Community Pressure and the Spatial Redistribution of Pollution: The Relocation of Toxic-Releasing Facilities

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Abstract: This paper analyzes the effects of community pressure on the relocation of toxic-releasing facilities by using the public disclosure of toxic release information through the Toxics Release Inventory (TRI) as a natural experiment. We find that facilities are more likely to relocate from communities with high population density, income, and educational attainment, whereas low wages, rent, and transportation amenities deter relocation. Facilities with emissions below reporting thresholds but expectations of emissions growth are more likely to relocate in anticipation of their inclusion in the TRI. Relocating facilities tend to move into communities with lower population density, income, and educational attainment, and this pattern is stronger for facilities whose scale of operations and emissions grows the most post-relocation. The spatial pattern of facility relocation provides indirect evidence that environmental information disclosure may unintentionally worsen environmental injustice because of differential effects of community pressure.

JEL Codes: D63, Q53, R3

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PUBLICLY AVAILABLE INFORMATION about the toxic releases from facilities in the United States has grown following the mandatory reporting of these releases by facilities and the disclosure of the Toxics Release Inventory (TRI) since 1990. The presence

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of toxic-releasing facilities in communities has led to public concern about the risks they pose to human health, environmental quality, and property values (Currie et al. 2015; Mastromonaco 2015). This "information empowerment" has facilitated environmental democracy by enabling affected citizens to impose pressure on facilities to reduce their releases (Lynn and Kartez 1994) and investors to signal their preference for lower toxic releases through the stock market (Hamilton 1995a). There is anecdotal evidence that community members have responded to this information through the media, targeted collective action, and "toxic torts" lawsuits for health and environmental damages claiming direct negative effects (see Shapiro 2005).

Following the disclosure of the TRI, toxic releases have declined on average by 40% by 2014 (US EPA 2016), but these reductions have not been distributed evenly across locations. Emissions fell by 18% in the poorest counties and 68% in the richer counties (Kalnins and Dowell 2015) and by less in African American communities compared to other communities (Ard 2015). Several early studies have noted that communities with low income, low education, and a high proportion of minorities face more exposure to risks due to toxic releases (Gould 1986; United Church of Christ, Commission for Racial Justice 1987; Kriesel et al. 1996). But these studies do not explain the mechanisms by which these environmental disparities may have arisen.

A few studies have analyzed the mechanisms by which information disclosure can lead communities to impose pressure on facilities to reduce their releases (Antweiler and Harrison 2003; Shapiro 2005). These cross-sectional studies do not account for reverse causality arising from households "voting with their feet" for environmental quality, as households may migrate in response to the entry or presence of toxic facilities and alter the community demographics. For example, Banzhaf and Walsh (2008) showed that the entry of toxic-releasing facilities in a community was associated with a decrease in population density over time and with the community becoming poorer and less white, and Boone et al. (2014) note that census tracts in Baltimore with a high density of toxic facilities became less white and more Hispanic.

Recent studies have overcome the reverse causality problem by examining the planned locations of facility expansion (Hamilton 1993, 1995b) and locations of new plant birth or exit which could not affect the preexisting demographics at the locations (List et al. 2003; Wolverton 2009; De Silva et al. 2016). These studies find that stringent regulation approximated by a county's nonattainment status deters new plant births after controlling for county characteristics (List et al. 2003) and that TRI plants

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are more likely to locate in census tracts with lower household income (Wolverton 2009). The effects of race on location choice for new plant births are mixed: Wolverton (2009) finds no impact while De Silva et al. (2016) find that new plants were more likely to locate in areas with a higher percentage of nonwhite residents.

Other studies use spatial and temporal lags to examine whether reduction of pollution is disproportionally affecting different social groups (Gray and Shadbegian 2004; Baryshnikova 2010). These studies find that paper and pulp plants were likely to reduce their emissions if located near vulnerable populations with lower educational attainment, whereas the effects of income and race are mixed. However, these studies examine the effects of community pressure on the spatial pattern of emissions reduction by firms at their current location.

The purpose of this paper is to examine the extent to which community pressure can lead facilities to relocate and generate disproportionate exposure of socioeconomically disadvantaged communities to toxic wastes, thus contributing to environmental injustice. By focusing on relocation decisions by firms instead of de novo entry decisions, this research provides richer insights on both the "push" and "pull" effects of community characteristics that influence a facility's location.[1] The former broadly consist of factors that raise a facility's reputational, legal, and other operating costs at its existing location, while the latter also include the siting and expansion costs at the new location. Comparing relocation patterns with those for de novo entry provides a more comprehensive understanding of how community pressures can affect the distribution of toxic polluters across communities. Additionally, analysis of relocation decisions allows us to compare the characteristics of the current location choice of a facility with those of the new location choice of the same facility, thereby controlling for unobserved facility heterogeneity. In the case of relocation decisions, the fundamental nature of the facility is substantively unaltered by the move, though the facility might grow in size and update its technology. Thus, a comparison of community characteristics between the old and new locations reveals how the importance of those characteristics has changed, holding other aspects of the facility constant. Relocation choices can have significant effects on environmental injustice if they are frequent and if the toxic emissions of relocating facilities are higher post-relocation.

There has been considerable research analyzing the "pollution haven" hypothesis, which predicts that pollution-intensive industry will shift from countries with stringent regulation to countries with lax environmental regulation after trade barriers are reduced (Copeland and Taylor 2004; Taylor 2004). This research evaluates the effects of differences in the stringency of environmental regulations in two international

1. There is evidence from the broader literature that the relocation of existing facilities responds differently to general community characteristics than the location of newborn facilities, in part because relocation takes place in a different stage of a facility's life cycle (van Dijk and Pellenbarg 2000; Holl 2004).

regions on inflow and outflow of investments on pollution-intensive industry and trade in pollution-intensive goods (e.g., Wagner and Timmins 2009; Mulatu et al. 2010; Erdogan 2014). Unlike these studies analyzing the effects of lower trade barriers and differences in the stringency of environmental regulations across states or countries on flows of capital and goods from pollution-intensive industries, we are undertaking a more microlevel study of the effects of local community pressure induced by pollution information disclosure on relocation decisions by existing polluting firms. This paper contributes to the pollution haven literature by showing that other factors, such as the spatial variation in local community pressure, can have an incremental effect on relocation decisions, beyond that arising from differences in regulatory stringency across jurisdictions.

More specifically, we examine the extent to which differential community pressure, proxied by community socioeconomic characteristics, led toxic-releasing facilities to relocate away from the communities where public opposition was strongest. The TRI disclosure after mid-1989 provides a natural experiment to examine the effects of the preexisting (as of 1990) community characteristics on the subsequent facility relocation. Though residents were often aware prior to that date of the presence of manufacturing facilities in their proximity, they lacked detailed knowledge of harmful chemicals in the emissions emanating from those facilities (and also of the extent that such harmful chemicals were present). The advent of the TRI resulted in dissemination of such knowledge, increasing the salience of the presence of such facilities to residents in close proximity. The use of the TRI disclosure as a starting point for our analysis mitigates possible endogeneity concerns caused by unobserved confounders, such as the opposition of residents against toxic facilities prior to a facility's initial location decision. Because the TRI "treatment" affected every locality and we do not have information prior to the TRI in our data, the effect we identify is the relative impact of the information release across localities that differ in socioeconomic characteristics and not the general level of that impact. Our analysis also controls for various location-specific economic and regulatory factors and facility-specific characteristics that can affect relocation decisions.

We construct a panel data set for 20,518 facilities existing before 1990 and that reported to TRI for at least some years during the 1990–2011 period. We first estimate the effects of the community characteristics in 1990 on the relocation decision of local toxic facilities over the following 10 or 20 years. The advent of the TRI yields a community pressure treatment effect of varying intensity on facility relocation; the intensity of the treatment effect depends on the community's socioeconomic characteristics. Our second set of analyses investigates the extent to which community characteristics (measured in 1990) affect the annual relocation probability as facility characteristics and selected other relevant factors evolve. Additionally, we distinguish between facilities that were reporting to the TRI in 1990 and those that started to report in later years to examine the effect of community pressure in prospectively inducing facilities to relocate if they expected to grow and report to the TRI in the future. Third, we compare the characteristics of the destination communities to those of the origin locations to confirm that facilities tend to move down the community pressure gradient and to examine the extent to which post-TRI relocations shift the distribution of pollution toward disadvantaged socioeconomic groups. Finally, we examine the change in the facilities' emission level, employment, and emission per employee following relocation to obtain further insights about the possible motivation for facility relocation.

We find that the toxic facilities located in a census tract with higher population density and a larger share of college-educated residents in 1990 were more likely to relocate in the following years; a one standard deviation increase in the population density and in the fraction of college-educated residents increases the annual relocation probability of the average facility from 0.78% to 0.86% and 0.96%, respectively (i.e., increases of 0.12 and 0.18 percentage points). Our estimates show that these effects are at the same scale as the marginal effect of a 1% increase in local labor cost (measured by wage rate). We also find that anticipated community pressures increased the relocation probabilities of facilities that were not reporting in 1990 but increased their emissions in later years. Moreover, we find that relocated toxic facilities tend to move into communities with lower population, lower income, and lower educational attainment. We also find that relocating facilities did not increase their pollution intensity relative to those that did not relocate; however, they tended to pollute more because their production levels increased by more. This is particularly true for facilities moving to locations with weaker community pressure. These findings show that subsequent to the public disclosure of the TRI, the reshuffling of existing toxic facilities across communities had an adverse distributional effect on the disadvantaged socioeconomic groups.

To the extent that the community pressures on firms were enabled by the public disclosure of the TRI, our research contributes to understanding the potential unintended implications of information disclosure programs. We do note, however, that in the absence of data about relocation choices by facilities prior to the release of the TRI, we do not seek to draw conclusions about the effect of information dissemination per se. We do not have the basis for projecting relocation decisions in the absence of the TRI disclosure.

