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Community Characteristics and Changes in Toxic Chemical Releases: Does Information Disclosure Affect Environmental Injustice?

Arturs Kalnins[1] · **Glen Dowell**[2]

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Abstract It is well known that environmental burdens are more pronounced in socioeconomically disadvantaged communities, a phenomenon known as environmental injustice. Yet, there have been few studies that have addressed whether the degree of environmental injustice has changed over time. We analyze toxic releases in the United States over the first 26 years of the toxics release inventory and examine whether the decreases in toxic releases differ according to characteristics of the communities in which the emitters reside. We find that decreases over these years are universal but far more substantial in high-income areas. Our results speak to both the nascent literature on information disclosure and that on environmental justice.

Keywords Collective action · Corporate social responsibility · Environmental justice · Information disclosure · Pollution inequality · Toxic releases

Introduction

There is an abundance of evidence that the risks from environmental issues such as toxic emissions from manufacturing facilities fall more significantly on socioeconomically disadvantaged communities (Ringquist 2005; Shapiro 2005; Freudenberg et al. 2011). This research, which falls broadly under the label of environmental justice, has largely been conducted within the fields of environmental studies, sociology, and economics. To date, the vast majority of the work has been devoted to documenting that environmental injustice actually exists and to attempting to ascertain what factors contribute to a community's vulnerability (Downey and Hawkins 2008). Relatively little work has examined the dynamics of environmental justice, that is, how exposure to environmental risks changes at different rates depending upon community characteristics (but see Hamilton 1995; Shapiro 2005; Campbell et al. 2010).

Understanding how this injustice may have changed is important for both theoretical and practical reasons. From a theoretical perspective, examining trends in environmental injustice can help shed light on the growing literature on environmental performance (Berchicci and King 2007; Etzion 2007), and especially on the way that organizations may respond heterogeneously to institutional pressures (Delmas and Toffel 2012). From a practical perspective, a number of studies have noted a significant reduction in overall toxic chemical emissions in the United States (EPA 1997; Fung and O'Rourke 2000; Hart 2010). Yet, we know relatively little about how the degree of improvement might differ from one community to another and, in particular, how socioeconomic characteristics might be related to the improvement.

In this paper, we explore the changes in toxic emissions over a 26-year period, and examine whether the degree of environmental injustice has increased or decreased over this time period. We perform our analysis using data from a prominent mandatory information disclosure program: the toxics release inventory (TRI). The TRI requires facilities to report on their use and disposal of a large number of

✉ Arturs Kalnins
atk23@cornell.edu

Glen Dowell
gwd39@cornell.edu

[1] School of Hotel Administration, Cornell University, Ithaca, USA

[2] S. C. Johnson Graduate School of Management, Cornell University, Ithaca, USA

toxic chemicals. In more than two decades since the TRI was enacted, the United States has experienced a precipitous decline in the emission of toxic chemicals and the TRI has been hailed as an effective and efficient policy (Fung and O'Rourke 2000; Hart 2010). While this reduction in the release of these chemicals is welcome, and signals that organizations may in fact be making significant strides in environmental performance, it is possible that these overall trends hide significant differences in chemical releases at more local levels. As we outline later in the paper, we do not claim that the TRI causes changes in injustice, but we can state that if we find increases or decreases in the degree of injustice, the TRI is likely to be a key factor in the changes.

Of course, the ultimate concern of such differential exposure to toxic chemicals is that areas that experience higher exposure may experience increased health problems. Prior studies have, in general, found that greater levels of pollution are associated with higher health risks. For example, Luo et al. (2011) found a significant relationship between TRI releases of six key carcinogens and lung cancer rates in 215 counties across the United States, while Luo and Hendryx (2011) reported a more general relationship between TRI emissions and lung cancer, and Hendryx and Luo (2013) reported a relationship with cancer hospitalizations. Agarwal et al. (2010) examined TRI emissions across the United States and find that decreases in industrial pollutants over the period 1989–2002 were associated with improved fetal health outcomes and Fortunato et al. (2011) reported decreases in bladder cancer. Thus, as we explore the degree to which environmental injustice has changed over the period of the TRI, we are, at the most basic level, exploring whether communities that experience less improvement in toxic emissions are at risk of also experiencing greater health problems due to these emissions.

Environmental Injustice

It is no longer a matter of dispute that exposure to environmental hazards is unevenly distributed within the United States as well as internationally, a pattern that has been labeled "environmental injustice" (Hester 1987; Downey 1998). Prior research has found that communities that have lower economic status and those that have a higher proportion of minority residents are subject to disproportionately greater environmental burdens (see, e.g., Chakraborty et al. 2011). Knowing that an issue exists and understanding why it does so are, of course, separate issues, and the origins of environmental injustice are not perfectly understood. However, three processes are believed to underlie the unequal exposure. First, it seems that polluters tend to locate in areas that are poorer and are home to larger minority populations (Austin and Schill 1991; Hamilton 1995; Downey and Hawkins 2008). Firms could be choosing these locations due to lower costs (i.e., land is cheaper) or reduced regulatory burdens (i.e., such areas tend to have fewer restrictions on operations). Second, the people in these areas have less ability to affect the polluters' operations or to move to cleaner locales. Thus, based on the sorting arguments of Tiebout (1956), the makeup of the communities may adapt to the polluting facilities, as those who can afford to leave the vicinity of the polluting facilities may do so (Austin and Schill 1991; Hamilton 1995). Third, some arguments suggest that poorer communities accept higher levels of pollution as a cost of enjoying potential economic growth, but that once these areas experience greater economic prosperity, they become more concerned with environmental issues and they tighten standards. This process has been documented at the national level; following Grossman and Krueger's (1995) discovery of an "environmental Kuznets curve" in which emissions first increased, then decreased as national income rose (Yandle et al. 2004).

While the idea that some communities were disadvantaged in terms of exposure to toxic emissions dates back many decades, the term environmental justice became more widely discussed and legitimized following a research project sponsored by the United Church of Christ and published in 1987 (UCC 1987). This report documented that hazardous waste sites were significantly more likely to be located proximate to communities with greater proportions of minority residents, and it urged government action to remedy this injustice. The attention that this report and subsequent actions by NGOs brought to the issue led to official recognition of environmental injustice within the Federal Government, and Executive Order 12898 in 1994 created an impetus for various federal agencies to explicitly account for environmental justice issues in their actions.[1]

Dynamics of Environmental Injustice in the United States

Thus far, research in the area of environmental justice has focused primarily upon either demonstrating that it exists or attempting to parse out the degree to which income and race play roles in the process. Relatively, little research has considered the dynamics of this process. The most complete examination to date is Shapiro (2005). Shapiro (2005)

[1] For details of this order, see http://www2.epa.gov/laws-regulations/summary-executive-order-12898-federal-actions-address-environmental-justice.

uses TRI data from 2 years, 1988 and 1996, to assess the degree of change in emissions according to the characteristics of a local community, including racial composition and socioeconomic attributes. He finds that those communities with higher proportions of African-American residents, lower income, and lower education levels all experienced worse outcomes in the early years of the TRI.

