicates that, all else equal, plants in that state spend more on pollution abatement operating costs than do otherwise similar plants in the omitted state, New York.

Oddly, this plant-level index is not highly correlated with the more aggregate industry-adjusted index. The correlation between the plant-level index and the industry-adjusted index in 1988 is only 0.19. There are several possible explanations. The plant-level index is from a regression of 1988 PACE data on 1987 Census of Manufactures data for the same firms. (The PACE data were not collected in 1987). This mismatch may account for some of the discrepancy. Also, the plant-level index controls for plant vintage with a new-plant indicator, to account for the age bias already discussed, although its coefficient is small and statistically insignificant.

Table 4.3 presents correlations among the two cost indexes and the five conventional indexes. Although they were compiled at different times with widely different sets of components, the five conventional indexes are highly positively correlated. Except for the LCV index, the conventional indexes are all fairly ad hoc. Each is based on a list of component measures, with no objective guide as to what criteria are included or excluded from the index. Furthermore, each index either adds up the unweighted ranks of the separate components or weights the separate scores according to the subjective judgment of the index's authors. Nevertheless, there is remarkable consistency across the indexes.

On the other hand, the two cost-based indexes are negatively correlated

13. Implicit in this specification is a Cobb-Douglas production function in which output (Y) is estimated as a function of capital (K), labor (L), and pollution (P), with dummy variables for new plants, industries, and states: $Y = A \cdot K^{\beta_1} \cdot L^{\beta_2} \cdot P^{\beta_3}$. This estimation substitutes pollution abatement, which is observable, for pollution, takes the logarithm of both sides, and inverts the function to estimate abatement as a function of the other variables.

Table 4.3 **Correlations among Indexes of State Environmental Effort**

	Unadjusted Average Cost (S_S) (1)	Adjusted Average Cost (S_S^*) (2)	Conservation Foundation (3)	FREE Index (4)	Green Index (5)	Southern Studies (6)	LCV Index (7)
Unadjusted cost	1.00	0.75	−0.20	−0.45	−0.43	−0.53	−0.29
Adjusted cost		1.00	−0.19	−0.37	−0.27	−0.31	−0.29
Conservation Foundation			1.00	0.65	0.67	0.46	0.67
FREE index				1.00	0.58	0.35	0.63
Green index					1.00	0.89	0.72
Southern Studies						1.00	0.62
LCV index							1.00

with the conventional indexes. While the adjusted and unadjusted indexes are correlated with each other, they are both negatively correlated with each of the conventional indexes. While the conventional indexes may measure something systematic about states, it is not correlated with industrial pollution abatement expenditures.

There are several reasons for the negative correlation between the compliance-cost-based measures and the environmental organizations' indexes. The environmental organizations' indexes often include the quality of the environment in each state as part of their measure. The Green and Southern Studies indexes include measures of ambient air and water quality, and of pollution emitted. In many cases, environmental quality is inversely associated with compliance costs because plants in the dirtiest states are required to spend more effort cleaning up. Los Angeles, for example, has both the most polluted air and the toughest emissions standards in the United States (Berman and Bui 1997).

Another explanation has to do with the fact that the LCV index, which is itself included in the Conservation Foundation index, ranks states according to their congressional delegations' voting records on national legislation, rather than state legislation. Furthermore, U.S. senators and representatives appear to vote for stricter regulations when they are imposed on other states (Pashigian 1985). Finally, many of the indexes contain elements unrelated to manufacturers' pollution abatement costs, such as curbside recycling programs, spending on public parks, and automobile inspection programs. While these state characteristics may indicate something about the overall environmental sentiment in a given state, they are not necessarily related to the compliance costs faced by manufacturers.

In general, the two groups of indexes measure different concepts. The compliance cost index measures how much it costs to locate a manufacturing facility in any one state, relative to others, in terms of pollution abatement costs. The subjective indexes combine many different measures, including the quality of the environment, national delegations' voting records, and environmental effort unrelated to the manufacturing industry.

