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'Optimal' Pollution Abatement   Whose Benefits Matter, and How Much?

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ABSTRACT

In this paper we consider the allocation of environmental regulatory activity across U.S. pulp and paper mills, and the resulting levels of air and water pollution from those mills. Many different factors are included in our tests of five different economic theories: "Benefits", "Coase Theorem", "Environmental Justice", "Collective Action", and "Transboundary Externality." We test these five, non-mutually exclusive, theories using a plant-level panel data set on approximately 300 pulp and paper mills from 1985-1997.

We find some support for most of these theories. Plants with larger benefits from pollution reduction emit less pollution, as do plants located in areas with high poverty rates or low housing values, and plants near state boundaries. Many of these variables are also associated with greater regulatory activity being directed towards the plant. Of the theories tested, the least support is found for Collective Action, while the nonwhite population has effects opposite to those predicted by Environmental Justice. Some of the differences in results across models suggest further research questions: e.g. plants near the Canadian border seem to face both significantly more air pollution regulation and significantly less water pollution regulation.

'Optimal' Pollution Abatement – Whose Benefits Matter, and How Much?

1. INTRODUCTION

In this paper we examine the optimal allocation of environmental regulation across pulp and paper mills. The optimal allocation depends on the costs and benefits of pollution abatement at the plant. The costs are related to the plant's age, size, and technology, while the benefits are related to the extent of the pollution being generated and the number of people affected. Past studies comparing benefits and costs have focused on fairly simple measures of abatement benefits. In this study we develop more sophisticated measures of air and water benefits from pollution abatement based on the SLIM-3 Air Dispersion Model and the Environmental Protection Agency's (EPA) National Water Pollution Control Assessment Model (NWPCAM) respectively. Clearly it is socially optimal for regulators to impose stricter regulation on plants located in areas with greater benefits from pollution abatement. However, we consider other factors, less associated with social optimality, that may influence the allocation of pollution abatement as well. The focus of our paper is on spatial differences across plants in the distribution of benefits from pollution abatement and the characteristics of the population living near the polluter. Responding to some of these population measures may be associated with socially optimum behavior, if certain population groups are more sensitive to pollution, but in most cases these measures suggest self-interested behavior by regulators, which may be socially sub-optimal.

To determine whether or not regulatory decisions are influenced by factors that could cause them to be optimal and/or sub-optimal we test five different theories of the allocation of pollution regulation: "Benefits"; "Coase Theorem"; "Environmental Justice"; "Collective Action"; and

"Transboundary Externality." The Benefits model in its simplest form implies that in a social optimum we should find higher levels of regulation in areas where there are greater benefits from pollution abatement. In addition to the number of people affected, an optimal regulator should consider different groups of people that may be more sensitive to pollution: for air pollution this would include the elderly, young, and high school dropouts. The Coase Theorem implies that plants should face more stringent regulation where people are more willing to pay for environmental quality. Environmental Justice predicts that plants will pollute more and regulators will be less stringent in areas with disproportionately more poor and minorities. Collective Action states that plants in communities with more political clout or better political organization will face stricter environmental regulation. Finally, the Transboundary Externality hypothesis states that plants located near political boundaries will face less regulation, since at least part of their pollution is exported to the neighboring community.

We test these five non-mutually-exclusive theories using a plant-level panel data set on approximately 300 pulp and paper mills from 1985-1997. There is substantial evidence in favor of some aspects of the Benefits, Coase Theorem, Environmental Justice, and Transboundary Externality theories, in terms of their predictions about the coefficients that would be obtained for specific variables. Plants with larger benefits to the overall population emit less water pollution, and those with more kids and elders nearby emit less air pollution. Plants located in high housing value neighborhoods get more regulatory attention and emit less pollution, while plants located in poor neighborhoods get less regulatory attention and emit more pollution. Plants located near state boundaries get less regulatory attention and emit more pollution, with these effects reduced if the nearby states have greater regulatory stringency.

Not every result fits those predicted by the models. The Benefits model gets the wrong sign for the benefits of air pollution cleanup to the overall population. The percentage nonwhite near the plant, expected to reduce regulatory attention in the Environmental Justice model, is actually associated with more regulatory activity and lower emissions. The Collective Action model finds little support, with higher voter turnout associated with less regulatory stringency for water pollution. In addition, the expected reinforcement from an interaction of voter turnout with conservation membership goes in the wrong direction for both air and water pollution.

On the positive side, some of the differences in results for different regulatory measures pose interesting research questions. There is a frequent pattern of unexpected signs for water pollution regulation, where factors associated with fewer regulatory actions tend to be associated with less, not more, pollution. We would have expected opposite signs on these coefficients, and found opposite signs for air pollution. Is this an artifact of the data, or does it represent a real difference in the process by which regulatory activity is allocated in different media? Similarly, do the different effects on air and water pollution of being near the Canadian border reflect real differences across pollution media in the mechanisms for ensuring international cooperation on pollution control?

The remainder of the paper is organized as follows. Section 2 provides a brief survey of the relevant literature. In section 3 we provide some background on the pulp and paper industry. Section 4 outlines the five models of the distribution of pollution abatement. In section 5 we present our empirical methodology and a description of our data. Section 6 contains our results and finally we present some concluding remarks and possible extensions in section 7.

2. PREVIOUS STUDIES

A few studies have addressed the issues raised above, providing empirical estimates of the impact of political boundaries, demographics, and political activism on exposure to pollution. For example, Helland and Whitford (2001), using annual county-level data from the Toxic Release Inventory (1987-1996), find that facilities located in counties on state borders (border counties) have systematically higher air and water pollution releases than facilities located in non-border counties: facilities in border counties emit 18 percent more air pollution and 10 percent more water pollution than facilities in non-border counties. Kahn (1999) also finds some evidence of a transboundary externality problem with particulates. Kreisel et al (1996) find that minorities are not disproportionately exposed to TRI emissions, but find some evidence that the poor are disproportionately exposed to TRI emissions. Arora and Cason (1999) find evidence of racial injustice only in the south. In particular, Arora and Cason find that race is a significantly positive determinant of TRI releases in non-urban areas of the south.

Hamilton (1993, 1995) examines whether exposure to environmental risk varies by demographics and political activism. Using data at the 'zip-code neighborhood level,' he relates the capacity expansion/contraction decisions of commercial hazardous waste facilities to race, income, education, and level of political activity (voter turnout), finding that capacity expansions are negatively correlated with voter turnout. Jenkins, Maguire, and Morgan (2002) show that minority communities receive lower 'host' fees for the siting of land fills while richer communities receive higher 'host' fees. Wolverton (2002) examines the issue of the location decision of 'polluting' plants. Previous studies indicate that 'polluting' plants tend to locate in poor and minority neighborhoods. However, Wolverton shows that once you consider the characteristics of the community at the time the plant is sited that contrary to popular opinion race no longer matters and that poor neighborhoods actually attract disproportionately *less* 'polluting' plants.

