Do Community Characteristics Determine Environmental Outcomes? Evidence from the Toxics Release Inventory

Seema Arora
Timothy N. Cason

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Resources for the Future
1616 P Street, NW
Washington, DC 20036
Telephone 202-328-5000
Fax 202-939-3460

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Abstract

This research uses neighborhood characteristics (at the zipcode level) to explain changes in toxic releases between 1990 and 1993. It combines the Toxics Release Inventory data with demographic data from the 1990 US Census. We first analyze the location of manufacturing facilities in a particular neighborhood using a sample selection model, and then attribute changes in the level of emissions between 1990 and 1993 to the demographic and socio-economic characteristics of the neighborhood in 1990. The results indicate that variables likely to affect the propensity for communities to engage in political action significantly influence environmental performance. Economic characteristics of neighborhoods (such as income levels and unemployment) also affect changes in releases. Release changes in the Southeastern US exhibit a pattern consistent with racial injustice.

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Seema Arora and Timothy N. Cason[1]

1. INTRODUCTION

The use of public information as an environmental policy tool is an innovative approach to regulation. The underlying premise of such a policy is that public knowledge of pollution can engender effective and informed participation by communities, which in turn can exert pressure on facilities to improve environmental performance. In 1986 the US Congress passed the Emergency Planning and Community Right-to-Know Act which embodied this principle of public disclosure. It mandated that all manufacturing facilities in the US make public their releases of over 320 toxic chemicals into the air, land and water. These data are released annually in the Toxics Release Inventory (TRI). The law was inspired by a severe environmental tragedy in Bhopal, India, where the release of a toxic gas led to the death of several thousand people. Residents living in the vicinity of these plants were unaware that such toxic chemicals were being used in their neighborhoods. Furthermore, they were ill-equipped

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[1] Seema Arora, Owen Graduate School of Management, Vanderbilt University, Nashville TN 37203; Timothy N. Cason, Department of Economics, University of Southern California, Los Angeles CA 90089-0253. We have benefited from helpful comments provided by seminar participants at UC-Santa Barbara, the University of Southern California and Resources for the Future, and conference participants at the European Agricultural and Resource Economists Meeting in Lisbon, Portugal. We would like to thank David Austin, Dallas Burtraw, Brian Kropp, Eduardo Ley, Ian Parry, Hillary Sigman, Jeff Wagner, Margaret Walls, and Chris Wernstedt. We retain responsibility for any errors. The paper was completed while the first author was visiting Resources for the Future. Arora gratefully acknowledges financial support from the Owen Graduate School of Management Dean's Fund for Summer Research.

to deal with the emergency. The Emergency Planning and Community Right-to-Know addressed both these problems.

Public disclosure may force companies to improve environmental performance for several reasons (Arora and Gangopadhyay, 1995). The pressure to clean up may be due to corporate concerns about bad publicity, fear of legal liabilities or fear of consumer boycotts. The TRI led to several voluntary initiatives by firms to reduce releases (Arora and Cason, 1996). However, a large variation in environmental releases exists across facilities even when these facilities are owned by the same parent company (Beede et al., 1991). This may be explained by plant specific characteristics like age of the plant, product mix, or the nature of the industry or different or complementary state regulations. However, environmental performance of facilities may also differ due to community pressures. It is not uncommon for industrial facilities confronting community action to lower emissions. Facing the possibility of reprimand and censure by communities and regulators responding to community interests, some facilities make voluntary release reductions and sometimes sign "good neighbor pledges." Good neighbor pledges are often the result of direct negotiations between the facility and the community, in which the facility promises to reduce emissions.[2] Some agreements permit communities to participate in environmental audits of the facility. The public information has empowered communities with information which they can use to participate in influencing

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[2] The 1988 TRI data revealed that Syntex Corporation, a pharmaceutical company, was one of the largest emitters of toxic air pollution in Boulder, Colorado. Residents of Boulder organized to form BREATHE (Boulder Residents for the Elimination of Airborne Toxins and Hazardous Emissions) It mobilized support from citizen action and pressured Syntex to sign a 'good neighbor' pledge. It pledged to reduce emissions by 50 percent by the year 1994. In 1989, the Goodrich facility in Akron, Ohio promised a 70 percent reduction in air toxics following community pressure.

environmental outcomes. Together with non-governmental organizations, citizen action groups and the media, the community can elicit voluntary pledges of emission reductions from the local facilities. There is evidence even in developing countries that community characteristics can be an important determinant of environmental performance (Pargal and Wheeler, 1995).

Our research combines the Toxics Release Inventory data with demographic data from the 1990 US Census. We use neighborhood characteristics (at the zipcode level) to explain changes in toxic releases between 1990 and 1993. In contrast to other studies, we first analyze the location of manufacturing facilities in a particular neighborhood using a sample selection model. This first stage relates the likelihood that a neighborhood experiences any toxic releases to the characteristics of that neighborhood. We then attribute changes in the level of emissions between 1990 and 1993 to the demographic and socio-economic characteristics of the neighborhood in 1990. We conduct the analysis for the entire United States as well as specific geographical regions.

The analysis captures three distinct aspects of the communities to assess the role that each plays in influencing environmental outcomes. First we consider the racial, immigrant and gender characteristics of neighborhoods. The results are relevant to the 'environmental justice' literature.[3] We find some evidence of a regionalized race bias in the southeastern states (i.e., environmental "injustice"). Next we examine the relationship between economic characteristics and environmental outcomes. Economic factors (such as median income and unemployment rates) have a significant impact on changing toxic release patterns nationwide. Finally we examine variables expected to be associated with the political activity of the community and its ability to collectively oppose environmental abuses. These variables influence environmental performance outside the southeastern states. We also find that releases tend to decrease in areas with greater voter turnout in California, but this impact is not statistically significant.