4.4 An Application: The Effect of Regulations on Foreign Direct Investment

As an example of the type of work that this index facilitates, in table 4.4 I present regressions of foreign direct investment (FDI) on characteristics of U.S. states, including their industry-adjusted indexes of environmental regulatory stringency, S^*.[14] Several studies have examined the effects of environmental regulations on FDI. However, all of the existing studies have either used a cross section of data, some unadjusted measure of regu-

14. This work is taken from Keller and Levinson (1999), where more details are provided.

Table 4.4 An Application: Foreign Direct Investment to U.S. States as a Function of Abatement Costs, 1977–94

		Pooled OLS		Dynamic Panel Data Model: GMM, First Differences	
	Mean (SD) (1)	Manufacturing (2)	Chemicals[a] (3)	Manufacturing (4)	Chemicals[a] (5)
Industry-adjusted index of abatement costs, S^*		500*	267	2.4	−338*
		(237)	(186)	(92.6)	(100)
Lagged FDI				0.90*	0.89*
				(0.02)	(0.03)
Market proximity	6,631	0.207*	0.098*	0.104*	0.041*
	(8,220)	(0.019)	(0.015)	(0.018)	(0.014)
Population (thousands)	4,940	0.175*	−0.016	−0.043	−0.003
	(5,134)	(0.033)	(0.023)	(0.051)	(0.054)
Unemployment rate	6.61	122*	86.0*	−67.5*	−56.6*
	(2.09)	(43)	(29.1)	(15.7)	(14.0)
Unionization rate	16.6	−108*	−84.6*	32.7	59.8*
	(6.7)	(20)	(13.9)	(21.4)	(20.0)
Wages	9.10	179*	32.9	−135.7	5.8
	(2.24)	(87)	(66.7)	(76.7)	(60.1)
Road mileage (thousands)	80.5	12.3*	10.8*	−0.37	−4.20
	(48.4)	(2.6)	(1.8)	(6.25)	(5.48)
Land prices (per acre)	887	0.52*	0.62*	0.21*	0.26*
	(775)	(0.12)	(0.10)	(0.10)	(0.08)
Energy prices	5.51	−288*	−144*	54.6*	58.1*
	(1.70)	(56)	(41)	(27.7)	(24.4)
Tax effort	96.1*	−31.0*	−11.4*	18.4*	16.6*
	(16.1)	(5.9)	(4.1)	(4.9)	(4.6)
Year		166*	32.4		
		(41)	(33.4)		
Constant		−11,602*	−1,525	60.4	12.2
		(3,072)	(2,516)	(25.9)	(21.5)
Number of observations	816	811	563	761	496
Number censored		5	109	7	272
R^2		0.70	0.47	0.10	0.15

Source: Keller and Levinson (1999). The dependent variable is property, plant, and equipment investment by foreign-owned manufacturers, from the BEA; see appendix.

Note: Standard errors are in parentheses. 1987 is dropped because no PACE data were collected that year.

[a] The chemical industry investment data are only available for 1977–91.

*Statistically significant at the 5 percent level.

latory stringency such as S in equation (1), or both (List and Co 2000; Friedman, Gerlowski, and Silberman 1992). Table 4.4 examines property, plant, and equipment investment by foreign-owned manufacturers, from the Bureau of Economic Analysis (BEA), as a measure of FDI. It presents regressions of FDI on state characteristics using a time series of data and the industry-adjusted index of environmental regulatory stringency.

The first column of table 4.4 presents means and standard deviations of the regressors. As a benchmark to compare to the previous literature, columns (2) and (3) contain pooled, ordinary least squares (OLS) regressions of FDI in the manufacturing sector and the chemical industry, respectively, on the industry-adjusted index of environmental stringency and other covariates. Controlling for other state characteristics, FDI appears to be positively correlated with stringency. In column (3), I examine FDI for the chemical industry (SIC 28). This is one of the only relatively pollution-intensive, two-digit SIC codes for which this measure of FDI is reported consistently by the BEA. Here, the coefficient on S^* remains positive, although it is smaller and statistically insignificant. These results, however, are based largely on the cross-sectional comparison of states. (Most of the variation in S^* is across states rather than within states over time.) These cross-sectional results are probably biased if states have unobserved characteristics correlated with both FDI and regulatory stringency.

To control for those characteristics, and to exploit the panel of data, consider a dynamic model. Suppose that a reduced-form relationship for FDI can be characterized by the following equation.[15]

$$(4) \qquad FDI_{st} = \delta FDI_{s,t-1} + \gamma S^*_{st} + X'_{st}\beta + u_{st},$$

where X_{st} is a vector of characteristics of state s at time t, and u_{st} is an error term composed of two parts, $u_{st} = \mu_s + \nu_{st}$. Equation (4) states that FDI is a function of current state characteristics and lagged values of FDI. Both FDI_{st} and $FDI_{s,t-1}$ are functions of μ_s and therefore OLS estimates of (4) will be biased because $FDI_{s,t-1}$, a regressor, is correlated with the error term.

