EXPORTING AIR POLLUTION? REGULATORY ENFORCEMENT AND ENVIRONMENTAL FREE RIDING IN THE UNITED STATES

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Abstract

Interjurisdictional pollution spillovers are a critical issue in environmental policy. Economic theory suggests that jurisdictions have incentives to promote these externalities to capture the benefits of economic production within their borders while exporting the environmental and health costs to their neighbors. In this paper we examine the extent to which U.S. states engage in this type of free riding behavior. Studying state enforcement of the federal Clean Air Act from 1990-2000, we employ zero-inflated negative binomial regression to predict the number of state-initiated enforcement actions conducted at the county-level. We find evidence that states perform fewer enforcement actions in counties adjacent to international borders, but no evidence that states conduct less enforcement in counties that border other states. This research suggests that states act carefully when deciding their clean air enforcement behavior, and that international pollution spillovers may be due, in part, to geographically strategic regulatory enforcement.

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Introduction

A central issue in environmental policy concerns interjurisdictional pollution externalities. These externalities occur when pollution released in one political jurisdiction creates adverse environmental consequences in another. Economic theory suggests that nations, states, and localities have significant incentives to "free ride" by promoting these externalities, thereby capturing the benefits of economic activity within their borders while compelling their neighbors to shoulder the resultant environmental and health costs (Hutchinson and Kennedy 2006; Oates 2001; Revesz 1996).

Interjurisdictional externalities are particularly relevant for air pollution, which is easily transported across political boundaries. At the international level, several agreements have been formed to address problems caused by cross-border air pollution, including the Long Range Transboundary Air Pollution (LRTAP) agreement, whose signatories include nations in Eastern and Western Europe, Russia, Canada, and the United States. Nations which decentralize pollution control efforts, such as the United States, may have transboundary pollution problems internally as well.

Transboundary pollution is an issue related to, but analytically distinct from, the possibility of an interjurisdictional race to the bottom (RTB) in environmental policy. The RTB thesis suggests that jurisdictions attempt to lure geographically footloose firms by relaxing environmental regulations. If all states behave similarly, there may be an aggregate movement toward the lowest common denominator (Revesz 1996). Collectively, the potential problems arising from interstate pollution externalities and an environmental RTB are among the most common criticisms of the decentralized system of environmental regulation in the United States, in which the federal government promulgates national (minimum) standards, but often relies on state implementation and enforcement. While the RTB argument has received some empirical attention in recent years (Fredriksson and Millimet 2002; Konisky 2007; Potoski 2001; Woods 2006a), issues related to interjurisdictional externalities have largely escaped systematic examination. This is somewhat surprising, since several scholars find interstate spillovers to be a far more theoretically compelling argument for uniform federal regulation than the possibility of an environmental RTB (Oates 2001; Revesz 1996, 1997).

States clearly believe that other states seek to export their pollution. In 2006, New Jersey sued the U.S. Environmental Protection Agency (EPA) accusing it of failing to control the emissions of a Pennsylvania coal-powered power plant across the Delaware River (Delli Santi 2006). This case joins a growing list of instances in which state regulators have been accused of giving preferential treatment to polluters located on or near a state border. In 1983 the state of Tennessee sued the state of North Carolina, in 1984 the state of Kentucky sued the EPA, and in 1987 the Supreme Court heard a case involving New Hampshire and Vermont. In each case a neighboring state alleged that another state's regulators had enforced national pollution laws less stringently in order to the protect local industry rather than reduce pollution that largely affected nonresidents (Revesz 1997).

In this study, we evaluate the contention that states seek to deliberately export the environmental costs of industrial production, thereby free riding on their neighbors. We assess free riding at both state and international borders using pooled zero-inflated negative binomial (ZINB) analyses of state air quality inspections and punitive enforcement actions over a ten year period. While our study joins an emerging scholarly interest in environmental free riding behavior, our approach differs from prior studies in three important respects. First, most research on interjurisdictional free riding focuses on pollution emissions or levels (Helland and Whitford 2003; Sigman 2002a, 2002b). Our study differs in that we consider inspections and enforcement actions. This approach provides us with a direct empirical assessment of regulatory behavior which contrasts with most prior research, which is forced to infer that elevated pollution levels near borders are a consequence of government policy.[1]

Second, our temporal and substantive focus is much broader than most extant studies. Much of the current literature is cross-sectional (Gray and Shadbegian 2007; Sigman 2002a, 2002b), and some of it focuses only on a single industry (Gray and Shadbegian 2004). Our analyses look at air quality regulation across all industries for a ten year period. This allows us to eliminate idiosyncratic or industry-specific factors which may influence results, providing a broader level of generalizeability.

Third, while much of the current literature focuses on either state or international borders exclusively (Gray and Shadbegian 2007; Sigman 2002a, 2002b, 2005, though see Gray and Shadbegian 2004), we consider both. Investigating how state enforcement varies across both state and national borders within the context of the same regulatory program allows us to isolate differences across different types of borders and to draw clear inferences about government behavior.

To summarize our results, we do not find evidence to support the contention that states enforce air pollution laws less stringently near state borders. However, we do find significantly weaker state air enforcement effort near international borders, providing substantial evidence that states strategically allocate their enforcement effort in ways that serve to export pollution to Canada and Mexico.

The balance of the paper proceeds as follows. In the next section we review the literature on environmental free riding at the state and national levels. We then discuss our application to air quality regulation in the United States. Next, we describe our data and develop a model to test for free riding behavior. We then report the results of our models and conclude with a discussion of the implications of our findings.

Prior Research on Environmental Free Riding

There is a small but growing literature that examines interjurisdictional environmental externalities. That such externalities exist is a matter of little dispute; several studies document the impact of pollution emitted in one jurisdiction on the physical environment of another (e.g., Kahn 1999; Kahn and McKitrick 2006). The major question is whether such spillovers are strategic – that is, whether nations or states deliberately seek to export the environmental and health costs of their pollution to their neighbors. In seeking to address this question, the standard approach is to look for evidence of higher levels of pollution at or near jurisdictional borders. Such findings are taken as evidence that political jurisdictions seek to free ride on the pollution abatement activities of their neighbors.