2. THEORETICAL FRAMEWORK AND HYPOTHESES CONSTRUCTION

Hamilton (1995) presents a careful description of three alternative explanations for pollution patterns resulting from capacity expansion plans for commercial hazardous waste facilities, and we adopt his framework to motivate our empirical hypotheses. The three explanations are (1) pure discrimination, (2) the Coase theorem and (3) the theory of collective action (Olson, 1965). If releases change due to discrimination, then facility owners and operators consider the racial composition of neighborhoods and increase releases in neighborhoods with a greater minority (and perhaps immigrant) population. In its pure form, this discrimination leads to greater releases in some neighborhoods that otherwise (from a pure profit-maximizing standpoint) would not experience greater releases; in this sense, "owners of waste facilities trade-off profits for prejudice" (Hamilton, 1995, p. 109).

Alternatively, in a world without transaction costs the Coase theorem implies that releases will increase in neighborhoods in which the releases will do the least damage. Because the damage will depend on the economic and demographic characteristics of a neighborhood,

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[3] E.G., Anderton et al. (1994), Bryant and Mohai (1992), Bullard (1983 and 1990) and Goldman and Fritton (1994).

however, outcomes could appear discriminatory. Some of the factors that may increase the costs of increased releases in a given neighborhood are higher incomes and property values.[4] Property values and income levels are related to education and race, so releases could increase in minority neighborhoods merely because they affect lower-valued property and lower wage-earners, not because of pure discrimination. Our analysis controls for property values and income in an attempt to sort out these alternative explanations.[5]

Finally, firms may decide to increase releases in a given neighborhood because they face less (political) collective action in that neighborhood. Residents in different neighborhoods vary in their ability to overcome free-rider problems and engage in collective action. Again, this could result in outcomes that appear similar to pure discrimination if, for example, minority or immigrant neighborhoods are less politically active. To distinguish between these explanations we include some variables that are likely to affect incentives to engage in collective action (such as the fraction of households with children); and in a model based on California data only we include some direct measures of political action and environmental preferences--voter turnout and vote results on an environmental initiative.

Economically disadvantaged neighborhoods in the US often have a large fraction of minority and female headed households. This correlation for some of our explanatory variables creates a classic multicolinearity problem. This problem has the potential to cause incorrect

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[4] For example, in litigation injured parties could recover damages based on reduced property values, and in the case of adverse health impacts that limit work ability the parties could recover lost income.

[5] This is a different point than stated by Been (1994). She argues that releases in a neighborhood decrease property values, which then attract minority populations. The intent is not discriminatory even though the result seems to be.

statistical inferences regarding individual coefficient estimates. This potential arises because although individual coefficient estimates are unbiased, variance estimates are inflated due to the multicolinearity. To sidestep this problem we focus on joint tests of significance to test the three alternative hypotheses. In particular, we employ the Wald test in a series of hypothesis tests of the form H_o: $Rb=r$, where R is a matrix that creates a joint test that specific elements in the parameter vector b are all equal to zero (r is a vector of zeros). We choose three different R matrices to test each of the three explanations described above.

To summarize, these alternative theories predict that only certain variables should predict changes in toxic releases. The pure discrimination hypothesis posits the null that factors such as race and the foreign-born composition of a neighborhood do not predict release changes. Rejection of the null implies that these factors are important and supports the pure discrimination hypothesis. The economic (Coase theorem) hypothesis postulates the null that economic factors such as income levels, property values, vacancy rates, unemployment rates and the proportion of poor households do not explain changing release patterns. Rejection of this null supports what we shall refer to as the economic/Coasian explanation for changing release patterns. Lastly, the political/collective action hypothesis posits the null that variables related to the political action propensity of local residents do not predict changes in releases. In addition to voter turnout and expressed preferences through environmental initiative voting, we include variables such as age, education and the number of households with children.[6] These factors can be reasonably expected to influence the incentives and tendency to engage in political action (e.g., see Filer et al., 1993). Rejection of this null supports the hypothesis that such variables associated with the political activity of local residents influence environmental outcomes.

We focus on hypothesis tests for these three sets of variables as a group, and then also interpret the significant individual variable effects. We recognize that our classification of variables under the different hypotheses is not exact. For example, the proportion of foreign-born residents may be associated primarily with discrimination, but it may also be considered a factor that influences the extent of community activism. Our presentation of individual coefficient estimates permits the reader to assess the implications of alternative groupings.

3. DATA AND MODEL SPECIFICATION

We combine the Toxics Release Inventory with the US Bureau of the Census data and determine the relationship between the releases in a particular zipcode and demographic attributes of that zipcode. We use data for nearly 30,000 zipcodes, including all zipcodes with residential population according to the US Census.