3. PULP AND PAPER INDUSTRY BACKGROUND

During the past 30 years environmental regulation has increased considerably both in terms of stringency and levels of enforcement. In the late 1960s environmental rules were primarily enacted at the state level, and were not vigorously enforced. Since the creation of the Environmental Protection Agency (EPA) in the early 1970's the federal government has been the lead player in proposing and developing stricter regulations, and in encouraging greater emphasis on enforcement (much of which is still performed by state agencies, following federal guidelines). The expansion in environmental regulation has imposed large costs on traditional 'smokestack' industries, like the pulp and paper industry, which is one of the most impacted industries due to its sizable generation of both air and water pollution.

The pulp and paper industry as a whole faces a high degree of environmental regulation. However, plants within the industry can face very different impacts from regulation, depending in part on the technology being used (pulp and integrated mills vs. non-integrated mills[1]), the plant's age, the plant's location, and the level of regulatory effort directed at the plant. The most important determinant of the regulatory impact is whether or not the plant contains a pulping process. Pulp mills begin with raw wood (chips or entire trees) and use a variety of techniques to separate out the wood fibers, which are then used to produce paper. The most common form of pulping in the U.S. is the Kraft technique, which separates the wood into fibers using chemicals. A large number of plants also use mechanical pulping (giant grinders separating out the fibers), while still others use some combination of heat, other chemicals, and mechanical methods. Once the fibers are separated out, they can be bleached and combined with water to produce a slurry. After the pulping stage is complete, residual matter remains which historically was released directly into rivers (hence water pollution), but now must first be treated. The pulping process is energy intensive, so most pulp mills have their own power plant, and thus are significant sources of air pollution. The pulping processes may also involve hazardous chemicals, such as the use of chlorine bleaching in Kraft pulp mills, which can create trace amounts of dioxin, raising the concern over toxic releases.

The paper-making process is not nearly as pollution intensive as pulping. Non-integrated mills either purchase pulp from other mills or use recycled wastepaper. During the paper-making process, the slurry (more than 90% water at the beginning) is laid on a rapidly-moving wire mesh which progresses through a succession of dryers in order to remove the water, thereby creating a continuous sheet of paper. The energy required during this stage is less than during the pulping stage, but it can still cause air pollution concerns if the mill produces its own power. Finally, during the drying process some residual water pollution is created. However, both of these pollution concerns are much smaller than those created during the pulping process.

The past 30 years has seen large reductions in pollution from the paper industry, with the advent of secondary wastewater treatment, electrostatic precipitators, and scrubbers. In addition to these end-of-pipe control technologies, some mills have altered their production process, more closely monitoring material flows to lower emissions. Overall these alterations have been much more prevalent at newer plants, which were at least partly designed with pollution controls in mind – some old pulp mills were deliberately built on top of the river, so that any spills or leaks could flow through holes in the floor for 'easy disposal.' These rigidities can be partially or completely offset by the tendency for most regulations to include grandfather clauses exempting existing plants from the most stringent requirements – e.g. until recent standards limiting NOx emissions, most small existing boilers were exempt from air pollution regulations.

[1] Integrated mills produce their own pulp and non-integrated mills purchase pulp or use recycled wastepaper.

4. FIVE MODELS OF POLLUTION ABATEMENT REGULATION

Why do profit-maximizing plants employ resources to abate pollution emissions? If pollution were a pure externality, with all of the burden falling on those who live downwind or downstream, we would not expect to see any profit-maximizing plant spend money on pollution abatement. Some market-based mechanisms like consumer demand for 'green' products or managerial taste for 'good

ntives for plants to abate pollution. However, we believe that the main motivation for controlling pollution emissions in the U.S. is government regulation of pollution, especially for the air and water pollutants being considered in this paper.

A socially optimal government regulator maximizes social welfare by increasing the stringency of environmental regulation (requiring greater pollution abatement) up to the point where the marginal benefit from another unit of abatement is equal to the marginal cost of that abatement. The marginal cost of abatement may differ across plants based on their production technology, size, and age. In this paper we focus on the possibility of differences in the marginal benefits of pollution abatement across plants, driven especially by the number (and characteristics) of the people near the plant who are being exposed to the pollution. Assuming that the marginal cost of pollution abatement increases with stringency (or at least cuts the marginal benefit curve from below), an increase in the marginal benefits curve will result in an increase in the desired level of pollution abatement, and hence be associated with more stringent environmental regulation.

Our study examines five different economic models of the allocation of pollution regulation, differing according to what factors are treated as benefits by the regulator. Our first model, the Benefits theory, assumes that regulators pursue social optimality and impose stricter regulation where there are greater health benefits from pollution abatement. In its simplest form this would treat all affected people equally, so that the goal is to reduce aggregate population exposure. However, different subgroups of the population might be especially sensitive to a particular pollutant. For example, studies suggest that air pollution in the form of particulates (by far the largest source of estimated dollar benefits from pollution abatement), has a greater mortality impact on the elderly and on high-school dropouts. Children may also receive greater attention, since they have more years of remaining life to be influenced by any health effects. Given this, an optimal regulator should choose to impose stricter regulations on an air polluter with an unusually high concentration of elderly residents, children, or high-school dropouts nearby. Thus, the Benefits theory suggests including a measure of the impact of pollution on the overall population, along with measures of any subpopulation expected to be especially vulnerable. For water pollution our effects are more based on usage values rather than health effects, so we will not use population characteristics in the water models.

Our other four models are Coase Theorem, Environmental Justice, Collective Action, and Transboundary Externality. These models are derived from a richer picture of the regulatory process, stressing self-interested behavior on the parts of polluters and regulators. Polluters may take into account the reaction of the population to pollution, avoiding areas where opposition is the greatest. Regulators may direct their activity to maximize the political support for their actions, rather than simply maximizing social benefits. The first three models were used by Hamilton (1995) as possible explanations of the expansion decisions of hazardous waste facilities.

According to the Coase Theorem model, firms locate plants where any pollution externality does the least damage, because that is where the firm's need to compensate the residents for pollution damages will be the lowest. In other words, polluting firms will choose to locate their plants where residents have the lowest willingness to pay for environmental quality. Likewise regulators will choose to regulate less in those areas, since residents there are less likely (or able) to complain about pollution levels. Note that if we treat willingness (and ability) to pay as the appropriate measure of the cost of pollution, the Coase model could also be viewed as socially optimum. The Coase Theorem model suggests including socio-economic characteristics such as poverty rates and property values to identify the benefits from pollution cleanup near the plant, with greater regulation at plants in areas with lower poverty rates and/or higher property values.

The Collective Action model focuses on transactions costs. Given positive transactions costs between firms and people, the compensation demands in the Coase Theorem need to be worked out through a political process. Olson (1965) argues that the classic 'free-rider' problem often limits the ability of individuals with shared goals to coordinate their efforts to achieve those goals. Furthermore, different groups of people vary in their ability and/or willingness to overcome the 'free-rider' problem and thereby take part in the political process. Thus compensation demands are impacted by two things: 1) the willingness to pay for environmental quality and 2) the ability/willingness to voice that willingness to pay through the political process. Therefore, the Collective Action model predicts that plants in communities with more political clout or better political organization will face stricter environmental regulation.