1. CONCEPTUAL FRAMEWORK

1.1. Information-Induced Motivations for Relocation

The provision of toxic release information to the public can increase community concern about the risk of accidental releases of hazardous waste and its adverse impacts on human health and to efforts by the community to induce the facility to reduce releases or to shut down/relocate. These efforts can take the form of public opposition to the operation of toxic-releasing facilities, social ostracism of the facilities' employees, adverse publicity, and lawsuits to establish liability for environmental and health damages (MacLean and Orum 1992; Pargal and Wheeler 1996; Karkkainen 2001; Hamilton

2005). Communities can also seek to impose pressure on such facilities by lobbying regulators and local political representatives to tighten the enforcement of existing regulations or intensify monitoring of such facilities (Earnhart 2004).

We hypothesize that the extent to which information provision influences a facility's decision to relocate from its existing location depends on the following six factors: (*a*) the strength of concerns about toxic releases in the community, (*b*) the ethnicity of the community, (*c*) the ability of the community to organize itself collectively, and (*d*) the potential for liability for damages to human health at its existing location. The facility will weigh these effects with other factors that affect its costs of operation at the existing location that include (*e*) regulatory pressures and (*f*) economic conditions. The latter include location-specific conditions as well as facility-specific characteristics that affect its costs of relocation and ability to relocate. Factors *a*–*d* depend on the composition of the community while *e* and *f* depend on local regulations and economic conditions and will, therefore, be location and facility specific. Factors *a*–*d* can lead a facility to reexamine its location choice after the provision of information and to weigh the advantages of relocating to a new location with the costs of relocation that depend on *e* and *f*. We now discuss the rationale for each of these hypotheses.

1.1.1. Strength of Community Concern

Concerns about toxic releases are expected to be stronger among communities with easier access to information, ability to interpret the information, and knowledge about the health risks due to toxic releases. Collecting and using TRI information requires considerable motivation and in the 1990s would have also required knowledge of computer technology, making it less accessible to the poor or less educated communities (Shapiro 2005). Education is critical for comprehending and reacting to risk, and several studies find that low educational attainment correlates with higher density of polluting facilities (see Boone et al. 2014). Rich and high-educated groups are also likely to own higher-valued properties and be more concerned about the impact of toxic releases on property values. They are also likely to have greater access to resources and political influence to generate negative publicity for these facilities and bargaining power to be taken seriously by these facilities to reduce emissions or relocate (Hamilton 1993, 1995b; Gray and Shadbegian 2004; Shadbegian and Wolverton 2010). These concerns are likely to be correlated with the quantity of toxic releases emitted by facilities in their community, potentially creating stronger incentives for larger polluters to relocate.

1.1.2. Ethnicity of the Community

The environmental justice literature has emphasized that facility owners and operators implicitly or explicitly account for the ethnic characteristics of surrounding neighborhood in considering the extent to which they should alter their generation of environmental externalities (Shapiro 2005). Communities with a large minority population or greater ethnic divisions are also likely to find it more difficult to organize collective action because of unfamiliarity with local political process or language barriers (Hamilton 1995b; Cole et al. 2013; De Silva et al. 2016). The early environmental justice studies indicated the presence of environmental inequities, but more methodologically sophisticated studies provide mixed evidence (see review in Shapiro 2005), with several finding contrary results indicating that nonminority groups were more exposed to pollution (Gray and Shadbegian 2004). As explained by Boone et al. (2014), in the case of Baltimore, this could be due to the preference of white residents in the early 1990s to live close to a factory job and the imposition of residential segregation and institutional constraints that restricted African Americans from moving into those neighborhoods.

1.1.3. Organizational Ability of the Community

In the non-Coasian world, the high transaction cost of individual bargaining makes reliance on the political process and on collective action necessary for negotiations between community residents and polluting facilities (Hamilton 1995b). Thus, the extent to which community concerns about toxic facilities manifest themselves into tangible pressure on the facility depends on the community's ability to organize itself collectively. Firms may face larger reputational damages, adverse publicity, and legal costs in locations where communities can overcome organizational transaction costs to protect perceived property rights to a toxic-free environment. Communities that are more politically active and have well-developed mechanisms for information gathering and dissemination and collective action are more likely to be able to organize themselves and impose pressure on toxic-releasing facilities to relocate. The willingness to organize collectively for an environmental cause also depends on political ideology (Becker 2004). Communities that have a higher percentage of Democratic voters may impose a higher pressure on polluting facilities to improve their performance and may be less pro-industry.

1.1.4. Potential for Liability

Information about toxic releases from specific facilities increases the likelihood of a facility being held liable by the local population for environmental and health damages. The expected cost of these liabilities depends on the size of the vulnerable population as well as on the bargaining power of the community. They are also related to the magnitude of the toxic releases being emitted by the facility, although large polluters may also be more able to resist community pressure and counter residents' and workers' claims against them (Cable et al. 2008).

1.1.5. Regulatory Pressures

The profitability of operating a facility at a location is also influenced by the stringency of local environmental regulations, as suggested by the pollution haven hypothesis. Most toxic releases are not regulated directly (Currie et al. 2015), and the government has relied on information disclosure and other voluntary programs to induce firms to reduce these releases (Khanna et al. 1998; Harrison and Antweiler 2003; Bi and

Khanna 2012). However, of the over 600 chemicals reported to the TRI, 189 have been designated as hazardous air pollutants (HAP) and regulated under the National Emissions Standards for HAP (NESHAP) of the Clean Air Act since 2000. Additionally, about 300 toxic chemicals are precursors to criteria air pollutants regulated under the National Ambient Air Quality Standards (NAAQS). The US EPA has designated counties as being in nonattainment with NAAQS, and counties in nonattainment are more likely to have a higher frequency of inspections, monitoring, and enforcement of penalties against violators than counties that are in attainment. Information about the HAP releases by a facility can increase the threat of enforcement of existing or anticipated regulations and increase the facility compliance costs by requiring the adoption of a costly environmental management system or specific technologies (Khanna and Anton 2002). These additional costs can lower profits and lead polluters to relocate to places with less stringent regulations, as is shown by List et al. (2003). Becker and Henderson (2000) also found a smaller number of new manufacturing plants born in nonattainment counties. Although the standards for HAP emissions are uniform across the United States, the stringency with which they are enforced could vary depending on the characteristics of communities. This is because local regulators could be influenced by political pressures and local community pressures (Sigman 2001).

1.1.6. Economic Conditions

The relocation decision of a facility could also be affected by its ability to bear the relocation cost and to benefit economically from the move (Grant et al. 2010). Location-specific relevant factors include the economic conditions at the facility's existing location, such as the availability and cost of labor, land rent, and access to suppliers. The cost of labor and land are important determinants of the production and operating cost of manufacturing firms and have been found to be significant factors influencing plants' location choice (Levinson 1996; Wolverton 2009). The density of existing toxic facilities in a community can affect local agglomeration benefits, such as easier access to suppliers and an industrially skilled labor pool (Puga 2010), and can also signal relative acceptability of pollution in an area (Wolverton 2009). Wolverton (2009) and De Silva et al. (2016) show that new toxic facilities in Texas tend to locate into census tracts with a larger number of preexisting toxic facilities. Local transportation cost, which can determine the commuting cost of facilities to input and output markets can also influence how "footloose" a facility can be.

The costs of relocation and economic ability to relocate also depend on facility characteristics, such as the size of the facility and its financial health. Small facilities typically have few employees, a simple organization, and few fixed production assets. These characteristics suggest a low relocating cost: it is easier to hire and train new workers, replace equipment, and search for an appropriate destination site since more sites could potentially accommodate the facility (McCann 2001). Facilities that employ fewer workers may also have lower local support since fewer jobs would be at stake if they relocate. Van Dijk and Pellenbarg (2000) examine the migration of firms in the Netherlands and find that small-sized firms (measured by the number of employees) have a higher tendency to relocate. Firms that have a weak financial standing can have limited ability to pay for the relocating cost (which could be substantial) if they cannot obtain external finance (van Dijk and Pellenbarg 2000). However, a less healthy financial status can also be an incentive for businesses to move their manufacturing into locations with lower production costs. Many studies have found that financial markets reacted positively and a firm's stock price increased when it announced relocation with a goal of cost savings or increased operational efficiency. These two opposing effects result in an ambiguous effect of financial health on the propensity of a facility to relocate (see Hu et al. [2008] for empirical evidence).

1.2. A Stylized Model

Based on the conceptual framework above, we now present a stylized model that underlies the empirical framework developed in the next section. We consider a profit-maximizing facility i ($i = 1, 2, \ldots, I$) in location l_0 that is generating toxic releases. In the absence of public information about its pollution, residents in the neighborhood are expected to be unaware or to underestimate a facility's toxic pollution. At time t_p, an information disclosure program is established that publicly discloses information about the magnitude of toxic chemical usage and disposal by facility i for the first time. This information is widely disseminated and easily accessible to the public (Hamilton 1995a; US EPA 2016). Facility i can respond to the pressure of its local community l_0 by reducing its toxic releases (see evidence in Khanna et al. [1998]) or by shutting down the operations at l_0 and relocating to some other location l_1 at some time $t > t_p$. Facility i weighs the costs and benefits of staying in l_0 with those of relocating. The benefits of relocating to various alternative locations depend on several factors, including the strength of community pressure, the threat of liability, stringency of local environmental regulations and economic conditions. The costs of relocation include the fixed costs due to the immobility of fixed assets, the transaction costs of rehiring or relocating employees, and the costs of transporting mobile assets; these costs are likely to be facility specific and higher for larger facilities.