Sigman (2002a) analyzes pollution levels in national and international rivers. Using data on water quality provided by the United Nations' Global Environmental Monitoring System Water Quality Monitoring Project, Sigman finds that rivers exhibit 42% more pollution directly upstream from other nations than they do at other domestic monitoring stations. Sigman (2002b) finds analogous results in a related analysis focused at the U.S. state level; data from monitoring stations in the EPA's National Stream Quality Accounting Network indicate that water quality is significantly lower at stations near state borders than it is at stations located further away.

In a similar paper, Helland and Whitford (2003) analyze data from EPA's Toxics Release Inventory from 1987-1996. Their analysis indicates that industrial toxic chemical releases to the air and water are systematically higher in counties that border other states. Helland and Whitford find a particularly strong effect for toxic releases to the air in counties on the eastern edge of states, where they are most likely to cross state lines. They estimate that toxic air emissions are about 194% higher in eastern counties than in other border counties.

Not everyone's findings comport neatly with the expectation of interstate environmental spillovers. In a study looking at several indicators of air and water pollution levels over a 12-year period, Gray and Shadbegian (2004) find that by most indicators, pulp and paper mills located near state borders do not emit more pollution, and that their air particulate emissions levels are actually *lower* than mills located further away. They do, however, find evidence of greater air and water emissions near state borders where the benefits of pollution control are high. In a later paper, the authors use spatial econometric techniques to look at industrial emissions from plants in all industries near state borders (Gray and Shadbegian 2007). The results of this analysis suggest that proximity to state borders has no effect on air pollution emissions.

In sum, the limited extant literature finds some modest evidence of higher pollution levels in areas near state and national borders. Researchers have inferred from these findings that government agencies may be deliberately implementing environmental regulations less stringently in border areas, either through lax permitting requirements or weak enforcement. However, we argue that these studies provide at best a very indirect empirical assessment of the free riding hypothesis. The free riding argument suggests that states alter their behavior to induce environmental externalities. Therefore, it is necessary to explicitly study measures of state behavior that could cause differences in pollution levels at or near state boundaries.

Studies looking at such measures are fairly rare. One branch of literature focuses on international agreements. Free riding is likely to be greatest in the anarchic international system where there is no regulatory superstructure. However, nations sometimes enter into multilateral agreements designed to mitigate this behavior. Studies have found that these agreements are generally effective in reducing international environmental externalities in sulfur and nitrogen oxide air emissions and CFC emissions (Murdoch and Sandler 1997a, 1997b; Murdoch, et al. 1997).

Other studies consider the U.S. context. Sigman (2005) looks at whether states that implement and enforce the Clean Water Act generate more transboundary pollution than those that leave these functions to the EPA. Her findings suggest that states that are authorized to implement the CWA themselves do export pollution to their neighbors; water quality is 4% lower at water quality monitoring stations downstream from an authorized state than at other stations. These findings provide indirect evidence that states which have control over permitting and enforcement use this control to free ride on their neighbors.

Gray and Shadbegian (2004) provide the most direct test of the thesis that states intentionally engage in free riding behavior. The authors look at inspections and enforcement actions to see if regulators alter their behavior for U.S. pulp and paper mills near state and national borders. Their results do not indicate that enforcement of either air or water regulations significantly differs for plants near state borders. They do find that plants near the Canadian border receive fewer water inspections, but that they also experience greater air enforcement actions. On the whole, their results provide little evidence that states strategically alter their enforcement behavior for border plants.

Virtually alone in the free riding literature, this study raises questions about the validity of the premise that states seek to export their pollution to other states. However, the authors do not distinguish between state and federal regulatory actions, which substantially weakens their test of the free rider thesis. While states may reduce enforcement near borders in order to export pollution to neighboring states, there is little reason to expect the EPA to do so. Gray and Shadbegian point this out themselves, and do not interpret their findings as being inconsistent with the free rider hypothesis.

Our analysis extends beyond the Gray and Shadbegian study by examining both a more comprehensive set of measures of government regulatory enforcement and by focusing explicitly on state behavior. We examine county-level air quality enforcement conducted by state governments toward all industries during 1990-2000. Specifically, we examine whether states conduct fewer inspections and punitive enforcement actions in counties that border other jurisdictions – state and international – relative to nonborder counties. Before we discuss our data and empirical approach, it is first useful to provide some background on the U.S. air quality regulatory system.

Air Quality Regulation

Air quality in the United States is primarily regulated by the federal Clean Air Act (CAA). The CAA is implemented through a system of partial preemption, under which the federal government delegates program responsibility to the states while retaining the ultimate authority to decide on the adequacy of state actions. Under the CAA, the EPA sets national minimum criteria that govern states' air quality programs, including their ambient air standards, the extent of states' monitoring and enforcement programs, the financial and legal resources granted to state environmental agencies, and other program areas.[2] States submit to the EPA a State Implementation Plan (SIP) that details how they will meet federal standards. If the EPA determines that a SIP is inadequate, it can preempt all or part of a state's air quality program, and administer the failing portions itself (Lester 1986; Woods 2006b). EPA preemption of even parts of state air quality programs has become rare; virtually all states have authority to partially or fully administer the major programs of the CAA. States are free to exceed EPA standards and develop more stringent clean air programs, as many states have done (Potoski 2001).[3]

Due to its intrinsic spatial nonexcludability, air pollution is particularly suited to producing environmental externalities. Recognizing this, lawmakers have inserted provisions into the CAA that are designed to address the issue of interstate spillovers. Various sections of the CAA prohibit a state from contributing to the nonattainment of National Ambient Air Quality Standards in other states.[4] The recently adopted Clean Air Interstate Rule (CAIR) also attempts to address pollution externalities by capping emissions in 28 Eastern states of two pollutants (sulfur dioxide and nitrogen oxides) that are likely to create unhealthy levels of fine particles and ground-level ozone in downwind states. The CAA contains no specific regulations, however, on the location of pollution sources or any explicit limit on the amount of pollution that can cross state lines. Such vague prohibitions that do exist are largely unenforced (Revesz 1997). As a consequence, several observers have argued that the EPA's efforts to reduce interstate air pollution externalities have been ineffective. Others have taken this a step farther, arguing that the Clean Air Act actually *encourages* interstate externalities because it provides an incentive to meet ambient air standards by exporting pollution across state lines (Revesz 1996, 1997).

