Toxic Releases and the States: Multilevel Analysis of the Relationship between State Politics and Policy and Improvements in Pollution Releases [1]

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Abstract

The literature in U.S. sub-national environmental policy has given attention to state, county, and other sub-national levels of policy outputs and environmental outcomes, but done so without thinking through the implications of clustering within levels or the interactions across levels. This research extends our understanding by examining facility-level trends in reduction of toxic chemical emissions through the lens of comparative state and sub-state environmental policy. We argue that facility-level environmental releases are a function of: (1) pollution severity; (2) county level demographic factors; (3) the intensity of industrial interests; (4) policy liberalism; and (5) state policy commitments. A three level hierarchical linear model is used on data representing trends in reported toxic air releases for 11,438 facilities reporting in 1991 and 1995. Pollution severity, educational attainment, regulatory stringency, and policy liberalism had statistically significant effects on pollution releases, and evidence was found to suggest that educational attainment variations within states also magnified the influence of policy liberalism on toxic emissions.

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As the new millennium unfolds, the use of performance measures as tools of environmental policy is moving into new terrain. Although conversations about being "in compliance" still dominate many discussions between the private and public sector, there is a growing understanding that our capacity to measure progress in the areas of environmental conservation, preservation, and restoration has dramatically improved. At the forefront of this new wave of environmental performance measures has been the U.S. Toxics Release Inventory (TRI). Though it has undergone a number of changes since its inception in 1988, the TRI has, at core, remained the same: a catalog of environmental releases of pollutants to the air, water, and land, by the industrial sector here in the United States. The TRI often has been cited as a success story in dissemination of information about releases of toxic chemicals by industrial facilities, and this despite the fact that the TRI looks at amounts of pollutants rather than the risk of those pollutants.

According to the most recent national summary report of 2004 data (EPA 2006), reportable toxic pollution releases decreased by 4 percent over the previous year. In general, over the life of the program (1988 to 2004 reports), the trends have been downward; manufacturing facilities reduced their reportable pollution releases by 57 percent. What sometimes gets overlooked in the reporting of national summary data is that in any given year states (and counties) can vary widely in their changes from previous years. For example, although Wisconsin saw its pollution levels steadily decrease between 1988 and 2004, the state of Washington saw more air pollution fluctuations with emissions increasing from 1993 to 1995 before declining again through 2004.

The lack of a focused accounting for the causal explanation for *sub-national* variations in *pollution performance* is the motivating force behind the analyses in this paper. Our goal is to better understand toxic *release* trends for facilities within counties within states. We analyze these variations at multiple levels partly because theory suggests that multiple levels do matter in the impact that public policies have on environmental conditions, and that such variations reflect important differences across states and the facilities within them.

Subnational variations in environmental performance

That subnational jurisdictions vary in pollution production and reduction is not really in doubt. However, some researchers have examined variations in environmental policy expenditures (Davis and Feiock 1992; Bacot and Dawes, 1996, 1997), state enforcement actions (Lombard 1993), or a locale's propensity to adopt recycling programs (Feiock and West 1993). Several articles extend this type of analysis to also explain a variety of ecological outcomes. Ringquist (1993b) , for instance, tested the relationship between economic factors, political pressures, political system elements and a dependent measure of state variations in air and water quality. His evidence suggested that economic resources did not strongly influence policy outputs, but strong regulatory choices did improve air quality (and water quality to a lesser extent). A subsequent analysis by Yu and others (1998) also found state enforcement to be an important determinant of decreases in industrial toxic releases. More provocatively, the paper measured and concluded that informational policy instruments (such as state pollution prevention education) may matter more than authoritative tools.

A similarly structured literature on local environmental performance also developed in the 1990s. Folz and Hazlett (1991) produced one of the earliest in this vein when they sought to test the success of recycling programs in diverting solid waste from local landfills. They postulated that waste diversion would vary across communities in different regions, with variations in population levels, contrasts in socioeconomic composition, differences in political cultures, and various forms of government. Perlin and others (1995) turned this kind of local environmental outcome analysis towards counties and toxic waste. Their research found that pollution emissions (measured by TRI) varied by a county's income and ethnic group composition.