We denote a facility i's profit π_{ilt} at location l at time t by the reduced-form function

$$\pi_{ilt} = \pi(M_{lt}, \boldsymbol{Z_{lt}}, \boldsymbol{X_{ilt}}, \boldsymbol{e_{ilt}}), \tag{1}$$

where M_{lt} is the cost of pollution generation imposed on the facility by local community pressure, $\boldsymbol{Z_{lt}}$ is a vector of location-specific economic and regulatory factors that affect the revenues and costs of operations, $\boldsymbol{X_{ilt}}$ is a vector of the facility's characteristics such as size and pollution level that may affect the specific gains and costs of relocation, and $\boldsymbol{e_{ilt}}$ includes the unobserved facility- and location-specific factors. Facility i selects the profit-maximizing level of $\boldsymbol{X^*_{ilt}}$ when establishing in location l_0 given M_{l_0t} and $\boldsymbol{Z_{l_0t}}$. The provision of toxic release information at time t_0 can result in a change in M_{l_0t}

for $t > t_0$. As a result, the facility may find it profitable to relocate to a more favorable alternative location l_1 at a relocation cost of $C_{l_0 l_1 t}$, even after it adjusts $\boldsymbol{X}_{il_0 t}$. Because $C_{l_0 l_1 t}$ can be substantive, a facility will move only if the reduction in community-pressure-related costs is greater than the cost of relocation. We denote by r_{it} the binary indicator that equals 1 if facility i relocates at time t, and equals 0 otherwise, and by r^*_{it} the expected net benefit of the relocation. It follows that these variables are related through the expressions

$$r_{it} = \begin{cases} 1, r^*_{it} = \pi^*_{il_1 t}\left(M_{l_1 t}, \boldsymbol{Z}_{l_1 t}, \boldsymbol{X}^*_{il_1 t}, \boldsymbol{e}_{il_1 t}\right) - \pi^*_{il_0 t}\left(M_{l_0 t}, \boldsymbol{Z}_{l_0 t}, \boldsymbol{X}^*_{il_0 t}, \boldsymbol{e}_{il_0 t}\right) - C_{l_0 l_1 t} > 0\,. \\ 0, \text{otherwise} \end{cases} \tag{2}$$

1.3. Variable Construction

We test our six hypotheses by constructing explanatory variables that proxy for various pressures and for the benefits and costs of relocation for a toxic-releasing facility. These variables are not mutually exclusive proxies for each hypothesis; instead some proxies may have multifaceted impacts on a facility's relocation decision.

1.3.1. Community Characteristics

We expect a community with a higher level of income, educational attainment, and a higher level of home ownership to impose higher pressure on toxic facilities to relocate.[2] We construct the variables, Income Level, measured by per capita income, Educational Attainment, measured by fraction of residents with bachelor's or higher degree, and indicators of home ownership, measured by fraction of Renters and fraction of Vacant Housing as proxies for the level of communities' concern about toxic releases by local facilities. Findings in the literature on the effects of these variables on location choice of facilities are mixed. Wolverton (2009) finds a negative effect of income and a positive effect of educational attainment on the propensity of newborn facilities to locate in a community, whereas De Silva et al. (2016) find an insignificant effect of income and a negative effect of educational attainment. Boone et al. (2014) find that the density of polluting industry is positively correlated with low-income neighborhoods and renter-occupied housing and with low educational attainment populations. Arora and Cason (1999) find that the probability of existence of toxic facilities in a community is positively correlated with fraction of renter-occupied housing in nonurban areas but not in urban areas.

We construct the fraction of Non-Hispanic White as a measure of the ethnicity of population. We consider Voter Turnout, measured by the fraction of residents voting in presidential election, as a proxy for a community's political engagement that reflects

2. Becker (2004) also mentioned the potential impact of unemployment and a community's engagement in manufacturing activities on community pressure. We include unemployment rate and the percentage of people employed in manufacturing industries as covariates in the model, but we did not find significant effects of them. See table B4 for details.

its ability to organize collective action and to impose pressure on regulators (as in Hamilton 1995b; Arora and Cason 1999; Wolverton 2009). Hamilton (1995b) finds that communities with higher voter turnout are less likely to experience expansion of hazardous-waste-generating plants; however, Wolverton (2009) finds that communities with higher voter turnout are more likely to attract new toxic facilities, perhaps because workers can also act collectively to voice their demand for jobs. We control for the effects of political ideology by including the variable Democrats, measured by the average percentage vote share for the Democratic presidential candidate in 1988 and 1992 elections.

We consider Population Density, measured by population per square mile, the fraction of population under the age of five (Children), and the fraction of population over age of 65 (Elderly) as proxies for the threat of liability for a facility. The number of residents in a neighborhood is a factor in legal calculations of the net present value of earnings streams in communities' damage claims in courts (Hamilton 1995b). Hamilton (1995b) shows that hazardous-waste-generating plants have a lower propensity to expand in large population centers. The fraction of the population that consists of young children and elderly indicates the vulnerability of the population to pollution. Gray and Shadbegian (2004) and Baryshnikova (2010) find that facilities located closer to more children and elderly emit less pollution.

1.3.2. Location-Specific Characteristics

We include proxies for regulatory pressure as well as for economic conditions at a location that can affect a facility's decision to stay or move to another location. As a measure of regulatory pressure, we include the Attainment Status of a county with the National Ambient Air Quality Standards (NAAQS). We expect a community with "nonattainment" status to impose higher pressure on the relocation of toxic polluting facilities, since many toxic pollutants are precursors to criteria air pollutants. The NAAQS has standards on six different criteria pollutants, including the ozone, NOx, SO_2, CO, PM2.5, and PM10. We designate a county as being in "nonattainment" when any of the six criteria pollutants exceeds the NAAQS.[3]

We also control for other sources of potential regulatory pressure under the Clean Air Act Amendments (CAAA) on toxic releases by constructing a variable HAP measured at the facility level by the ratio of HAP emissions to the total amount of TRI chemical releases of each facility.[4] We expect these pressures to be greater on facilities with higher HAP, and they may, therefore, be more likely to relocate from their existing location.

Several economic factors may also affect a facility's costs of operation at its existing location. These include labor costs and land rent. Labor costs are measured by the

3. The dummy variable Attainment Status equals 1 in the years in which a county is in nonattainment and switches to 0 in the years when the county is in attainment.

4. Brouhle et al. (2009) adopted a similar approach, using an index based on hazardous air emissions.

average Wage Rate of production workers. Bartik (1985) and Wolverton (2009) find a negative relationship between the level of workers' wage rate and the propensity of a toxic-releasing plant to locate in a community. We measure land rent by the median value of owner-occupied housing (Housing Value). We control for overall availability of infrastructure and public services, which affects the ease and cost of conducting business, by including the variable Urban, which is defined as the fraction of urban population (as in Wolverton 2009). The effect of this variable on costs of operating at a location is ambiguous, since urban areas are also likely to have a higher tax rate and crime rate. We control for transportation costs of operating at a location by including the Miles of Highways and Miles of Railways in each community. Since facilities may prefer to operate in the vicinity of other industrial activity, we include the number of other toxic facilities (Toxic Facilities) as a variable, following De Silva et al. (2016). This variable also acts as a proxy for other unobserved factors that make a location attractive for such facilities.

1.3.3. Facility-Specific Characteristics

We include three facility characteristics that may affect the costs and benefits of relocation for a facility, following our discussion in section 1.1. The first is the level of Toxic Emissions. We measure Toxic Emissions using the total toxic releases that aggregate the releases of all reported chemicals by a facility.[5] We do not weight chemicals by toxicity following the results from Arora and Cason (1999), who find that most chemicals on the TRI list have similar toxicity and that the response of facilities' releases to local community demographics is not sensitive to the weighting scheme. As discussed above, direct community pressure, threat of liabilities, and indirect regulatory pressure are likely to be stronger on facilities with larger toxic releases. Because relocation can be an alternative to emission abatement as a way to reduce local community pressure and regulatory scrutiny, large polluters could have a strong incentive to relocate. But on the other hand, large polluters are also more able to resist community pressure and counter residents' and workers' claims against them (Cable et al. 2008). Equally importantly, large polluters may be subject to higher costs of relocation, not least because there are fewer locations that could be suitable physically and whose residents would be willing to accommodate them. Therefore, we expect a more complex relationship between the level of Toxic Emissions and relocation propensity.

The second factor is Size. We use the log number of employees of facilities as a measure of Size because we have no information about the physical capital or assets at the

5. The TRI had a major change in 1995 when the list of traced chemicals increased from 333 to 619. The newly added chemicals were selected by the EPA based on toxicity and health impact, which are exogenous to the relocation decisions of facilities. We include the aggregate emissions of all chemicals in Toxic Emissions, as we expect community pressure is based on the observed total level of toxic releases disclosed to TRI and not affected by the change in reporting requirements. This issue, however, does not affect our cross-sectional model that uses the 1990 emissions.

facility level. Based on our discussion above, we expect facilities with a small number of employees to be more likely to relocate.

The third factor is the Financial Health of the parent firm. We measure Financial Health using the PayDex score, a credit score similar to the FICO score for individuals but measured based on the payment history of businesses. Our data provide the maximum and minimum values of the PayDex score of a business in each year. A low PayDex score indicates a higher probability of delayed payment of debt.[6] We use the max PayDex score to control for the status of a facility's payment capacity and use the difference between the max and min as to control for the variation in the score which represents short-run volatility in the firm's finances. As discussed above, the effect of Financial Health on facility relocation remains to be tested.

2. EMPIRICAL MODEL

Our empirical model builds on equation (2) and predicts relocation, r_{it}, using a reduced-form discrete choice model with vectors of community characteristics $\boldsymbol{M}_{l_0t}$, other location-specific factors $\boldsymbol{Z}_{l_0t}$, and facility characteristics $\boldsymbol{X}_{il_0t}$ as exogenous variables to explain the likelihood of relocation by facility i from location l_0 at time t. The underlying latent variable, r_{it}^*, is given by

$$r_{it}^* = \alpha + \boldsymbol{\beta} \boldsymbol{M}_{l_0t} + \boldsymbol{\gamma}_1 \boldsymbol{Z}_{l_0t} + \boldsymbol{\gamma}_2 \boldsymbol{X}_{il_0t} + \boldsymbol{e}_{il_0t}, \tag{3}$$

where $\boldsymbol{e}_{il_0t}$ is a disturbance term, and $r_{it} = 1$ if $r_{it}^* > 0$ and 0 if $r_{it}^* \leq 0$. The main difference between this specification and the framework described in section 1 is that destination characteristics and relocation costs are absent from equation (3). Destination characteristics are only available for the subset of facilities that did relocate (and are used in sec. 6). To arrive at specification (3), the implicit assumption is that the expected payoff in the best alternative location and the cost of relocation are both linear functions of current location and facility characteristics (possibly with zero slopes with respect to some variables).[7] Then, the estimated coefficient for each of the variables in

6. A PayDex score of 80 indicates an on-time payment. A score higher than 80 means a payment ahead of the due date. Details of the methods for calculating the PayDex score can be found at https://www.nav.com/business-credit-scores/dun-bradstreet-paydex/.