Arellano and Bond (1991) suggest a generalized method of moments (GMM) estimate of equation (4) that uses lagged values of $FDI_{s,t-1}$ as instruments and first differences to eliminate the fixed state effects μ_s. First, take first differences of (4):

$$(5) \qquad \Delta FDI_{st} = \delta \Delta FDI_{s,t-1} + \gamma \Delta S^*_{st} + \Delta X'_{st}\beta + \Delta \nu_{st},$$

where Δ symbolizes first differences. Since $FDI_{s,t-2}$ is correlated with $\Delta FDI_{s,t-1}$, but not correlated with ΔFDI_{st}, it is a valid instrument. In fact, all past values $FDI_{s,t-3}$, $FDI_{s,t-4}$, and so on are valid instruments for $\Delta FDI_{s,t-1}$.

Columns (4) and (5) of table 4.4 present GMM estimates of (5) using Doornik, Arellano, and Bond (1999).[16] When equation (5) is estimated

15. This discussion is based on Baltagi (1995) and Arellano and Bond (1991).

16. Doornik, Arellano, and Bond's GMM estimation is written for the computer package Ox, and may be downloaded from http://www.nuff.ox.ac.uk/Users/Doornik/. See Doornik (1998) and Doornik, Arellano, and Bond (1999).

using all manufacturing FDI, in column (4), the large spurious positive coefficient on S^* disappears. Instead, the coefficient (2.4) is tiny and statistically insignificant, although still positive. Turning to the chemical industry, in column (5), the coefficient (−338) is negative and statistically significant. This suggests that the positive coefficients found in the cross-sectional evidence in this study and others are spurious, and are based on unobserved characteristics correlated with both environmental regulations and economic activity.

To interpret the size of these coefficients, consider the following. The fixed-effects coefficient in column (5) suggests that a 1-unit increase in the stringency index is associated with a decline in chemical industry FDI of $338 million. The standard deviation of this index within states over time ranges from 0.04 for Wisconsin to 0.56 for Colorado, and averages 0.18. So the coefficient suggests that a 1 standard deviation increase in the index, for the average state, is associated with a decline of investment by foreign-owned chemical manufacturers of $61 million. This amounts to approximately 6 percent of the annual average chemical industry FDI investment of $1,017 million per state.

The industry-adjusted index plays two important roles in the regressions in table 4.4. First, because the index spans 18 years, it is possible to use changes in the variables from year to year to control for unobserved fixed state characteristics that may be correlated with both stringency and FDI. The stringency coefficients in these first-differenced specifications are negative, while those in the pooled specification are positive, suggesting that these unobserved state characteristics are extremely important. Second, by adjusting for industrial composition, the index avoids merely measuring concentrations of polluting industries and instead assesses average abatement costs, holding industrial composition constant.

While these results are meant only as an example, they do suggest that an index such as the one described has considerable advantages over empirical approaches taken thus far.

4.5 Conclusion

The research described here creates an industry-adjusted index of state environmental compliance costs from 1977 to 1994. The index supports several conclusions. First, industry composition plays an important role in determining spending on environmental compliance costs for different states. Rank orderings of states by pollution abatement spending look very different once their industrial compositions have been controlled for. Second, differences among states are exaggerated by differences in their industrial compositions. The coefficient of variation of the unadjusted index is 0.65, while the coefficient of variation of the industry-adjusted index is 0.37. Third, once industrial composition has been accounted for, states appear to be converging in their environmental standard stringency. Fourth, when compared to conventional indexes of state environmental regulations, these cost-based indexes have opposite implications for the relative stringency of states. The two types of indexes are negatively correlated across states. Finally, when used in an analysis of the effect of regulatory stringency on economic activity (FDI in this case), time-series analyses using the industry-adjusted index have more sensible results than cross-sectional analyses or analyses using the unadjusted index. Together, these results imply that using conventional indexes or unadjusted cost indexes to analyze state environmental policies can lead to misleading conclusions about the effects of those policies on economic activity.

Appendix

Pollution Abatement Costs and Expenditures (PACE) Data

PACE data come from U.S. Department of Commerce, Bureau of the Census. The data are published in Current Industrial Reports: Pollution Abatement Costs and Expenditures, MA-200, 1974–94. The variable of interest from this source was the pollution abatement gross annual cost (GAC) total across all media types. Starting in 1977, the Census Bureau collected data only for establishments with 20 or more employees. Although PACE data were collected from all establishments for the years 1973–79, in order to lessen the administrative burden on small businesses, they were dropped from the survey starting in 1980. The PACE Survey was not collected in 1987. There are some censored observations for the state totals, and in those cases values were interpolated.

Gross State Product Data

All GSP data were acquired via the Regional Economic Information System CD, 1969–94, published by the U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Measurement Division.