A later county-level analysis of the spatial distribution of air pollution in the southeastern U.S. also considered toxic releases as a measure of environmental outcomes. Responding to concerns about environmental injustice, Cutter and Solecki (1996) failed to find an association between a county's racial composition and the frequency of airborne toxic releases. They did however find that economic indicators correlated with air releases, albeit in a positive and unexpected direction. A subsequent analysis by Ringquist (1997) continued the focus on associations between TRI emissions and socioeconomic characteristics at the zip code level. He found that even with background controls, TRI facilities and releases were concentrated disproportionately in residential zip codes with large minority populations. Hird and Reese (1998) followed with a return to a county-level analysis. Their research first examined associations among variations in county demographics and numerous measures of surrogates for environmental quality. Second, they focused on the variations in socioeconomic characteristics of counties with high levels of multiple pollutants. Their data produced strong positive associations between population density, manufacturing activity, race, ethnicity, and pollution. Moreover, their results paralleled earlier research (Cutter and Solecki 1996) with the unexpected finding of a positive correlation between wealthier locales and lower environmental quality.

In the same year, Neumann and others (1998) produced an innovative study constrained to Oregon. The research combined TRI releases, a media-specific toxicity index, and GIS to screen for hazards associated with demographic variables. The study found that while TRI facilities were located disproportionately in ethnic and minority neighborhoods, the analysis found no relationship between the hazardousness (releases + toxicity) of industrial sites and the socioeconomic characteristics of surrounding communities. Two significant papers followed in 1999 and continued to advance the literature on a locale's environmental quality measured with TRI releases.

Daniels and Friedman (1999) examined the question of whether pollution distributed unevenly across counties and the correlation with social groups. They found evidence of uneven pollution releases across the U.S. in a manner supportive of environmental injustice. Their study controlled for urbanization and industrial location but environmental inequalities remained as a county's proportion of African-Americans positively associated with toxic air releases. Arora and Cason (1999) completed a similar study but used zip-code level data and a dependent measure of three-year changes in TRI releases. Their study proffered three significant conclusions. First, race positively associated with releases in nonurban areas in the southeast. Associations between pollution, income levels, and unemployment suggested that economic factors were a second determinant of toxic releases. Third, in an analysis of California only, they found that voter turnout influenced environmental outcomes mainly in nonurban areas.

In sum, previous research suggests a multi-faceted examination of the policy relevant factors which may influence changes in industrial pollution over time. Key categories of variables include both political and administrative factors. Regulatory and non-regulatory variations across states, counties, and facilities are potentially critical and cannot be ignored.

Finally, control variables—such as the severity of the problem or socioeconomic conditions—must be included in order to better assess whether policy choices are proactive or reactive.

Modeling Environmental Performance at Multiple Levels

Building on the literatures related to both state variations and county variations (and on two earlier papers of our own looking at state variations (Stephan, Abel, and Kraft 2006) and county variations (Abel, Kraft, Stephan 2005)), we here introduce a multilevel model for consideration. Our analysis does not introduce new independent variables or even a new dependent variable, but it does offer an expanded look across facilities, counties, and states in order to better understand the role of political, policy, and resource factors on changes in industrial environmental performance in the area of pollution releases. In particular, the model is built on two suppositions. First, that community-based, political, and policy factors all work to influence the environmental performance of facilities within states. Second, that clustering can occur within states and within counties, and therefore multilevel modeling is arguably the best method to account for such clustering (Steenbergen and Jones 2002).

The argument is made that political influences work through both governmental and non-governmental channels. In an open, pluralistic society interest groups have multiple means to communicate their preferences to industry. Pollution practices do not exist in a political vacuum, but rather occur within particular political contexts. The extent to which a state government's policies are liberal overall are expected to influence the direction of corporate behavior and the set of expectations that corporate actors within a particular state are likely to share.

Finally, the *attempt to look across levels will highlight variation across states that otherwise would be missed or misunderstood*. In particular, our sense is that policy innovative states are likely to be moving ahead on reducing releases, but that sub-state factors will influence the nature of state variations.