7. This linear relationship can contain a "disturbance" term. We implicitly assume that the firm relocates based on the expected payoff in the best location, not the actual payoff based on the characteristics of the chosen location. There may be an unobserved to us, but observed to the firm, component of the payoff in the best alternative location. In that case, the attributes of the best alternative ($M_{\text{destination}}$) would be an omitted variable in the estimating regression. In a binary choice model, an uncorrelated omitted variable result in attenuation bias (e.g., see Yatchew and Griliches 1985). However, the best alternative destination and origin location characteristics are likely positively correlated, which suggests a second source of bias that would reinforce the causal effect of the location attribute. This would go against the attenuation bias. Therefore, the net bias is of unknown sign.

equation (3) is the net contribution of that variable to the expected payoff in the best alternative location minus the opportunity payoff of staying in a location (and also minus the cost of relocation). It is in this sense that our analysis is reduced form; we interpret our results accordingly. We next describe each variable set, before returning to the estimation of our empirical model.

We define "relocation" as a move by a facility across census tracts or counties (depending on specification). Compared to other narrow geographical units such as zip codes, a census tract has relatively stable boundaries over time (Been and Gupta 1997) and therefore can be used to compare community characteristics consistently over years. The community characteristics in $\boldsymbol{M}_{lt}$ (Income Level, Educational Attainment, Non-Hispanic White, Renters, Vacant Housing, Population Density, Children, Elderly) are also mostly available at the census tract level. To consider the potential pressures from neighboring tracts that are within a close distance of a facility and thus could be affected by its toxic releases, we draw a 1-mile circle around each facility and calculate the average demographics of the census tract where the facility is located and those of the census tracts with centroids falling within the circle. Thus, two facilities that are located in the same census tract may be associated with different levels of community pressure depending on their exact location within that tract. We cluster standard errors at the census tract level to adjust for the nonindependence in facilities' behavior in the same location due to the potential interactions among collocated facilities on environmental management, knowledge spillovers that may affect relocation (Gray and Shadbegian 2007), and other common location-specific factors.

Voter Turnout, Democrats, Wage Rate, and Attainment Status are measured at the county level because they are not available in a spatially more disaggregated form. This may not be a material limitation since, as Hamilton (1995b) has pointed out, the relevant geography for a firm's labor inputs is broader than a 1-mile circle and can extend to a county or broader region. Because of the coarseness of the county-level data, we examine the cross-county and within-county relocations separately and only include the county-level explanatory variables in the regressions explaining cross-county moves. The analysis of within-county moves is particularly important because they are clearly not driven by regulatory or market considerations, since these are largely invariant within a county.

Toxic Facilities, Housing Value, and Urban are measured at the census tract level. Miles of Highways and Miles of Railways are also measured at the census tract level and are derived by overlaying census tract boundary information with geographic data on the location of major highways and railways throughout the United States.

The elements of $(\boldsymbol{X}_{il_0t})$ are all measured at the facility level, including Toxic Emissions, Size, and Financial Health. Toxic Emissions is left-censored because the TRI program only requires facilities to report if their emissions of a chemical exceed a threshold. We treat the missing values in Toxic Emissions as zero but add a binary indicator Zero Emission in the regressions so that these facilities do not impact our estimates of the marginal effect of emissions on firm behavior above the threshold. This variable also accounts for the possibility that facilities that are not emitting in a particular year (or period) are qualitatively different than those that are emitting. Because emissions levels differ markedly across facilities, with the largest emitters emitting many times the level of the typical emitter, we use a linear spline to allow Toxic Emissions to enter the model in a flexible manner and allow the emission level to have a nonlinear effect on the relocation propensity of facilities.

In the specification described by equation (3), the coefficient vector $\boldsymbol{\beta}$ is of primary interest. It predicts the direction of the relationship between the community characteristics $\boldsymbol{M}_{lt}$ and the likelihood of facility relocation. An important concern in identifying $\boldsymbol{\beta}$ is the possibility of reverse causality, as households may "vote with their feet" in response to the presence of toxic facilities, so that location demographics are determined by facility siting decisions rather than vice versa (Tiebout 1956). We avoid this problem by using the 1990 value of the community demographics, $\boldsymbol{M}_{l1990}$, to explain relocations after 1990. As such, the demographic characteristics predate the relocation decision of facilities and can be treated as exogenous. To examine the heterogeneity of $\boldsymbol{\beta}$ between heavy and light polluters, we also include in some specifications the interaction of Toxic Emissions with the community characteristics $\boldsymbol{M}_{l1990}$.

We estimate two versions of the model in equation (3) via logit regression. First, we explain a facility's probability of relocation over a period after the first TRI disclosure. The model uses $\boldsymbol{M}_{l1990}$ and other covariates evaluated at 1990 to predict the likelihood of relocating within T years after 1990. We set the value of T at 5, 10, and 20 years. Defining by R_{iT} the indicator variable for relocation within T years of 1990, the specification becomes

$$\ln\left(\frac{\text{Prob}(R_{iT})}{1-\text{Prob}(R_{iT})}\right) = \alpha + \boldsymbol{\beta}\boldsymbol{M}_{l1990} + \boldsymbol{\gamma}_1\boldsymbol{X}_{il1990} + \boldsymbol{\gamma}_2\boldsymbol{Z}_{l1990} + \boldsymbol{\lambda}_{s_l} + \boldsymbol{\lambda}_{k_i}. \quad (4)$$

The unit of observation is the individual facility; thus, this regression is of a cross-sectional nature. Given that the TRI data are only available to the public in one or two years after being reported by facilities, we use the 1988 Toxic Emissions variables to the relocation decisions from 1990 onward. The model includes state fixed effects, denoted as $\boldsymbol{\lambda}_{s_l}$, to control for the unobserved state characteristics such as local tax policies, transportation networks, and amenities that have been shown in the literature to influence facilities' relocation decision. We did not use fixed effects at a finer spatial scale because many districts below the state level do not experience any facility relocation during the sampling period, and as a result, adding county or lower-level dummies would effectively eliminate a large part of our sample. We also include industry fixed effects $\boldsymbol{\lambda}_{k_i}$ to control for unobserved industry-specific differences in business relocation.

Second, we estimate a panel model that explains the annual probability of relocation and that adds time variation for some of the covariates. The community characteristics

$\boldsymbol{M}_{l1990}$ are still measured in 1990 given that most of these characteristics are only available in census years, and interpolating values would possibly lead to reverse causality.[8] This model is given by:

$$\ln\left(\frac{\text{Prob}(r_{it})}{1-\text{Prob}(r_{it})}\right) = \alpha + \boldsymbol{\beta M}_{l1990} + \boldsymbol{\gamma}_1\boldsymbol{X}_{it-1} + \boldsymbol{\gamma}_2\boldsymbol{Z}_{lt-1} + \boldsymbol{\lambda}_{s_l} + \boldsymbol{\lambda}_{k_i} + \boldsymbol{\lambda}_t, \quad (5)$$

where r_{it} in the panel model is a binary indicator of whether a facility i relocated in year t.[9] The facility-specific ($\boldsymbol{X}_{it-1}$) and other location-specific ($\boldsymbol{Z}_{lt-1}$) characteristics are time varying and lagged by 1 year as relocation decisions are executed with a lag. Again, because of the lag of public availability of the TRI reported data, we use a 2-year lag on the toxic emission variables. We also include year fixed effects $\boldsymbol{\lambda}_t$ to control for the influence of unobserved year-specific events, for example, the 2008 financial crisis that was followed by a sharp increase in the relocation rate of facilities over several years. We estimate the model using maximum likelihood. We do not use facility-specific intercepts (with fixed effects) because of the inclusion of $\boldsymbol{M}_{l1990}$, which has no time variation. This may lead to concerns about the endogeneity of Toxic Emissions arising from potential facility-specific or location-specific omitted factors. As a robustness check, we use the control function approach with a 5-year temporal lag of Toxic Emissions as the instrumental variable (IV) to deal with this potential endogeneity issue. The IV is valid when there are no persistent factors affecting both the past emission levels and the current relocation decisions. We also use the 1988 Toxic Emissions, which are not affected by the pressures that emerged after the TRI was established, as an alternative IV.

3. DATA AND SAMPLE

The sample consists of manufacturing facilities that were operating in 1990, reported to the TRI at least once during 1988–2011, and also have their location data collected by the Dun and Bradstreet (DB) database over the same period. The Dun and Bradstreet data are obtained from the National Establishment Time-Series (NETS) database (Walls & Associates 2011). The NETS database provides information on the

8. These variables are highly stable across consecutive censuses. We regressed the variables on their 10-year lags and found the coefficients of the lags close to unity: 0.97 for Population Density, 1.01 for Educational Attainment, and 0.90 for Share of White. The smallest coefficient is that for Income, 0.69. Interpolated figures using the future values are inappropriate since the latter may be affected by firm relocation decisions, but using interpolated values does not significantly affect our results.

9. We use data on stayers and on movers in the years before relocation to predict the relocation decision of facilities. This model is similar to a hazard model with a probability of move that is independent of facility's age. We did not estimate a hazard model because we have no information on the start year of facilities.

location and relocation history, size, industry, and other characteristics of business establishments from 1990 to 2011. It defines relocation by comparing the address of a facility in year t and year $t + 1$ and identifies relocation as occurring at time t if the census tract in the addresses of the two years is different. The TRI data provide facility-level information about the amount of toxic chemical releases, the facility name, address, and industry Standard Industrial Classification (SIC) code in each year since 1987. Not all of the existing facilities in our sample reported to the TRI when it was first disclosed; 36% of them began reporting after 1990.

We merge the TRI and the NETS data by matching their common information on the facility name, address, and eight-digit SIC code. Of the full set of 51,620 facilities reporting to the TRI during the sampling period, we were able to match 70.1% with the NETS data.[10] Of the remaining facilities, we dropped the ones born after 1990, since their initial location choice was affected by the availability of the TRI data, which may also affect the need for subsequent relocation. We also dropped the facilities with missing data for the locations where they were sited. As compared to the sample of all facilities that have ever reported to TRI, the facilities in our sample have a similar mean and median of toxic releases and also similar values at other percentiles.