Our approach, which we describe in greater detail below in the "Data" section, extends and complements Shapiro's (2005) study as well as the other dynamic analyses of environmental justice (e.g., Freudenberg, Pastor, and Israel 2011; Saha and Mohr 2013) in several ways. First, we analyze changes over a longer time period (1987–2012), which allows for greater impact of the community actions that the recognition of environmental injustice may have stimulated (Suro 1990). Second, while Shapiro focused upon risk-weighted emissions, which is valuable in understanding potential health impacts, we examine raw emissions. While the latter are not as indicative of health hazards, they are the focus of most of the media attention that has accompanied the release of toxic emission information (Doshi et al. 2013) and are thus valuable to examine. We also cover a larger portion of the country, as our analysis includes over 2000 counties across the study period, while Shapiro covers 313 counties. Third, we attempt to ascertain whether observed changes stem mostly from differential improvements at existing facilities or from population dynamics as dirty facilities exit certain communities and are replaced by cleaner ones. And, finally, we examine separately cross-state and within-state variation in incomes and pollution emissions.

Using the Toxics Release Inventory to Assess Changes in Environmental Injustice

Given the relative lack of attention to changes in environmental justice over time, it is important to consider whether environmental injustice has increased or decreased. The chemical trends over the period covered by the toxics release inventory (TRI) provide an appropriate lens through which to analyze changes in exposure. There are two primary reasons why the TRI is particularly valuable for this purpose. First, the TRI was first enacted in 1986 and the first year of TRI reporting was 1987 (the results were not released until 1990), which coincides with the 1987 UCC report that brought increased attention to the issue of environmental justice. Thus, the TRI covers the period in which the issue of environmental injustice became more widely recognized by community residents, activists, managers, and regulators.

Second, the TRI is an information disclosure program and as such, it forces polluters to reveal their activities but does not incite direct action by regulators. This is important because early discussions of environmental injustice noted the inequity in regulatory enforcement that existed in which poorer communities and those with greater proportions of people of color appeared to receive less regulatory support. Information disclosure appears to offer hope for improving environmental justice, because inequities in environmental outcomes are made more visible to stakeholders, who can then take action against polluters independent of the regulatory bodies.

Information disclosure programs such as the TRI are premised on the notion that reducing information asymmetry between the organization and interested parties such as consumers, community members, and shareholders can lead to pressures for lagging organizations to improve (Weil et al. 2006). The pressures can be enacted by users actually (or potentially) changing their purchases from the information providers, for example, by being informed of the calorie content of restaurant offerings (Bollinger et al. 2010). Or, the pressures can take the forms of collective action that shames laggard firms as well as "free-riding" citizens (Olson 1965; Ostrom 1998) or of non-governmental organizations that pressure the laggards to improve. Following the enactment of the TRI, for example, communities became aware of the scope of pollutants emitted by local industrial facilities, which led to increased pressure on those facilities to reduce emissions (Suro 1990).

Studies of early years of the TRI data indicated a significant gap between rich and poor areas and some evidence that the gap may have widened over the first few years of that program (Shapiro 2005; Freudenberg et al. 2011). It is unclear, however, whether this trend has continued, as there are reasons to expect either a narrowing or widening of environmental injustice over the period covered by the TRI. One reason to expect that the gap may have narrowed is that the issue of environmental injustice has been salient over this period, and thus pressures to improve are stronger in the disadvantaged communities than they previously were. This idea is consistent with prior research in institutional theory that has found that information tends to create pressures on laggards to improve (Chatterji and Toffel 2010).

There are, however, reasons to expect that despite increased attention to environmental justice issues, the problem has increased over the period that the TRI has been in effect. In particular, the more that improving environmental outcomes depends upon pressures from stakeholders, the more that those communities with greater economic resources and social capital will have advantages. For example, when firms disclose their production and emissions of harmful chemicals, those communities that have higher socioeconomic status can more easily fund the kinds of social movement activities needed to put pressure on the producers. Second, communities with higher socioeconomic status are more likely to attend to the often complex and opaque information that disclosure programs mandate (see, e.g., Weil et al. 2006 on the opacity of TRI information). Third, prior research suggests that members of disadvantaged groups such as lower income people are more likely to have an external locus of control, believing that events are outside of their influence (Garcia and Levensen 1975). Communities of lower socioeconomic status, therefore, may be less likely to believe that they can influence the polluters.

Our primary research question, then, is *over the period of the TRI, has the degree of environmental injustice in the United States widened, narrowed, or remained unchanged?*

Our approach is exploratory in nature and we do not claim a causal link between the introduction of the TRI and changes we observe in the degree of environmental injustice. Simply put, we lack a counter-factual case with which to compare the outcomes we observe. We have articulated, we believe, plausible reasons why information disclosure might be associated with changes in the degree of environmental injustice, and it is this trend that we investigate. As we outline in the conclusion, further work may find a method by which more direct causal arguments may be made.

Data

The Toxics Release Inventory was initiated in conjunction with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. The impetus for this Act was the tragic chemical spill in Bhopal, India, and the subsequent concern that harmful chemicals were being produced, stored, and emitted in the United States without communities being sufficiently aware of the hazards (EPA 1997). The TRI, by all accounts, was a relatively unheralded piece of the larger legislation (Hart 2010; Fung and O'Rourke 2000). Yet, when the first reports were issued, there was widespread coverage in local and national media outlets, and the increased information was credited with spurring greater community activism (Suro 1990).

We combined the full Toxic Releases Inventory files from 26 years, from 1987 through 2012, the most recent year that is currently available. The 26-year time span gives us a convenient split at the dawn of the new millennium that we can use to compare pollution levels before and after the new millennium in order to assess the decline of emissions over time. We note that the EPA has added chemicals to the reporting list over time. We present results that ignore these changes, which slightly bias us against finding decreases in pollution emissions over time. However, we have replicated our core results using only the chemicals initially included in 1987, and the results are unchanged.

The TRI data have been widely used in management, sociology, and economics research to study environmental performance (see, e.g., King and Lenox 2002; Chatterji et al. 2009; Grant et al. 2002). Each year, production facilities in the United States report their production, use, and disposal of hundreds of chemicals that are designated as toxic by the environmental protection agency (EPA). All facilities that employ ten or more people and operate in the industrial sector (old SICs 20-39) and handle more than the threshold amount of any of the chemicals (the threshold differs according to the chemical's toxicity) are required to file a report. The TRI data are reported annually by each facility at the chemical level, so that, for example, a facility that uses five chemicals covered by the regulation would submit five reports detailing the use, storage, and disposal (e.g., to recycling or by emission to land, water, or air) of each chemical. In the early years of the TRI, the data were disseminated via telephone inquiry and CD-ROM, and often third parties such as the Right-to-know network (http://www.rtknet.org/) helped facilitate community access to the data. In recent years, the primary method of dissemination has been through the EPA's own website, which allows individuals and groups to run queries to see the industrial chemical production and release in a given area.[2]

The merged 26-year data file gave us 1,483,463 individual instances of an emitter releasing toxic substances into the air. Before the year 2000, there were 732,245 instances. In 2000 through 2012, there were 751,218 but the quantities associated with each instance are lower after the new millennium. These emissions were released by 44,180 plant-level entities in the United States.