Data and Methods

The EPA's TRI database provided facility-level data for this study's key measures. To characterize state-level TRI trends, the study analyzed a sample of facilities (11,438) reporting in both 1991 and 1995 and their changes in reported releases of toxic chemical pollutants. We begin with 1991 because it is the first year following enactment of the 1990 Pollution Prevention Act (serving as a partial control) and because it allows us a view of a five-year trend while ignoring the early years of the TRI program which are likely to contain more errors. We use 1995 because it allows sufficient time to pass for facilities to make the kind of improvements necessary for pollution reductions (we follow the reasoning of Konar and Cohen (1997) and Shapiro (2005)), and the interval provides sufficient coverage to measure significant changes over time in facility environmental performance. The sample included only the 1991 core chemicals to ensure consistent comparisons of facility-level toxic chemical management across the 1991 to 1995 period.

We used raw TRI pollution release data to create our dependent variable. We first calculate the ratio of 1995 release to 1991 releases. We then proceed to take the natural log of these values – raw data from companies producing the largest quantities of hazardous releases would skew statistical analysis. Values greater than zero suggest that a facility is increasing its pollution output rather than decreasing. Values less than zero suggest that a facility is moving in the right direction by reducing its pollution output. Though this measure could potentially have some problems, given the questions raised about the accuracy of pound for pound release data

(DeMarchi and Hamilton 2006), we felt sufficiently comfortable in these preliminary analyses to move forward with the measure. It is important to note that in separate analyses, not reported here, using a more conservative dependent variable, we found results similar to those reported below.

Independent predictors encompassed a facility-level measure of problem severity, county level measures of community resources, and state-level political factors and policy conditions. We mostly used static measures because we treated each of the predictors as initial conditions that would influence facility-level performance in the ensuing years; a dynamic measure. Though there is the possibility that changes in the independent measures may influence change in the dependent variable, we follow the logic of others who examine both initial conditions and the ensuing environmental changes (Ringquist 1993a; Ringquist 1993b; Ringquist 1995; Shapiro 2005). We also combine static and dynamic measures because many of the key factors affecting industrial environmental performance are not available to build pooled time-series models. In particular, our principal measures of political and policy factors are drawn from the groundbreaking work of Erikson, Wright, and McIver (1993). In fact, recent studies suggest that public opinion and policy liberalism were relatively stable through the 1990s (Burden 2005; Gray et al. 2004; McIver, Erickson, and Wright 2001).

Table 2 about here

Following much of the comparative environmental policy literature, our analysis employed a measure of the pollution problem severity. We are able to use a facility-level measure, which allows a more refined understanding of initial conditions. Using the toxic releases in 1991 (logged) as our measure, we expected that facilities with higher levels of initial pollution would see greater reductions in releases. That is, larger facilities polluting at greater levels would better be able to pick the lowest hanging fruit – big polluters would be the easiest places for big reductions.

Our two *socioeconomic* predictors were meant to serve as controls. Our intent was to avoid attributing to policy or politics what may have more to do with demographic or economic differences across counties (although the three categories of predictors are intertwined to some degree). Our sense was that higher levels of education would increase the likelihood of facility reductions within counties, while higher levels of poverty would have the opposite effect. Both measures can be thought of as measures of the latent resources a community could bring to bear when dealing with polluting industries. Educational attainment and a measure of poverty levels both came from the U.S. Census**.**

Our single political predictor at the county level was of the percent Democratic vote for president. Following the general logic of partisan connections to particular policy preferences, we predicted that as the percentage of the vote for the Democratic candidate increased, so to would there be greater reductions in pollution releases.

Following Potoski and Woods (2002) and Ringquist (1993b; 1994), we included a surrogate political measure related to *industry group strength (*operationalized through a measurement of *industrial economic contribution).* The state-level measure looks at the value added by manufacturing (as a percentage of the state's gross product) associated with state industries most responsible for air pollution. States with higher levels of value added by manufacturing from pollution facilities are expected to have greater industry group strength both economically and politically. The measure is derived from data obtained from the U.S. Commerce Department's Bureau of Economic Analysis.