The census-tract demographics data are obtained from the US decennial census. We use the 1990 values as explained earlier. The highways and railways data are obtained from the National Highway Planning Network and the National Transportation Atlas database. The presidential voting data are obtained from Dave Leip's Atlas. The county economic characteristics and attainment status to NAAQS are obtained from the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics and the EPA Greenbook, respectively. These data sets are merged with the TRI using geographic coordinates and the county Federal Information Processing Standards (FIPS) code corresponding to each facility.

In the final sample, we have an unbalanced panel of 20,518 facilities; 1,343 facilities relocated across census tracts within a county, and 1,335 facilities relocated across counties between 1991 to 2010 (i.e., a total relocation rate of 13.1%). The locations of all facilities cover 12,219 census tracts in 2,140 counties. Table B1 (tables B1–B11, C1–C3 are available online) presents the industry-wide distribution of facilities. The standard deviation of the relocation rates across industries is small. Table 1 presents summary statistics of the explanatory variables. Among the variables, we note the higher values of Income Level, Educational Attainment, Democrats, Population Density, and the higher propensity of nonattainment to the NAAQS in the areas where facility relocations were observed. The levels of Non-Hispanic White and Elderly are unexpectedly lower in communities from which relocations occurred while the level of Renters is higher. Table 1 also shows that relocated facilities are on average smaller

10. Technical details about data merge are provided in app. A.

Table 1. Summary Statistics: Facility Movers versus Stayers

Variables	Definition	Movers (1)	Stayers (2)
Community characteristics at census tract level in 1990:			
Income level	Log per capita income in 1,000$	9.25	9.19
		[.01]	[.61]
Educational attainment	Fraction bachelor's degree or higher	.13	.10
		[.10]	[.07]
Non-Hispanic white	Fraction non-Hispanic white	.79	.87
		[1.01]	[3.28]
Voter turnout	Fraction voting in presidential election (1988 and 1992 average, county)	.63	.63
		[.09]	[.09]
Democrats	Fraction votes cast for Democratic presidential candidate (1988 and 1992 average, county)	.44	.43
		[.10]	[.09]
Population density	Log population per square mile	7.46	6.70
		[1.60]	[1.80]
Children	Fraction children under age 5	.09	.09
		[.33]	[.59]
Elderly	Fraction population over age 65	.12	.13
		[.05]	[.05]
Race diversity index	Ethnic fractionalization index, $E = 1 - \Sigma_i^I(\frac{\text{Race}_i}{\text{Total Pop}})^2$	4.01	4.56
		[1.43]	[1.32]
Renters	Fraction housing renters	.41	.37
		[.21]	[.18]
Vacant housing	Fraction vacant housing	.08	.08
		[.06]	[.06]
Location characteristics in 1990:			
CAAA attainment status	Attainment status under NAAQS (1 = nonattainment, county)	.75	.57
		[.43]	[.50]
Toxic facilities	Number of toxic facilities in a census tract	2.25	2.51
		[2.61]	[2.66]
Wage rate	Log industry-specific wage rate ($ per week, county)	6.30	6.25
		[.26]	[.27]
Miles of highways	Highway miles in census tract	10.13	15.79
		[15.29]	[20.07]

Table 1 (*Continued*)

Variables	Definition	Movers (1)	Stayers (2)
Miles of railways	Railway miles in census tract	7.53	11.83
		[10.10]	[12.94]
Urban	Fraction urban population	.87	.76
		[.28]	[.36]
Housing value	Median housing value in 1,000$ in a census tract	181.57	138.63
		[122.91]	[94.15]
Facility characteristics in 1990:			
Size	Log number of employees (person)	4.01	4.56
		[1.43]	[1.32]
Toxic emissions	Toxic emissions of all TRI chemicals (1,000 pounds)	49.86	91.59
		[1044.9]	[1507.9]
Financial health	PayDex score max (scale: 0 – 100)	75.2	75.9
		[8.3]	[7.5]
	PayDex score difference (max – min, 0–100)	8.43	7.79
		[8.06]	[7.41]
Number of facilities units		2,678	17,840

Note. Standard deviations shown in brackets in cols. 1 and 2. All variables are evaluated at their 1990 values. Income level and wage rate are converted to constant 2012 dollars using the CPI from 1990 to 2011. T-tests on the mean difference between col. 1 and col. 2 are shown in table B2.

and emit less than nonrelocated facilities, whereas their emission intensity with respect to the labor inputs is not significantly different.

4. RESULTS

Table 2 presents the results that explain the relocation probability of a facility within 20 years after 1990.[11] Columns 1–3 show the results for all relocation. We find robust and statistically significant evidence for a positive effect of Educational Attainment on the likelihood of facility relocation. The effect of Income Level is not statistically significant after controlling for the effects of Educational Attainment. These results provide partial support for the hypothesis that facility relocation is influenced by community concern about toxic releases. We do not find support for the effect of ethnicity on

11. The results for $T = 5$ and $T = 10$ are qualitatively similar to those reported here but are based on a much smaller number of relocations. Results are shown in table B3.

Table 2. Effects of Community Pressure on Likelihood of Facility Relocation

	Dependent Variable: Binary Indicator Moved in 20 Years				
	All Moves			Cross-County Moves	Within-County Moves
	(1)	(2)	(3)	(4)	(5)
Community demographics in 1990:					
Income level in log	–.021	–.021	–.013	–.056	.040
	(.051)	(.051)	(.052)	(.068)	(.071)
Educational attainment	3.920***	3.755***	2.476***	2.236***	2.534***
	(.304)	(.303)	(.401)	(.494)	(.545)
Non-Hispanic white	.004	.003	.002	–.018	.012
	(.009)	(.009)	(.009)	(.029)	(.008)
Voter turnout	–.131	–.063	.041	–.557	
	(.388)	(.389)	(.400)	(.520)	
Democrats	–.143	–.145	–.294	.816**	
	(.278)	(.277)	(.280)	(.366)	
Population density in log	.259***	.267***	.242***	.115***	.320***
	(.018)	(.018)	(.033)	(.044)	(.047)
Facility characteristics in 1990:					
Size	–.333***	–.277***	–.275***	–.218***	–.310***
	(.018)	(.019)	(.019)	(.025)	(.027)
Financial health (PayDex score difference)	.005**	.005*	.005*	.004	.005
	(.003)	(.003)	(.003)	(.004)	(.003)
Financial health (PayDex score max)	–.004	–.004	–.003	–.005	–.000
	(.003)	(.003)	(.003)	(.004)	(.004)
Toxic emissions 46th–65th percentile		–.107	–.105	.039	–.254**
		(.079)	(.079)	(.100)	(.116)

Toxic emissions 65th–75th percentile		.004	.004	–.004	.014
		(.010)	(.010)	(.013)	(.015)
Toxic emissions 75th–90th percentile		.002	.002	.002	.002
		(.002)	(.002)	(.002)	(.003)
Toxic emissions 90th–95th percentile		–.002**	–.002**	–.002	–.003*
		(.001)	(.001)	(.001)	(.002)
Toxic emissions > 95th percentile		.000	.000	.000	.000*
		(.000)	(.000)	(.000)	(.000)
Toxic emissions zero emission (1 = yes)		.510***	.498***	.413***	.556***
		(.062)	(.062)	(.082)	(.085)
Location-specific characteristics in 1990:					
Attainment status			.259***	.373***	
			(.070)	(.094)	
Toxic facilities			–.014	–.008	–.009
			(.011)	(.014)	(.016)
Wage rate in log			.286***	.094	
			(.107)	(.139)	
Miles of highways			.004*	.004	.001
			(.002)	(.003)	(.005)
Miles of railways			–.009***	–.006	–.017***
			(.003)	(.004)	(.006)
Urban			–.121	–.176	.099
			(.129)	(.164)	(.193)
Housing value			.001***	.002***	.001**
			(.000)	(.000)	(.001)
Facility	20,518	20,518	20,518	20,518	19,183
Industry FE, state FE	Y	Y	Y	Y	Y

Note. Robust standard errors clustered at the census tract level are reported in parentheses. The percentiles of the toxic emission level are 4.2, 17.2, 84.7, and 203.5 thousand pounds in the 65th, 75th, 90th, and 95th percentile. Observations in col. 5 are smaller because the regression explaining within-county moves excludes facilities with cross-county moves and only uses the facility stayers as the control group. County-level characteristics are omitted in these regressions. FE = fixed effects.

the relocation decision of facilities. Non-Hispanic White has a positive but statistically insignificant effect on relocation, which accords with the findings from Hamilton (1995b), Wolverton (2009), and Boone et al. (2014). We also do not find a significant effect of Voter Turnout or Democrats on the likelihood of relocation. Similarly, Renters and Vacancy Housing have an insignificant effect, as shown in table B4. These results provide weak support for the hypothesis that a facility located in a community with greater ability to organize collectively is more likely to relocate. We find a robust and statistically significant positive effect of Population Density on the likelihood of facility relocation. But Children and Elderly show no significant marginal effects (table B4). These results generally support the hypothesis that the threat of liability increases the likelihood of relocation.

Column 4 shows results for cross-county relocation. The effect of Voter Turnout is still statistically insignificant, but Democrats now has a positive effect, indicating that political ideology of communities may affect the cross-county relocation decision of facilities. Column 5 shows results for within-county relocation. Variables measured at county-level exhibit no variation and are not included in this regression.[12] Population Density shows a much higher effect on within-county than on cross-county relocation. Educational Attainment also shows a robust positive effect. These within-county moves are important because they cannot be explained by access to markets or inputs.

Table 3 presents the results from the panel model that explain the annual probability of relocation. The results with respect to the proxy variables for community pressure are consistent in terms of the signs and significance with their counterparts in tables 2 and 3. We use the coefficients in column 3 and calculate the marginal effects of Educational Attainment and Population Density (measured in log) on the relocation propensity of facilities at the means of other variables. We find a one standard deviation increase in the share of high-educated residents in 1990 increases the annual relocation probability of a toxic-releasing facility from a mean of 0.78% to 0.86%, and a one standard deviation increase in the population density increases the probability from a mean of 0.78% to 0.96%. These effects are at the same scale as the effect of a 1% increase in local labor cost (proxied by industry-specific wage rate), which increases the probability by 0.15 percentage points. The results suggest that local community pressure has a significant impact on the relocation decision of toxic-releasing facilities.