The literature on Environmental Justice asserts that the poor and minorities are disproportionately exposed to pollution. The Environmental Justice explanation is that plants and regulators prefer to discriminate against minorities and the poor, expending little or no effort on their behalf, similar to employer discrimination models in the labor market. There is little systematic evidence to validate this theory. Nevertheless we will take the Environmental Justice literature at face value and predict that plants will pollute more and regulators will be less stringent in communities with a greater percentage of poor and minority populations.

Finally, the characteristics of the surrounding population also matter in the Transboundary

Externality model, where politically optimizing regulators put little or no weight on the impact of pollution on people who are not part of their political jurisdiction. Given that some plants are located near borders while others are located in the interior of jurisdictions, we might expect to see greater regulatory pressures directed towards the interior plants. There might also be a tendency for regulators to encourage new polluting plants to locate closer to the border. The Transboundary Externality hypothesis predicts that plants located near political boundaries will face less regulation, since at least part of their pollution is exported to the neighboring jurisdiction or jurisdictions.

However, some countervailing pressures may arise, reducing this boundary effect. In the case of Canada two agreements exist which strive to limit the levels of transboundary pollution: 1) Canada-United States Great Lakes Water Quality Agreement (GLWQA) of 1972 and 2) Canada-United States Air Quality Agreement (AQA) of 1991.[2] The GLWQA establishes that the U.S. and Canada will act to restore and preserve the chemical, physical and biological soundness of the Great Lakes Basin Ecosystem and it contains a number of goals and guidelines to reach those goals. The AQA is the first bilateral pact between the U.S. and Canada aimed at controlling transboundary air pollution caused by sulphur dioxide and nitrogen oxide emissions.[3] Given these two agreements it is not unreasonable to expect that plants along the Canadian border will face more stringent (or at least no less stringent) environmental regulation.

Similarly, the creation of a federal EPA in 1972 was at least in part designed to limit cross-state pollution flows, and EPA oversight of state regulatory decisions may be stricter for plants near state boundaries. In addition to a dummy for a plant being located near the border with another state or Canada, we include a measure of the regulatory stringency of the neighboring state, since that might serve as a proxy for the intensity of that state's objections to any transboundary pollution.

[2] A memorandum of intent has been in place since 1981.
[3] For more information on both of these agreements see the web site (http://www.ijc.org/ijcweb-e.html) of the

5. DATA AND EMPIRICAL METHODOLOGY

Our study measures the relationship between regulatory activity and emissions, and characteristics of the surrounding population, using data on the intensity of environmental regulation faced by U.S. pulp and paper mills. We use data on both air and water pollution, to measure the enforcement and monitoring activity directed towards each mill, along with the relative stringency of the pollution limits faced by the mill. To measure actual outcomes from regulation at the mill we use data on both air and water pollution emissions at the mill. Our analysis controls for a variety of plant- and firm-specific characteristics, as well as the past compliance status of the mill. We also include a number of other control variables designed to capture characteristics of the location of the mill that could influence the level of regulatory activity.

We use models of the spread of pollution downwind and downstream to estimate the relative impacts of the pollution on people living near the plant. On the air pollution side, the modeling utilizes an air dispersion model, SLIM-3, which calculates the total impacts of pollution on the surrounding population separately at each plant. The air dispersion model incorporates information from the pollution source (stack height and characteristics of the pollutants being emitted) and meteorological data (mixing height, wind directions and speeds) to calculate the aggregate exposure at all points within a wide circle around the plant. The exposure data is combined with measures of the number of people living near the plant and estimates from the literature on the health impact of pollutant exposures to quantify the overall dollar benefits from reducing air pollution at each plant [see Shadbegian et al. (2000) for more details].

On the water pollution side we use data from the EPA's National Water Pollution Control

International Joint Commission which was created by the International Boundary Waters Treaty Act of 1909.

Assessment Model (NWPCAM). This model includes discharge data for over 50,000 industrial and 13,000 municipal water polluters, combined with stream and river flow data to calculate the transport of pollutants downstream and the resulting water quality on a mile-by-mile basis for every affected stream. Of the paper mills in our dataset, 182 have data present in the NWPCAM model. For each of these mills, we first calculate a baseline model using current discharges and store the water quality results. We then estimate 10 scenario models, increasing the discharges from the mill by a wide range of amounts. Water quality is measured in NWPCAM using the traditional water quality ladder: unusable, boatable, fishable, and swimmable. Changes in water quality in each stream mile are evaluated in dollar terms using the benefits measured in Carson and Mitchell (1993), then combined with state population and river miles to estimate the total dollar costs (in terms of diminished usability) for each scenario. These costs are divided by the amount of additional pollution being discharged in that scenario, giving a per-unit cost of pollution. The largest per-unit value from the 10 scenarios is used to estimate the marginal benefits of pollution abatement at that mill.

Detailed data on the characteristics of the population within a 50-mile radius of each plant, such as age distribution, racial composition, or within-jurisdiction residency, are based on the 1990 U.S. Census of Population, as compiled in the Census-CD datasets prepared by Geolytics, Inc. This provides information based on detailed geographic areas (block groups). Distances are calculated between the paper mill and the centroid of each block group to determine which block groups fall within 50 miles of the mill, and the block group values for each population characteristic are aggregated to get the overall value for each mill.

In past studies we developed a comprehensive database of U.S. pulp and paper mills to study the impact of environmental regulation on plant-level productivity and investment. This database includes annual plant-level Census data from the Longitudinal Research Database (LRD) and published plant-level data from the Lockwood Directory and other industry sources to identify each plant's production, investment, productivity, age, production technology, and corporate ownership. We add firm-level financial data taken from Compustat, identifying firm profitability. (At the time of this writing we have not completed analyzing the results using the confidential Census data in the LRD datasets, but we anticipate having those results completed soon, at which point we will prepare them for Census disclosure review - they will be incorporated in a later draft of this paper).

Our comprehensive pulp and paper mill data set is merged with annual plant-level information on regulatory enforcement, compliance, and quantities of pollution, for both air and water pollution, taken from EPA regulatory databases. Regulatory enforcement and compliance data for 1985-1997 come from the Envirofacts and Integrated Data for Enforcement Analysis databases, as do the water pollution discharges data for Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS). These datasets allow us to differentiate between two different types of regulatory actions – enforcement actions (e.g. notice of violation) vs. regulator inspections. Air pollution emissions data comes from the Aerometric Information Retrieval System database for 1985-1990 and from the National Emissions Inventory for 1990-1997, for both particulates (PM10) and sulfur dioxide (SO2).