League of Conservation Voters (LCV) Index

This index is the unweighted average of the House and Senate environmental voting records. Each record is the average voting record for each member of the state's delegation. Thus, for states with more House members than Senate members, the Senate votes are weighted more heavily (and vice versa). The bills that are used to construct the index have been chosen by the LCV. See http://www.lcv.org. For the Senate votes, the years 1977–78, 1979–80, 1983–84, 1985–86, and 1987–88 each had only one scorecard. Therefore, the voting records for these years were entered separately for each year. For the House votes, the years 1987–88 had only one scorecard. Here also the same value was entered for both years. Also, the House had a scorecard for 1985 and for 1985–86. The information from the 1985 scorecard was used to disaggregate the 1985–86 scorecard by a weighted average.

Property, Plant, and Equipment Investment by Foreign-Owned Manufacturers

Bureau of Economic Analysis (BEA), Department of Commerce, *Foreign Direct Investment in the U.S.,* 1980, 1987, 1992, 1999.

Table 4A.1 Industry-Adjusted Index of State Environmental Compliance Costs

State	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994
AL	1.36	1.26	1.28	1.19	1.26	1.30	1.94	1.12	1.08	1.01	0.90	1.01	1.04	1.18	1.07	1.13	1.12
AR	2.59	2.43	1.70	1.33	1.47	1.12	0.89	1.72	1.64	1.29	1.46	1.06	1.11	1.02	1.02	0.87	0.86
AR	1.14	1.17	1.19	1.24	1.13	1.16	1.08	1.21	1.30	1.21	1.13	1.26	1.05	1.07	1.22	1.21	1.20
CA	0.93	0.96	0.83	0.83	0.75	0.67	0.79	0.82	0.90	1.03	1.00	1.01	1.11	1.00	0.90	0.86	0.96
CA	1.06	0.96	0.77	0.83	0.88	0.61	0.64	0.58	0.72	0.91	0.72	1.87	2.42	2.07	0.64	0.60	0.82
CT	0.49	0.55	0.60	0.60	0.59	0.51	0.58	0.63	0.63	0.62	0.76	0.92	0.92	0.80	0.67	0.68	0.80
DE	1.16	1.47	1.56	1.53	1.61	1.35	1.20	1.17	1.33	1.35	1.58	1.44	1.00	1.10	1.05	1.08	1.12
FL	1.70	1.55	1.35	1.24	1.15	1.35	1.19	1.17	1.22	1.19	1.18	1.19	1.04	0.92	1.00	0.97	1.10
GA	0.92	0.83	0.77	0.80	0.81	0.87	0.89	0.90	0.86	0.84	0.88	1.18	1.05	1.05	0.85	0.93	0.96
ID	1.59	1.64	1.92	1.93	1.98	2.29	2.11	2.02	1.63	1.92	1.43	1.16	1.25	0.94	1.44	1.41	1.54
IL	0.82	0.76	0.86	0.83	0.83	0.85	0.93	0.96	0.97	0.96	0.95	0.96	1.02	0.95	1.02	0.97	0.89
IN	1.15	1.14	1.15	1.28	1.30	1.44	1.28	1.18	1.16	1.08	1.13	1.04	0.97	1.02	1.01	1.02	0.99
IA	1.00	1.02	1.00	1.01	1.05	0.94	0.93	1.18	1.04	0.91	0.88	0.91	0.77	0.78	0.91	0.89	1.05
KS	0.68	0.64	1.30	0.72	0.68	0.69	0.62	0.84	0.65	0.75	0.62	0.85	0.90	0.79	0.67	0.81	0.77
KY	0.88	1.05	0.98	0.98	0.99	0.87	1.06	1.10	0.95	0.92	0.93	1.05	1.02	1.07	0.97	0.99	1.01
LA	1.26	1.27	1.52	1.34	1.62	1.59	1.79	1.92	1.97	1.75	1.32	1.21	1.17	1.18	1.56	1.56	1.57
ME	1.28	1.43	1.39	1.44	1.54	1.68	1.68	1.66	1.46	1.48	1.34	1.61	1.45	1.79	1.71	1.64	1.69
MD	1.08	1.23	1.25	1.24	1.10	1.06	1.11	1.17	1.25	1.25	1.32	1.10	1.04	1.19	1.17	1.25	1.03
MS	0.59	0.58	0.61	0.54	0.58	0.48	0.77	0.67	0.63	0.65	0.75	0.83	0.76	0.75	0.75	0.75	0.78
MI	0.98	0.96	1.02	1.11	1.12	1.05	1.00	1.11	1.04	0.94	1.07	0.99	0.99	0.96	0.97	0.95	0.88
MN	0.58	0.61	0.66	0.69	0.61	0.65	0.70	0.64	0.59	0.58	0.60	0.67	0.63	0.71	0.68	0.84	0.84
MS	1.72	1.85	1.54	1.56	1.18	1.35	1.52	1.64	1.52	1.42	1.29	1.16	1.32	1.37	1.62	1.60	1.39
MO	0.73	0.82	0.71	0.78	0.77	0.71	0.79	0.74	0.77	0.87	0.80	0.94	0.95	0.71	0.73	0.84	0.71
MT	1.19	1.23	1.36	1.35	1.53	1.85	1.69	1.69	1.85	1.58	1.93	1.88	1.67	1.56	0.76	0.63	1.65
NE	0.76	0.80	0.75	0.77	0.82	0.65	0.81	1.16	1.13	0.94	0.97	0.63	0.64	0.65	0.95	0.84	0.85
NV	0.42	0.59	0.58	0.61	0.57	0.62	0.61	0.86	0.69	0.68	0.93	0.63	0.48	0.60	0.72	0.60	0.45
NH	1.05	0.90	0.73	0.64	0.60	0.64	0.61	0.55	0.60	0.73	0.70	0.90	0.87	0.81	0.69	0.78	0.97