3.1 The Toxics Release Inventory

Title III of the Superfund Amendments and Reauthorization Act (1986) requires manufacturing establishments (Standard Industrial Classification (SIC) 20-39) to report their releases and transfers of 320 toxic chemicals. The Act requires facilities that manufacture or process more than 25,000 pounds or use more than 10,000 pounds of any of the reportable

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[6] Recall the incident at Love Canal, where an elementary school was built on a toxic dump. That caused a public outcry when the chemicals started seeping from the walls and affecting children.

chemicals to submit a TRI report [EPA (1992)]. This study aggregates releases into the air, land and water, and does not analyze toxics transfers. Arora and Cason (1995) compare two methods of aggregation--one weighting all chemicals equally and another that accounts for the different toxicity of the different chemicals. Most of the volume of toxic chemicals have similar toxicity [EPA(1989)], so the results were not sensitive to the weighting scheme.[7] Therefore, here we simply aggregate the releases and employ equal weights.[8]

In addition to the environmental data, each facility reports its location, primary SIC code and parent company. We employ the zipcode of the facility location to merge these data with the Census data. Note that our measure of environmental outcomes is based on releases and not exposures. Exposures differ from releases due to the geographic dispersion of households and releases within each zipcode. We do not attempt to analyze exposures here as it would entail very elaborate mappings using the census tract and a geographical information system. Given the scope of our study (for the entire US) this exercise is prohibitively expensive. Note also that since the analysis is conducted at the zipcode rather than at the firm level, it is not possible to control for industry since multiple facilities (from multiple industries) exist in many zipcodes.

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[7] Indeed, EPA has not assigned risk scores to many of the less toxic chemicals on the TRI list, which makes differential weighting problematic.

[8] A limitation of the TRI data set is that it is self reported and so there may be an incentive to under-report the releases. There may also exist an incentive to over-report if firms expect to be rewarded for improvements relative to a baseline emission level. Nevertheless, at present it is the best available dataset that provides a comprehensive analysis of toxic release patterns for the entire US. While there is some non-reporting it appears due to ignorance and not evasion (Brehm and Hamilton, 1996).

3.2 The Census Data

The Sourcebook of Zipcode Demographics compiles the 1990 US Census separately for every residential zipcode. Table 1 summarizes the variables we employ. All variables are for 1990 unless noted otherwise. We conduct the analysis at the zipcode level. This level of aggregation is most straightforward and practical given this broad-based study of the entire US. There undoubtedly exists some spatial correlation of releases and demographic characteristics across zipcodes. Adjacent zipcodes (numerically) are often not adjacent geographically, so accounting for this correlation would require a detailed geographic information system. This is more practical for less broad studies, such as the analysis of health risks in Pennsylvania's Allegheny County conducted by Glickman and Hersh (1995).

3.3 Additional California Variables

We present results in Section 4.3 based California zipcodes, after adding two variables that that we obtained only for California--voter turnout and vote outcomes on a specific ballot proposition. These variables are intended to capture the political activity and environmental preferences of residents of different areas of the state. Unlike the other zipcode-specific demographic and economic characteristics described above, these data are provided at the county level.[9]

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[9] It would be possible, in principle, to collect voter turnout data for every state; unfortunately, such data are compiled at the state rather than federal level. The California Secretary of State also compiles voting data at different levels of aggregation--such as by Congressional district--but they are not compiled by zipcode and the county-based totals are most easily merged into the zipcode-level records we employ. We thank John Matsusaka for generously providing these voting data.

Table 1: Description of the CENSUS data

The Sourcebook of Zipcode Demographics provides data on all residential neighborhoods in the region. All variables are for 1990, in 1990 $.

Variable	Definition
FEMHEAD	Percentage of family households with a female as the head of the household
PCTFORN	Percentage of foreign born residents
PCTNONWT	Percentage of non-white residents (Black, American Indian, Asian/Pacific Islander, Other)
PCTASIAN	Percentage of residents classified as Asian/Pacific Islander
PCTNONWA	Percentage of non-white and non-Asian residents (Black, American Indian, Other)
VACANT	Percentage of housing units that are vacant. Includes housing units that were temporarily occupied at the time of the census; seasonal or recreational units, units for sale or rent, units rented or sold but not occupied, and new units not occupied.
MDINCOME	Median household income. The median has been computed from the nine intervals in the reported distribution of income.
POOR	Percentage of residents living in poverty. Poverty status is calculated in 1989. Poverty thresholds are calculated from the number of persons in the family and the number of related children under 18 years. The average threshold for a family of four in 1989 was $12,674; for two persons it was $8,076.
MEDOOHU	Median value of owner occupied housing units
UNEMP	Unemployment rate (in percent)
BACH	Percent of population (over 25 years of age) with bachelor's degree
CARPOOL	Percentage of workers sixteen years and older who journey to work by carpool
HHWKIDS	Percentage of family households with children (below 18 years of age)
MANU	Percentage of workers employed in manufacturing industries
MEDAGE	Median age of residents
RENTPCT	The percent of occupied housing units that are renter occupied. Contract rent is the monthly amount, regardless of any utilities, furnishings, or fees, that may be included. These renter-occupied units exclude single family homes on more than 10 acres and renter units that are occupied without payment of cash rent.
TOTPOP	The total number of residents in an area, where residence refers to the "usual place" where a person lives, which is not necessarily the legal residence.
PCTURB	Percentage of residents living in an urban area. Urban includes population of places with at least 2500 persons and urbanized area. Urbanized area consists of one or more places with a minimum population of 50,000 people plus adjacent area with a density of 1000 persons per square mile.

We employ voter turnout from 1990, the same year as the census data. The turnout measure is the total votes cast in the county in the 1990 general election, as a percentage of the total 1990 population in the county. Traditional measures of voter turnout use either eligible or registered voters in the denominator. We chose total population for our denominator so that our measure captures not only the political activity of the residents, but also level of enfranchisement of the population. Our version differs from traditional measures because the proportion of children, immigrants, and others ineligible to vote varies across counties. Our logic is that the political influence of a population declines if either (a) the eligible voters in that population tend to vote less often or (b) more members of that population are ineligible to vote. The measure we construct combines these two components of political activity.