We estimate the following equation to test our five models of the allocation of pollution abatement regulation:

Y= f(BENEFITS, COASE, JUSTICE, COLLECTIVE, TRANSBOUNDARY, Control Vars)

where Y is one of the eight dependent variables in our analysis: Air and Water Pollution Inspections and Enforcement, Water Discharges of BOD and TSS, and Air Emissions of PM10 and SO2. The expectation is that increased regulatory activity will be seen directly in larger numbers of inspections and enforcement actions, and indirectly (by increasing firms' incentives for pollution abatement) in smaller water pollution discharges and air pollution emissions. Thus we would anticipate seeing opposite signs for coefficients in the regulatory activity and pollution quantity equations. We test each theory in turn for all of the dependent variables.

First, let us review the plant-, firm-, state-, and county-level control variables included in each model. These controls include lagged compliance status, plant capacity, plant age, firm financial condition, county attainment status (air only), major source and public health effects (water only), and state environmental attitudes. All the results presented here include state dummies, but the models without state dummies tend to lead to similar conclusions (results available from authors upon request). To avoid having the state dummies absorb too much of the cross-plant variation, we only include state dummies for states with 5 or more plants in the given regression (e.g. the air pollution inspection model includes 22 state dummies, with the base group being all other non-specified states).

In terms of plant-level controls we include a lagged measure of regulatory compliance (COMPLAG). Previous research has shown a strong relationship between compliance and enforcement [Magat and Viscusi (1990); Deily and Gray (1991); Nadeau (1997); and Gray and Shadbegian (2000)]. We also include pulp and paper capacity (PULP/PAPER CAPACITY) to control for plant size, a dummy variable to indicate if the plant was established after 1960 (NEW PLANT), and a dummy variable to indicate if the plant is the only paper or pulp mill owned by the firm (SINGLE). We also include three additional variables to control for exogenous factors affecting the level of regulatory stringency faced by the plant. On the air-side we include a dummy variable to indicate if the plant is located in a county that is in non-attainment status with respect to particulate or sulfur dioxide standards (NONTSP and NONSO2; in our data the two variables overlap heavily and TSP non-attainment is much more common so the NONSO2 variable is used in only the SO2 emissions equation). On the water-side we include a numeric rating from EPA's Majors Rating Database indicating the extent to which the plant is a large water polluter (MAJORS) and a dummy variable to indicate if the plant discharges into a stream whose water quality has potential health effects, due to being a source of drinking water (PUBLIC HEALTH). We also include the number of the plant's Occupational Safety and Health Agency's violations (OSHA VIOL), since previous research has shown that OSHA violations are positively correlated with EPA violations [see Gray and Shadbegian (2000)]. To indicate the financial health of the plant we include a measure from Compustat of the owning-firm's rate of return on its assets (RETURN ON ASSETS).

We control for the state-level regulatory climate using GREEN VOTE, a measure of support for environmental legislation in Congress. The League of Conservation Voters calculates a scorecard for each member of Congress on environmental issues, with data available back to the early 1970s. We use the average score for the state's House of Representative members in our analysis. We tested other measures of state regulatory climate, but these were all cross-sectional in nature and thus dropped out of our analyses when we included state dummies, so we do not discuss them further here.

Now consider each of the five specific models we considered. We test the Benefits model by including our measures of air and water benefits (AIRBEN and WATBEN), as well as the percentage of the nearby population under the age of 6 (KIDS), 65 and over (ELDERS), and high school dropouts (HSDROP). We would expect each of them to be positively related to regulatory activity (inspections and enforcement actions), and negatively associated with pollution quantities.

The Coase hypothesis is tested by including two measures of differences in willingness to pay to avoid pollution: poverty and property values. Poverty is measured by the percentage of the nearby population living below the poverty line (POOR). Property values are measured by the median housing value nearby (HOUSEVAL). We expect POOR to be negatively related to regulatory activity, while HOUSEVAL should be positively related.

We test for Environmental Justice by including two measures of characteristics expected to be associated with "less valuable" populations: poverty rates and minorities. POOR is the same variable used for the Coase hypothesis. The minority variable is the percentage of the population that is nonwhite (NONWHITE). We would expect both to be negatively associated with regulatory activity and positively associated with pollution levels.

The Collective Action model is tested by including a measure of voter activity. Voter activity is measured using voter turnout in the previous presidential election (TURNOUT). This would ordinarily be expected to be positively associated with regulatory activity. However, it is possible that not all members of the electorate are supportive of environmental regulation, so that higher turnout need not always increase regulation. Thus we include an interaction between turnout and state membership in conservation organizations (TURNOUT*CONVMEMB), which would be expected to have a positive association with regulatory activity.

Finally, we test for Transboundary Externalities by including two simple dummy variables indicating whether the plant is within 50 miles of another jurisdiction (STATE BORDER or CANADIAN BORDER). For these plants, it is presumed that their pollution may "spill over" to the other jurisdiction. All else equal, regulators should care less about such pollution, so regulatory activity should be diminished for those plants. However, it is possible that the other jurisdiction(s) could respond strongly to any transboundary pollution. Depending on the institutional arrangements in place, the political costs associated with transboundary pollution could be larger than the costs of intrastate pollution. For cross-state pollution, the sensitivity of the other state is presumed to be associated with that state's GREEN VOTE measure of regulatory stringency.

We estimate the eight different equations for the dependent variables measuring regulatory stringency using two statistical techniques. For both air and water pollution we measure stringency as the number of inspections (INSP) and enforcement actions (ENFORCE) a plant receives in a given year. Since both INSP and ENFORCE are often zero we estimate the equations using a Tobit model (to allow for the possibility that the observed values are better represented by a truncated distribution than by ordinary least squares). For the four pollution quantity equations, we use ordinary least squares on the logarithm of emissions quantities, allowing for the wide dispersion in emissions across plants.

6. RESULTS

Table 1 contains the means and standard deviations (along with variable descriptions) of all variables used in this study. Note that the number of observations varies across the models being estimated, depending on the availability of data for the dependent variable and some specific explanatory variables. We have more data for regulatory activity (inspections and enforcement actions) than we do for pollution quantities. To simplify the table, all of the control variables have their values reported only for the largest dataset, corresponding to air pollution regulatory activity.

In our data the average plant-year observation receives nearly ten times as many inspections as enforcement actions: approximately two air and water pollution inspections per year and one air or water enforcement action every three or more years. Actually, the distribution of enforcement activity in our data is rather skewed, with many plants receiving none and others receiving several. Most of our plants are in compliance with air and water regulations (84% and 70% compliance rates respectively). The majority of our plants were born prior to 1960 (75%) and are owned by a firm with more than one paper mill (75%). Approximately half our plants (43%) have water pollution discharges that have potential public health impacts and 34% of our plants are located in counties that are not in attainment with particulate emission standards.