In terms of controlling international pollution spillovers with its neighbors, the United States has entered into bilateral agreements with both Canada and Mexico designed to reduce cross-national air pollution. The United States and Canada signed the U.S.-Canada Agreement on Air Quality in 1991, which committed them to reductions in sulfur dioxide and nitrogen oxide emissions, and the nations are currently negotiating an annex to address particulate matter. Previously, the United States and Mexico entered into the La Paz agreement of 1983, which created a cooperative program of air monitoring to address ambient air quality issues near the U.S.-Mexican border. Each agreement has faced persistent criticism from observers as being ineffective, since neither contains any mechanism for enforcement (Smith and Taylor 2007).[5]

The potential for interjurisdictional air pollution spillovers is heightened by the enormous discretion states have in how they choose to enforce the federal CAA. Once the EPA has delegated program authority to states, their agencies assume enforcement responsibility to ensure that pollution sources comply with emissions regulations. The principal means by which government agencies detect violations is through compliance monitoring activities, which vary in intensity, ranging from “drive-by” inspections to comprehensive sampling inspections. In cases where an inspection detects noncompliance, the state agency must determine the severity of the violation and whether to respond with no further action or with an informal or formal punitive action. Informal actions include any notification of a violation, and range from phone calls to written letters to official notices of violation. Formal actions include more direct measures to move violators back into compliance such as administrative orders, consent decrees, and civil penalties. Formal actions also include civil and criminal judicial referrals to the state Attorney General or the U.S. Department of Justice.

Since the mid-1980s, the EPA has attempted to establish some degree of uniformity in state enforcement behavior by emphasizing a deterrence strategy (Mintz 2001; Rechtschaffen 1998). The EPA’s guidance to the states delineates that “timely and appropriate” enforcement measures are to be taken to address violations, and, in cases where authorized states fail to take adequate action, the relevant EPA regional office is to step in with superseding action. While in principle, this should result in broad uniformity, there is considerable variation in enforcement performance across the states for at least two reasons.

First, EPA oversight of the states varies across the country. The EPA’s ten regional offices each have coordination and oversight responsibilities for a different set of states, and studies have repeatedly found that regional offices differ in the way they oversee state-delegated programs (e.g., EPA/OIG 1998; GAO 2006; GAO 2000). Second, the ultimate power that the EPA has to rein in recalcitrant states is to withdraw program delegation. If a state fails to meet federal regulatory requirements or does not adequately enforce these regulations, the EPA reserves the legal right, and, in fact, is obligated under the law to take superseding action. If a state persistently fails to implement and enforce the federal statutes, the EPA can fail to reauthorize a state's SIP. In practice, however, this is largely an empty threat. The EPA has never suspended a state's authorization for failure to meet federal requirements, even in cases where states clearly are not enforcing the federal regulations as envisioned (Rechtschaffen and Markell 2003; Sigman 2003).[6] On a pragmatic level, the EPA simply does not have the resources to assume complete enforcement responsibilities in lieu of a state program.[7]

In sum, the EPA's sanction of preemption lacks credibility, and, as a result, states may largely adopt the approach to enforcement that they see fit, even if it deviates from the EPA's preferred deterrence approach. Sigman (2003, p.112) concludes in her discussion of state delegation that "once authorized, states have quite a free hand to conduct (or ignore) the program." This high degree of discretion enables states to also strategically determine where to concentrate their enforcement efforts, providing an opportunity to perform less enforcement in areas bordering other jurisdictions. For these reasons, state CAA enforcement is a good context to test the free riding argument, and we evaluate the extent to which states conduct fewer enforcement actions in areas where they can most easily export the externalities.

Data and Methods

Our empirical approach is to compare state enforcement of the federal CAA in counties that border other jurisdictions with that of nonborder counties. In this section of the paper, we summarize our dependent variables, measures of county border status, and the control variables we include in our statistical analysis. We also describe the ZINB model we use to test the free rider argument.

Dependent Variables

The enforcement data we analyze in this paper come from EPA's AIRS Facility Subsystem. Specifically, we study state-led enforcement actions taken under the CAA for the period 1990-2000. These data are reported at the facility-level, but we aggregate them into county-year measures, since we are interested in county-level enforcement effort.[8] We construct three measures of state environmental enforcement effort. The first measure is the annual number of state-conducted sampling inspections. The second measure is the unweighted sum of punitive actions – informal and formal – taken by state environmental agencies annually. Last, we consider the annual number of formal punitive actions only, which enables us to consider the pattern of state use of the more serious set of sanctions available.[9] Similar enforcement measures have been used in past studies of regulatory enforcement (e.g., Davis and Davis 1999; Konisky 2007; Ringquist 1993; Wood 1992, 1991; Woods 2006a). We present descriptive statistics for these variables and the other measures we consider in Table A.1 of the Appendix.

Border Counties

The explanatory variables of primary interest are a series of indicator variables that represent a county's border status. We first consider two interstate border designations – counties on the eastern edge of states and all other counties on interstate boundaries. This setup enables us to take into account prevailing wind patterns, as it is the counties on the eastern edge of states that are most likely to escape the reduced local air quality that might result from less enforcement effort.[10] We also consider indicator variables for international border designations, to designate whether a county borders Canada or Mexico. Last, we consider counties that border an ocean or a Great Lake, since the basic logic of the free-rider argument also applies to these counties. In each case, the free riding argument predicts that state-level enforcement will be lower in border counties than in non-border counties, all else equal. We expect enforcement to be particularly less intensive in counties that border Canada and Mexico, due to the lack of enforceable institutional arrangements to curb transboundary air pollution.

Control Variables

We control for various county-level characteristics that might confound our estimates about the effects of a county's border status on state enforcement effort. In particular, we include variables to capture variation in county economies, political and regulatory climates, and demographics.