The proposition we chose to represent environmental preferences is Proposition 128, popularly known as "Big Green," which was defeated in the 1990 general election. The most notable feature of the proposition was a ban on the use of pesticides that cause cancer or reproductive harm, which would have eliminated about 350 chemicals (out of about 2,300 currently in use). The initiative was also wide-ranging, including a ban on new offshore oil drilling, increased water quality standards, $300 million in bonds to buy redwoods, and a proposal to reduce greenhouse gas emissions by 40 percent. Clearly, an increase in the proportion of voters voting for proposition 128 in a region indicates more pro-environment preferences in that region.[10]

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[10] See Kahn and Matsusaka (1996) for a comprehensive analysis of voting behavior on a large sample of California environmental initiatives.

3.4 Model Specification

Our goal is to explain the changes in toxic chemical releases using the socio-economic characteristics of zipcode neighborhoods. Our dependent variable is the change in releases between 1990 and 1993.

Some research in the environmental justice literature fails to recognize that the neighborhood characteristics and environmental performance are determined simultaneously. A facility locates in an area, increasing the environmental risk and causing the land and housing values of that area to decline. Residents that choose to live in that area may either place a low value on the environment or may have a low income that limits their ability to locate in a less environmentally degraded area. Our strategy to avoid this endogeneity problem is to use 1990 demographic characteristics to explain changes in releases after 1990. Increases in releases occur from new facilities or expansion or existing facilities after 1990, so the 1990 demographic characteristics are most likely exogenous to these post-1990 firm decisions. We do acknowledge, however, that our results are still subject to some (we believe minor) endogeneity bias if residents are located in a given neighborhood in 1990 based on expectations of how releases will change after 1990.

An immediate problem that arises in constructing the dependent measure of toxic release changes is that many neighborhoods do not have any toxic chemical releases in 1990 or 1993. In particular, 72 percent of the nearly 30,000 zipcodes with demographic data experienced no toxic chemical releases according to the TRI. Simply excluding these zipcodes from our analysis would lead to a potentially significant sample selection bias, since these zero-release neighborhoods are obviously not a random sample of neighborhoods. We therefore employ a two-stage maximum likelihood sample selection model so that our estimates of the change in releases equation account for the non-random selection of the neighborhoods with any toxic chemical releases (Heckman, 1979). The first stage estimates a probit model, with the dependent variable equal to 1 if the neighborhood experienced any toxic releases in 1990 or 1993 (and 0 otherwise). The second stage estimates our main model (with the change in releases as the dependent variable), adding the estimated likelihood of any releases for that zipcode calculated from the first stage.

The second econometric issue that arises in our problem is heteroscedasticity. Zipcode boundaries are designed to facilitate the delivery of mail rather than group the population into roughly equal-sized neighborhoods; consequently, the number of residents in each zipcode varies considerably.[11] More populous zipcode neighborhoods were more likely to experience toxic releases, and our diagnostic tests (the White (1980) test for heteroscedasticity based on first and second moments) indicated that the populous zipcodes also had greater variance in levels and changes of toxic releases (Chi-square (119 d.f.)=499.6). To account for this heteroscedasticity in the estimates we assume that the standard deviation in each observation is proportional to the residential population of the zipcode neighborhood. This assumption is translated into the econometric estimation by weighting each observation by the inverse of the square root of residential population.

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[11] A number of entirely industrial or commercial zipcodes have no residents, so they have no demographic data and cannot contribute to our analysis. The most populous zipcode had 112,046 residents.

Table 2: Summary Statistics

		zipcodes with no releases	zipcodes with a decrease in releases	zipcodes with an increase in releases
		(N=21215)	(N=4726)	(N=3261)
FEMHEAD	Median	9.90	13.90	13.40
(Percentage of Female-	Mean	11.29	16.36	15.73
Headed Family Households)	Std. Dev.	6.44	9.04	8.59
PCTFORN	Median	1.00	2.20	1.70
(Percentage of Foreign-	Mean	2.94	5.37	4.32
Born Residents)	Std. Dev.	5.79	8.26	7.40
PCTNONWT	Median	2.50	7.10	6.40
(Percentage of Non-White	Mean	10.56	16.31	15.48
Residents)	Std. Dev.	18.03	20.92	20.29
VACANT	Median	11.80	7.30	7.50
(Percentage of Housing	Mean	16.32	9.21	9.53
Units that are Vacant)	Std. Dev.	13.76	7.30	7.53
MDINCOME	Median	24.06	27.02	26.53
(Median Household Income,	Mean	26.05	29.06	28.17
in Thousands)	Std. Dev.	9.66	9.91	9.21
POOR	Median	13.00	11.30	11.80
(Percentage of Residents	Mean	14.92	13.54	13.69
living in Poverty)	Std. Dev.	9.70	9.55	9.22
MEDOOHU	Median	47.50	61.77	57.62
(Median Value of Owner-Occ.	Mean	68.62	83.76	75.19
Housing Units, in Thousands)	Std. Dev.	65.30	62.20	54.69
UNEMP	Median	5.70	5.80	5.80
(Unemployment Rate in	Mean	6.74	6.63	6.53
Percent)	Std. Dev.	4.40	3.58	3.51
BACH	Median	11.10	13.60	12.70
(Percentage of Population	Mean	14.51	16.85	15.81
over 25 with Bachelors Degree)	Std. Dev.	10.92	10.82	10.21
CARPOOL	Median	14.90	13.70	13.90
(Percentage of Labor Force over	Mean	15.74	14.41	14.67
16 years old who carpool)	Std. Dev.	5.92	4.65	4.78
HHWKIDS	Median	50.00	51.20	51.30
(Percentage of Households	Mean	49.94	51.42	51.50
with Children < 18 years)	Std. Dev.	8.50	7.14	6.82
MANU	Median	15.30	20.20	20.40
(Percentage of Labor Force	Mean	16.84	21.37	21.84
in Manufacturing Industries)	Std. Dev.	10.38	9.24	9.80
MEDAGE	Median	34.70	33.50	33.50
(Median Age of Residents)	Mean	34.90	33.47	33.55
	Std. Dev.	4.94	3.72	3.80