Tables 2 and 3 present the results of the basic model for air pollution and water pollution regulation respectively, including only the control variables in each equation. We see that lagged compliance is associated with significant reductions in both pollution quantities and regulatory activity for air pollution, but for water pollution the only significant impact comes in reduced water inspections. OSHA regulatory compliance is associated with lower pollution quantities (though significant for only SO2). The impact of plant capacity on regulation seems to come primarily in terms of pulping capacity, rather than paper capacity (larger coefficients and more frequently significant). Larger plants generate more pollution and face more regulatory activity. Plants in urban areas generate less pollution, but also (surprisingly) face somewhat less regulatory activity. Plants in areas with high unemployment rates generate more air pollution and less water pollution. The time trends are mostly unremarkable. The base year is 1985 (during the Reagan administration) except for the water pollution quantity equations which use a base year of 1989 (during the Bush administration). We see significantly higher regulatory activity and lower pollution quantities during the Clinton administration (except for water inspections, which are significantly lower).

Tables 4-8 build upon the basic model by separately adding the variables corresponding to each of the five models. The top half of each table shows the results for air pollution, with the bottom half showing the results for water pollution. In general we would expect to get similar signs for air and water pollution, and opposite signs for regulatory activity and pollution quantity. Given the wide range of variables considered, it is perhaps not surprising that our results present frequent exceptions to these patterns.

Table 4 examines the Benefits model. Higher aggregate benefits from pollution reductions and higher concentrations of population groups especially affected by pollution are expected to lead to more regulatory activity and less pollution. The results are mixed. The benefits per unit of pollution for the overall population are associated with significantly lower water pollution (as expected), but significantly higher air pollution. On the other hand, two of the three sensitive population groups (KIDS and ELDERS) are negatively related to air pollution quantities in all cases as expected, and significantly so for all but particulate emissions. Since the dependent variables are measured in log form, the coefficients reflect percentage impacts on pollution. For example, a one standard deviation increase in ELDERS (.0187) is predicted to reduce SO2 pollution by 41 percent and particulate pollution by 16 percent; the comparable reductions for KIDS are 23 percent and 9 percent. On the water side, a one standard deviation increase in water pollution benefits (2.627 in logs) is predicted to reduce BOD by 20 percent and TSS by 16 percent.

The regulatory activity measures also give mixed results, with the expected positive signs found only for enforcement actions and only occasionally significant, while unexpectedly negative signs are found for inspections, with the WATERBEN coefficients being significant for water pollution inspections. A reversal of the expected signs is found for the other population characteristic measure, high school dropouts (HSDROP), which is significantly associated with less regulatory activity and more pollution. This is not too surprising, as HSDROP could be acting as a measure of poverty and minority presence in the area, and hence be overlapping with some other models (such as Coase Theorem or Environmental Justice).

Table 5 examines the Coase Theorem model. Poor people are expected to be less likely to pay large sums for pollution reductions, while people in highly priced housing are expected to be more likely to do so. Thus we would expect to see POOR with negative effects on regulatory activity and positive effects on pollution, with the reverse for HOUSEVAL. We see the expected HOUSEVAL results in most cases, with significantly lower values for both air and water pollution, and higher values for air regulatory activity. Given that HOUSEVAL is measured in logarithmic terms, a 10% increase in housing values would be expected to reduce each water pollutant by about 16%, SO2 by 14%, and particulates by 4%. HOUSEVAL's impact on water inspections and enforcement actions is surprisingly negative. The results for POOR seem different from those expected, but this turns out to be a result of including both POOR and HOUSEVAL in the same regression (the two variables have a correlation of -.57). When the same models are estimated with HOUSEVAL excluded, the coefficients on POOR show a pattern similar to the HOUSEVAL coefficients (allowing for their different sign): significantly positive for both air and water pollution quantities, negative for air regulatory activity and (surprisingly) positive for water regulatory activity. Overall, the Coase Theorem model is reasonably well supported by the data.

Table 6 examines the Environmental Justice model. People who are poor or nonwhite are expected to be given less weight in regulatory calculations, so that paper mills in poor and nonwhite areas would receive less regulatory activity and hence pollute more. We see that POOR has the expected effects in all cases (again, except for water regulatory activity): significantly more air and water pollution, and significantly fewer air enforcement actions. However, the NONWHITE coefficient is always opposite in sign from POOR, and usually significant. This presents a problem for the Environmental Justice model (unlike the Coase Theorem case of POOR and HOUSEVAL, the results when POOR and NONWHITE are entered separately are quite similar to those reported here). It appears that nonwhites are not being discriminated against by regulators, although the poor may be.

Table 7 examines the Collective Action model. Plants which are located in areas of high political activity as measured by TURNOUT are expected to face more regulatory activity and thus have less pollution, but only where the interested citizens are likely to support environmental regulation, as measured by state membership in conservation groups (CONVMEMB). One would expect that TURNOUT*CONVMEMB would increase regulation and reduce pollution. At first glance, this appears to be true for water pollution discharges, but a closer examination shows that the TURNOUT coefficient has the wrong sign and is much larger than the interaction, so even for states with CONVMEMB one standard deviation greater than average (12.3) the net effect of greater turnout is more water pollution, not less. Of the 8 equations in Table 7, the expected pattern of coefficients is found only for air enforcement actions, where a state with above average CONVMEMB would find greater turnout leading to increasing regulation.

Table 8 examines the Transboundary Externality model. Plants which are located near borders (either state or Canadian) are expected to face less regulatory activity and therefore pollute more. A variation on the model has the result differing based on the regulatory stringency of the nearby state, with plants near a border with a stringent state being more heavily regulated and polluting less. The results for state boundaries support the model (with the usual exception of water regulatory activity): more air and water pollution and fewer enforcement actions for plants located near state borders. We find some support for interactions with the neighboring state's regulatory stringency (measured by its own GREEN VOTE), with stricter neighbors resulting in less of a border effect. Being near a state border is associated with 40% higher air pollution emissions, assuming the neighboring state has the average GREEN VOTE value of 54. If the neighboring state's GREEN VOTE is one standard deviation higher (72) the state border effect is only about half as large.

The results for Canadian plants suggest opposite effects on air and water pollution regulation. On the water pollution side we observe more pollution and less regulatory activity (not always significant). On the air pollution side we observe significantly less pollution and significantly more enforcement actions. This discrepancy across pollution media suggests that it might be valuable to examine the mechanisms for regulatory cooperation between the US and Canada more closely. It appears that air pollution regulation is being better coordinated than the water pollution regulation.

Table 9 presents an overall summary of the pattern of results across all the models, boiled down to a display of the sign and significance of each key coefficient. As noted above, there is substantial evidence in favor of some aspects of the Benefits, Coase Theorem, Environmental Justice, and Transboundary Externality theories, in terms of their predictions about the coefficients that would be obtained for specific variables. Plants with larger benefits to the overall population emit less water pollution, and those with more kids and elders nearby emit less air pollution. Plants located in high housing value neighborhoods get more regulatory attention and emit less pollution. Plants located in poor neighborhoods get less regulatory attention and emit more pollution. Plants located near state boundaries get less regulatory attention and emit more pollution, with these effects reduced if the nearby states have greater support for regulation.