These emissions were split at the county level into quartiles based on population-weighted county average per capita income, and in robustness tests, on years of education, percent residing in an urban area, and percent African-American. The county-level variables for all counties within the contiguous United States all came from the 1980 population census. We weighted counties by their population when constructing the quartiles such that each quartile would represent a near-identical population. The amounts of pollution in each quartile would then represent an apples-to-apples comparison regarding the possible pollution exposure on individual Americans in the four income quartiles. Note that we included all U.S. counties, including zero-pollution counties, when creating the quartiles. There are almost one thousand counties in the U.S. where no TRI emitters are located: these must be included

[2] While the data are widely available, the data are complex enough that groups such as the Right-to-Know network and academic researchers are still active in aggregating the data and analyzing trends.

to accurately capture the average level of pollution for each income quartile.

We chose the 1980 population census as the most recent census before the start of the TRI data program to reduce issues of reverse causality of these variables with pollution. Particularly, we wanted to reduce the Tiebout (1956) sorting effect that might result in pollution "causing" lower incomes. We revisit this issue in the robustness section of the paper.

We present extensive descriptive statistics before engaging in a regression analysis because of the information that these statistics can convey regarding magnitudes of pollution inequality effects. In our opinion, the descriptive statistics below help us to understand the magnitude of the pollution inequality in a fashion that complements existing regression results. Given that we are using 26 years of the TRI data our primary aim is to establish the magnitudes of the changes in pollution effects, not to parse the relative significance levels of many individual variables—thus descriptive statistics are ideal. Nonetheless, regression results are also presented to be able to distinguish the relative effects of the basic variables.

Analysis and Results

Overall Emissions

In Table 1, we present summary statistics for emissions broken down by the income quartile of the county in which the emissions occurred. While this approach does not control for other factors that might affect changes in emission levels, it allows for a direct comparison of emissions over the first (1987–1999) and second (2000–2012) periods. In addition, breaking the results down by income quartiles reveals patterns in the emissions that are less obvious from the regression results that follow.

The last two rows of Table 1 show that Industry in the United States emitted 24.1 billion pounds of toxic emissions into the air in the 13 years between 1987 and 1999. In the first 13 years of the new millennium, that number decreased by 31.5 % to 16.5 billion pounds. The decrease over time of toxic releases has been noted in other studies (Fung and O'Rourke 2000; Hart 2010). Similarly, the total risk, based on risk-screening environmental indicator (RSEI; please see http://www.epa.gov/oppt/rsei/pubs/) weights of each chemical released, has dropped 48.3 %—note that these absolute numbers of risk here have no simple interpretation, but the drop in the risk is interpretable because it represents a relative amount of cumulative health risks to the population.

Splitting the U.S. counties where toxic emissions occur based on quartiles of per capita income, we observe that the lowest income counties have borne the brunt of toxic emissions, and that the gap in emissions between high-income and low-income counties has grown in the new millennium. U.S. industry has emitted 10.5 billion pounds of toxic releases into the air in the thirteen years from 1987 through 1999 in counties associated with the lowest income populations. This represents 43.5 % of the total of 24.1 billion pounds for the entire U.S. In the years 2000 through 2012, this amount dropped to 8.62 billion pounds, a drop of 17.9 %. However, this amount increased as a proportion of total emissions, such that the poorest quartile of counties now experience 52.2 % of the total emissions in the country.

Toxic emissions in the counties of the second income quartile totaled 6.13 billion pounds in the 1987–1999 period. In the 2000–2012 period, this amount dropped to 4.43 billion pounds, a drop of 27.7 % from the 1987–1999

Table 1 All toxic releases emitted by industrial sources in United States, broken down by 1980 per capita income in county

1980 per capita income quartile	Time period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	1.05E+10		1.68E+14		9488	1103388.0	
	2000–2012	8.62E+09	−17.9	1.10E+14	−34.5	8531	1011004.0	−8.4
2nd	1987–1999	6.13E+09		1.12E+14		9523	643834.6	
	2000–2012	4.43E+09	−27.7	5.24E+13	−53.2	8005	553535.1	−14.0
3rd	1987–1999	4.55E+09		1.09E+14		7904	575515.9	
	2000–2012	2.46E+09	−45.9	7.79E+13	−28.5	6177	398675.1	−30.7
4th	1987–1999	2.94E+09		6.03E+13		7860	373700.3	
	2000–2012	9.50E+08	−67.7	1.77E+13	−70.6	5094	186468.1	−50.1
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593375.8	−14.4

amount. Both the original 1987–1999 amount and the percentage drop from 1987–1999 to 2000–2012 were statistically significantly lower in the second quartile than in the first.

Toxic emissions in the third-quartile counties totaled 4.45 billion pounds in the 1987–1999 period, or 74.1 and 43.5 % of the amounts emitted in the second and lowest income counties, respectively, in that time period. In the 2000–2012 period, this amount dropped to 2.46 billion pounds, a drop of 45.9 % from the 1987–1999 amount. Both the original 1987–1999 amount and the percentage drop were statistically significantly lower in the third quartile than in the second or first.

Finally, toxic emissions in the counties with the highest income quartile totaled only 2.94 billion pounds in the 1987–1999 period, or 64.5, 47.9, and 28.0 % of the amounts emitted in the third, second, and lowest income counties, respectively, in that time period. In the 2000–2012 period, this amount dropped to 0.95 billion pounds, a drop of 67.7 % from the 1987–1999 amount. As a final contrast, note that the 2000–2012 amount for the highest income quartile was only 11.0 % of the 2000–2012 emissions in the lowest income quartile. The same statistic for the 1987–1999 period was 28.0 %. Thus, despite the fact that the pollution has decreased throughout the United States, the population of the higher income counties not only enjoyed a far lower level of pollution to begin with, but has enjoyed the vast majority of the drop in pollution levels.

The highest income counties benefitted the most when we break apart total emissions into total emitting plants and emissions per plant. The total number of emitters in the highest income counties was both lower to begin with (7860) and dropped at a higher rate (36.2 % fewer facilities) than that of the other three quartiles.

The total risk-weighted emissions (RSEI) shown in the fifth column of Table 1 tell a similar story, if less decisively. The total risk faced by the highest income quartile in the 1987–1999 period was only 36.8 % that of the risk faced by the lowest income quartile in that period ($6.03e^{13}$ divided by $1.68e^{14}$). In the 2000–2102 period, this percentage was 16.8 % ($1.77e^{13}$ divided by $1.10e^{14}$). However, the drop in risk for the lowest income quartile between the two time periods was steeper at 34.5 % relative to the drop of 17.9 % in terms of raw emissions.

We have established that lower income Americans are subject to more pollution and risk in their locales than are high-income Americans, and that the drops in pollution levels favored the high-income areas. Further, even though most of America enjoyed some pollution reduction in the new millennium, the drops in levels exacerbated the pollution inequality.