Table 2: Summary Statistics (continued)

		zipcodes with no releases	zipcodes with a decrease in releases	zipcodes with an increase in releases
		(N=21215)	(N=4726)	(N=3261)
RENTPCT (Percentage of Residents Renting Primary Residence)	Median Mean Std. Dev.	21.30 24.62 13.80	28.80 32.54 15.57	27.40 30.70 14.19
TOTPOP (Residential Population in Thousands)	Median Mean Std. Dev.	1.63 5.04 9.15	14.31 18.20 15.35	12.22 16.58 14.41
SUMREL90 (Toxic Releases reported for 1990, in Thousands)	Median Mean Std. Dev.	0 0 0	63.91 547.48 3592.53	13.81 221.13 1744.37
SUMREL93 (Toxic Releases reported for 1993, in Thousands)	Median Mean Std. Dev.	0 0 0	14.70 278.18 2485.34	55.72 551.32 3894.86
PCTURB (Percentage of Residents living in Urban Areas)	Median Mean Std. Dev.	0.00 21.69 36.78	77.15 64.61 37.35	70.60 59.47 38.73

Note: Statistics for 134 zipcodes with no change in (positive) releases not shown.

Table 2 presents summary statistics for the analysis variables, divided into three subsamples. Column (1) presents a summary of the socio-economic characteristics of the zipcode neighborhoods with no toxic releases in either 1990 or 1993. Column (2) presents this same information for the subsample of neighborhoods that experienced a decrease in toxic releases between 1990 and 1993, and column (3) contains a summary for the neighborhoods that experienced an increase in releases over this time period. Many of these variables differ substantially across subsamples. For example, the neighborhoods that have no toxic releases in either year have a lower non-white percentage, are less urban and have more vacant housing units. The two subsamples that experience toxic releases have more in common with each other than with the no-release subsample, but they also differ in some respects. For example, neighborhoods that experienced an increase in toxic releases have a slightly lower non-white population, have a smaller percentage of residents with a Bachelor's degree, and have lower median home values. The multivariate regressions presented next attempt to isolate the marginal impact of each of these characteristics on toxic release patterns.

4. RESULTS

4.1 Full Sample Estimates

Panel A of Table 3 contains the probit sample selection parameter estimates, and Panel B of Table 3 contains the parameter estimates that explain the change in toxic releases between 1990 and 1993. Column (1) presents estimates based on all zipcodes in the United States with any residential population.

Consider first the sample section estimates in Panel A. Bear in mind that no causality should be inferred from these estimates, because the existence of toxic releases in a particular neighborhood undoubtedly influences the decision of many residents to locate in that neighborhood, and therefore partially explains its socio-economic characteristics. Nevertheless, the results of these selection equations provide useful information. The positive and significant coefficients on MANU, FEMHEAD, MDINCOME, TOTPOP and PCTURB indicate that toxic chemical releases are more likely to occur in neighborhoods in which more residents work in manufacturing industries, a greater fraction of households are headed by women, residents have higher median incomes, and are more populous and urban. Most of the other variables in the sample selection equation are significantly less than zero, indicating that increases in these characteristics are associated with reductions in the likelihood that the neighborhood experiences any toxic releases.

Table 3: Estimation Results for Entire US, Southeastern and Non-South States

Panel A: Sample Selection Equation (Dependent Variable is Any Releases)

	US		South		Non-South	
	(1) Estimate	(2) Std Error	(3) Estimate	(4) Std Error	(5) Estimate	(6) Std Error
Constant	-1.074***	(0.142)	-0.797***	(0.268)	-0.911***	(0.157)
FEMHEAD	0.041***	(0.002)	0.055***	(0.005)	0.036***	(0.002)
PCTFORN	-0.000	(0.002)	-0.026***	(0.004)	0.008***	(0.002)
PCTNONWT	-0.004***	(0.001)	-0.001	(0.001)	-0.010***	(0.001)
VACANT	-0.005***	(0.001)	-0.005**	(0.002)	-0.004***	(0.001)
MDINCOME	0.010***	(0.002)	0.005	(0.005)	0.012***	(0.002)
POOR	-0.012***	(0.002)	-0.023***	(0.004)	-0.010***	(0.002)
MEDOOHU	-0.002***	(0.000)	0.005***	(0.001)	-0.002***	(0.000)
UNEMP	-0.020***	(0.003)	-0.006	(0.007)	-0.017***	(0.004)
BACH	-0.015***	(0.001)	-0.030***	(0.003)	-0.015***	(0.002)
CARPOOL	-0.020***	(0.002)	-0.038***	(0.004)	-0.016***	(0.002)
HHWKIDS	-0.003**	(0.001)	-0.003	(0.003)	-0.006***	(0.002)
MANU	0.029***	(0.001)	0.026***	(0.002)	0.030***	(0.001)
MEDAGE	-0.017***	(0.003)	-0.018***	(0.005)	-0.022***	(0.003)
RENTPCT	0.001	(0.001)	0.000	(0.002)	0.004***	(0.001)
TOTPOP	0.042***	(0.001)	0.065***	(0.002)	0.038***	(0.001)
PCTURB	0.009***	(0.000)	0.005***	(0.001)	0.011***	(0.000)

Notes: * denotes significantly different from zero at the 10 percent level; ** denotes significantly different from zero at the 5 percent level; *** denotes significantly different from zero at the 1 percent level (all two-tailed tests).