There are, of course, caveats to attach to the above summary. First, not every variable functions as predicted, although this can sometimes be explained by the variable playing different roles in different models. For example, the finding that having more high school dropouts nearby is supposed to result in more regulatory pressure according to the Benefits model, since high school dropouts are believed to be more affected by air pollution. However, high school dropouts might also be associated with less ability to pay for pollution reductions (Coase Theorem), lower valuation by regulators (Environmental Justice) and less political participation (Collective Action), which would seem to provide ample justification for the reversal in sign.

A more substantive negative finding relates to the Collective Action model, which finds little support. The signs of the TURNOUT coefficients are not generally as expected. In addition, the expected reinforcement from an interaction of turnout with general support for regulation goes in the wrong direction. The Environmental Justice model could be described as "half empty" or "half full", since while the POOR coefficients generally have the expected signs, the NONWHITE coefficients have the unexpected signs. Both of these negative findings are similar to results found in other papers (see Wolverton (2002) for NONWHITE and Kreisel, et. al. (1996) for TURNOUT). The Benefits model also gets the wrong sign for the benefits of air pollution cleanup to the overall population.

On the positive side, some of the differences in results for different regulatory measures may pose further research questions. There is a frequent pattern of unexpected signs for water pollution regulation, where coefficients in models explaining discharge quantities tend to get the same sign as in models explaining regulatory activity, instead of the expected opposite signs, found for air pollution. Is this an artifact of the data, or does it represent a real difference in the process by which regulatory activity is allocated in different media? Similarly, do the differences between air and water pollution in the impact of being near the Canadian border reflect some substantial differences in the mechanisms for ensuring international cooperation on pollution control?

Given that each model is being estimated for eight different equations (four air and water pollutants, along with inspections and enforcement equations), one might wonder whether the unobserved factors influencing each equation are correlated. To test this, we estimated a model including the explanatory variables from all 5 models, calculated the residuals for each of the 8 equations being estimated, and checked the correlations among these equations. The only cases of really large correlations across residuals come for the pollutants, where plants with surprisingly high emissions of one pollutant also tended to emit surprisingly large amounts of the other pollutant in that same media. These values are quite high, with a correlation of .77 between BOD and TSS discharges and a correlation of .60 between particulates and sulfur dioxide emissions. Other correlations are also statistically significant, though not especially large, with positive correlations of about .14 between the residuals for air inspections and air enforcement actions, and between air pollution inspections and BOD and TSS discharges.

7. CONCLUSIONS AND POSSIBLE EXTENSIONS

In this paper we examine the optimal allocation of environmental regulation across pulp and paper mills by testing test five different economic theories of the allocation of pollution regulation: “Benefits”, “Coase Theorem”, “Environmental Justice”, “Collective Action”, and “Transboundary

-level panel data set on approximately 300 pulp and paper mills from 1985-1997. As noted above, we find substantial evidence in favor of some aspects of the Benefits, Coase Theorem, Environmental Justice, and Transboundary Externality theories, in terms of their predictions about the coefficients that would be obtained for specific variables. Plants with larger benefits to the overall population emit less water pollution, and those with more kids and elders nearby emit less air pollution. Plants located in high housing value neighborhoods get more regulatory attention and emit less pollution, while plants located in poor neighborhoods get less regulatory attention and emit more pollution. Plants located near state boundaries get less regulatory attention and emit more pollution, with these effects reduced if the nearby states have greater regulatory stringency.

Not every result fits those predicted by the models. The Benefits model gets the wrong sign for the benefits of air pollution cleanup to the overall population. The percentage nonwhite near the plant, expected to reduce regulatory attention in the Environmental Justice model, is actually associated with more regulatory activity and lower emissions. The Collective Action model finds little support, with higher voter turnout associated with less regulatory stringency rather than more.

On the positive side, some of the differences in results for different regulatory measures pose interesting research questions. There is a frequent pattern of unexpected signs for water pollution regulation, where factors associated with fewer regulatory actions tend to be associated with less, not more, pollution. We would have expected opposite signs on these coefficients, and found opposite signs for air pollution. Is this an artifact of the data, or does it represent a real difference in the process by which regulatory activity is allocated in different media? Similarly, do the different effects on air and water pollution of being near the Canadian border reflect real differences across pollution media in the mechanisms for ensuring international cooperation on pollution control?

Potential extensions of this project include a more careful examination of these border effects and the differences between air and water pollution regulation. In the short-term we will be adding Census data on the plant's productivity and size, and creating a measure of the plant's local political clout (based on its share in county employment). We also plan to separate state and federal enforcement and to explore other ways to more accurately measure the political activism of a community.

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TABLE 1
DESCRIPTIVE STATISTICS
(N=4032, air enforcement dataset, unless otherwise noted)

VARIABLE (N)	MEAN	(STD DEV)	{log mean,std}
AIR INSP number of air pollution inspections	2.396	(4.214)	
AIR ENF number of air pollution enforcement actions	0.356	(1.143)	
PM10 (N=2282) Tons of particulate emissions per year	404.0	(568.8)	{4.55,2.20}
SO2 (N=2272) Tons of sulfur dioxide emissions per year	2148.1	(3672.3)	{6.15,2.41}
WATER INSP (N=3431) number of water pollution inspections	1.650	(1.560)	
WATER ENF (N=3431) number of water pollution enforcement actions	0.183	(0.710)	
BOD (N=1939) biological oxygen demand	4.057	(8.251)	
TSS (N=2024) total suspended solids	7.611	(31.442)	
AIRBEN the dollar cost per ton of air pollution (average of particulate + SO2) ($)	10617	(3990)	{9.16,0.54}
PMBEN the dollar cost per ton of particulate air pollution ($)	12531	(4578)	{9.32,0.53}
SO2BEN the dollar cost per ton of SO2 air pollution ($)	5218	(1909)	{8.45,0.52}
WATERBEN (N=3431) Dollar cost per unit of water pollution abatement ($)	291.1	(899.6)	{3.70,2.63}
KIDS the percentage of the population under 6 years old	0.087	(0.006)	
ELDERS the percentage of the population 65 years old and over	0.131	(0.019)	
HSDROP the percentage of the population over 25 with < 12 years of education	0.253	(0.061)	
POOR the percentage of the population living below the poverty line	0.135	(0.051)	
HOUSEVAL the median home value (in 1000's)	77.321	(40.447)	
NONWHITE the percentage of the population who are nonwhite	0.137	(0.132)	
TURNOUT percentage of the population over 18 voting in previous presidential election	41.673	(6.859)	

Table 1 (cont.)