We examine robustness of the results using several tests shown in appendix B (apps. A–C are available online) shows test results where we control for the impact of regulatory pressure from CAAA on HAP on facility relocation. We find no incremental effect of regulatory pressure on HAP. Table B6 shows test results where we include county random effects to control for the potential impact of spatial dependence,

12. Facilities making cross-country moves are completely eliminated from the data in the analysis of within-county moves. This introduces some truncation bias in this analysis. There is no truncation bias in the analysis of across-county moves.

which can arise when unobserved location-specific factors such as local tax or other economic policy affect the relocation of facilities in the same locality.[13] The estimated coefficients for the community characteristic variables are very similar to those in tables 2 and 3. Table B7 shows results where we omit Educational Attainment, Democrats, and Financial Health of facilities to check whether these variables absorb the effects of Income Level and Voter Turnout. We find that Educational Attainment absorbs the effect of Income Level in some specifications, but no such effects with regard to the other variables.

Results on the effect of Toxic Emissions provide minimal (or no) support for the notion that facilities with larger volume of emissions are more likely to relocate due to community pressure. In the results shown in tables 2 and 3, we find that most of the Toxic Emissions spline slopes are not statistically significant. There are only some significant and negative effects for the 90th–95th percentiles and positive significant effects for the 75th–90th percentiles and the >95 percentiles. It is possible that high community pressure on large polluters is balanced by the high relocation cost of the large-size plants. To address the potential endogeneity in estimating effect of Toxic Emissions, we instrument Toxic Emissions by its 5-year lag and find little change in the coefficients (see table B8). We also estimate regressions including interaction between Toxic Emissions and community characteristics and find little significance in the coefficient of the interaction terms (see tables B9, B10).

While Toxic Emissions splines show insignificant effects, the binary indicator for Zero Emission shows a positive and significant effect in all specifications. The positive sign indicates that facilities without emissions or with emissions below the TRI reporting threshold are more likely to relocate. However, this does not necessarily signal a higher sensitivity of small polluters to community pressure. Tables B9 and B10 show little significance in the interactions between Zero Emission and community characteristics. We find that the facilities with zero reported emissions also have low employment and sales, indicating their relatively small production scale (and possibly recent entry) with potential for growth. These plants may relocate in order to expand, especially when their costs of moving are low due to their smaller size, as supported by the negative coefficient of Size. The low pollution level of the facilities may also reduce cost because of low liability to clean up the original site (Levinson 1996) and possible ease of obtaining the necessary permits for a new site. Thus, Zero Emission may reflect the effects of production scale, age, or environmental liabilities for site cleaning, which explains its positive coefficient.

The county Attainment Status, as a proxy for the local environmental regulatory pressure, consistently shows a positive impact on the likelihood of relocation across county lines. Facilities that are moving within counties are also less likely to relocate

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13. We have also tested the effect of proximity to state borders by adding a dummy for whether a census tract is within 25 miles (or 10 miles) to state borders. We did not find a significant effect of this indicator.

Table 3. Effects of Community Pressure on Annual Relocation Probability

	Dependent Variable: Dummy for Moved in Year *t*				
	All Moves			Cross County	Within County
	(1)	(2)	(3)	(4)	(5)
Community characteristics in 1990:					
Income level in log	–.020	–.014	.002	–.052	.075
	(.048)	(.048)	(.049)	(.068)	(.069)
Educational attainment	3.746***	3.353***	2.319***	2.452***	2.413***
	(.274)	(.275)	(.372)	(.499)	(.519)
Non-Hispanic white	.005	.004	.002	–.013	.012
	(.007)	(.007)	(.008)	(.016)	(.007)
Voter turnout	.225	.228	.193	–.376	
	(.370)	(.366)	(.376)	(.522)	
Democrats	–.141	–.166	–.235	.929**	
	(.264)	(.261)	(.265)	(.377)	
Population density in log	.256***	.250***	.221***	.133***	.279***
	(.018)	(.018)	(.031)	(.044)	(.044)
Facility characteristics with 1-year lag:					
Size	–.317***	–.233***	–.234***	–.248***	–.233***
	(.016)	(.017)	(.017)	(.026)	(.024)
Financial health (PayDex score diff.)	.007**	.005*	.005*	.005	.005
	(.003)	(.003)	(.003)	(.004)	(.004)
Financial health (PayDex score max)	–.011***	–.010***	–.009***	–.013***	–.006
	(.003)	(.003)	(.003)	(.003)	(.004)
Toxic emissions 46th–65th percentile		.203	.203	.111	.277
		(.142)	(.141)	(.197)	(.202)
Toxic emissions 65th–75th percentile		–.020	–.020	.002	–.042*
		(.015)	(.015)	(.021)	(.022)

Toxic emissions 75th–90th percentile		.006*	.006**	.002	.011**
		(.003)	(.003)	(.004)	(.004)
Toxic emissions 90th–95th percentile		−.005**	−.005**	−.003	−.009**
		(.002)	(.002)	(.003)	(.004)
Toxic emissions > 95th percentile		.000***	.000***	.000	.000
		(.000)	(.000)	(.000)	(.000)
Toxic emissions zero emission (1 = yes)		1.711***	1.706***	1.611***	1.798***
		(.140)	(.140)	(.192)	(.203)
Location characteristics with 1-year lag:					
Attainment status			.110*	.193**	
			(.061)	(.083)	
Toxic facilities			−.017*	−.009	−.021
			(.010)	(.012)	(.014)
Wage rate in log			.308***	.175	
			(.088)	(.126)	
Miles of highways			.003	.003	.002
			(.002)	(.003)	(.004)
Miles of railways			−.013***	−.010**	−.019***
			(.003)	(.004)	(.006)
Urban			−.123	−.231	.107
			(.123)	(.163)	(.188)
Housing value			.001***	.001***	.001**
			(.000)	(.000)	(.000)
Facility-year	294,015	294,015	294,015	294,015	279,534
Facility	20,518	20,518	20,518	20,518	19,183
Industry FE, state FE, year FE		Y	Y	Y	Y

Note. Percentiles of the Toxic Emission Level are the same as those in regressions in table 2. The emission splines and zero-emission indicator have a 2-year lag based on the discussion in the contexts. Robust standard errors clustered at the census tract level are reported in parentheses. FE = fixed effects.

from a census tract that has a higher density of existing Toxic Facilities, though, as we discussed earlier, we do not attribute a causal effect to this variable. Wage Rate and Housing Value show a positive correlation with relocation, indicating that facilities are more likely to leave from locations with high labor and land costs. Access to Railways reduces the propensity to move, whereas access to Highways has near zero effects. This could be because railway access provides an economic advantage that is not broadly available, whereas one can easily access a main highway from a small road. We also find in the panel regression that the PayDex score (max – min) and PayDex score (max), both serving to measure Financial Health, show a significant positive and negative effect on the likelihood of relocation. This implies that facilities with unstable and low business credits have a higher propensity to relocate.

We now investigate the possibility that facilities respond to TRI reporting prospectively, that is, their relocation propensity is affected by the anticipation of reporting to the TRI rather than current inclusion in the TRI. As a first step in this analysis, we identify the first year in which each facility in our sample reported to the TRI; in prior years, its emissions were below the threshold for the reported chemicals. To eliminate the effect of the 1995 TRI chemical list change, we do this analysis on a subsample of observations from 1995 onward. We define an indicator variable that takes a value of one for the years preceding a facility's first report to the TRI. For those years, the facility would be "invisible" to those browsing the TRI database. These facilities will become visible at a later point in time, when they exceed the TRI reporting threshold for one or more chemicals and are included in the TRI database. We added this variable with and without its interactions with selected demographic characteristics to the panel data specifications in columns 3 and 4 of table 3.[14] In these regressions, the coefficient of this indicator variable and its interaction compares the annual relocation probability of facilities that have not yet ever reported but will report in the future with that of the facilities that are not currently reporting, have reported in the past, and may or may not report in the future. This interpretation of the coefficient of this indicator variable follows from the observation that we also include a dummy variable for facilities that are not reporting now, regardless of the prior and future reporting studies. The results are presented in table 4. The point estimate for the indicator for not yet having reported is positive, and the effect is stronger for denser and more educated localities. Facilities that are not yet "on the radar" but anticipate that they will be in the future should indeed be more likely to depart from high community pressure locations compared to facilities whose emissions have dropped below the threshold and may not go above it again. If firms are forward looking, the former group would expect higher future levels of community pressure for its activities compared to the latter. With relocation taking place on the basis of future payoffs, it is the expected pressure that matters, not any pressure that the facility has faced in the past.

14. Since the indicator variable on reporting history is time varying, using it in the cross-section regressions is not meaningful.

5. COMPARISON BETWEEN ORIGIN AND DESTINATION LOCATIONS

A relocating facility could in principle move to any location in the United States. But quite clearly, a firm does not consider all 74,000+ census tracts in the United States as possible destinations; even if it did, formulating and estimating a suitable discrete choice model with that many alternatives would be a daunting exercise.[15] In the absence of information of about each facility's choice set or about how these choice sets are determined, we adopt a different approach based on the observations that (i) a moving facility relocates if it derives a higher payoff from being in the new location than remaining in the old one, and (ii) there is a sufficiently large number of possible destinations so that the choice set can be approximated by a continuum with respect to the relevant location characteristics we consider in our analysis. Suppose the advent of the TRI changed the trade-off between a community characteristic associated with higher community pressure and the location's other characteristics by making that characteristic "more expensive." Then, we would expect that the optimal bundle of characteristics in the new location will have less of the community features that are now more expensive. Of course, not all facilities would choose to move to the new optimal location, because of the presence of fixed costs. But those that do choose to move because the benefits outweigh the costs (possibly for reasons unrelated to environmental considerations) would "buy" a location with less of the expensive characteristics.[16]

Based on this reasoning, we compare the values of each of the community characteristics and the Attainment Status in the new versus the old locations via pairwise *t*-tests and identify those characteristics whose value has decreased. To examine the heterogeneity in the destination choices among the facilities, the *t*-test on the differences is conducted separately for the small polluters, recognized as those with no TRI-reported emission before moving, and the polluters with positive reported emission. Table 5, panel A, presents the results. We find that facilities are on average relocating into communities with a lower Income Level, lower Population Density, lower share of Democrats, and lower propensity of being in nonattainment under NAAQS, especially for the cross-county movers. This relocation tendency is stronger for the facilities with below-threshold emissions, which also tend to relocate into communities with lower educational attainment and lower voter turnout. In contrast, polluters with above-threshold emissions (i.e., large polluters) are found to relocate into communities with higher educational attainment and higher voter turnout. Facilities are also found to relocate into communities with a higher share of whites.