We expect county-level enforcement to be related to the economic composition of the county, although the direction of this relationship is not obvious. On one hand, it would seem that states are likely to perform more enforcement of the CAA in counties with more industrial activity. These counties should contain more factories and other establishments subject to air quality regulation. On the other hand, counties with large numbers of facilities may also represent areas with high degrees of industrial influence. The state environmental politics literature commonly uses the size of industrial activity in a state as a proxy measure of interest group strength (e.g., Potoski and Woods 2002;

Ringquist 1993), in which case the expectation is that, as the number of facilities increases, the degree of enforcement will decrease. Measuring the number of facilities regulated under the CAA is difficult because the EPA does not maintain data on the number of active facilities governed by air quality regulations. As a proxy, we consider two measures to control for the size of the manufacturing industry in the county – the number of manufacturing establishments and the number of manufacturing establishments with ten or more employees.[11]

Another county characteristic that we need to consider is the health of the local economy. States may be less inclined to conduct stringent enforcement of industry during difficult economic times, due to concerns that an imposition of additional regulatory costs may harm the competitiveness of local companies. Numerous studies have demonstrated that governments perform less enforcement at facilities at risk of closing (Deily and Gray, 2007; Gray and Deily 1996; Helland 1998a), and in communities with struggling economies (Helland, 1998b.) To control for the health of the county economy, we include the county's unemployment rate in our models.[12]

We also control for the county political and regulatory climate. State enforcement behavior may be responsive to county political forces. Areas with more pro-environmental citizens are likely, all else equal, to demand more regulatory enforcement from their state government. Guber (2003) has demonstrated that political party affiliation and political ideology are correlated with environmental attitudes. We use the Democratic percentage of the two-party vote in the last presidential election to measure the political dynamics of each county, with the expectation that counties voting more Democratic will have more enforcement.

The regulatory climate in the county should also matter. The CAA mandates that states as part of their SIPs perform more stringent enforcement in counties failing to meet ambient air quality standards for six criteria air pollutants: particulate matter, ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen oxides, and lead. Each July, the EPA designates each county as being in either attainment or nonattainment with the standards for each of these pollutants.[13] Thus, by statute, states should perform more enforcement actions in nonattainment counties, and county-level variation in state enforcement will partially reflect government action responding to the severity of air pollution. To control for the annual nonattainment status of each county, we include a dummy variable coded one if the county is in nonattainment for any one criteria air pollutant and zero otherwise. To further control for pollution severity in the county, we include annual emissions totals for several pollutants, including particulate matter, ground-level ozone, carbon monoxide, sulfur dioxide, and volatile organic compounds.[14] Controlling for county air emissions also captures remaining variation in economic structure not measured by the manufacturing establishment variables.

As noted previously, EPA oversight of state CAA enforcement varies considerably from state to state due to variation in the behavior of the ten regional EPA offices. To control for the degree of EPA monitoring of state enforcement, we include a measure of the number of EPA inspections conducted in each county in the prior year. Our expectation is that more federal oversight in the previous year would prompt additional state enforcement in the current year.

Last, we control for a number of demographic characteristics, including county population, county population density, county per capita income, percent of county population that is college educated, percent of county population in poverty, and percent of county population that is minority.[15] We expect to find positive relationships between population and population density and state enforcement – larger and more densely-populated counties are more likely to contain facilities regulated under the CAA. In addition, we also expect positive coefficients for the per capita income and college educated variables, since counties with more wealth and education contain populations that will demand more environmental protection.[16] Finally, the environmental justice literature suggests that poorer and larger minority population areas suffer from disproportionate environmental burdens (see Ringquist (2004) for an excellent summary). Therefore, we expect that states will conduct fewer enforcement actions in counties with higher percentages of the population that are poor and minority.

Our statistical models also include year fixed effects to capture an overall trend of increased enforcement during the 1990-200 period, as well as any year-specific shocks that might affect enforcement behavior across the country (e.g., such as decreases in federal funding to state environmental agencies). We also use clustered standard errors at the state level, since county observations within each state are unlikely to be independent. Clustering at the state level is appropriate because enforcement decisions are made by state environmental agencies, which suggests that dependence across county observations is likely caused by state-level phenomena.[17]

Specification

To examine our hypotheses about differences in state CAA enforcement in border counties and non-border counties, we employ a ZINB regression model (Cameron and

Trivedi 1998; Greene 1994; Lambert 1992). We use a ZINB model because of several features of our dependent variables. First, given that each of our dependent variables is a count (i.e., discrete and nonnegative), OLS regression is inappropriate since it may lead to negative predicted values (King 1988; Long 1997). Second, a Poisson model is inappropriate, both because it assumes independence across events,[18] and because our data indicate overdispersion.[19] Last, we opt for a ZINB model because it allows for a process in which zeros can be generated in two distinct ways. Zero-inflated count models change the mean structure to explicitly account for the generation of zero counts (Long 1997). Since we do not have data on all CAA-regulated facilities,[20] we only observe government behavior at facilities at which there has been an enforcement action. As a result, counties with zero enforcement may reflect truly no state enforcement of regulated facilities, or alternatively counties that have no CAA-regulated facilities – that is, counties for which there is a zero probability of enforcement. The ZINB specification explicitly models each reason we might observe zeros in our data.

The ZINB model estimates the probability of observing a specific number of state-initiated enforcement actions in a county by combining a logit and a negative binomial distribution. Specifically, the ZINB specification computes a logit (or inflation) model to predict the probability of there being no opportunity for the state to enforce the CAA. We use the set of demographic variables as well as the number of manufacturing establishments as the covariates in the logit model, while the negative binomial equation includes the full set of controls in addition to the county border designations.

Diagnostic tests indicate that the ZINB is the appropriate count model for our data. The alpha parameters are significant in each of our regressions, which confirms that the count portion of the distribution is better estimated with a negative binomial model than a Poisson model. Moreover, the Vuong (1989) test is significant in each of the regressions, which indicates that the ZINB model is more suitable for our data than a single equation negative binomial model that fails to account for the multiple processes for generating zeros. To evaluate the sensitivity of the results to our model choice, we also estimate several additional models, as we explain below.

Results

Before presenting the results from the ZINB models, we first descriptively analyze the aggregate pattern of air emissions and state enforcement behavior in border and nonborder counties. Recall that the previous literature has suggested that elevated pollution levels near state and international borders may reflect weak regulatory enforcement. Figure 1 presents some strong contradictory evidence. The data in the top panel shows total emissions (sum of all criteria air pollutants) during 1990-2000. Similar to the findings of previous studies, emissions are noticeably higher in counties that border other jurisdictions (in this case, states, oceans, or other countries). Across this period, mean emissions were about 91,000 tons/year in border counties, compared to just 56,000 tons/year nonborder counties. We present similar data for total state enforcement actions (sum of inspections and punitive actions) in the lower panel of Figure 1. These data indicate that states also perform more enforcement in counties that border other jurisdictions. Across this eleven-year period, states conducted on average six more enforcement actions in border counties compared to nonborder counties.[21]

The data in Figure 1 seem to undermine the inference that higher pollution levels are due to lax enforcement. Rather, states appear to be economically heterogeneous, with higher concentrations of industrial activity (or a different mix of it) leading to both greater emissions and greater enforcement actions near borders. Considering that borders are often located along natural features, such as rivers, which promote population centers, commerce, and industrial activity, this finding is not surprising. Some researchers have, in fact, raised this heterogeneity as a possible explanation for the robust finding in prior research that pollution levels are elevated near jurisdictional boundaries (Gray and Shadbegian 2004; Helland and Whitford; 2003; Sigman 2002, 2005).