STATE BORDER PLANT dummy indicating a plant located within 50 miles of a state border	0.281	(0.449)
CANADIAN BORDER PLANT dummy indicating a plant located within 50 miles of the Canadian border	0.126	(0.332)
AIR COMPLAG dummy variable indicating (lagged) compliance with air pollution regulations	0.835	(0.371)
WATER COMPLAG (N=3431) dummy variable indicating (lagged) compliance with water pollution regulations	0.703	(0.457)
PULP CAPACITY log of tons of pulp produced per day	2.893	(3.284)
PAPER CAPACITY log of tons of paper produced per day	4.999	(2.266)
NEW PLANT dummy variable indicating the plant was born after 1960	0.249	(0.433)
SINGLE dummy variable indicating that this is the only paper plant owned by the firm	0.247	(0.431)
MAJOR SOURCE (N=3431) numeric majors rating from the EPA's Majors Rating Database	114.627	(37.388)
PUBLIC HEALTH (N=3431) dummy variable indicating the potential public health impact of discharges	0.430	(0.495)
RETURN ON ASSETS rate of return on assets (Compustat)	0.023	(0.056)
OSHA VIOLATIONS fraction of OSHA inspections with violations (3-year moving average, last-this-next years)	0.293	(0.408)
STATE AIR INSPECTIONS state air pollution inspection rate (inspections/plants)	0.294	(0.160)
STATE WATER INSPECTIONS state water pollution inspection rate (inspections/plants)	0.527	(0.289)
NONTSP dummy indicating plant is located in non-attainment area for TSP	0.342	(0.474)
NONSO2 dummy indicating plant is located in non-attainment area for SO2	0.076	(0.266)
URBAN Percent of county designated as urbanized	39.140	(39.22)
GREEN VOTE pro-environment Congressional voting (League of Conservation Voters)	54.309	(17.768)
UNEMP State unemployment rate	6.000	(1.584)
CONVMEMB membership in 3 conservation groups, late 1980s, per 1000 population	8.957	(3.386)

TABLE 2
BASIC AIR MODEL

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
COMPLAG	-0.981 (-5.700)	-2.031 (-8.590)	-0.701 (-8.610)	-0.648 (-5.850)
PULP CAPACITY	0.437 (16.860)	0.366 (8.700)	0.396 (26.130)	0.310 (14.930)
PAPER CAPACITY	-0.026 (-0.860)	-0.066 (-1.490)	0.020 (1.270)	0.061 (2.820)
NEW PLANT	-0.363 (-2.420)	0.322 (1.430)	-0.035 (-0.450)	-0.089 (-0.850)
SINGLE	-0.202 (-1.250)	-0.287 (-1.090)	-0.120 (-1.480)	-0.143 (-1.310)
RETURN ON ASSETS	1.871 (1.470)	-0.099 (-0.050)	1.333 (2.180)	2.583 (3.100)
OSHA VIOLATIONS	0.027 (0.130)	1.257 (3.910)	-0.140 (-1.410)	-0.376 (-2.780)
STATE AIR INSPECTIONS	14.074 (22.800)	0.351 (0.370)	-0.700 (-2.520)	0.284 (0.750)
NONTSP	0.090 (0.530)	-0.055 (-0.220)	-0.013 (-0.150)	
NONSO2				-0.518 (-2.890)
URBAN	-0.004 (-2.120)	0.001 (0.440)	-0.007 (-6.990)	-0.008 (-6.460)
GREEN VOTE	-0.009 (-1.300)	-0.010 (-0.930)	-0.003 (-0.810)	0.011 (2.240)
UNEMP	-0.043 (-0.770)	0.321 (3.230)	0.109 (3.680)	0.079 (1.970)
YR86	0.378 (1.260)	1.852 (2.830)	0.054 (0.310)	-0.039 (-0.170)
YR87	0.430 (1.400)	3.002 (4.670)	0.062 (0.350)	-0.129 (-0.540)

TABLE 2
BASIC AIR MODEL (cont.)

YR88	0.340	3.352	0.153	-0.019
	(1.060)	(5.070)	(0.870)	(-0.080)
YR89	0.191	3.804	0.181	-0.063
	(0.580)	(5.730)	(1.010)	(-0.260)
YR90	0.483	3.665	-0.068	-0.412
	(1.510)	(5.640)	(-0.400)	(-1.790)
YR91	0.300	2.833	-0.388	-0.411
	(0.980)	(4.490)	(-2.400)	(-1.860)
YR92	0.796	3.093	-0.451	-0.391
	(2.570)	(4.910)	(-2.730)	(-1.740)
YR93	0.899	4.004	-0.321	-0.526
	(2.940)	(6.480)	(-1.960)	(-2.360)
YR94	0.781	4.661	-0.275	-0.459
	(2.470)	(7.360)	(-1.660)	(-2.030)
YR95	0.439	4.488	-0.275	-0.478
	(1.310)	(6.720)	(-1.580)	(-2.010)
YR96	0.060	4.472	-0.353	-0.503
	(0.180)	(6.670)	(-2.030)	(-2.120)
YR97	0.602	5.312	-0.257	-0.495
	(1.750)	(7.870)	(-1.450)	(-2.050)
R2	0.146	0.113	0.621	0.418

T-statistics in parentheses.   All regressions include state dummies.

TABLE 3
BASIC WATER MODEL

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
COMPLAG	-0.169 (-2.660)	-0.095 (-0.440)	-0.093 (-1.350)	0.008 (0.120)
MAJORS	0.011 (12.290)	0.006 (1.970)	0.016 (13.710)	0.014 (12.470)
PUBLIC HEALTH	0.237 (3.660)	0.231 (1.100)	0.130 (1.780)	0.108 (1.510)
PULP CAPACITY	-0.013 (-1.080)	0.064 (1.590)	0.237 (18.430)	0.201 (16.080)
PAPER CAPACITY	0.014 (1.150)	0.025 (0.570)	-0.051 (-3.760)	-0.055 (-4.200)
NEW PLANT	-0.048 (-0.780)	-0.621 (-2.780)	0.155 (2.280)	0.090 (1.340)
SINGLE	0.078 (1.050)	0.598 (2.330)	-0.282 (-3.380)	0.001 (0.010)
RETURN ON ASSETS	-0.141 (-0.340)	1.823 (0.720)	-0.242 (-0.640)	-0.089 (-0.250)
OSHA VIOLATIONS	-0.018 (-0.200)	0.347 (1.160)	-0.052 (-0.510)	-0.084 (-0.850)
STATE WATER INSPECTIONS	4.049 (20.660)	-0.357 (-0.480)	-0.813 (-3.140)	0.077 (0.280)
URBAN	-0.002 (-2.920)	-0.005 (-1.840)	-0.004 (-4.680)	-0.004 (-4.150)
GREEN VOTE	-0.005 (-1.630)	-0.009 (-0.830)	-0.016 (-4.720)	-0.011 (-3.120)
UNEMP	0.005 (0.200)	0.053 (0.620)	-0.165 (-4.030)	-0.155 (-3.890)
YR86	-0.040 (-0.300)	0.714 (1.340)		
YR87	-0.438 (-3.310)	1.284 (2.460)		

TABLE 3
BASIC WATER MODEL (cont.)