These could be two explanations for these results. First, it could be that the economic industry mix of different communities has changed in such a way that favors the upper income areas. In other words, some polluting industries may simply be leaving the high-income areas at a greater rate than they are leaving the lower income areas, and the substitutes that enter may be smaller or different industries that happen to be cleaner in nature. And the facilities that remain may be doing nothing differently. On the other hand, continuously operating facilities may be actively improving their pollution control within their operations, but perhaps with a greater emphasis on decreasing pollution within the high-income areas.

Continuously Operating Plants versus Entries and Exits

To investigate these alternatives, we generated separate data tables for facilities in continuous operation throughout the 1987–2012 period, and for facilities that entered or exited during this period. Table 2 presents the results for the continuously operating facilities. Comparing the toxic releases emitted by facilities in operation continuously between 1987 and 2012 in Table 2 versus all facilities in Table 1, we observe that the continuously operating facilities release about half of all emissions into the air, 12.7 billion pounds or 52.6 % of the 24.1 billion pound total for the 1987–1999 period, and 6.23 of the 16.5 billion pounds (37.7 %) of the 2000–2013 period. Note also that these facilities emit far more toxic releases than the average facility. The 4767 facilities here represent only about one-seventh of the total number of emitting facilities existing at some point between 1987 and 1999 for example, but still emit over 50 % of all toxic releases.

The distribution among the continuously operating facilities by per capita income quartile follows that same pattern as shown in Table 1, that is, the levels of pollution are larger, and the drops in the new millennium are smaller, in the lower per capita income quartiles than in the higher per capita income quartiles. Further, the pollution inequality increase is quite compatible. For example, the highest income quartile of counties was subjected to 1.3 billion pounds of emissions between 1987 and 1999, or 23.2 % of the lowest income quartile's 5.55 billion pounds. This is similar to the overall relative level of 28.0 % in Table 1. However, due to a steep drop among the continuously operating facilities in the lowest income quartile in the new millennium, from 5.55 to 2.99 billion pounds of emissions (a 46.1 % drop), the post-new millennium emission level for the highest income quartile is 16.4 % of that for the lowest income quartile (0.484 vs. 2.99 billion pounds of emissions), higher than the Q4–Q1 comparison of 11.0 % based on the results of Table 1.

Table 2 All toxic releases emitted by facilities in operation continuously between 1987 and 2012

1980 per capita income quartile	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	5.55E+09		7.05E+13		1440	3,853,919	
	2000–2012	2.99E+09	−46.1	6.77E+13	−4.0	1440	2,076,489	−46.1
2nd	1987–1999	3.20E+09		4.04E+13		1360	2,350,672	
	2000–2012	1.60E+09	−50.0	1.76E+13	−56.4	1360	1,177,974	−50.0
3rd	1987–1999	2.67E+09		3.87E+13		1097	2,438,027	
	2000–2012	1.15E+09	−56.9	1.46E+13	−62.3	1097	1,051,254	−56.9
4th	1987–1999	1.30E+09		1.95E+13		870	1,493,321	
	2000–2012	4.84E+08	−62.8	6.48E+12	−66.8	870	556,698	−62.8
Total (all US)	1987–1999	1.27E+10		1.69E+14		4767	2,668,400	
	2000–2012	6.23E+09	−51.0	1.06E+14	−37.3	4767	1,306,847	−51.0

The total risk-weighted emissions (RSEI) shown in the fifth column of Table 2 lead us to the same conclusion: the continuously operating facilities are improving in terms of raw emissions and risk-weighted emissions in the counties of all income quartiles, but the steepest declines appear to be focused on the counties of residence for the highest income quartile.

In Tables 3 and 4, respectively, we consider the remaining facilities: those that entered after 1987 and/or exited before 2012. We do not break down these numbers by the 1987–1999 and 2000–2012 periods because the differences between the time periods would largely be driven by the exit and entry timing. To better control for the number of years that the entering and exiting facilities were actually in operation, we add the new columns "Pounds per Emitting Facility-Year" and "Risk per Emitting Facility-Year." These numbers allow an apples-to-apples comparison of the entering versus exiting firms and allows us to evaluate the role of firm-level dynamics in the result of pollution inequality.

Comparing Tables 3 and 4, the "Pounds per Emitting Facility-Year" measure shows that the average entrant in the lowest income quartile is just as dirty as the average exiting firm: entrants emitted 109,668 pounds per year, while the exiters emitted 112,340 pounds per year. The entrants become cleaner, relative to the exiters, in the higher income quartiles. In the highest income quartile, the entrants emit only 17,033 pounds per year on average, or 32.2 % of what the exiters emitted throughout the 1987–2012 time period. The "Risk per Emitting Facility-Year" measure yields similar conclusions: the entrants cause far lower risk than the exiters did in the upper income quartiles, while the risk caused by entrants and exiters is highly similar in the two lower income quartiles.

We recognize that the "cleaner" entrants in the highest income quartiles might just be smaller and produce less output, partly because the highest income quartiles may have moved away from heavy industry in the 1987–2012 period. Nonetheless, the steeper drops of emissions from 1987–1999 to 2000–2012 in the highest income quartiles, relative to the lowest income quartiles, for the facilities that operate continuously through this time period, combined with the fact that the entrants are cleaner than the exiters in the highest income quartiles but not in the lowest income quartiles, suggest that firm-level pollution control is improving at a faster rate in the highest income quartiles,

Table 3 All toxic releases emitted 1987–2012 by facilities in operation in 1987 but exited before 2012

1980 per capita income quartile	Total emissions (pounds)	Total risk-weighted emissions	Number of emitting facilities	Total emitting facility-years	Pounds per emitting facility-year	Risk per emitting facility-year
1st	3.18E+09	4.30E+13	2773	28,307	112,340	1.52E+09
2nd	1.90E+09	3.36E+13	3019	28,781	66,016	1.17E+09
3rd	1.39E+09	7.51E+13	2713	24,428	56,902	3.07E+09
4th	1.44E+09	2.48E+13	3185	27,176	52,988	9.13E+08
Total (all US)	7.91E+09	1.76E+14	11,690	108,692	72,774	1.62E+09

Table 4 All toxic releases emitted 1987–2012 by facilities that began operation after 1987

1980 per capita income quartile	Total emissions (pounds)	Total risk-weighted emissions	Number of emitting facilities	Total emitting facility-years	Pounds per emitting facility-year	Risk per emitting facility-year
1st	7.38E+09	9.65E+13	8222	67,294	109,668	1.43E+09
2nd	3.86E+09	7.29E+13	7859	64,053	60,263	1.14E+09
3rd	1.79E+09	5.87E+13	6175	47,789	37,456	1.23E+09
4th	6.68E+08	2.72E+13	5467	39,218	17,033	6.94E+08
Total (all US)	1.37E+10	2.55E+14	27,723	218,354	62,742	1.17E+09

and that a local economy-level substitution effect from exiters to entrants is taking place as well.