In order to assess whether states use their enforcement discretion to encourage greater pollution emissions near borders, we use multivariate ZINB models to determine if enforcement actions are lower near jurisdictional borders at a given level of emissions. These models enable us to consider the pattern of state enforcement behavior more systematically, by allowing us to control for factors beyond border status that explain state enforcement behavior. Since our theoretical interest is to understand the pattern of state clean air enforcement in border counties relative to nonborder counties, we only present and discuss the results for the negative binomial model – that is, the part of the ZINB model that predicts the number of inspections and punitive actions for counties in which there was the opportunity for CAA enforcement to take place. We present the results for the inflation part of the ZINB model in Table A.2 in the Appendix.

Consider first the results for the model using the inspections dependent variable reported in the first column of Table 1. Neither the coefficient for eastern border counties nor ocean is not statistically significant as predicted by the free rider argument, and there is some evidence that states perform *more* enforcement in noneastern border counties (though this result is only marginally statistically significant). However, we find strong evidence that states perform fewer inspections in counties adjacent to other countries. The coefficients on each of the indicator variables designating counties bordering Canada and Mexico are negative and statistically significant.

The results for the model using the punitive actions dependent variables (column 2) suggest a similar pattern. The coefficients on Canada and Mexico each directionally support the idea that states export pollution to other countries, although only the coefficient for Canada is statistically different from zero (at only at the .10 level). We again find no effects for counties that border other states or oceans or the Great Lakes.

Last, we estimated the ZINB model using only formal punitive actions conducted by the states under the federal CAA (column 3). We again find some modest evidence that states perform less enforcement in counties with international borders, as indicated by the negative coefficient for counties bordering Mexico. However, contrary to the free riding hypothesis, we again find no evidence that states attempt to export their pollution across interstate borders or to oceans or the Great Lakes through lax regulatory enforcement of facilities in border counties.

An intuitive way to interpret the coefficients from the ZINB models is in terms of the discrete change in the expected count of enforcement actions between a border county and a nonborder county. We present these expected changes in Table 2. Looking first at inspections, on average, in a given year states perform 3 to 4 fewer inspections in counties that border Canada and 6 fewer inspections in counties that border Mexico. While this may seem negligible, this represents about 25% and 50% fewer inspections for counties bordering Canada and Mexico, respectively. In terms of punitive enforcement actions, the discrete change of -.52 for counties adjacent to Canada variable suggests that states conducted about 30% fewer punitive enforcement actions in counties that border Canada compared to all other counties. In the model considering formal punitive actions only, the discrete change of -.27 for the Mexico variable suggests that states conducted about 15% fewer punitive enforcement actions in counties that border Mexico compared to all other counties.

The coefficients for the control variables generally reflect the anticipated relationships. Our measures of county-level economic characteristics suggest that states perform less enforcement in counties with more manufacturing establishments, though the opposite relationship exists for the number of large manufacturing establishments. Regarding the political leanings of the county, as the percentage of the county voting Democratic in the previous presidential election increases, so too does the expected count of state inspections. A similar pattern emerges with respect to county nonattainment status. Consistent with air quality control regulations, state environmental agencies conduct more facility inspections in counties failing to meet ambient air quality standards than those counties in compliance with NAAQS. Many of the coefficients on the emissions variables are statistically significant, although the signs vary from pollutant to pollutant and from model to model. Across the three models, the demographic measures do not indicate consistent relationships of interest.

To test the robustness of our findings, we also estimated OLS models (not reported). Because each of our dependent variables is discrete and nonnegative, we first standardized each of the enforcement actions measures by total county emissions. These measures can be thought of as the annual number of inspections and punitive actions per 1000 tons emitted in the county. The OLS estimates of the effects of border status are generally consistent with those of the ZINB models reported above. With respect to each of the dependent variables, the results suggest that states perform fewer enforcement actions in counties that border Canada and Mexico, but we again find no evidence of interstate effects. In sum, the results from these OLS models reaffirm our findings from the ZINB models that, while states do not seem to be imposing externalities on other states, they do appear to be exporting their pollution to their international neighbors.

In the analyses we have described, we pooled counties across the United States. This approach provides a general picture of the effect of a county's border status on state air quality enforcement behavior, but it may disguise important heterogeneity. As an additional check on our results, we consider the possibility that our national-level research design drives our findings. In particular, the above analyses do not allow for regional variation in the free riding behavior at interest in this paper. Helland and Whitford (2003), for instance, find that proximity to state borders generally increases toxic chemical releases, but for some EPA regions their findings suggest that such proximity serves to *decrease* these releases. To investigate the extent to which there are systematic differences across regions, we re-estimated the ZINB model for each of four U.S. regions – Northeast, Midwest, South, and West – for both the inspections and punitive actions dependent variables.[22]

We present the results from estimating the regional models in Table 3, but for succinctness only report the coefficients for the county border status variables. Similar to the national models, we again find strong evidence that states perform fewer enforcement actions in counties that border Canada and Mexico. With respect to each of the dependent variables, we find that states in both the Northeast and Midwest conduct fewer clean air enforcement actions in counties adjacent to Canada, and that Southern states perform less enforcement in counties that border Mexico. We do not find any evidence that states in the West deliberately perform less enforcement in border counties, and we again show no indication of states free riding on their domestic neighbors. These regional equations support our findings from the national models, and indicate that the results are not driven by a single part of the country.

Discussion and Conclusion

This paper has provided a direct empirical assessment of the argument that states seek to free ride on the environmental protection efforts of other political jurisdictions by exporting their pollution across jurisdictional boundaries. Our findings suggest that regulatory enforcement behavior along jurisdictional boundaries differs significantly depending on the type of adjoining jurisdiction: while state enforcement effort is significantly lower near international borders, we do not find significant differences in enforcement effort along state borders.