Table 3: Estimation Results for Entire US, Southeastern and Non-South States (cont'd)

Panel B: Dependent Variable is Change in Releases in Thousands of Pounds
(Releases in 1993 - Releases in 1990)

	US		South		Non-South	
	(1) Estimate	(2) Std Error	(3) Estimate	(4) Std Error	(5) Estimate	(6) Std Error
Constant	-2294.3***	(592.72)	-5140.50	(6330.10)	77.02	(313.44)
Discrimination Variables						
FEMHEAD	16.94	(15.65)	13.36	(127.75)	-3.75	(8.03)
FEMHEDSQ	-0.62**	(0.25)	-1.16	(1.62)	0.48***	(0.13)
PCTFORN	-10.16*	(6.12)	3.15	(83.35)	-6.02**	(3.00)
PCTNONWT	-13.20**	(5.40)	-40.64	(30.58)	-0.20	(3.41)
PCTNWTSQ	0.25***	(0.06)	0.78***	(0.29)	-0.05	(0.04)
Economic Variables						
VACANT	-6.89	(4.84)	-23.09	(31.33)	-5.27**	(2.15)
MDINCOME	33.27**	(15.26)	171.55	(130.99)	-7.25	(8.21)
MEDINCSQ	-0.48**	(0.22)	-1.98	(2.38)	-0.03	(0.11)
POOR	1.01	(14.79)	-24.23	(111.10)	4.21	(6.28)
POORSQ	0.49*	(0.25)	1.92	(1.59)	-0.45***	(0.12)
MEDOOHU	-0.40	(1.19)	-1.30	(15.92)	-1.36*	(0.58)
UNEMP	25.81	(24.00)	218.08	(179.41)	3.68	(13.21)
UNEMPSQ	-2.77***	(0.83)	-15.20**	(6.54)	-0.18	(0.59)
Political/Collective Action Variables						
BACH	-3.20	(4.86)	10.28	(43.66)	-6.27**	(2.75)
CARPOOL	25.31	(25.57)	118.04	(183.62)	-0.78	(10.61)
CARPOLSQ	-0.65	(0.62)	-2.64	(4.46)	-0.27	(0.24)
HHWKIDS	21.01	(16.77)	44.69	(169.73)	-6.23	(7.56)
HHWKIDSQ	-0.75***	(0.17)	-0.58	(1.65)	-0.27***	(0.08)
MANU	2.29	(3.74)	-17.75	(34.47)	2.17	(1.73)
MEDAGE	9.58	(10.24)	13.19	(82.09)	-0.22	(5.28)
RENTPCT	3.68	(3.47)	15.42	(31.52)	-0.46	(1.73)
Control Variables						
TOTPOP	6.62**	(2.81)	-5.50	(32.27)	6.98***	(1.39)
SUMREL90	-0.14***	(0.00)	0.07***	(0.01)	-0.49	(0.00)
PCTURB	-2.71	(2.84)	-10.19	(20.74)	1.86	(1.47)
PCTURBSQ	0.17***	(0.03)	0.01	(0.20)	0.10***	(0.01)
Number of Observations		29332		6691		22461
Estimated Log Likelihood		-89987.5		-23336.7		-63907.1

Notes: * denotes significantly different from zero at the 10 percent level; ** denotes significantly different from zero at the 5 percent level; *** denotes significantly different from zero at the 1 percent level (all two-tailed tests).

Consider next the parameter estimates in Panel B, in which we use the demographic characteristics in 1990 to explain changes in toxic releases between 1990 and 1993. Due to differences in state regulations as well as other differences due to economic conditions, changes in releases could differ across states. We therefore include 49 state dummy variables, but suppress them in the tables to conserve space. The omitted dummy variable is for the most populous state (California). The constant term in Panel B indicates that releases fall on average (controlling for the demographic variables).[12] Forty-six of the 49 state dummy variables are not significantly different from zero (at the 5-percent level), indicating that this substantial reduction in releases in the early 1990s is widespread.[13] The marginal impacts of the demographic characteristics discussed below are relative to this overall decline in releases captured by the constant term.

We have no theory that suggests only a linear relationship between any of our explanatory variables and release changes, and some case studies (Bullard, 1983; GAO, 1983) have found negative environmental outcomes when certain factors (such as the non-white population) are very high in the local population. For these reasons we include squared terms for many of the variables. [Preliminary estimates indicated that no significant non-linear relationships for certain variables, so we report results in Table 3 without squared terms for those variables.]

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[12] Recall that we employ weights in the model estimation to account for heteroscedasticity. The coefficient estimates in Table 3 are not marginal effects, and must be adjusted for the heteroscedasticity weighting. This adjustment of the constant term in column (1) of Panel B leads to a predicted reduction in releases of about 27 thousand pounds, which as expected is near the 26 thousand pound average reduction in releases for zipcodes with positive releases. In the entire US, toxic releases declined by over 250 million pounds between 1990 and 1993.

[13] The three significant state dummy variables are for Kansas (estimate=-405), Utah (-1066) and Louisiana (1358). The positive state dummy for Louisiana is less than the negative constant term (in absolute value), so our estimates indicate that releases fall on average (controlling for demographics) in every state.