State-Level Analyses

Substantial environmental legislation takes place at the State level in the United States (Ringquist 1993), and some states are wealthier than others. It is thus important to investigate the possibility that our results are driven by state-level income and pollution effects rather than county-level effects. To assess the role of the state, we present two tables below.

The first table, Table 5, replicates Table 1 except that the Per Capita Income Quartiles are quartiles of states, based on the state-level per capita income. This table ignores all within-state variation in pollution and income and focuses only on differences across the states. Each quartile is again population weighted, so that there is an approximately equal 1980 population in each quartile, but this is also now at the state level. First, in Table 5, we observe that the total emissions are highest in the lowest income states, with 10.7 billion pounds emitted between 1987 and 1999, or 44.4 % of all emissions. In contrast, the wealthiest quartile of states enjoyed far lower emissions of 2.53 billion pounds during this period, only 10.3 % of the total.

Further, the changes in emissions between the two time periods favor the wealthier population-weighted half of states. The top two income quartiles enjoyed emissions drops of 50.9 and 44.7 % in the 2000–2012 period relative to the 1987–1999 period, while the poorer half of states enjoyed drops of only 28.7 and 14.4 %. Unlike our county analysis, however, the poorest quartile enjoyed a greater emissions drop than did the 2nd quartile and the 3rd quartile enjoyed a slightly higher drop than the wealthiest quartile. Nonetheless, consistent with arguments regarding the importance of state-level legislation, this table confirms that the wealthier states enjoyed lower emissions levels to begin with and have disproportionally enjoyed reductions in emissions.

We present a second state-level table, Table 6, which examines only within-state variation because we wish to keep state-level legislation constant for each analysis. Table 6 shows the emission levels by state, with columns 2–4 showing information from the poorest 50 % of counties (population weighted) based on 1980 per capita income

Table 5 All toxic releases at the state level, not county level: quartiles of states split based on per capita income at the state level

1980 state per capita income quartile	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds Emitted per facility	Change (%)
1st	1987–1999	1.07E+10		1.62E+14		9475	1129192	
	2000–2012	7.63E+09	−28.7	1.56E+14	−3.7	8358	912541.1	−19.2
2nd	1987–1999	5.80E+09		1.39E+14		10105	573939.6	
	2000–2012	4.96E+09	−14.5	5.31E+13	−61.8	8176	606604.4	5.7
3rd	1987–1999	5.05E+09		9.36E+13		7864	642685.4	
	2000–2012	2.48E+09	−50.9	3.40E+13	−63.7	6328	392150.4	−39.0
4th	1987–1999	2.53E+09		5.53E+13		7331	345589.5	
	2000–2012	1.40E+09	−44.7	1.47E+13	−73.4	4945	283167.3	−18.1
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693,026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593,375.8	−14.4

Table 6 Toxic releases within 25 largest states at the county level: states split in half based on county-level per capita income

State	Poorest 50 % of counties within state (pop. weighted) by 1980 per cap. income			Wealthiest 50 % of counties within state (pop. weighted) by 1980 per cap. income			Change in emissions post-2000 versus pre-2000 (poorest 50 % minus wealthiest 50 %) (%)
	1980 per capita income ($)	Change post-2000 versus pre-2000 (%)	Number of counties with polluters	1980 per capita income ($)	Change post-2000 versus pre-2000 (%)	Number of counties with polluters	
TX	7749	−29	136	11341	−59	31	30**
OH	8444	15	76	10417	−46	11	61**
IL	9175	−32	82	11484	−73	4	41^{+}
CA	9565	−69	41	11770	−75	9	6
PA	8228	30	50	10556	−28	14	58**
IN	7965	−7	71	9793	−57	17	50**
MI	8624	−20	65	11125	−62	5	42*
WI	8207	−35	52	10498	−63	11	28^{+}
NC	6633	5	62	8846	−30	23	35**
LA	7138	−43	48	10014	−54	10	11
NY	8470	−64	48	12105	−68	11	4
NJ	9519	−21	12	12012	−69	9	48*
GA	6568	72	104	9638	−33	18	105**
AL	6430	2	53	8516	−70	11	72**
MO	6989	−38	77	10427	−63	10	25
TN	6378	−32	71	8978	−45	11	13
SC	6340	−8	35	8231	−33	11	25*
KY	6306	44	64	9144	17	27	27*
FL	8558	36	52	10512	−25	8	61**
AR	6218	−49	45	8158	−35	19	−13
MA	8851	−66	8	11068	−70	5	3
IA	8403	−29	64	10210	−39	28	10
MN	7860	−58	62	11459	−70	11	12
MS	5655	−20	56	7737	−55	19	35**
WA	8847	−61	22	11411	−55	11	−6

Significance levels based on two-tailed tests of differences between "Emissions as % of pre-2000 levels" columns with the "Number of Counties" as the N values: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

and columns 5–7 showing the wealthiest 50 % of counties. Because of the relatively small number of counties in some states, we could not meaningfully split the population into equal quartiles. For this reason also, we restrict our results to the largest 25 states in terms of the number of polluting establishments.

In each set of three columns, the first column shows the average per capita income across this set of counties, the second column shows the percentage drop of 2000–2012 emissions relative to the 1987–1999 emissions for those same counties, and the third column shows the number of counties. The eighth and final column shows the differences between the poorest 50 % of counties and the wealthiest 50 % for the emissions percentages shown in columns 3 and 6. For example, in the column for Texas, the 30 % in the eighth column is the difference of the −29 % in the 3rd column and the −59 % in the 7th column. These differences can be analyzed for statistically significant values based on the number of counties in each group as the "N" value. We note that this is a conservative test: they could also be analyzed using the number of individual emitting facilities as the N value.

We observe in Table 6 that in 23 of the 25 states the pollution reduction is greater in the wealthiest half of counties than in the poorer half. Only in Arkansas and Washington State did pollution decline more in the poorer half of the state, with a 6 and 13 percentage point greater decrease. Further, in 13 of the 25 states, the pollution-reduction percentage is statistically significantly greater at $p < 0.05$ for the wealthier half of the state than for the poorer half. From this analysis, we conclude that state-level legislation accounts for some, but far from all of, the relationship between per capita income and toxic emissions. Much of the relationship occurs at the local level.

Regression Analysis

Given the correlation between per capita income and variables such as educational attainment (years of education), urbanization (percent of a county's residents that live in an urban area), and percent of a county's residents that are African-American, we supplement our descriptive statistics with regression analyses where the dependent variable is the difference between pollution in the 2000–2012 period and that in the 1987–1999 period, and where all these independent variables, taken from the 1980 U.S. Population Census, can be considered simultaneously. Further, as we discussed above, many pollution-related policies are determined at the state level, so we have included fixed effects for each state in some regressions. Thus, state-level policies that are correlated with restrictions on pollution and the presence of high-income counties (e.g., California, Connecticut) will not be confounded with the actual income effects within these high-income states.