The international border results are striking: for both inspections and punitive actions we find robust evidence of a strong negative relationship between enforcement levels and proximity to international borders. In counties adjacent to either Canada or Mexico, we find that states conduct markedly less enforcement of the CAA, suggesting that widely remarked upon instances of cross border air pollution are not merely accidents of industrial location. Rather it appears that states may be intentionally inducing international air pollution externalities through lax regulatory enforcement. These findings underscore the relative weakness of international agreements designed to reduce transborder air pollution between the United States and its neighbors.

Our findings for state borders are also notable. In marked contrast to the results for international borders, we do not find proximity to state borders to be associated with fewer inspections or punitive actions. These results run contrary to the expectations of a fairly well developed set of theoretical literature (e.g., Hutchinson and Kennedy 2006; Oates 2001; Silva and Caplan 1997), which predicts that states will exert significantly less enforcement effort near state borders. In fact, several observers consider this to be the single most significant criticism of environmental federalism in the United States (Oates 2001; Revesz 1996, 1997).

Our findings also point out the perils of drawing inferences about state behavior purely on the basis of observed pollution levels. We do not find evidence to support the contention that increased pollution levels along state borders are indicative of reduced regulatory stringency in areas where pollution is likely to cross state lines. In fact, descriptively we show that, relative to nonborder counties, states actually conduct more CAA enforcement actions in counties that border other states. However, once we control for confounding factors, our results provide no evidence that state enforcement of the CAA is different in interstate border counties than in nonborder counties.

There are differing possible interpretations of this result. One is that, in contrast to existing bilateral agreements between the United States and Canada and Mexico, the provisions of the CAA which are designed to combat environmental free riding are effective in doing so. This would rebut critics who have argued that its weak oversight allow states substantial opportunity to free ride, and provide a model for successful institutional arrangements for reducing environmental free riding that could potentially be applied elsewhere.

An alternative possibility is that states do engage in free riding behavior, but that they employ policy instruments other than enforcement in order to do it. Due to states' role in conducting enforcement actions and the substantial discretion they are perceived to have, regulatory enforcement is the most commonly cited means by which states could promote environmental externalities. It is not, however, the only potential mechanism which could be used for this purpose. Revesz (1996), for instance, argues that states may allow greater emissions on plants with higher stacks, which have less environmental impact close to the source and greater impact farther away. States could also impose less-stringent permitting requirements for plants near state borders, or induce plants to locate near borders via tax incentives or subsidies. These and other explanations could explain previous findings of higher pollution levels near jurisdictional borders, and they each merit future research.

These results have important implications for thinking about how federalism shapes government behavior. Critics of federalism often worry that devolution of authority to subnational governments may lead to strategic behavior with adverse consequences for other subnational governments. Instead of being exported to jurisdictional counterparts, however, our findings indicate that these externalities may be exported to other nations. Thus decentralized enforcement authority further complicates — and perhaps weakens — efforts to create effective, cross-national institutional arrangements.

Appendix

Table A.1. Descriptive statistics

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Dependent variables				
CAA inspections	13.1	32.6	0	1197
CAA punitive actions	1.69	6.41	0	199
CAA formal punitive actions	0.57	2.63	0	99
Border status				
Eastern	0.11	0.32	0	1
Noneastern	0.35	0.48	0	1
Canada	0.02	0.15	0	1
Mexico	0.01	0.09	0	1
Ocean	0.09	0.29	0	1
Control variables				
No. manufacturing establishments (1000s)	0.12	0.49	0	19.6
No. manufacturing establishments with 10+ employees	59.7	244.4	0	10,239
Unemployment rate	5.98	3.12	.5	40.8
Percent Democratic vote	41.9	11.0	0	86.9
Nonattainment status	0.14	0.34	0	1
EPA $inspections_{t-1}$	0.23	1.24	0	44
CO emissions (1000 tons/yr.)	41.7	97.8	0	3,439
NO_x emissions (1000 tons/yr.)	7.89	16.5	0	411
PM10 emissions (1000 tons/yr.)	7.88	9.34	0	286
PM2.5 emissions (1000 tons/yr.)	2.21	2.80	0	65.2
SO_2 emissions (1000 tons/yr.)	6.38	22.4	0	625
VOC emissions (1000 tons/yr.)	6.69	15.0	0	553
Population (1000s)	85.4	280.8	0.05	9546
Population density (1000s/square mile)	0.21	1.49	0.0002	66.9
Per capita income ($1000s)	18.8	5.01	4.14	85.8
Percent college educated	9.93	4.54	0	40.3
Percent poverty	15.5	7.20	0	63.1
Percent minority	13.8	15.6	0	95.0

N = 33,583.

Table A.2 Determinants of state CAA inspections in counties, 1990-2000

Variable	***Number of inspections* (1)** *Coef. (Std. error)*	***Number of punitive actions* (2)** *Coef. (Std. error)*	***Number of formal punitive actions* (3)** *Coef. (Std. error)*
No. manufacturing establishments (1000s)	-14.75	-28.49**	-6.585
	(10.28)	(9.591)	(9.379)
Population (1000s)	-.209**	-0.054*	-0.062†
	(.034)	(0.023)	(0.034)
Population density (1000s/square mile)	2.398**	0.992**	-1.278
	(0.864)	(0.253)	(6.203)
Per capita income ($1000s)	0.019	-0.041	-0.033
	(0.275)	(0.037)	(0.032)
Percent college educated	0.093**	0.085**	0.101**
	(0.022)	(0.030)	(0.029)
Percent poverty	0.065*	0.002	-0.003
	(0.026)	(0.020)	(0.023)
Percent minority	-0.003	0.005	0.010
	(0.010)	(0.009)	(0.009)
Constant	-1.349	1.531†	1.635*
	(0.959)	(0.849)	(0.789)

Note: Table reports estimates from the logit part of the ZINB model only. Cells contain coefficients, with clustered standard errors in parentheses. All models contain year fixed effects (not reported). Significance levels: † p<.10, * p<.05, ** p<.01.

[1] As discussed below, Gray and Shadbegian (2004) also look at enforcement actions. However, like the other literature cited, they draw their conclusions about jurisdictional free riding primarily on the basis of pollution emissions near borders.

[2] As used in this paper, air quality policy refers to stationary source air pollution, which covers industrial sources and power plants, as opposed to mobile source air pollution policy, which primarily regulates emissions from automobile tailpipes.