Another important state-level industrial measure was drawn from the environmental economics literature. Primarily concerned with the distorting effects of varying compliance costs due to differences in the stringency of state environmental regulation, researchers have developed measures of abatement costs in comparative studies on new industrial locations (Bartik 1988; Levinson 1996), industrial employment levels (Duffy-Deno 1992); plant-level productivity (Gray and Shadbegian 1995); and manufacturing employment growth (Crandall 1993; Kahn 1996).

However, as one researcher observed, this literature has been troubled by the inconsistent measurement of state variations in regulatory stringency (Tannenwald 1997). Three kinds of estimates have been common; (1) compliance costs; (2) stringency; and (3) enforcement effort. In one of the most recent studies, Levinson (2001) introduced an average stringency index we use here. His index is a weighted average of pollution abatement costs faced by industry across the states from 1977 to 1994. Larger index values reflect more stringent regulations that cost facilities in abatement effort.

Our key political factor at the state level in the model of industrial environmental performance was the policy liberalism measure developed by Erikson, Wright, and McIver (1993). Many observers assume that pollution reductions are made voluntarily because the program is non-regulatory in nature, but we believe that a more realistic explanation would acknowledge the incentives created by the larger political environment. In particular, we expect companies to improve pollution performance because of concerns over negative attention marshaled by environmental groups or potential state regulatory action.

Finally, in one of our analyses we include an interaction term that accounts for the role that education and policy liberalism may have in conjunction. The basic idea is that we would expect policy liberalism's influence to be greatly improved by higher levels of education at the county level. This magnification of political liberalism would occur in cases where a well-educated population could be anticipated by industry to use both interest group pressures and governmental pressures to push for better industrial performance. Industry might move ahead of such pressures, but facilities in very policy liberal states with highly educated citizens at the local level could be expected to have the potential for strong political action.

A three-level hierarchical linear model was used to analyze the data. We analyzed both a fixed-effects model and mixed model.

Results

We compare two models here; one with no cross-level interaction predictors and one that includes a cross-level interaction predictor that attempts to measure the relationship of educational attainment at the county level and policy liberalism at the state level. After adjusting for error structures within levels, we find a number of significant results.

Table 2 about here

Both models did yield significant coefficients for educational attainment, suggesting that as education levels increased, pollution release levels went down. Policy liberalism was also significant in the first model and its interaction with educational attainment was significant in the second model. In both cases the sign was as predicted and the result for policy liberalism in particular suggests that states that are more liberal in their overall policies also see the greatest reductions in pollution releases. Facility-level industrial environmental performance is therefore related to socioeconomic conditions at the county level as well as the relative policy liberalism in the states. Unexpectedly, industry group strength did not produce a significant relationship in either model. Similarly, neither poverty levels nor Democratic vote percentages seemed to have an influence on the dependent variable.

Pollution severity had an expected positive effect, suggesting that facilities with greater initial levels of pollution were also facilities reducing pollution release levels at more significant rates. Unexpectedly, the measure of regulatory stringency yielded a statistically significant but negative sign. Facilities paying higher compliance costs for more stringent regulations in some states produced more, not less pollution risk.

Finally, and importantly, the statistical significance of our variance components suggest that much of the variance at the facility-level, county-level, and state-level has yet to be explained. The predictors only begin to account for the variations in industrial environmental performance.

Discussion

The results, taken in their entirety, are suggestive. There are two initial points we take away from them.

The first is that socioeconomic and political factors may both play a role in driving variations. The cross-level interaction term is interesting, because it suggests a process of magnification that can occur when state predictors interact with county predictors to affect the pollution performance of private industry. In particular, educational levels at the county-level interact with the level of policy liberalism of states in such a way that counties with less well-educated populations within more regressive states are likely to see fewer environmental performance improvements from industry. Among other implications, this result may suggest another layer of environmental inequalities that has yet to be addressed in the literature.