15. Discrete choice methods for location choice, such as those using a conditional logit model, are far more conceptually appealing and computationally tractable for studies that focus on a narrower geographic scope (e.g., List et al. 2003).

16. Molloy and Shan (2013) have adopted a similar reasoning when analyzing the impact of household relocation decisions in the face of higher fuel prices.

Table 4. Effects of Prospective Reporting on Annual Relocation Probability

	Dependent Variable: Moved in Year *t* after 1990					
	All Moves			Cross-County Moves		
	(1)	(2)	(3)	(4)	(5)	(6)
Past TRI reporting (1 = no report)	.819***	.664**	.606***	.638***	–.217	.314*
	(.067)	(.297)	(.108)	(.099)	(.411)	(.163)
Current TRI reporting (1 = no report)	1.508***	1.508***	1.510***	1.517***	1.520***	1.520***
	(.155)	(.155)	(.155)	(.213)	(.213)	(.213)
Past TRI reporting × population density		.021			.119**	
		(.039)			(.055)	
Past TRI reporting × educational attainment			1.623**			2.400***
			(.644)			(.914)
Community characteristics in 1990:						
Income level in log	–.011	–.011	–.011	–.115	–.120	–.116
	(.057)	(.057)	(.056)	(.075)	(.076)	(.075)
Educational attainment	2.260***	2.258***	1.862***	2.376***	2.366***	1.877***
	(.474)	(.474)	(.502)	(.620)	(.621)	(.655)

Non-Hispanic white	.003	.002	.003	−.012	−.013	−.012
	(.007)	(.007)	(.007)	(.012)	(.012)	(.012)
Voter turnout	.374	.375	.365	−.080	−.072	−.085
	(.440)	(.440)	(.441)	(.630)	(.631)	(.632)
Democrats	.109	.120	.118	1.119**	1.169**	1.131**
	(.323)	(.324)	(.323)	(.462)	(.464)	(.462)
Population density in log	.199***	.194***	.198***	.124**	.100*	.122**
	(.037)	(.038)	(.037)	(.050)	(.052)	(.050)
Facility-year	216,070	216,070	216,070	215,693	215,693	215,693
Facilities	18,526	18,526	18,526	18,496	18,496	18,496
Industry FE, state FE, year FE	Y	Y	Y	Y	Y	Y
Facility and location characteristics controls	Y	Y	Y	Y	Y	Y

Note. Past TRI Reportingt = 1 if a facility did not report before year *t* regardless of whether it reported after or at *t*. Current TRI Reportingt = 1 if a facility did not report at *t* regardless of whether it reported before or after *t*. If both indicators equal to 1, the facility must have reported emission after *t*. The control group in these regressions, which has both indicators equal to 0, are the facilities that reported before or at *t* and may or may not have reported after *t*.

Table 5. Comparison of Origin versus Destination Community Characteristics

A. Summary Statistics of the Community Characteristics

Mean Diff.: Destination – Origin	*N*	Income Level in log (1)	Educational Attainment (2)	Non-Hispanic White (3)	Voter Turnout (4)	Democrats (5)	Pop Density in log (6)	Attainment Status (7)
All moves:								
All facilities	2,678	–.08***	.003	.21***	.001	–.016***	–.73***	–.04***
		(.02)	(.002)	(.08)	(.001)	(.002)	(.04)	(.01)
No report before move	1,160	–.14***	–.016***	.13*	–.003	–.015***	–.84***	–.07***
		(.02)	(.003)	(.07)	(.002)	(.003)	(.05)	(.01)
Reported before move	1,518	–.04*	.017***	.27**	.004**	–.016***	–.63***	–.03***
		(.02)	(.003)	(.13)	(.002)	(.002)	(.05)	(.01)
Cross-county moves:								
All facilities	1,335	–.09***	.005	.20**	.002	–.03***	–.79***	–.07***
		(.03)	(.003)	(.10)	(.003)	(.003)	(.06)	(.01)
No report before move	530	–.18***	–.026***	.15***	–.006	–.03***	–1.05***	–.11***
		(.04)	(.005)	(.03)	(.004)	(.005)	(.09)	(.02)
Reported before moving	805	–.03	.025***	.24	.008**	–.03***	–.62***	–.05***
		(.04)	(.005)	(.16)	(.003)	(.004)	(.08)	(.02)
Within-county move:								
All facilities	1,343	–.08***	.001	.22*			–.66***	
		(.02)	(.003)	(.13)			(.04)	
No report before moving	630	–.10***	–.008**	.12			–.68***	
		(.03)	(.004)	(.13)			(.06)	
Reported before moving	713	–.06*	.008**	.31			–.64***	
		(.03)	(.004)	(.21)			(.06)	

B. Community Pressure Score: Difference between Origins and Destinations of Relocating Facilities

	N	ΔS_M (1)	$\Delta(S_M + S_{\text{Attn}})$ (2)
All moves:			
All facilities	2,678	−.144***	−.151***
		(.010)	(.010)
No report before moving	1,160	−.215***	−.226***
		(.014)	(.014)
Reported before moving	1,518	−.089***	−.093***
		(.013)	(.014)
Cross-county moves:			
All facilities	1,335	−.121***	−.140***
		(.014)	(.015)
No report before moving	530	−.228***	−.256***
		(.020)	(.022)
Reported before moving	805	.050***	.062***
		(.017)	(.019)
Within-county moves:			
All facilities	1,343	−.170***	. . .
		(.013)	
No report before moving	630	−.198***	. . .
		(.019)	
Reported before moving	713	−.145***	. . .
		(.018)	

Note. Mean Diff. = $X_{\text{destination},1990} - X_{\text{origin},1990}$. A negative number means X decreases after moving. No report before moving = reported zero emission to TRI or under the TRI reporting threshold before moving. S_M is calculated using community characteristics in M_{1990}. S_{Attn} is calculated using Attainment Status.

This last set of results regarding the relocation pattern of large polluters could be driven by two possible reasons. One is that locating in a high educational attainment (and white) community is associated with higher benefits for large facilities, compared to earlier years. For example, large facilities may be more complex and require a more highly trained workforce or may obtain special incentives to choose a particular location. Another possibility is that the choice set is not as dense in terms of the combination of characteristics, especially for large facilities that have more stringent siting requirements, for example, infrastructure and access to suppliers. Thus, their location choice could involve trade-offs between the various observable characteristics. To address the second possibility, we construct an index score that integrates all the proxies in one statistic to examine the "overall" effect of community pressure on the location choice of the toxic facilities. The statistic is based on the premise that, even though a facility cannot choose any value of all individual characteristics at its new location, its set of choices is continuous in the index statistic, that is, it is continuous after we allow for trade-offs between the characteristics. We take the estimated coefficients of the community characteristics ($\hat{\boldsymbol{\beta}}$) from column 3 of table 3 as weights, and calculate the location score as the weighted summation of the level of those characteristics for the relocating facilities' origins ($\hat{\boldsymbol{\beta}}\boldsymbol{M}_{l_0}$) and destinations ($\hat{\boldsymbol{\beta}}\boldsymbol{M}_{l_1}$). Table 5, panel B, presents the pairwise *t*-test results on the difference between the origin and destination scores. We find that both small and large polluters are on average relocating into communities with a significantly lower score for community pressure, and that regulatory pressure contributes to this pattern.

6. COMPARISON OF FACILITY PERFORMANCE PRE- AND POST-RELOCATION

An open question related to our findings is whether relocation is associated with changes in the environmental performance of facilities. We briefly explore this issue using pairwise *t*-tests to examine the change in the facilities' emission level, employment, and emission per employee following relocation. Because emissions are somewhat volatile, and because they may be transiently affected by the relocation process, we make the comparison based on the average of 3 years following the post-relocation year with the average of the 3 years preceding the pre-relocation year.[17] Columns 1–3 of table 6 show the changes in levels of those performance outcomes, while columns 4–6 show these changes in logs. We calculate the changes by subtracting the value of an

17. If relocation happened around 1995, the difference in the emission levels may include the emissions of the new chemicals added after 1995. This would happen both for actual and placebo moves, and the comparison should still be valid. Nonetheless, we added table B11 where we only compare the emissions of the 1988 TRI-listed chemicals as a robustness check. Tables 6 and B11 show qualitatively similar results.

outcome in the destination location by its value in the original location. We also conduct the test separately for small (below reporting threshold) and large (above reporting threshold) polluters, partitioned on the basis of their pre-move emission levels.

Comparisons of emissions of a facility across locations involve a simultaneous comparison across time, in fact one that spans 9 years given that we use multiyear averages and omit the years adjacent to the relocation year. Therefore, any secular trends in emissions might be mistaken for changes due to the relocation. A proper comparison would be of a difference-in-difference nature, which we perform by computing changes in these variables from placebo moves. For each facility that has not moved, we randomly assign a hypothetical "moving" year and compute the "change" in its emissions and employment around that year in the same manner that we would have if the facility had moved. We observe from these placebo moves that facilities tend to reduce emissions and employment over time and also reduce emissions per employee; these trends are not surprising given the US trend toward more automated and cleaner industrial facilities. This pattern is not present for the facilities that are not initially reporting any emissions. Given the zero lower bound, the emissions of these facilities cannot possibly go down and may go up; these facilities are also relatively small to begin with and thus do not exhibit any reduction in employment. Because of the dispersion in the size and emissions of facilities, the figures in levels exhibit relatively large standard errors. The log changes, which reflect percentages and put all facilities in a similar scale, exhibit much smaller standard errors. We will thus generally focus our discussion on those.