[3] More detailed information on clean air policy implementation is available from Hamel and O'Hara (1993) and Nicewander (1995).

[4] See sections 110 (a) (2) (D) and 126 (b), which are part of the 1977 CAA amendments.

[5] Canada, Mexico, and the United States also agreed to an environmental side agreement as part of the North American Free Trade Agreement, but this arrangement did not include binding mechanisms for controlling transboundary air pollution.

[6] The EPA did rescind Massachusetts' authorization of the CAA's PSD program in 2003 in response to its refusal to adopt EPA's revised New Source Review rule, but in this case, Massachusetts viewed the new rule as a weakening of pollution control standards.

[7] In 1993 congressional testimony, then EPA Administrator Browner stated that "[t]here are some States that have seriously considered returning primacy to the Federal government. I will be very honest with you, we don't have the resources to manage even one major State if primacy were to be returned" (quoted in Steinzor and Piermattei 1998).

[8] According to the U.S. Census Bureau, there are 3,141 U.S. counties. We consider fewer counties in our analyses because we drop Alaska and Hawaii, and there are missing data for some of the control variables.

[9] Data quality is another reason to focus on formal punitive actions. The EPA does not track all types of informal enforcement actions used by states under the CAA, and the data we compiled from the AIRS Facility Subsystem only contains Notices of Violation.

[10] The EPA does have air dispersion models which can used to estimate the direction of emissions for specific sources, but these are not applicable to county-level analysis.

[11] These data come from the U.S. Census Bureau's County Business Patterns dataset. About 60% of the enforcement actions in our data took place at manufacturing facilities.

[12] These data come from the Bureau of Labor Statistics (http://www.bls.gov/cew/home.htm).

[13] The EPA can designate a whole county or part of a county as being in nonattainment. In this paper, we code partial nonattainment counties as being in nonattainment.

[14] These data were provided to us by the EPA and come from the National Emissions Inventory. Emissions data are only available for 1990 and 1996-2000, so we used linear interpolation to impute data for the missing years.

[15] The annual population and per capita income data come from the U.S. Bureau of Economic Analysis (http://www.bea.gov/bea/regional/reis/). The education, poverty, and minority population data come from decennial censuses of the U.S. Census Bureau, as does the land area used to construct the population density. These data are not available for all years so we linearly interpolate the missing values.

[16] Environmental quality is often considered to be a normal economic good, and there is some evidence that environmental quality is a luxury good (Coursey 1992).

[17] An alternative approach would be to cluster at the county-level. The primary logic for this approach is that there may be county-level variables omitted from our models, which

would introduce dependence across observations. A county-fixed effect would help control for this variation (to the extent that it is time invariant), but county fixed effects are perfectly collinear with out border status designations. We did estimate the models with county clustered errors, and the core results remain largely unchanged.

[18] We cannot assume independence in our count observations in each county, because it is distinctly possible that inspections of a facility lead to more/less inspections of the same facility in a given year, or of other facilities in the county in a given year.

[19] The Poisson model assumes that the conditional variance and conditional mean of the count distribution are equal, which is not the case for either environmental enforcement measure. Likelihood ratio tests of the alpha parameters also indicate overdispersion.

[20] The EPA does not maintain these data on a historical basis.

[21] Differences of means t-tests for both enforcement actions and emissions are statistically significant at the .01 level.

[22] For these purposes, we define regions using a modification of the Bureau of Economic Analysis (BEA) classification. Specifically we, combine the BEA's New England and Mideast regions to form a Northeast region (CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT), the BEA's Great Lakes and Plains regions to form a Midwest region (IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI), the BEA's Southeast and Southwest region to form a South region (AL, AR, AZ, FL, GA, KY, LA, MS, NC, NM, OK, SC, TN, TX, VA, WV), and the BEA's Rocky Mountain and Far West regions to form a West region (CA, CO, ID, MT, NV, OR, UT, WA, WY).

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Figure 1. Air emissions and state enforcement actions in border and nonborder counties, 1990-2000.