In Table 7, we observe in Column 1 that counties in the 3rd and 4th income quartiles enjoyed statistically significantly greater drops, on average, in pollution in the 2000–2012 period than in the 1987–1999 period, relative to the lowest income quartile: 7.5 million pounds and 21.2 million pounds, respectively, per county. In Column 2, we observe a similar trend for educational quartiles when the income quartiles are not included in the regressions. However, we note that the drop in pollution in the 4th Educational Quartile in Column 2 is substantially smaller in absolute magnitude than the 4th Income Quartile in Column 1, at 8.2 million pounds relative to 21.2 million pounds. Further, in Column 3, when we include both the income quartiles and the educational quartiles, we observe that the statistically significant results for education disappear. The income results remain similar to those in Column 1. The comparison of Columns 1–3 suggests that income is a real cause of pollution changes while levels of education appear to be significant in Column 2 merely due to correlation with the omitted income variable.

In Column 4, we add the urban area quartiles and notice that the income effects are cut in absolute magnitude by almost half. The educational quartile variables remain insignificant. And, the urban area results are statistically significant and large in absolute magnitude: we observe in Column 4 that counties in the 3rd and 4th urban quartiles enjoyed significantly greater drops, on averages, in pollution in the 2000–2012 period than in the 1987–1999 period, relative to the least urban quartile: 12 million pounds and 20.5 million pounds, respectively. Column 4 suggests that income remains a real cause of pollution changes and urbanization represents a real effect as well.

In Column 5, we add the percent African-American quartiles, the 4th quartile of which actually has a negative and significant effect controlling for income, education, and urbanization. The educational quartile variables remain insignificant. Column 5 confirms that income and urbanization appear to be real causes of pollution level changes. Surprisingly, in contrast with previous work, at the county level, the quartile of counties with the highest African-American populations actually enjoyed greater pollution reductions, 4.14 million pounds per county, relative to counties with lower African-American populations. This result, though only marginally statistically significant, is particularly surprising because it holds even when controlling for level of urbanization.

Columns 6–10 add state fixed effects to the regressions otherwise the same as those in Columns 1–5, which only had a single constant. Likelihood ratio tests for the differences of the log likelihood of the regressions in Columns 6–10, compared to those five columns earlier, are all statistically significant at the $p < 0.01$ level, as designated next to the "Yes" indication in the "State FE" row. Thus, these regressions explain more variation than those without the fixed effects. It also means that state-level factors, possibly particular laws and policies, are driving some of the drop in pollution levels after the new millennium (Shapiro 2005). Importantly, once the state fixed effects are added, the per capita income results remain strong for the higher income quartiles even in the presence of the urban area quartile variables, complementing our results from Table 6. We observe in Column 9, for example, that counties in the 3rd and 4th income quartiles enjoyed significantly greater drops, on average, in pollution in the 2000–2012 period than in the 1987–1999 period, relative to the lowest income quartile: 5.0 million pounds and 18.0 million pounds, respectively. Further, Column 10 shows a confirmation of the African-American results: the two quartiles of counties with the highest African-American populations enjoyed greater pollution reductions, 3.18 and 7.82 million pounds per county, relative to counties with lower African-American populations. The latter result is now strongly statistically significant.

Robustness Tests

Finally, we conduct four robustness tests. First, we use 2012 per capita income in place of 1980 per capita income to determine the quartiles. Second, we replace income quartiles in Table 1 with quartiles from all three additional variables from the Table 7 regression: educational attainment, urbanization, and percent African-American population. For all these robustness results save that of the

Table 7 Regression analyses: dependent variable is change in total pounds of emissions from 1987–1999 to 2000–2012 in U.S. counties

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PC income	−1.67		−0.99	0.22	−0.51	−3.26**		−2.95*	−1.19	−1.15
2nd quartile	(1.16)		(1.57)	(1.60)	(1.69)	(1.11)		(1.14)	(1.15)	(1.16)
PC income	−7.54**		−6.38*	−2.39	−2.99	−9.61**		−9.40**	−5.04**	−4.73**
3rd quartile	(2.17)		(2.66)	(2.54)	(2.61)	(2.06)		(1.74)	(1.77)	(1.70)
PC income	−21.21**		−19.89**	−11.54*	−12.47*	−25.08**		−26.02**	−18.03**	−18.34**
4th quartile	(4.82)		(5.70)	(5.03)	(5.14)	(4.78)		(5.03)	(4.38)	(4.41)
Education		−3.47*	−1.84	−1.20	−1.65		−4.50*	−1.99	−0.51	−0.44
2nd quartile		(1.64)	(1.42)	(1.36)	(1.34)		(1.92)	(1.52)	(1.37)	(1.31)
Education		−6.49*	−2.81	−2.16	−2.75		−7.10**	−1.93	−0.24	−0.34
3rd quartile		(2.92)	(3.80)	(4.00)	(3.86)		(1.91)	(1.77)	(1.95)	(1.95)
Education		−8.18**	−0.86	2.00	1.27		−7.19+	2.84	6.85+	6.75+
4th quartile		(2.21)	(2.34)	(2.47)	(2.43)		(3.68)	(3.58)	(3.51)	(3.48)
Urban %				−4.21*	−4.09*				−4.93**	−4.92*
2nd quartile				(1.85)	(1.87)				(1.77)	(1.84)
Urban %				−12.00**	−11.11**				−12.31**	−11.18**
3rd quartile				(3.34)	(3.07)				(3.02)	(3.20)
Urban %				−20.45**	−18.58*				−20.07*	−17.05*
4th quartile				(7.58)	(7.62)				(7.96)	(7.95)
African-American %					0.31					−1.29
2nd quartile					(1.04)					(0.96)
African-American %					−0.21					−3.18+
3rd quartile					(1.62)					(1.69)
African-American %					−4.14+					−7.82**
4th quartile					(2.06)					(2.00)
State FE	No	No	No	No	No	Yes**	Yes**	Yes**	Yes**	Yes**
R^2	0.0261	0.0107	0.0273	0.0418	0.0451	0.0309	0.00775	0.0327	0.0461	0.0502
Ll	−10,473	−10,491	−10,472	−10,433	−10,430	−10,421	−10,448	−10,419	−10,381	−10,376

Note that correlations among these variables were very moderate. The two highest correlations were between Q4 Income and Q4 Education (0.35) and between Q4 Income and Q4 Urbanization (0.39). Standard errors in parentheses

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

African-American population, the results for facilities in continuous operation throughout the 1987–2012 period, and for facilities that entered or exited during this period, are similar to those for all emitters, i.e., the equivalents of Table 1. The numbers for continuous operators, entrants, and exits are not presented to save space but are available upon request.