The placebo changes form the basis of comparison for the performance effects of actual movers. Compared to these, we find that movers exhibit smaller reductions in emissions accompanied by an increase in employment. Emissions per employee follow the same trend as nonmovers. It seems that moving facilities tend to grow; possibly the move is driven by a desire to increase the scale of production. Because they grow, they also emit more. But their pollution intensity is not affected. Facilities with no emissions prior to the relocation grow in size and emissions even more than the larger relocating facilities. But their emissions intensity exhibits the same trend. A natural question is whether the performance effects associated with relocations within a county are different than those across county lines. There seems to be little evidence that they do. However, a clear pattern emerges when we distinguish moves based on the socioeconomic characteristics of the destination locations relative to the socioeconomic characteristics of the origin locations. We have used the changes in demographic characteristics of the locations weighted by the parameter estimates of column 3 of table 3 to construct summary indexes associated with changes in community pressure. We find that facilities relocating to areas with lower community pressure grow more than those relocating to areas with higher community pressure, and their emissions changes are much higher than those of the nonrelocating facilities. In contrast, facilities that relocate to areas with higher community pressure exhibit a growth and emissions pattern that is more similar to the nonrelocators.

Table 6. Change in Facility Characteristics Pre- and Post-relocation

Mean Diff.: Destination - Origin	*N*	Emp (1)	Emis (2)	Emis per Emp (3)	log (Emp) (4)	log (Emis) (5)	log (Emis per Emp) (6)
				A. Placebo Moves			
All facilities	14,446	−9.81***	−9.26	.01	−.03***	−.47***	−.44***
		(2.41)	(6.74)	(.33)	(.01)	(.02)	(.02)
No report before moving	2,212	−.73	47.00**	.24***	.09***	.05	−.04
		(7.64)	(20.89)	(.06)	(.01)	(.04)	(.04)
Reported before moving	12,234	−11.45***	−19.44***	−.03	−.05***	−.58***	−.52***
		(2.48)	(7.00)	(.39)	(.01)	(.02)	(.02)
				B. Actual Moves			
All facilities	2,678	9.28	2.64	.38	.14***	−.21***	−.35***
		(6.45)	(12.34)	(.34)	(.02)	(.05)	(.05)
No report before moving	1,160	53.77***	35.17	1.12	.58***	.24***	−.34***
		(10.43)	(21.90)	(.94)	(.04)	(.07)	(.08)
Reported before moving	1,518	−15.91*	−15.77	−.04	−.11***	−.47***	−.36***
		(8.12)	(14.81)	(.04)	(.03)	(.07)	(.07)
Actual moves: cross-county only:							
All facilities	1,335	15.93	4.98	.04	.10***	−.24***	−.35***
		(11.20)	(5.01)	(.04)	(.04)	(.07)	(.08)
No report before moving	530	80.44***	9.52**	.11***	.68***	.26**	−.43***
		(21.85)	(4.32)	(.04)	(.07)	(.11)	(.12)
Reported before moving	805	−16.55	−2.69	−.002	−.20***	−.51***	−.31***
		(12.59)	(7.20)	(.062)	(.04)	(.10)	(.10)
Actual moves: within-county only:							
All facilities	1,343	3.06	.46	.70	.18***	−.17**	−.35***
		(6.78)	(23.42)	(.68)	(.03)	(.07)	(.07)
No report before moving	630	32.16***	55.96	1.93	.49***	.21**	−.27***
		(6.44)	(35.49)	(1.70)	(.04)	(.09)	(.10)
Reported before moving	713	−15.25	−34.49	−.08	−.02	−.43***	−.41***
		(10.23)	(28.89)	(.06)	(.03)	(.10)	(.10)

Table 6 (*Continued*)

Mean Diff.: Destination - Origin	N	Emp (1)	Emis (2)	Emis per Emp (3)	log (Emp) (4)	log (Emis) (5)	log (Emis per Emp) (6)
	C. Moves with Large Change in Community Pressure						
Lower pressure ΔS_M	738	34.37***	6.42	.96	.35***	−.08*	−.54***
		(12.17)	(35.87)	(.99)	(.04)	(.04)	(.09)
Lower pressure $\Delta(S_M + S_{\mathrm{Attn}})$	743	34.38***	6.19	.97	.35***	−.18**	−.53***
		(12.1)	(35.63)	(.99)	(.04)	(.09)	(.09)
Higher pressure ΔS_M	720	−17.25	−2.14	.04	−.07*	−.30***	−.23**
		(10.80)	(3.86)	(.06)	(.04)	(.08)	(.09)
Higher pressure $\Delta(S_M + S_{\mathrm{Attn}})$	713	−11.32	−2.05	.04	−.08*	−.31***	−.22**
		(12.64)	(3.90)	(.06)	(.04)	(.08)	(.09)

Note. Mean Diff = $\mathrm{Mean}(X)_{\text{after move}} - \mathrm{Mean}(X)_{\text{before move}} = \mathrm{Mean}(X)_{T_r+2\le t\le T_r+4} - \mathrm{Mean}(X)_{T_r-4\le t\le T_r-2}$, where T_r is the relocation year. When a facility has moved less than 4 years before the start or end of our sample, we use all available years to calculate the facility's employment, emissions, and emissions per employee. This happens for 23% of the relocated facilities. We did not use the facilities with only 1-year data before or after moving (8%) because that 1 year of data preceding or following the relocation may contain excessive noise. log(Emis) and log(Emis per Emp) cannot be calculated if a facility reported zero emission or did not report to TRI. Facilities reporting zero emissions are excluded from cols. 5 and 6. Some facilities report zero emissions for some year during the window used for calculating changes in emissions. These facilities count for 6.7% of the sample ($N = 210$), and all observations involving them have been dropped when computing the figures for cols. 4 and 6. Facilities that do not report to the TRI because their emissions are below the reporting threshold constitute a larger portion of our data; observations involving them exceed 60% of our data, and thus it is not practical to eliminate all of them. Instead, we assume (but only for the purpose of table 6) that their emissions level is at the reporting threshold of 0.5 thousand pounds. For consistency of calculations in this table, we did the same when calculating ΔEmis and ΔEmis per Emp. This substitution may lead to an upward bias in ΔEmis, ΔEmis per Emp, Δlog(Emis), and Δlog (Emis per Emp) because the percentage of facilities with nonreported emission levels after relocations exceeds the corresponding percentage before relocation by 20.3%. S_M and S_{Attn} follow the same definition as in table 5. Unit of variables: emission level in 1,000 lb emission per employee in 1,000 lb per person.

All these findings, taken together, suggest that relocation is associated with facility growth and, thus, also with an increase in emissions. But emissions per employee (which we refer to here as emissions intensity) do not change differentially for relocating facilities compared to those who stay in the same location. Thus, it appears that facilities do not relocate to become "dirtier"; they relocate when they want to grow. When they do, they choose to move down the socioeconomic gradient, and those that grow the most (and thus emit the most) move further down that gradient. Of course, a relocating facility would likely also take that opportunity to update its processes and reduce emissions per unit output or per employee.[18] In principle, it is possible that facilities take advantage of low community pressure in the relocating destinations and forgo some of these emission reduction technology updates. However, in cases where facilities move into less disadvantaged communities, we observe a similar decrease in emission intensity than in cases where facilities move into more disadvantaged communities (and even in cases where facilities that do not move at all). In brief, the adverse effects on environmental justice arise from the relocation pattern itself and also from the fact that moves to more socially disadvantaged localities are associated with growth in facility size, not from changes in facility emissions conditional on size.

7. CONCLUSION

Environmental disclosure programs are meant to correct informational asymmetries and increase welfare by helping communities take action based on solid facts. The notion that more information can increase efficiency is seductive but might be erroneous. If the disclosure programs increase information but do so differentially across communities, they will lead to information asymmetries between them. Moreover, some communities may be better able to organize based on the information they receive and be more effective in obtaining a response from policy makers. As a result, information disclosure may well lead to adverse outcomes for the other, "disadvantaged," communities and might potentially reduce welfare for their residents.

Though we cannot perform welfare analysis with the data at our disposal, we are able to provide evidence of detrimental outcomes for communities of low socioeconomic status. One channel through which these adverse effects materialize is the relocation of toxic facilities from communities with high socioeconomic status to those of low socioeconomic status. Our analysis also shows distributional effects that are unrelated to those emphasized in the environmental justice literature. Most important among those is the migration of facilities from more to less densely populated areas. The causes of relocation may include community pressure in the current location arising from greater information availability, but quite likely other factors are more important. The facilities that do relocate tend to move into communities with lower population density, income, and educational attainment (especially the smaller, growing,

18. A technology update can also save labor. Thus, emissions intensity measured by emissions per employee may understate the improvement in emissions per unit output. If the improvements in the labor-saving aspect of product technology are unrelated to the facility's destination, such labor-saving technologies would not impact the relative comparisons of emissions across destinations. If labor-saving technology improvements are less pronounced when a facility moves to a socially disadvantaged location, then an equal change in emissions per employee across destinations would imply a relative deterioration in the emissions per unit output ratio when a facility moves to a socially disadvantaged location.

facilities). This "migration" of toxic facilities down the socioeconomic gradient results in adverse distribution effects. Our results show that facilities that are not yet reporting to the TRI but anticipate that they will be in the future are also likely to depart from high community pressure locations. This implies that environmental disclosure programs not only affect existing facilities but also have an anticipatory effect on location choices of facilities that expect to increase their emissions in the future. On a more positive note, we find that relocation does not appear to have been associated with facilities becoming dirtier and increasing emissions per employee; instead it appears to be motivated by a desire for growth by facilities. However, this does indicate that relocation can be expected to increase emissions, especially for communities with disadvantaged socioeconomic groups, for which post-relocation facility growth is particularly high.

Overall, our findings provide empirical evidence that the public disclosure of TRI has redistributive effects in the spatial allocation of pollution, by inducing facilities to relocate into socioeconomically disadvantaged and low population density areas and potentially increasing their toxic emissions. These findings have direct implications for the design and implementation of information disclosure programs such as the TRI. Policy makers need to consider the potential side effect of such a regulatory tool on distributional justice and strengthen the channels for vulnerable populations to voice their concerns about facility location in addition to strengthening zoning laws and regulations.

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