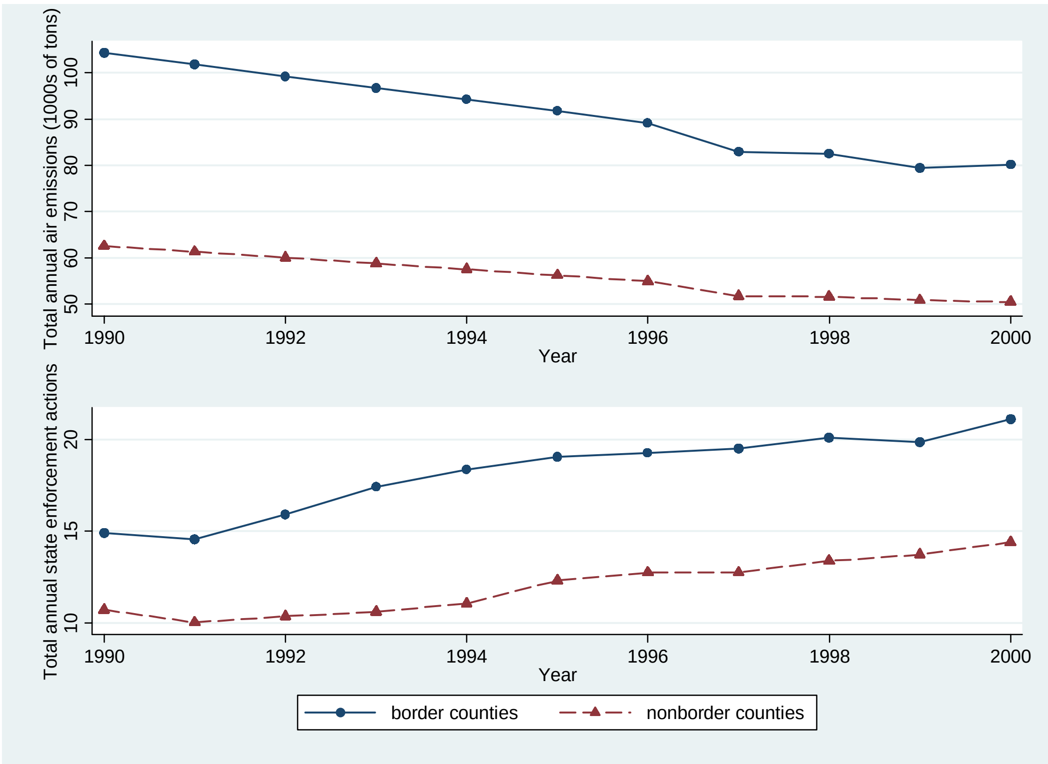

Table 1. ZINB model of state CAA enforcement actions in counties, 1990-2000

	***Number of inspections* (1)**		***Number of punitive actions* (2)**		***Number of formal punitive actions* (3)**	
Variable	*Coef.*	*Std. Error*	*Coef.*	*Std. Error*	*Coef.*	*Std. Error*
Border status						
Eastern border	0.053	(0.110)	0.123	(0.106)	0.205	(0.129)
Noneastern border	0.115†	(0.064)	0.098	(0.065)	0.136	(0.084)
Canada	-0.443*	(0.213)	-0.465†	(0.262)	-0.238	(0.310)
Mexico	-1.001**	(0.294)	-0.490	(0.361)	-0.665†	(0.398)
Ocean	-0.147	(0.139)	-0.097	(0.138)	-0.152	(0.128)
Control variables						
No. manufacturing establishments (1000s)	-3.386**	(1.015)	-3.655**	(1.104)	-2.641*	(1.236)
No. manufacturing establishments with 10+ employees	0.006**	(0.002)	0.007**	(0.002)	0.005*	(0.002)
Unemployment rate	0.005	(0.020)	0.020	(0.021)	0.017	(0.028)
Percent Democratic vote	0.008	(0.006)	0.009	(0.007)	-0.000	(0.007)
Nonattainment status	0.381**	(0.138)	0.774**	(0.141)	0.936**	(0.149)
EPA inspections_{t-1}	0.073**	(0.023)	0.087**	(0.022)	0.069*	(0.029)
CO emissions (1000 tons/yr.)	-0.004*	(0.002)	-0.003	(0.002)	-0.004*	(0.002)
NO_x emissions (1000 tons/yr.)	0.008†	(0.005)	0.013**	(0.004)	0.018**	(0.006)
PM10 emissions (1000 tons/yr.)	-0.028†	(0.016)	-0.010	(0.009)	-0.001	(0.011)
PM2.5 emissions (1000 tons/yr.)	0.110*	(0.053)	0.087**	(0.029)	0.012	(0.040)
SO_2 emissions (1000 tons/yr.)	0.003†	(0.002)	-0.002	(0.002)	-0.002	(0.002)
VOC emissions (1000 tons/yr.)	0.053**	(0.016)	0.031*	(0.013)	0.030*	(0.013)
Population (1000s)	0.001	(0.001)	-0.000	(0.001)	0.000	(0.001)
Population density (1000s/square mile)	0.014	(0.026)	0.053*	(0.026)	0.015	(0.028)
Per capita income ($1000s)	0.030†	(0.016)	0.016	(0.020)	0.026	(0.024)
Percent college educated	-0.015	(0.012)	-0.018†	(0.010)	-0.005	(0.016)
Percent poverty	0.004	(0.005)	0.002	(0.009)	0.012	(0.012)
Percent minority	-0.004	(0.013)	0.010	(0.018)	-0.008	(0.020)
Constant	1.134*	(0.467)	-1.009†	(0.563)	-1.702*	(0.767)
Model Fit						
Log likelihood	-103821.1		-40953.3		-22536.7	
Log likelihood χ^2 (d.f.)	19043.2** (40)		11060.5** (40)		6776.6** (40)	
Vuong test	32.8**		26.5**		21.2**	
N	33583		33583		33583	

Note: Table reports estimates from the negative binomial part of the ZINB model only. All models contain year fixed effects (not reported). Standard errors are clustered at the state-level. Significance levels: † p<.10, * p<.05, ** p<.01.

Table 2. Discrete change in expected count of state CAA enforcement actions

	Number of inspections	***Number of punitive actions***	***Number of formal punitive actions***
Border status			
Eastern border	0.52	0.18	0.12
Noneastern border	1.13	0.14	0.08
Canada	-3.47*	-0.52†	-0.12
Mexico	-6.11**	-0.54	-0.27†
Ocean	-1.33	-0.13	-0.08

Significance levels: † p<.10, * p<.05, ** p<.01.

Table 3. Determinants of state CAA enforcement actions, by region (1990-2000)

Inspections								
	Northeast		***Midwest***		***South***		***West***	
	Coef. (Std. error)	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*
Border status								
Eastern	-0.127 (0.185)	-3.2	0.136 (0.093)	0.97	0.161 (0.153)	1.55	-0.158 (0.205)	-0.98
Noneastern	0.011 (0.168)	0.29	0.014 (0.074)	0.09	0.103 (0.078)	0.94	0.073 (0.140)	0.48
Canada	-0.263† (0.155)	-6.23	-0.673** (0.205)	-3.39			-0.265 (0.405)	-1.53
Mexico					-0.786** (0.261)	-4.95	-0.275 (0.292)	-1.57
Ocean	-0.170† (0.098)	-4.28	-0.048 (0.138)	-0.32	0.165 (0.192)	1.59	-0.035 (0.229)	-0.23
Punitive Actions								
	Northeast		***Midwest***		***South***		***West***	
	Coef. (Std. error)	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*	*Coef. (Std. error)*	*Discrete Change*
Border status								
Eastern	0.068 (0.142)	0.34	0.268* (0.127)	0.22	0.165 (0.100)	0.22	-0.058 (0.202)	-0.08
Noneastern	-0.109 (0.099)	-0.54	-0.034 (0.130)	-0.03	0.027 (0.057)	0.03	0.214 (0.144)	0.30
Canada	-0.629* (0.305)	-2.46	-0.465** (0.219)	-0.28			0.080 (0.340)	0.11
Mexico					-0.451† (0.258)	-0.46	1.02** (0.364)	2.41
Ocean	0.037 (0.161)	0.19	-0.025 (0.315)	-0.01	0.010 (0.212)	0.01	0.347 (0.245)	0.55

Note: Cells contain coefficients, with state-level clustered standard errors in parentheses. All models include full set of controls and year fixed effects. Significance levels: † p<.10, * p<.05, ** p<.01.

Regions.
East: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT.
Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI.
South: AL, AR, AZ, FL, GA, KY, LA, MS, NC, NM, OK, SC, TN, TX, VA, WV.
West: CA, CO, ID, MT, NV, OR, UT, WA, WY.