First, we produced Table 8, an equivalent of Table 1, using 2012 Per Capita Incomes instead of the 1980 Per Capita Incomes. The 1980 incomes were used in our main analysis because they preceded all years of the TRI. Thus, we could reduce at least the concerns that the pollution levels might be directly influencing the incomes, possibly via Tiebout (1956) sorting. However, the 2012 Per Capita Income quartiles, while very possibly influenced by the pollution levels between 1987 and 2012, show highly similar pollution results to those using the 1980 data. While only 1767 counties remain in the same income quartile in 2012 as they were in 1980 and the remainder move up or down, the top income quartile counties as assessed based on 2012 income suffered only 25.2 % of the toxic releases than did the lowest income quartile. Further, the highest 2012 income quartile enjoyed a 50.4 % drop in pollution in the 2000–2012 period, while the lowest 2012 income quartile experienced only a 22.2 % drop. While these numbers tell a similar story to those of 1980, we do note that the disparity in the drops in pollution levels are more modest than those from 1980 (67.7 and 17.9 % drops, respectively). This suggests that substantial Tiebout sorting is not likely taking place: if better earners were consistently moving to less polluted areas, we should observe a greater disparity when using 2012 incomes rather than 1980 incomes. Instead what this result suggests is that pollution may be correlated with a more productive economy with

Table 8 Robustness test; all toxic releases emitted by industrial sources in United States, broken down by per capita income in county in 2012

2012 per capita income quartile	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	9.92E+09		1.85E+14		9894	1002880.0	
	2000–2012	7.72E+09	−22.2	1.23E+14	−33.5	8789	878739.3	−12.4
2nd	1987–1999	6.89E+09		1.22E+14		9210	747713.3	
	2000–2012	4.66E+09	−32.4	8.96E+13	−26.6	7670	607344.1	−18.8
3rd	1987–1999	4.65E+09		8.84E+13		8522	545144.3	
	2000–2012	2.75E+09	−40.9	2.65E+13	−70.0	6293	437167.2	−19.8
4th	1987–1999	2.50E+09		5.30E+13		6832	365630.9	
	2000–2012	1.24E+09	−50.4	1.81E+13	−65.8	4852	254846.0	−30.3
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593375.8	−14.4

incomes rising as a result. Unfortunately, the decline in the income disparity is not sufficient to have eliminated the pollution inequality based on income.

Second, in Table 9, we replicate the analysis for income, using average educational attainment in a county and splitting the counties by educational quartile. Splitting the U.S. counties where toxic emissions occur based on the average years of education for adults within counties tells a similar story to that of per capita income. Indeed, education and income are correlated 0.525 at the county level. We observe that the least educated counties have borne the brunt of toxic emissions, and that the gap in emissions between the high-education and low-education counties has grown in the new millennium. U.S. industry has emitted 13.3 billion pounds of toxic releases into the air in the 13 years from 1987 through 1999 in counties with the least educated populations. This represents 55.2 % of the total of 24.1 billion pounds for the entire U.S. In the years 2000 through 2012, this amount dropped to 11.1 billion pounds, a drop of 15.9 %. However, this represents 67.5 % of the 16.5 billion pounds released throughout the U.S. in the 2000–2012 period. Due to the discrete nature of the schooling variable (it is rounded, at the country level to the tenths of years) and because 12.0 years of education represents a very common average, almost 33 % of the population fits into the bottom "quartile." Nonetheless, the fact that bottom third of the population, in terms of education, is exposed to two-thirds of industrial pollution, remains a striking and sobering result.

Thus, the remaining two-thirds of the population are exposed to only one-third of the pollution. But the most educated quartile is subject to even less. Toxic emissions in the counties with the most educated adults totaled only 2.5 billion pounds in the 1987–1999 period. In the 2000–2012 period, this amount dropped to 1.03 billion pounds, a drop of 58.8 % from the 1987–1999 amount. Contrast this

Table 9 All toxic releases emitted by industry, broken down by years of education for adults in 1980

1980 years of education quartile	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	1.33E+10		2.22E+14		14,354	929130.9	
	2000–2012	1.11E+10	−16.5	1.38E+14	−37.8	12,021	926997.4	−0.2
2nd	1987–1999	3.99E+09		9.39E+13		6834	583284.1	
	2000–2012	2.45E+09	−38.6	7.22E+13	−23.1	5476	448255.1	−23.1
3rd	1987–1999	4.26E+09		8.77E+13		7549	564619.9	
	2000–2012	1.84E+09	−56.8	2.78E+13	−68.3	5780	318382.4	−43.6
4th	1987–1999	2.50E+09		4.59E+13		6038	414230.4	
	2000–2012	1.03E+09	−58.8	1.99E+13	−56.6	4530	227390.0	−45.1
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593375.8	−14.4

Table 10 Robustness test; all toxic releases emitted by industry, broken down by counties' level of urbanization in 1980

1980 urbanization	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	1.01E+10		1.41E+14		9946	1012169	
	2000–2012	8.35E+09	−17.3	1.05E+14	−25.5	9104	917214.6	−9.4
2nd	1987–1999	7.20E+09		1.50E+14		10032	718173.1	
	2000–2012	4.83E+09	−32.9	1.05E+14	−30.0	8459	571472.3	−20.4
3rd	1987–1999	4.79E+09		1.06E+14		8187	585505.3	
	2000–2012	2.63E+09	−45.1	3.46E+13	−67.4	6304	417528.1	−28.7
4th	1987–1999	1.89E+09		5.12E+13		6274	300972.6	
	2000–2012	5.96E+08	−68.5	1.27E+13	−75.2	3739	159414.4	−47.0
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593375.8	−14.4

Table 11 Robustness test; all toxic releases emitted by industrial sources in United States, broken down by percentage of residents that are African-American in County in 1980

1980% African-American quartile	Period	Total emissions (pounds)	Change (%)	Total risk-weighted emissions	Change (%)	Number of emitting facilities	Pounds emitted per facility	Change (%)
1st	1987–1999	7.12E+09		1.37E+14		10,003	712279.3	
	2000–2012	5.24E+09	−26.4	1.01E+14	−26.3	8657	605657.8	−15.0
2nd	1987–1999	4.92E+09		1.04E+14		8788	559588.4	
	2000–2012	3.41E+09	−30.7	4.41E+13	−57.6	6850	497784.4	−11.0
3rd	1987–1999	4.44E+09		7.97E+13		7977	556015.2	
	2000–2012	2.98E+09	−32.9	2.79E+13	−65.0	5895	505730.5	−9.0
4th	1987–1999	7.61E+09		1.3E+14		8007	950221.1	
	2000–2012	4.83E+09	−36.5	8.44E+13	−35.1	6405	754742.1	−20.6
Total (all US)	1987–1999	2.41E+10		4.49E+14		34,775	693026.6	
	2000–2012	1.65E+10	−31.5	2.58E+14	−42.5	27,807	593375.8	−14.4

percentage drop with the 16.5 % drop of the lowest quartile, the most educated population has not only enjoyed the lowest pollution levels over the last 26 years but also the greatest drop, from a lower base level.

Third, in Table 10, we split the counties by quartiles of urbanization, that is, the percentage of residents classified as urban within each county. These results confirm what we found in our regression analysis in Table 7. Urbanization has a strong pollution-reducing effect. On the one hand, the least urban quartile of counties were subject to 10.1 billion pounds of emissions between 1987 and 1999 and only a slightly (17.3 %) smaller 8.35 billion pounds between 2000 and 2012. On the other hand, the most urban quartile enjoyed low emissions of 1.89 billion pounds between 1987 and 1999, only 18.8 % of the level in the least urban quartile. Further, this already low amount shrunk by 68.5 % in the post-millennium period. However, based on the regressions of Table 7, we conclude that these numbers are not completely confounded with the income results. The regressions show that income and urbanization have separate effects.