(*continued*)

Table 4A.1 (continued)

State	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994
NJ	0.95	0.80	0.93	0.99	0.79	0.81	0.84	0.77	0.72	0.73	0.82	0.86	0.86	0.87	0.85	0.69	0.61
NM	2.46	2.49	2.12	2.11	1.70	1.15	1.27	1.15	1.32	0.97	2.49	1.67	1.77	1.09	1.50	1.64	1.05
NY	0.71	0.71	0.79	0.78	0.80	0.83	0.73	0.65	0.66	0.80	0.84	0.84	0.80	0.85	0.82	0.84	0.71
NC	0.95	0.80	0.81	0.81	0.78	0.93	0.84	0.86	0.81	0.77	0.76	0.78	0.77	0.73	0.88	0.81	0.81
ND	0.77	0.69	0.53	0.47	0.40	0.36	0.48	0.79	0.84	0.88	1.09	0.51	0.68	0.74	1.74	1.55	0.64
OH	0.79	0.82	0.82	0.78	0.80	0.79	0.71	0.72	0.74	0.81	0.94	0.91	0.89	0.86	0.84	0.82	0.95
OK	0.77	0.68	0.63	0.69	0.48	0.65	0.78	0.51	0.43	0.54	0.59	0.49	0.49	0.44	0.55	0.57	0.60
OR	1.33	1.33	1.32	1.16	1.15	1.39	1.45	1.19	1.09	1.12	1.38	0.96	1.07	1.25	1.14	1.14	1.21
PA	0.93	0.95	0.87	0.92	0.98	1.02	0.93	0.75	0.97	0.96	0.96	0.98	0.97	0.80	0.81	0.78	0.86
RI	0.47	0.48	0.37	0.35	0.39	0.36	0.43	0.52	0.66	0.69	1.59	1.40	1.20	0.73	0.68	0.62	1.24
SC	1.12	1.05	1.07	0.78	0.83	0.91	0.83	0.92	0.97	0.97	1.02	1.15	1.16	1.08	0.99	1.08	0.98
SD	0.39	0.60	0.58	0.65	0.64	0.79	0.56	0.68	0.64	0.60	0.87	0.45	0.51	0.66	1.18	0.84	0.94
TN	1.14	1.03	1.05	1.02	1.00	0.97	1.05	1.30	1.31	1.28	1.19	1.01	1.10	1.05	1.06	1.08	1.11
TX	1.29	1.34	1.29	1.42	1.40	1.51	1.37	1.59	1.53	1.44	1.17	1.11	1.12	1.38	1.53	1.69	1.52
UT	0.80	0.98	0.93	1.04	0.96	0.89	0.82	0.77	0.75	0.96	0.76	1.08	1.05	0.84	1.18	1.16	0.88
VT	0.65	0.61	0.57	0.54	0.57	0.66	0.67	0.66	1.11	0.98	0.81	0.50	0.60	0.51	0.63	0.56	0.68
VA	0.99	0.99	0.93	0.90	0.93	0.95	1.05	1.08	1.04	0.97	1.03	0.88	0.82	0.78	0.98	1.01	0.96
WA	1.54	1.41	1.37	1.28	1.47	1.42	1.71	1.54	1.65	1.18	1.21	1.10	1.08	1.41	1.32	1.31	1.34
WV	1.65	1.87	1.94	1.83	2.04	1.82	1.25	1.09	1.02	1.20	1.03	1.31	1.40	2.32	1.89	1.78	1.38
WI	0.88	0.86	0.81	0.84	0.83	0.88	0.93	0.92	0.92	0.91	0.90	0.93	0.88	0.85	0.89	0.93	0.94
WY	0.38	0.38	0.37	0.36	0.35	0.23	0.34	0.29	1.10	1.25	1.72	0.75	0.92	0.77	1.37	1.00	0.69