Table 4: Wald Tests of Three Primary Hypotheses

Null Hypothesis: All variables in each group are jointly equal to zero

	Geographic Areas			
Variable Group	US (1)	South (2)	Non-South (3)	California (4)
Discrimination (5 variables)	29.14*** (<0.001)	9.52* (0.090)	46.69*** (<0.001)	1.50 (0.982)
Economic (8 variables)	38.07*** (<0.001)	20.51*** (0.009)	69.14*** (<0.001)	5.68 (0.683)
Political/Collective Action (8 variables)	177.4*** (<0.001)	1.41 (0.994)	250.7*** (<0.001)	20.48** (0.025)

Notes: All test statistics are distributed as Chi-Squared under the null hypothesis (degrees of freedom equal to the number of variables indicated for each variable group). * denotes that null hypothesis is rejected at 10 percent; ** denotes that null hypothesis is rejected at 5 percent; *** denotes that null hypothesis is rejected at 1 percent. The number of restrictions for the California model (column 4) is 7 for discrimination, 8 for economic and 10 for political/collective action.

Table 4 presents the results of Wald tests for the hypotheses that our three classes of variables are each jointly insignificant. Tests based on the entire US dataset are shown in column (1). [We discuss the other columns after presenting the regional estimates.] The data reject all three null hypotheses that each of the three classes of variables do not influence toxic releases. The strongest result is for the set of political action variables. We next consider the individual coefficient estimates in Panel B of Table 3.

The impact on release changes of the variables with quadratic specifications depends on the level of the variables. Figure 1 illustrates the estimated impact for these quadratic-specified variables to aid in their economic interpretation. In all cases the figure only displays the estimated impact for the range of the explanatory variable between the first and 99th percentile in the data; e.g., we only display the impact of POOR below 50 percent, because the 99th percentile (across zipcodes) of the percentage of residents living in poverty is approximately 50.

Consider first the discrimination variables. Figure 1 shows that releases increase slightly and then decrease in neighborhoods with a greater percentage of female-headed households. Releases decrease modestly in neighborhoods with a greater non-white population until the non-white population exceeds about 55 percent.

Many of the economic variables also impact releases. Figure 1 shows that neighborhoods with a median household income below about $65,000 experience an increase in releases. More wealthy neighborhoods (above the 99th percentile, and therefore not shown in the figure) experience a decline in releases. Neighborhoods with a greater percentage of residents living in poverty experience an increase in releases, and this increase is greater as the poverty rate rises. Neighborhoods with high unemployment (above about 10 percent) experience a decrease in releases.

Finally, consider the variables that we expect to capture the political action propensity of local residents. Figure 1 illustrates that the estimated impact of more children in the neighborhood is negative and quite large in magnitude. According to our point estimates, releases fall by roughly 10,000 pounds or more in neighborhoods in which more than one-half of the households have children. This reduction is *in addition to* the average 27,000 pound reduction captured in the constant term.

4.2 Southeastern US Estimates

The remaining columns of Table 3 present estimation results when segmenting the US into two regions. The estimates shown in column (3) are for 11 southeastern states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Virginia), and the estimates shown in column (5) are for the remaining 39 states. We were motivated to segment the US along these lines because historically racial discrimination was more pronounced in the south.

Many parameter estimates differ in the two regions. The differences in the discrimination variables are relevant for the environmental justice conclusions. In the South, the non-white population percentage significantly affects changes in releases, while this variable is insignificant outside the South. Figure 2 illustrates that our model estimates for the South imply a substantial increase in releases for those neighborhoods with a large non-white population. In neighborhoods in which the non-white population exceeds about 70 percent, releases are estimated to increase by more than 10,000 pounds. The negative (but statistically insignificant) constant term in this South estimate implies an average reduction in releases of about 60,000 pounds per zipcode (after adjusting the parameter estimate for the weighting). This suggests that even neighborhoods with a substantial non-white population experience an overall decline in releases on average over this time period. The decline is greater, however, in neighborhoods with a lower non-white population.

The Wald tests shown in columns (2) and (3) of Table 4 indicate that the data reject the null hypothesis that the discrimination variables do not affect changes in releases, although only at the 9-percent level for the South. We cannot reject the hypothesis that the set of political/collective action variables do not affect changes in releases for the South. As shown in column (3) of Table 3 (Panel B), outside the South both the percentage of female-headed households and foreign-born residents affect changes in releases. Contrary to an implication of environmental discrimination, neighborhoods with more immigrants experience a decline in

releases. There is some evidence that releases increase in neighborhoods with more female-headed households, but the magnitude of this increase is small. Even when the percentage of female-headed households reaches 40 percent (which is approximately the 98th percentile), releases are predicted to increase by only about 7,000 pounds.

4.3 California Estimates

The remaining results are based on the subsample of California zipcodes and are shown in Table 5. This specification differs from the estimates in Table 3 in two main ways. First, we specify the racial variables slightly differently in a more refined analysis of possible discrimination. As mentioned above, the correlation between the percentage of non-white residents and certain economic variables is substantial. For example, in the overall sample, the correlation coefficient between the percentage of non-white residents and the percentage of households living in poverty is 0.46. This colinearity makes it difficult to identify significant marginal impacts for these variables individually. Fortunately, the data indicate that one minority group does not have this high correlation with economic characteristics: Asians. Unfortunately for our purposes, the percentage of Asian residents nationally is quite small, averaging 1.2 percent across zipcodes. This makes identifying an independent impact for this racial group unlikely based on the entire US sample.

However, the percentage of Asian residents is significantly greater in more racially-diverse California, averaging 6.4 percent across zipcodes. This percentage also varies substantially across zipcodes in California and is uncorrelated with the percentage of residents living in poverty (the estimated correlation coefficient is -0.01). Therefore, the California specification in Table 5 separates the non-white population percentage into two categories: percent Asian and percent non-white and non-Asian. The results indicate whether an Asian discrimination effect is evident in the release data, and due to the nature of the data this effect is orthogonal to our poverty measures.