Finally, in Table 11, we split the counties by the percentage of African-American residents of each county. In contrast to previously reported findings that also use some of the TRI data (e.g., Hamilton 1995; Ringquist 1993; Campbell et al. 2010), we do not observe that counties with more African-American residents suffer from higher levels of pollution, nor that this level has decreased at a slower rate than that of counties with fewer African-American residents. U.S. industry has emitted 7.12 billion pounds of toxic releases into the air in the 13 years from 1987 through 1999 in counties with the fewest African-American residents, and 7.61 billion pounds of toxic releases from 1987 through 1999 in counties with the most African-American residents. In the years 2000 through 2012, these amounts dropped by 26.4 and 31.5 %, respectively.

Consistent with our regression results in Table 7, the counties with more African-American residents actually dropped by a slightly greater percentage than those with the fewest. We note that this result differs sharply from Ringquist's (2005) meta-analysis of environmental equity studies which finds "ubiquitous evidence of environmental inequities based upon race, existing research does not support the contention that similar inequities exist with respect to economic class" (p. 223). We believe that one possibility is that racial pollution inequality may be more likely at levels of analysis smaller than the county (e.g., Campbell et al. 2010; Taylor, 2014). We do not wish to discount the possibility that race does indeed affect community pollution levels. Rather we wish to push back on the notion that class inequality is not associated with pollution. We believe that our results have demonstrated a strong association between class inequality and environmental injustice.

Conclusion

We studied the change in toxic chemicals emitted in the United States over the period 1988–2014, and found that while chemical releases have indeed substantially decreased over that time period (Fung and O'Rourke 2000), the improvements are much stronger in certain areas. Specifically, our results provide very strong evidence for a widening pollution gap between rich and poor counties over the period of the TRI. On a simple basis of total pounds of chemicals emitted, those people living in the poorest counties in the US saw overall reductions in emissions of 17.9 %, while those in the richest counties enjoyed a drop of 67.7 %.

Our results provide additional evidence toward the environmental justice literature (Weinberg 1998; Shapiro 2005; Downey and Hawkins 2008). We examine data from the first 26 years of the TRI and find that people with greater economic status have enjoyed significant advantages in terms of environmental improvements over this period, and that the gap between rich and poor in terms of environmental outcomes has widened considerably. While there has long been evidence for environmental injustice, there is a dearth of evidence about how the differential exposure to environmental issues may be changing over time. Our results confirm those of Shapiro (2005), while extending his analysis for an additional 24 years, over a larger portion of the country and with analyses of total unweighted emissions in addition to RSEI risk-weighted emissions, and cross-state and within-state pollution levels.

The results suggest that the degree of environmental injustice has increased in the United States over the past several decades. This is particularly noteworthy because our data cover a period in which this issue gained significant traction among activists (UCC 1987), researchers (Downey 1998; Freudenberg et al. 2011), and regulators. In additional analysis, we demonstrate that the patterns are found both for facilities that are in continuous operation over the panel and for those that begin operations during our observation period, and in fact that the results are stronger for the latter. This suggests that the initial explanation for environmental injustice, namely that facilities were choosing to locate in disadvantaged communities (UCC 1987; Downey 1998) continues to hold true.

Beyond the contribution to the environmental justice literature, our results have implications for managers and policy makers. For managers, our analysis points to the ways that firms may be, either consciously or unconsciously, reacting differently to institutional pressures in different communities. There is a growing scholarly interest in such heterogeneous responses to institutional pressures (Eesley and Lenox 2006; Doshi et al. 2013; Delmas and Toffel 2012). Prior research on responses to institutional pressures has demonstrated that laggards tend to improve once information about performance is disseminated to stakeholders (Chatterji and Toffel 2010).

Our analysis suggests that the improvement in toxic emissions has been realized largely among facilities in more affluent areas, suggesting that not all laggards are equally likely to improve, and that there are moderating influences on firm responses. For policy makers and activists interested in reducing toxic emissions, and especially in improving environmental justice, our results suggest that we need to understand better what catalyzes improvement in some areas compared to others. Much of the prior research on effectiveness of information disclosure, for example, has focused upon the way that aspects of the programs determine their effectiveness (see, e.g., Weil et al. 2006). Our results suggest that program construction is only part of the problem and that heterogeneous outcomes can result within a single program. Here, areas of higher income, lower proportions of minority residents, and more educated residents have enjoyed greater improvement in toxic emissions, but further research is needed to help stakeholders understand the complex factors that have enabled these improvements.

Our results also have implications for the growing literature on information disclosure as a form of regulation. The TRI has been lauded for its effectiveness and efficiency (EPA 1997; 2000) based upon overall observed reductions in chemical emissions. We confirm the overall reduction but demonstrate that the reductions are far from evenly distributed. We cannot claim, of course, that the

TRI *causes* the increased discrepancy between poor and rich counties (or black and white counties) but what we find is that over the period that the TRI has been in operation, the gap in emissions of the chemicals covered by this program has grown. While it is of course possible that the gap might have grown (or even been worse) absent the TRI, our results suggest that we should be cautious in lauding information disclosure as a regulatory mechanism. This caution is especially prudent in light of other research on information disclosure that suggests that disclosure programs are "income elastic" forms of regulation in which wealthier stakeholders demonstrate greater response, presumably because of higher capacity to utilize the information provided to them (Bollinger et al. 2010).

We note that our data do not allow us to observe the actual actions that counties are taking to create improvement. Thus, we recognize that there are potentially alternative explanations for the patterns we observe. Regardless, the policy implications are similar. Our aforementioned split of the data into continuously operating facilities and those that exit and enter help mitigate the possibility that our results are simply driven by the richer counties becoming less economically viable locations for manufacturing, for example. One additional issue that we have not yet controlled for is the possibility that the results partly reflect a change in economic activity such that some industries are more likely to have fled to other countries and for some reason these industries are also both cleaner and more likely to have been located in richer counties. While this is worthy of future analysis, it is at least partly refuted by our results for continuously operating facilities, in which we find that even for these facilities, there has been a greater change in the wealthier counties. This demonstrates that the trends we note are not solely due to the 'pollution haven' pattern by which firms flee stringent jurisdictions in order to produce in areas where they are less regulated (Dowell et al. 2000). Of course, to the residents of the counties that have not experienced as significant an improvement, knowing whether their toxins come from new entrants or existing facilities is likely less important than trying to close the gap that we have documented.

Overall, our results suggest that while much has been accomplished to improve environmental outcomes in the United States in recent decades, these improvements are far from evenly distributed. The wealthiest quartile of counties in this country has seen toxic emissions decrease to a far greater degree than their poorer counterparts. Thus, despite increased recognition that environmental injustice is a serious issue and that those communities with higher proportions of minority residents and those with lower income are at significant risk, the problem has only increased. For residents of the affected communities and concerned stakeholders, the question is: "what can be done to address this issue?"

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