The second point is that despite the amount of variance left unexplained, the models indicate that further work using multilevel models to fully analyze subnational variations in industrial environmental performance is in order. Significant independent predictors found at each level of analysis plus across levels are indicative of the richness of variations across states and at smaller units of analysis.

In the end, a fuller accounting of the variation at the facility, county, and state levels would be helpful, including thinking through a wider set of predictors.

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Table 1. Descriptive Statistics for Selected Variables

Dependent Variable and Predictors	Minimum	Maximum	Mean	Standard Deviation
Ratio of 1995 air releases to 1991 releases	0.0001	114144	57.45	1612.74
Natural log of the ratio of 1995 air releases to 1991 releases	-11.23	11.65	-0.38	2.04
Natural log of 1991 facility air releases (facility level)	0.00	17.93	9.02	3.00
Educational Attainment (county level) – Percent B.A.	3.70	49.90	18.26	7.21
Percent below Poverty (county level)	2.60	43.40	14.42	5.50
% Vote Democratic (county level)	1.07	85.80	47.73	10.28
Industry group strength (or Value added by Air Polluters)	0.11	0.75	0.34	0.14
Levinson's Regulatory Stringency Index (1977-1994)	0.58	1.66	1.02	0.31
Standardized index of composite policy liberalism	-1.54	2.12	-0.01	0.99

Source for *1991 and 1995 total state air releases*: U.S. EPA.
Source for *educational attainment and poverty levels*: U.S. Census.
Source for *value added by air polluters*: Commerce Department. Value added by air polluters refers to the percentage of a state's gross product added by manufacturing industries most responsible for air pollution. The Manufacturing GSP refers to the manufacturing share of the Gross State Product, expressed in millions of dollars, as of 1989.
Source for *Levinson's regulatory stringency*: Levinson, Arik. 1999. "An Industry-Adjusted Index of State Environmental Compliance Costs." Prepared for National Bureau of Economic Research, Inc. (NBER) and Fondazione Eni Enrico Mattei (FEEM) Conference on the Distributional and Behavioral Effects of Environmental Policy June 11-12, 1999, Milan, Italy
Source for *policy liberalism*: Taken from Erickson, Wright, McIver (1993).

Table 2. Determinants of Pollution Release Reductions – Multilevel Estimates (three-level hierarchical model – maximum likelihood estimations)

(DV: Natural log of the ratio of 1995 air pollution releases to 1991 releases)

Predictors **Fixed Effects**	**Estimated Coefficients** **Model 1**	**Estimated Coefficients** **Model 2 (Cross level Interaction)**
Natural log of 1991 facility air releases (facility level)	-0.237** (0.006)	-0.237** (0.006)
Educational Attainment (county level)	-0.017** (0.003)	-0.023** (0.008)
Percent below Poverty (county level)	0.000 (0.004)	0.001 (0.004)
% Vote Democratic (county level)	0.000 (0.001)	0.000 (0.001)
Industry group strength (or Value added by Air Polluters)	-0.019 (0.013)	-0.019 (0.013)
Levinson's Regulatory Stringency Index (1977-1994)	0.363** (0.137)	0.366** (0.132)
Standardized index of composite policy liberalism	-0.189** (0.018)	0.049 (0.048)
Educ Attainment x Policy Lib	…	-0.012*** (0.002)
Constant	1.868** (0.205)	1.838** (0.200)
Variance Components		
State Level	0.154** (0.032)	0.141** (0.032)
County Level	0.188** (0.041)	…
Constant	…	0.153 (0.454)
Educational Attainment	…	0.011 (0.017)
Constant, Educational Attainment	…	-0.524 (2.144)
Facility Level	1.880*** (0.013)	1.877** (0.013)
-2 X Log Likelihood	-24251.89	-24238.041
Number of Facilities	11438	11438
Number of Counties	1790	1790
Number of States	48	48

*Statistically significant at $p < 0.05$.
**Statistically significant at $p < 0.01$.
***Statistically significant at $p < 0.001$.

Note: Counties had the following range of facilities: Min: 1, Max: 334, Average: 6.4. States had the following range of facilities: Min: 11, Max: 940, Average: 238.3.