Table 4A.2 **Unadjusted Index of State Environmental Compliance Costs**

State	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994
AL	0.0211	0.0205	0.0219	0.0215	0.0225	0.0208	0.0333	0.0193	0.0208	0.0192	0.0161	0.0191	0.0217	0.0250	0.0228	0.0232	0.0239
AZ	0.0237	0.0222	0.0177	0.0145	0.0166	0.0113	0.0101	0.0160	0.0177	0.0143	0.0156	0.0122	0.0134	0.0121	0.0126	0.0105	0.0105
AR	0.0125	0.0135	0.0150	0.0168	0.0153	0.0145	0.0148	0.0163	0.0177	0.0161	0.0169	0.0196	0.0172	0.0179	0.0205	0.0203	0.0201
CA	0.0104	0.0106	0.0098	0.0107	0.0101	0.0090	0.0106	0.0112	0.0123	0.0128	0.0131	0.0139	0.0160	0.0151	0.0134	0.0125	0.0139
CO	0.0100	0.0092	0.0079	0.0088	0.0093	0.0056	0.0067	0.0063	0.0081	0.0102	0.0077	0.0218	0.0294	0.0262	0.0077	0.0073	0.0091
CT	0.0041	0.0050	0.0060	0.0064	0.0063	0.0051	0.0069	0.0065	0.0069	0.0072	0.0090	0.0121	0.0128	0.0111	0.0090	0.0090	0.0102
DE	0.0252	0.0344	0.0386	0.0418	0.0420	0.0362	0.0319	0.0316	0.0377	0.0391	0.0392	0.0375	0.0292	0.0322	0.0304	0.0290	0.0294
FL	0.0164	0.0157	0.0145	0.0137	0.0126	0.0131	0.0132	0.0129	0.0138	0.0143	0.0145	0.0151	0.0138	0.0124	0.0128	0.0120	0.0135
GA	0.0099	0.0101	0.0099	0.0110	0.0109	0.0104	0.0113	0.0120	0.0121	0.0119	0.0128	0.0180	0.0167	0.0167	0.0135	0.0142	0.0145
ID	0.0152	0.0153	0.0196	0.0222	0.0232	0.0218	0.0201	0.0209	0.0180	0.0217	0.0161	0.0131	0.0152	0.0128	0.0185	0.0161	0.0174
IL	0.0099	0.0095	0.0115	0.0116	0.0109	0.0109	0.0132	0.0129	0.0136	0.0144	0.0140	0.0147	0.0162	0.0153	0.0168	0.0154	0.0140
IN	0.0144	0.0155	0.0173	0.0211	0.0216	0.0225	0.0225	0.0200	0.0212	0.0208	0.0191	0.0204	0.0195	0.0208	0.0202	0.0186	0.0176
IA	0.0083	0.0091	0.0095	0.0098	0.0100	0.0087	0.0102	0.0123	0.0121	0.0115	0.0103	0.0114	0.0100	0.0109	0.0120	0.0114	0.0134
KS	0.0086	0.0088	0.0179	0.0110	0.0102	0.0089	0.0105	0.0107	0.0102	0.0108	0.0101	0.0136	0.0153	0.0143	0.0109	0.0122	0.0119
KY	0.0092	0.0109	0.0114	0.0125	0.0127	0.0110	0.0152	0.0164	0.0142	0.0144	0.0146	0.0170	0.0184	0.0191	0.0177	0.0162	0.0169
LA	0.0408	0.0424	0.0465	0.0471	0.0576	0.0568	0.0616	0.0677	0.0682	0.0649	0.0430	0.0423	0.0461	0.0518	0.0606	0.0589	0.0580
ME	0.0163	0.0199	0.0197	0.0207	0.0217	0.0204	0.0227	0.0228	0.0220	0.0230	0.0206	0.0262	0.0263	0.0316	0.0309	0.0293	0.0288
MD	0.0141	0.0173	0.0193	0.0204	0.0186	0.0166	0.0183	0.0184	0.0190	0.0192	0.0205	0.0178	0.0174	0.0196	0.0198	0.0209	0.0168
MA	0.0044	0.0045	0.0051	0.0046	0.0050	0.0038	0.0072	0.0064	0.0061	0.0069	0.0073	0.0090	0.0087	0.0088	0.0089	0.0087	0.0091
MI	0.0086	0.0090	0.0107	0.0133	0.0127	0.0106	0.0111	0.0121	0.0120	0.0113	0.0134	0.0133	0.0145	0.0145	0.0144	0.0132	0.0110
MN	0.0065	0.0069	0.0078	0.0084	0.0076	0.0077	0.0094	0.0091	0.0089	0.0091	0.0080	0.0095	0.0098	0.0119	0.0114	0.0122	0.0119
MS	0.0179	0.0202	0.0180	0.0202	0.0157	0.0171	0.0207	0.0230	0.0224	0.0216	0.0198	0.0194	0.0241	0.0253	0.0285	0.0260	0.0226
MO	0.0070	0.0083	0.0081	0.0099	0.0097	0.0081	0.0101	0.0085	0.0097	0.0114	0.0110	0.0138	0.0155	0.0114	0.0118	0.0125	0.0104
MT	0.0221	0.0216	0.0247	0.0297	0.0375	0.0476	0.0396	0.0425	0.0454	0.0339	0.0334	0.0358	0.0373	0.0451	0.0217	0.0168	0.0448
NE	0.0058	0.0067	0.0069	0.0075	0.0080	0.0057	0.0081	0.0114	0.0122	0.0109	0.0110	0.0075	0.0078	0.0083	0.0116	0.0100	0.0101
NV	0.0047	0.0057	0.0061	0.0069	0.0070	0.0071	0.0069	0.0094	0.0083	0.0081	0.0109	0.0084	0.0062	0.0073	0.0083	0.0064	0.0049