YR88	-0.109 (-0.790)	1.849 (3.540)		
YR89	-0.169 (-1.220)	2.015 (3.840)		
YR90	-0.314 (-2.290)	2.102 (4.070)	0.014 (0.120)	0.073 (0.630)
YR91	-0.535 (-3.990)	2.255 (4.430)	0.027 (0.200)	0.064 (0.480)
YR92	-0.753 (-5.500)	1.825 (3.450)	-0.122 (-0.790)	0.041 (0.280)
YR93	-0.823 (-6.190)	1.184 (2.230)	0.013 (0.100)	0.098 (0.770)
YR94	-0.660 (-4.910)	1.814 (3.550)	-0.210 (-1.680)	-0.110 (-0.910)
YR95	-0.732 (-5.130)	1.244 (2.250)	-0.526 (-3.910)	-0.334 (-2.530)
YR96	-0.854 (-5.930)	0.840 (1.490)	-0.503 (-3.780)	-0.338 (-2.600)
YR97	-0.991 (-6.790)	0.896 (1.580)	-0.553 (-4.240)	-0.408 (-3.210)
R2	0.114	0.142	0.608	0.546

T-statistics in parentheses. All regressions include state dummies.

TABLE 4
BENEFITS MODEL

AIR POLLUTION

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
AIRBEN	-0.254	-0.419		
	(-1.010)	(-1.170)		
PMBEN			0.256	
			(1.810)	
SO2BEN				1.697
				(8.990)
KIDS	-9.765	17.099	-14.310	-38.476
	(-0.580)	(0.660)	(-1.720)	(-3.430)
ELDERS	-3.014	24.854	-8.727	-22.152
	(-0.520)	(2.790)	(-2.830)	(-5.370)
HSDROP	-2.556	-11.377	1.917	-0.060
	(-1.400)	(-3.800)	(2.110)	(-0.050)
R2	0.146	0.117	0.624	0.450

WATER POLLUTION

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
WATERBEN	-0.026	0.016	-0.077	-0.061
	(-2.330)	(0.440)	(-6.230)	(-5.090)
R2	0.114	0.142	0.616	0.552

Models include all control variables from Tables 2 and 3.
T-statistics in parentheses.

TABLE 5
COASE THEOREM MODEL

AIR POLLUTION

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
POOR	3.448	-2.874	0.530	-5.218
	(1.480)	(-0.780)	(0.450)	(-3.300)
HOUSEVAL	0.905	0.799	-0.409	-1.389
	(2.830)	(1.650)	(-2.500)	(-6.180)
R2	0.146	0.114	0.623	0.428

WATER POLLUTION

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
POOR	0.597	-0.277	-3.413	-2.635
	(0.590)	(-0.080)	(-3.060)	(-2.390)
HOUSEVAL	-0.381	-0.294	-1.609	-1.682
	(-2.800)	(-0.600)	(-9.470)	(-9.860)
R2	0.115	0.142	0.628	0.573

Models include all control variables from Tables 2 and 3.
T-statistics in parentheses.

TABLE 6
ENVIRONMENTAL JUSTICE MODEL

AIR POLLUTION

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
POOR	-1.389 (-0.620)	-7.187 (-2.090)	4.175 (3.680)	5.422 (3.510)
NONWHITE	0.771 (0.800)	0.566 (0.370)	-1.555 (-3.160)	-3.910 (-5.830)
R2	0.146	0.114	0.624	0.427

WATER POLLUTION

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
POOR	4.256 (4.490)	-2.176 (-0.620)	8.693 (8.030)	9.286 (8.580)
NONWHITE	-1.709 (-4.040)	2.733 (1.720)	-4.586 (-8.840)	-3.932 (-7.610)
R2	0.116	0.143	0.626	0.565

Models include all control variables from Tables 2 and 3.
T-statistics in parentheses.

TABLE 7
COLLECTIVE ACTION MODEL

AIR POLLUTION

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
TURNOUT	0.015 (0.770)	-0.066 (-2.350)	-0.013 (-1.340)	-0.027 (-2.060)
TURNOUT* CONVMEMB	-0.0005 (-0.380)	0.010 (5.210)	-0.001 (-1.030)	0.0002 (0.190)
R2	0.146	0.117	0.623	0.420

WATER POLLUTION

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
TURNOUT	0.032 (4.010)	0.050 (1.620)	0.062 (7.000)	0.076 (8.870)
TURNOUT* CONVMEMB	-0.002 (-3.140)	-0.006 (-2.540)	-0.004 (-6.510)	-0.005 (-8.300)
R2	0.115	0.144	0.619	0.566

Models include all control variables from Tables 2 and 3.
T-statistics in parentheses.

TABLE 8
TRANSBOUNDARY EXTERNALITY MODEL

AIR POLLUTION

_DEPVAR	AIR INSP	AIR ENF	PM10	SO2
_NOBS	4032.00	4032.00	2282.00	2272.00
STATE BORDER	0.222 (0.760)	-0.906 (-1.950)	0.861 (5.790)	0.932 (4.610)
STATE BORDER *GREEN VOTE	0.004 (0.740)	0.016 (1.930)	-0.011 (-4.100)	-0.010 (-2.580)
CANADIAN BORDER	0.064 (0.300)	1.592 (4.700)	-0.301 (-2.790)	-0.585 (-3.980)
R2	0.146	0.117	0.628	0.428

WATER POLLUTION

_DEPVAR	WATER INSP	WATER ENF	TSS	BOD
_NOBS	3431.00	3431.00	2024.00	1939.00
STATE BORDER	0.455 (3.880)	0.475 (1.250)	0.205 (1.640)	0.264 (2.200)
STATE BORDER *GREEN VOTE	-0.007 (-3.340)	0.004 (0.610)	-0.002 (-0.690)	-0.002 (-1.030)
CANADIAN BORDER	-0.176 (-1.970)	-0.276 (-0.960)	0.007 (0.070)	0.339 (3.560)
R2	0.115	0.145	0.609	0.551

Models include all control variables from Tables 2 and 3.
T-statistics in parentheses.

TABLE 9
MODEL SUMMARY

_DEPVAR	AIR POLLUTION INSP	ENF	PM10	SO2	WATER POLLUTION INSP	ENF	BOD	TSS
				BENEFITS (Table 4)				
BENRATE	-	-	+	++	--	+	--	--
KIDS	-	+	-	--				
ELDERS	-	++	--	--				
HSDROP	-	--	++	-				
				COASE THEOREM (Table 5)				
POOR	+	-	+	--	+	-	--	--
HOUSEVAL	++	+	--	--	--	-	--	--
				ENVIRONMENTAL JUSTICE (Table 6)				
POOR	-	--	++	++	++	-	++	++
NONWHITE	+	+	--	--	--	+	--	--
				COLLECTIVE ACTION (Table 7)				
TURNOUT	+	--	-	--	++	+	++	++
TURNOUT* CONVMEMB	-	++	-	+	--	--	--	--
				TRANSBOUNDARY EXTERNALITY (Table 8)				
STATE BORDER	+	-	++	++	++	+	+	++
STATE BORDER* GREEN VOTE	+	+	--	--	--	+	-	-
CANADIAN BORDER	+	++	--	--	--	-	+	++

+, -   indicates signs of coefficients.
++, -- indicates significant at 5% level.