Table 5: Estimation Results for California

Panel A: Sample Selection Equation (Dependent Variable is Any Releases)

	Estimate	Std. Error
Constant	-0.051	(1.132)
FEMHEAD	-0.009	(0.025)
PCTFORN	0.003	(0.012)
PCTASIAN	0.001	(0.013)
PCTNONWA	-0.001	(0.009)
VACANT	-0.019	(0.027)
MDINCOME	-0.002	(0.014)
POOR	0.007	(0.027)
MEDOOHU	0.000	(0.002)
UNEMP	-0.011	(0.042)
BACH	-0.010	(0.015)
CARPOOL	-0.015	(0.026)
HHWKIDS	0.003	(0.010)
MANU	0.023*	(0.013)
MEDAGE	-0.032	(0.029)
RENTPCT	-0.001	(0.008)
TURN90	-0.009	(0.014)
PCT4_128	-0.003	(0.014)
TOTPOP	0.015**	(0.006)
PCTURB	0.007	(0.005)

Notes: * denotes significantly different from zero at the 10 percent level; ** denotes significantly different from zero at the 5 percent level; *** denotes significantly different from zero at the 1 percent level (all two-tailed tests).

Table 5: Estimation Results for California (continued)

Panel B: Dependent Variable is Change in Releases in Thousands of Pounds (Releases in 1993 - Releases in 1990)

	Estimate	Std Error
Constant	153.390	(2546.60)
Discrimination	Variables	
FEMHEAD	-47.087	(77.85)
FEMHEDSQ	0.558	(1.61)
PCTFORN	-5.722	(22.32)
PCTASIAN	-14.379	(61.49)
PCTASQ	0.434	(1.65)
PCTNONWA	-9.763	(30.44)
PCTNWASQ	0.041	(0.35)
Economic	Variables	
VACANT	-36.25**	(16.16)
MDINCOME	-6.782	(70.00)
MEDINCSQ	0.066	(0.83)
POOR	44.906	(68.09)
POORSQ	-0.849	(1.45)
MEDOOHU	-0.254	(2.71)
UNEMP	-47.876	(141.57)
UNEMPSQ	1.834	(5.46)
Political/Collective	Action Variables	
BACH	-24.718	(17.81)
CARPOOL	-38.189	(66.96)
CARPOLSQ	0.052	(1.23)
HHWKIDS	14.581	(78.36)
HHWKIDSQ	-0.035	(0.79)
MANU	42.335**	(20.16)
MEDAGE	-55.323*	(33.44)
RENTPCT	3.210	(14.75)
TURN90	-24.122	(20.37)
PCT4_128	1.457	(16.59)
Control	Variables	
TOTPOP	22.026**	(9.99)
SUMREL90	-0.861***	(0.10)
PCTURB	-2.442	(14.31)
PCTURBSQ	0.156	(0.15)
Number of Observations		1501
Estimated Log Likelihood		-4546.89

Notes: * denotes significantly different from zero at the 10 percent level; ** denotes significantly different from zero at the 5 percent level; *** denotes significantly different from zero at the 1 percent level (all two-tailed tests).

The second difference in the California estimates is the addition of two new variables: voter turnout (TURN90) and voting outcomes on Proposition 128 (PCT4_128), a wide-ranging initiative to improve environmental conditions. Voter turnout (defined as the percentage of residents that cast votes in the 1990 general election) ranged from 15 to 42 percent, with a mean of 28 and a median of 27 percent. The percentage of residents voting in favor of Proposition 128 ranged from 12 to 62 percent, with a mean of 33 and a median of 32 percent. As discussed above, these variables capture the political activity and environmental preferences of local residents.

In contrast to the earlier estimates, most of the variables in this model based only on California are insignificant. This is probably due in part to the substantially smaller sample size compared to the estimates shown in Table 3. The key results from the California model in Table 5 are the following. First, the percentage of Asian residents as well as all other discrimination variables do not explain changes in releases. Second, increased voter turnout has a negative impact on releases, although this variable does not achieve significance at conventional levels (the one-tailed p-value is 0.12). Third, vote outcomes on proposition 128 do not have a significant impact on release changes. The Wald tests based on California (column (4) of Table 4) indicate, however, that the political variables as a group affect changes in releases, while the discrimination and economic variables are jointly insignificant.

5. SUMMARY

This paper presents an analysis of the relationship between environmental performance and neighborhood characteristics throughout the entire United States. We conduct regional regressions within the United States to capture the differences in the geographic areas. It uses the change in toxic chemical releases between 1990 and 1993 as the measure of environmental performance, based on the Toxics Release Inventory. The 1990 US Census provides the data on neighborhood characteristics, and the analysis is conducted at the zipcode level. The goal is to distinguish between three alternative explanations for differences in environmental performance--pure discrimination, an economic (Coasian) explanation, and an explanation based on political/collective action.

We are unable to reject any explanation outright, and the results highlight important differences across regions. Outside the Southeastern US, variables that are likely to affect incentives and propensity to engage in political action significantly influence environmental performance. Release changes in the South exhibit a pattern consistent with racial discrimination, and this pattern is not observed outside the South. In all estimates except the (smaller sample size) California model, economic variables significantly impact releases. The estimates based on the entire US indicate that releases decline in neighborhoods with very wealthy residents, as well as in neighborhoods with high unemployment. Releases increase in neighborhoods with a high poverty rate, which could be interpreted as economic ("class") discrimination. Finally, our California sample estimates provide some weak evidence that releases tend to decline in areas with greater voter turnout.

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