(continued)

Table 4A.2 (continued)

State	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994
NH	0.0077	0.0063	0.0057	0.0053	0.0050	0.0050	0.0059	0.0049	0.0058	0.0073	0.0070	0.0096	0.0100	0.0094	0.0080	0.0087	0.0105
NJ	0.0141	0.0132	0.0155	0.0174	0.0138	0.0142	0.0154	0.0133	0.0136	0.0150	0.0153	0.0175	0.0192	0.0193	0.0195	0.0174	0.0155
NM	0.0413	0.0433	0.0392	0.0418	0.0380	0.0264	0.0284	0.0317	0.0313	0.0273	0.0424	0.0300	0.0337	0.0155	0.0193	0.0188	0.0112
NY	0.0067	0.0070	0.0081	0.0083	0.0085	0.0082	0.0083	0.0072	0.0078	0.0096	0.0089	0.0100	0.0097	0.0105	0.0103	0.0102	0.0085
NC	0.0074	0.0065	0.0072	0.0078	0.0075	0.0083	0.0084	0.0087	0.0089	0.0085	0.0087	0.0095	0.0099	0.0096	0.0115	0.0105	0.0112
ND	0.0083	0.0076	0.0061	0.0060	0.0052	0.0046	0.0066	0.0117	0.0122	0.0131	0.0154	0.0074	0.0099	0.0108	0.0243	0.0207	0.0087
OH	0.0101	0.0108	0.0119	0.0127	0.0136	0.0129	0.0132	0.0119	0.0132	0.0136	0.0155	0.0157	0.0173	0.0166	0.0158	0.0146	0.0165
OK	0.0115	0.0088	0.0088	0.0105	0.0078	0.0115	0.0140	0.0094	0.0095	0.0114	0.0100	0.0090	0.0087	0.0108	0.0112	0.0108	0.0122
OR	0.0117	0.0115	0.0128	0.0128	0.0134	0.0141	0.0157	0.0130	0.0129	0.0136	0.0170	0.0124	0.0146	0.0183	0.0148	0.0131	0.0142
PA	0.0150	0.0155	0.0150	0.0167	0.0177	0.0169	0.0181	0.0151	0.0179	0.0180	0.0168	0.0177	0.0185	0.0174	0.0175	0.0159	0.0178
RI	0.0037	0.0039	0.0035	0.0035	0.0038	0.0032	0.0044	0.0051	0.0069	0.0076	0.0152	0.0149	0.0147	0.0081	0.0074	0.0068	0.0146
SC	0.0128	0.0128	0.0143	0.0114	0.0120	0.0129	0.0125	0.0142	0.0160	0.0164	0.0161	0.0206	0.0218	0.0205	0.0198	0.0202	0.0181
SD	0.0030	0.0037	0.0040	0.0046	0.0048	0.0053	0.0047	0.0053	0.0058	0.0056	0.0080	0.0043	0.0049	0.0066	0.0105	0.0063	0.0079
TN	0.0148	0.0141	0.0152	0.0156	0.0147	0.0135	0.0155	0.0171	0.0188	0.0184	0.0174	0.0162	0.0186	0.0184	0.0175	0.0172	0.0173
TX	0.0282	0.0287	0.0265	0.0306	0.0294	0.0312	0.0337	0.0355	0.0341	0.0346	0.0260	0.0264	0.0296	0.0346	0.0343	0.0331	0.0317
UT	0.0117	0.0149	0.0145	0.0168	0.0161	0.0135	0.0131	0.0120	0.0124	0.0133	0.0126	0.0199	0.0207	0.0182	0.0246	0.0251	0.0191
VT	0.0047	0.0044	0.0045	0.0044	0.0046	0.0051	0.0063	0.0060	0.0109	0.0099	0.0084	0.0060	0.0070	0.0063	0.0077	0.0064	0.0079
VA	0.0097	0.0106	0.0107	0.0109	0.0111	0.0105	0.0122	0.0123	0.0125	0.0119	0.0128	0.0117	0.0116	0.0113	0.0136	0.0136	0.0130
WA	0.0177	0.0166	0.0178	0.0190	0.0221	0.0188	0.0230	0.0224	0.0229	0.0188	0.0183	0.0175	0.0192	0.0210	0.0194	0.0186	0.0203
WV	0.0370	0.0446	0.0487	0.0478	0.0536	0.0473	0.0347	0.0310	0.0325	0.0348	0.0272	0.0363	0.0416	0.0697	0.0577	0.0517	0.0401
WI	0.0080	0.0084	0.0086	0.0094	0.0093	0.0094	0.0113	0.0107	0.0117	0.0120	0.0114	0.0125	0.0124	0.0126	0.0130	0.0133	0.0131
WY	0.0174	0.0161	0.0124	0.0144	0.0141	0.0100	0.0137	0.0120	0.0375	0.0396	0.0595	0.0265	0.0310	0.0310	0.0489	0.0331	0.0235

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Comment Domenico Siniscalco

The new analysis carried out in this paper on the effects of environmental compliance costs on economic activity stems from the unsatisfactory performance of the existing indexes of environmental effort in U.S. states. The author calculates a new industry-adjusted index of U.S. states' environmental regulatory efforts, taking into account environmental compliance costs and the differences in industrial composition across states and within states over time. This approach differs from subjective indexes, which are based on perceptions of the states' efforts at one time, and conventional cost-based measures, which do not control for industrial composition.

There are three key motivations for creating this index. First, there is poor enforcement of environmental federal standards in many U.S. states. An industry-adjusted index is thus needed to analyze the variation of environmental compliance costs across states. Second, the decentralization of the responsibility for monitoring and enforcing environmental regulation from the federal government to local regulators may cause the states' stringency to converge over time. Thus, an index is required to obtain data on the level of such stringency. Third, it is difficult to assess the effects of environmental regulation on economic activity because existing indexes do not take into account industrial composition and this reduces the link between compliance costs and environmental regulation.

Levinson's index provides new data on historical trends in U.S. states' regulatory differences. It differs from conventional wisdom regarding states' relative environmental efforts and provides a useful tool for researchers and policymakers exploring and testing the effects of compliance costs on economic activity.

The most striking finding is that when states' regulatory stringency is ranked according to the industry-adjusted index, results are quite different from the ranking according to cost-based unadjusted indexes. Moreover, the dynamic evolution of the index shows that only few states' rankings change over time. It is, however, worth noticing that some results, especially for small U.S. states, might be heavily affected by noisiness in the data. Nevertheless, there is an evident downward trend in the variability of regulatory stringency among states, although their industrial composition has become much more dissimilar.

This paper provides a new and important tool for both regulators and policymakers because it allows us to conduct meaningful analyses of states' environmental efforts, taking into account variations among states' industrial composition. When policymakers set compliance standards they need a complete picture of environmental regulation stringency and en-

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forcement over time, compared with other U.S. states, to guarantee high environmental standards and to avoid restriction of local firms' competitiveness. An effective comparison of the environmental effort across states implies the definition of adjusted indexes that discriminate according to the characteristics of each state area. An index that is not industry adjusted can lead to misleading conclusions about the actual effects of environmental regulation on economic activities; that is, highly polluting industries have higher compliance costs regardless of regulation strictness and enforcement. Even if Levinson's index is still not a measure of regulatory stringency alone, when it is used together with other state-specific information, such as age of manufacturers, average dimension of firms, and average wages, it allows us to answer several often-raised questions about environmental law and enforcement.

The information provided by the index may also help firms in deciding the location of new sites and the extent of investment in existing sites.

Considering the whole set of findings and the interesting implication for regulators and firms' decision making, this paper certainly indicates a promising research area.